



Illinois Department of Transportation

Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

MESSAGE TO THE RESIDENT ON CONSTRUCTION By the Engineer of Construction

There is no other individual position in the Illinois Division of Highways so important to the proper functioning of this agency as the position of Resident Engineer/Technician (Resident). As Resident, you are charged with a heavy responsibility, since you represent the Division of Highways in dealings with the Contractor, cooperating governmental agencies, the traveling public, and the taxpayer.

It is in the public interest and, therefore, our practice to cooperate with the construction industry to achieve maximum efficiency in producing a quality project. The Contractor has obligated funds, equipment, and manpower to the job and must necessarily be concerned in protecting his/her investment. To continue as a Contractor, it is necessary to make a reasonable profit. At the same time, a Contractor takes pride in the proper completion of the work. The reduction of cost is in the interest of the State, and timely completion of the job is a benefit to the traveling public. When the entire picture is viewed, it is apparent that the interests of the Contractor and the Department are not different but basically similar.

It is necessary at all times to insist on a high quality of work in accordance with the specifications, but it is also necessary to consider the following points:

Each construction job is "custom built" due to the many variables caused by weather, topography, local conditions and design considerations.

It is important to provide necessary decisions in the shortest possible time on the many problems which will develop. A delay in giving a decision might cause unnecessary cost to the Contractor due to idle personnel and equipment.

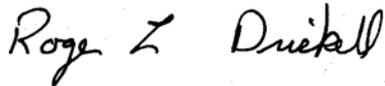
It is recognized that due to other cooperating governmental agencies it sometimes takes time for a question to go through all the necessary channels. This fact makes it all the more important for the Resident to constantly discuss problems and progress with the Contractor in an attempt to anticipate and resolve problems in a timely manner and to keep delays to a minimum.

The construction industry is a fast-moving and fast-changing business. Extremely large amounts of capital are necessary for operation and it is

therefore important that the Contractor be reimbursed for work completed in accordance with the specifications without delay..

In addition, accounting procedures are continually reviewed and modernized to the maximum extent possible to provide fast payment which is necessary for an economical operation. It is therefore important for the Resident to ensure that all monies due the Contractor are provided to the fullest extent possible in the shortest possible time.

As a representative of the Illinois Department of Transportation, you will be viewed by the public as the representative of the State. The impression of the public as to your efficiency, devotion to duty, and personal conduct in the field will be based on your actions. In your dealings with the local public officials, the local residents, and the traveling public, it is important that prompt, sympathetic attention to the problems of these various groups be given when these problems concern the improvement in which you are involved. You should deal with these people at all times in a manner which will gain respect and confidence and in turn make your job easier while constructing the work. The Resident should not attempt to speak for the Illinois Department of Transportation on questions of general policy or practice which might be controversial. If you do not agree with a policy or practice, it is incumbent on you to discuss it with your supervisor but in no case should the matter be discussed with people from outside the Department of Transportation. It is important to realize that a courteous approach will normally yield respect where an arbitrary stand without due consideration for other factors or other people's viewpoints will usually cause resentment towards you and the Department of Transportation as a whole. Your personal actions while serving as Resident on a construction project will be a strong influence in the development of favorable and constructive public relations.

A handwritten signature in black ink that reads "Roger L. Driskell". The signature is written in a cursive style and is positioned above a vertical red line.

Roger L. Driskell, P.E.
Engineer of Construction



Illinois Department of Transportation

Departmental Policies

CON-1
April 1, 1999

CONSTRUCTION MANUAL

1. POLICY.

The Bureau of Construction, Division of Highways, will publish and maintain a manual which establishes construction policies consistent with the [Standard Specifications for Road and Bridge Construction](#) and provides uniform procedures for highway construction field work. The manual will carry a title of *Construction Manual*.

2. PURPOSE.

The Construction Manual will contain a compilation of policy statements and guidelines which will define the Illinois Department of Transportation's construction practices relative to achieving maximum production and quality performance in highway construction field work, and promote uniformity in contract administration.

3. GUIDELINES FOR IMPLEMENTATION.

The policy statements and guidelines which constitute the *Construction Manual* are effective on the date they are forwarded to recipients of the manual or as noted on the material itself. The manual covers subject areas such as:

- A. Clarification of corresponding sections of the [Standard Specifications for Road and Bridge Construction](#)
- B. [Construction Memorandums](#)
- C. [Documentation](#)
- D. [Project Procedures Guide](#)

- E. [Construction Inspector's Checklists](#)
- F. [Forms and Reports](#)
- G. [Equal Employment Opportunity](#)

4. **RESPONSIBILITIES.**

The Central Bureau of Construction is responsible for construction policy development. The bureau is also responsible for preparing and maintaining this manual.

The districts will provide policy guidance in the implementation of this Manual and assistance in the development of current policy provisions contained herein.

5. **ACCESSIBILITY.**

Copies of this manual may be obtained from the Bureau of Highways Administration in the Harry R. Hanley Building. This policy and the corresponding manual may be examined in the Hanley Building Library.

CLOSING NOTICE.

Supersedes: Departmental Policy CON-1, *Construction Manual*,
January 3, 1995

Approved: 
Director of Highways

April 1, 1999
Date



ADMINISTRATION

The *Construction Manual* is to be used as a guide by field personnel. The Manual is not a set of Specifications. It was compiled to clarify the Standard Specifications and to suggest uniform procedures in the highway construction field work. The Standard Specifications, Supplemental Specifications, plans, proposals, special provisions and all supplementary documents are all binding parts of the contract. Nothing in this Manual changes a contract.

The *Construction Manual* is divided into fourteen major sections. The Administration Section, Sections 100 through 900 (correspond to like numbered sections of the *Standard Specifications for Road and Bridge Construction*), *Construction Memorandums*, *Documentation*, *Project Procedures Guide*, *Construction Inspector's Checklists*, *Forms* and *Equal Employment Opportunity*. Due to constantly changing parameters in construction, it is important to review a particular contract's supplemental specifications and special provisions since they take precedence over the Standard Specifications and plans.

Metric conversions in this manual are a mixture of hard and soft conversions. Check your contract to determine which units apply.

Other sources of information available, but not included in this Manual, are listed below:

- *Departmental Orders*
- *Design and Environment Manual*
- *Standard Specifications for Road and Bridge Construction*
- *Manual of Test Procedures for Materials*
- *Manual on Uniform Traffic Control Devices for Streets and Highways*
- *Policy on the Accommodation of Utilities on Right-of-way of the Illinois State Highway System*
- *Policy on Permits for Access Driveways to State Highways*
- *Employee Safety Code*
- *Geotechnical Manual*
- *Subgrade Stability Manual*
- *Work Site Rotation Manual (Other than Highway Maintenance & Traffic Crews)*

METRIC INFORMATION

Definitions: Soft Conversion is an exact conversion of the English Unit. Hard Conversion is a close approximation of the English Unit, but is rounded logically in the metric system. The Construction Manual indicates hard metric conversions. Soft metric conversion units are listed on the back of this page.

<u>Basic Dimensions</u>		<u>Prefixes</u>		
millimeter	(mm)	deci (d)	10^{-1}	one tenth
meter	(m)	centi (c)	10^{-2}	one hundredth
square meter	(sq m)	milli (m)	10^{-3}	one thousandth
cubic meter	(cu m)	micro (μ)	10^{-6}	one millionth
		nano (n)	10^{-9}	one billionth
liter	(L)	deca (da)	10^1	ten
		hecto (h)	10^2	one hundred
pascal	(Pa)	kilo (k)	10^3	one thousand
kilopascal	(kPa)	Mega (M)	10^6	one million
Megapascal	(MPa)	Giga (G)	10^9	one billion
newton	(N)			
kilonewton	(kN)			
joule	(J)			
degree Celsius	($^{\circ}$ C)			
gram	(g)			
kilogram	(kg)			
Megagram	(Mg) (metric ton)			
kilogram per square meter (kg/sq m)				
Hectare (ha)				

Metric Measurements

Length	= millimeters, meters, kilometers
Area	= square meters or hectare (10,000 sq m)
Volume	= Liters or cubic meters
Mass	= kilograms, metric tons (1000 kg)
Force	= newton ($N = kg\ m/s^2$)
Pressure, Stress	= Pascal ($Pa = N/sq\ m$)
Energy, Work	= Joule ($J = N\ m$)
Torque	= Newton meter (N m)
Speed, Velocity	= meter/second, kilometers/hour
Acceleration	= meters/second squared, kilometers/hours squared
Density	= kilogram/cubic meter
Temperature	= degrees Celsius
Power	= Watt

Conversions	<u>From English</u>	<u>To Metric</u>	<u>Multiply By</u>
LENGTH			
	in.	mm	25.4
	ft	mm	304.8
	ft	m	0.3048
	yd	m	0.9144
	mile	km	1.609344
	mile	m	1609.344
	inches/mile	mm/km	15.7828
AREA			
	sq inch	sq mm	645.16
	sq ft	sq m	0.092903
	sq yd	sq m	0.836127
	acre	sq m	4046.856
	acre	ha	0.404685
	sq mile	sq km	2.59
VOLUME			
	cubic inch	cu mm	16387.06
	cubic foot	cu m	0.028316
	cubic yard	cu m	0.764555
	gallon	L	3.78541
	gal/yd	L/m	4.1398
	gal/sq yd	L/sq m	4.5273
	gal/cubic yd	L/cu m	4.9511
	gal/acre	L/ha	9.354
	gal/ton	L/metric ton	4.1726

Conversions	<u>From English</u>	<u>To Metric</u>	<u>Multiply By</u>
MASS			
	ounces	g	28.349523
	pound	kg	0.453592
	kip (1000 lbs.)	metric ton	0.453592
	ton	metric ton	0.9072
FORCE			
	pound	N	4.44822
	kip	kN	4.44822
FORCE/UNIT LENGTH			
	lb/ft.	N/m	14.5939
	lb/in.	N/mm	0.1751
PRESSURE, STRESS			
	lbs./sq ft	Pa	47.8803
	kips/sq ft	kPa	47.8803
	lbs./sq in.	kPa	6.89476
	lbs./sq in.	MPa	0.006895
	kips/sq in.	MPa	6.89476
ENERGY			
	foot pound	J	1.35582
MASSES/LENGTH			
	ounces/sq yd	kg/sq m	0.0339057
	lbs./sq ft	kg/sq m	4.8824
	lbs./sq yd	kg/sq m	0.5425
	lbs./cubic ft	kg/cu m	16.01894
	lbs./cubic yd	kg/cu m	0.5933
	lbs./acre	kg/ha	1.1208
	ton/acre	metric ton/ha	2.2417
TEMPERATURE			
	$(^{\circ}\text{F} - 32)/1.8 = ^{\circ}\text{C}$		

FEDERAL HIGHWAY ADMINISTRATION (FHWA)

On a highway project financed wholly or in part with Federal funds, the terms of Federal participation are set up in an agreement between the Department and the [Federal Highway Administration](#) (FHWA). Each Federal-aid project agreement provides that the work is to be done in accordance with predetermined standards embodied in the plans and specifications, in other approved standard drawings, and in any special provisions required due to the nature of the project.

The contract for the Federal-aid project is awarded by the Department with the concurrence of the FHWA. Supervision of construction is a function of the Department and its Engineers and Inspectors. However, Engineers from the FHWA will make inspections on Federal-aid projects at times selected by them. In addition, FHWA Engineers may make a final inspection on selected projects with federal funds.

The relationship between the FHWA and the Department does not directly involve the Contractors. [Federal Highway Administration](#) representatives periodically inspect projects for the purpose of reviewing the Department's procedures requiring the project to be constructed in accordance with the commitments contained in the Federal-aid project agreement. The FHWA representative will inspect the Department's performance, not the Contractor's. The FHWA representative has neither responsibility nor authority to deal directly with the Contractor.

Department employees should cooperate with the FHWA representatives in their inspections. Their comments should be noted in the diary and matters that require action should be promptly referred to the Regional Engineer. When an Area Engineer representative from the FHWA inspects any Interstate project, attention should be called to necessary extra work and to any proposed changes. All major changes on Interstate projects and to the commitment file on all Federal-aid projects must have concurrence of the FHWA before any of the work is started. Refer to Construction [Memorandum No. 4](#), Contract Changes, Articles 104.02 and 109.04.

ILLINOIS DEPARTMENT OF TRANSPORTATION REGION and DISTRICT BOUNDARIES WITH OFFICE LOCATION

Region 1

DISTRICT 1
201 WEST CENTER COURT
SCHAUMBURG, ILLINOIS 60196-1096
PHONE: 847/705-4000

Region 2

DISTRICT 2
819 DEPOT AVENUE
DIXON, ILLINOIS 61021-3546
PHONE: 815/284-2271

DISTRICT 3
700 EAST NORRIS DRIVE
P. O. BOX 697
OTTAWA, ILLINOIS 61350-0697
PHONE: 815/434-6131

Region 3

DISTRICT 4
401 MAIN STREET
PEORIA, ILLINOIS 61602-1111
PHONE: 309/671-3333

DISTRICT 5
STATE HIGHWAY BUILDING
13473 IL Hwy. 133
P. O. BOX 610
PARIS, ILLINOIS 61944-0610
PHONE: 217/465-4181

Region 4

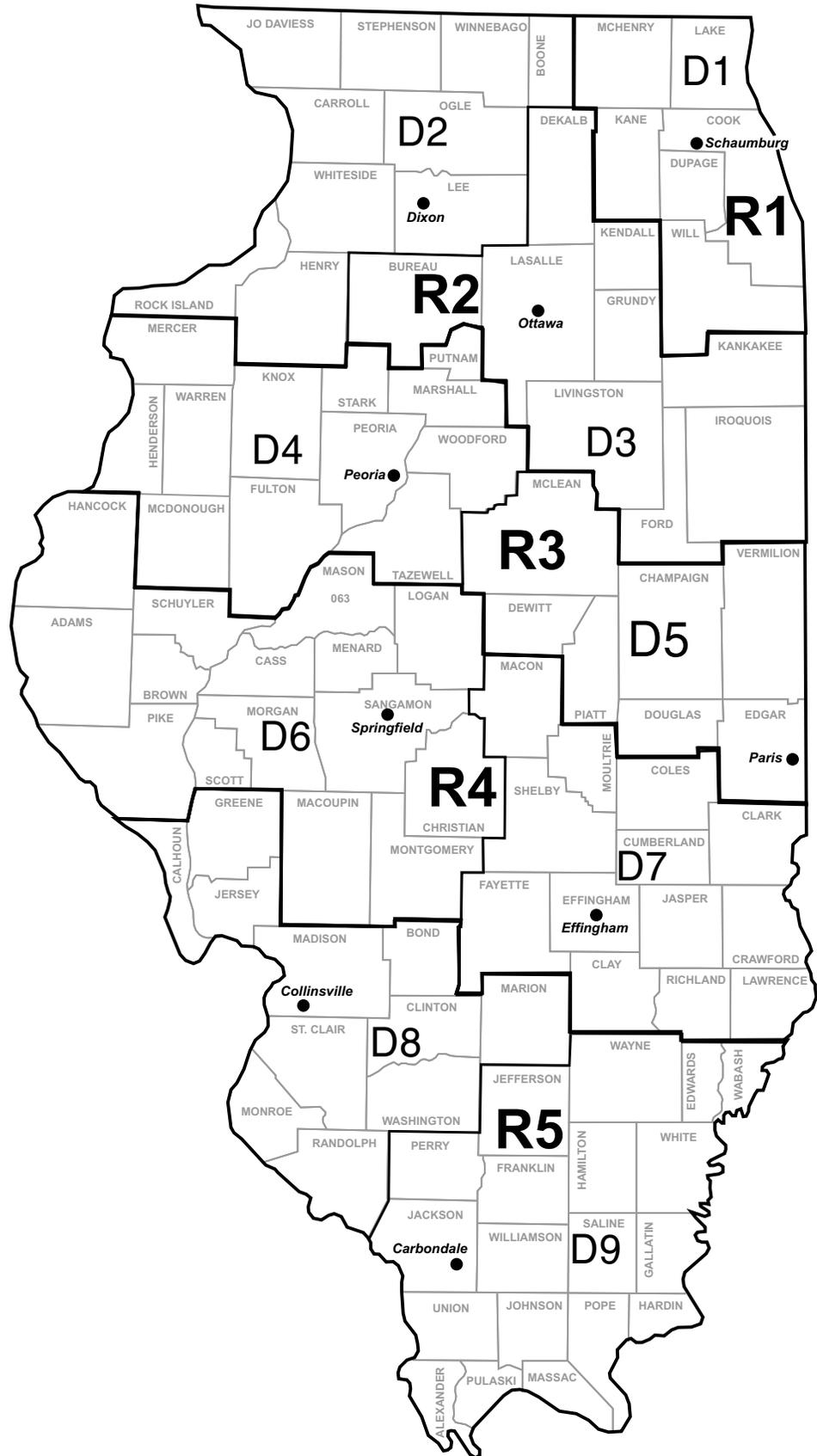
DISTRICT 6
126 EAST ASH STREET
SPRINGFIELD, ILLINOIS 62704-4792
PHONE: 217/782-7301

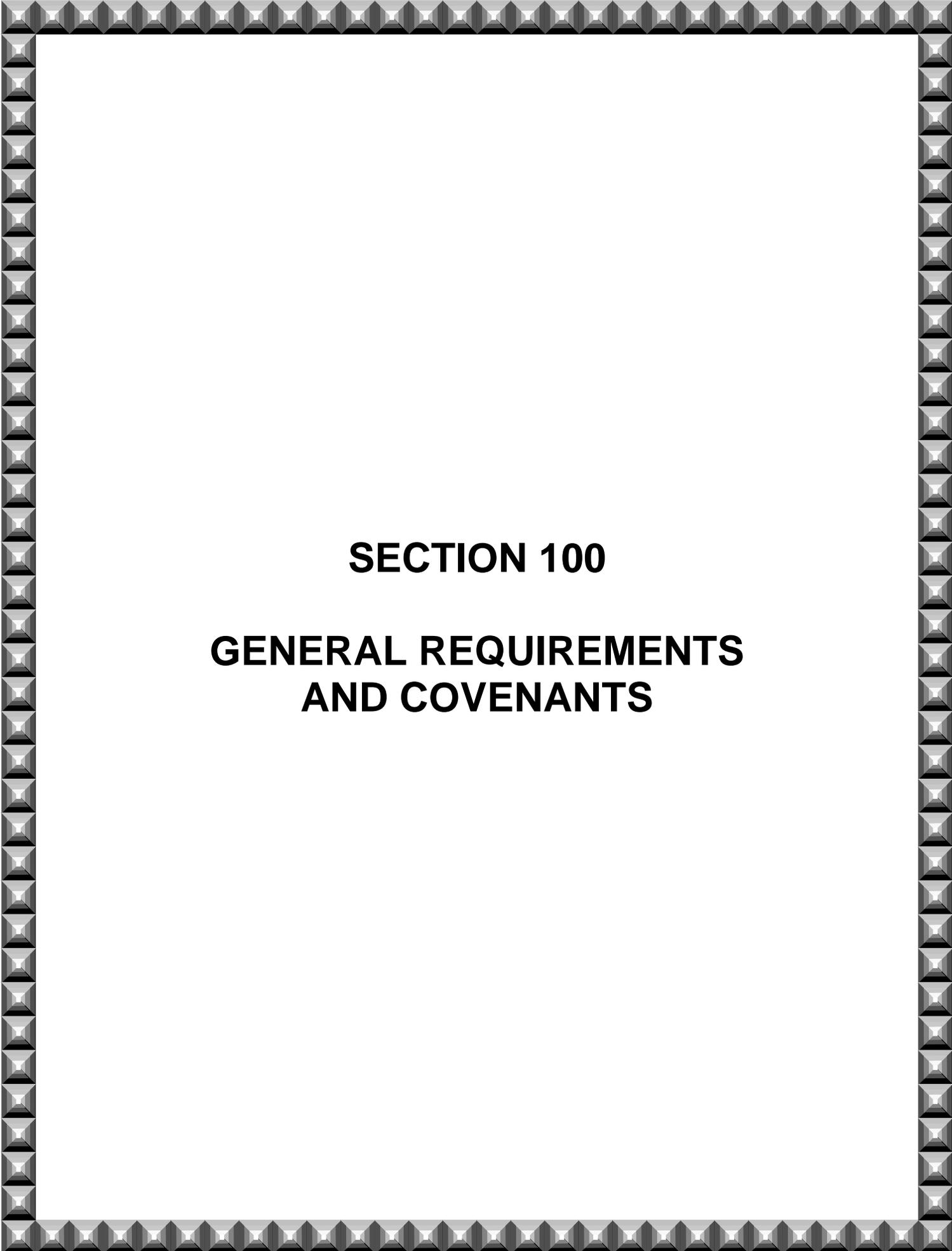
DISTRICT 7
STATE HIGHWAY BUILDING
400 WEST WABASH
EFFINGHAM, ILLINOIS 62401-2699
PHONE: 217/342-3951

Region 5

DISTRICT 8
1102 EASTPORT PLAZA DRIVE
COLLINSVILLE, ILLINOIS 62234-6198
PHONE: 618/346-3100

DISTRICT 9
STATE HIGHWAY BUILDING
P. O. BOX 100
CARBONDALE, ILLINOIS 62903-0100
PHONE: 618/549-2171





SECTION 100

**GENERAL REQUIREMENTS
AND COVENANTS**

SECTION 100. GENERAL REQUIREMENTS AND COVENANTS

The following section has to do with the general description of terms used within the Department and an explanation of the general covenants required by the Department in relation to bidding and award, scope and control of work to include materials, legal regulation and responsibility to the public, as well as, prosecution, progress, measurement and payment for work completed. Because many of the Articles in this section are either self-explanatory or of value to the Resident as a knowledgeable reference only, little additional information is required.

SECTION 101. DEFINITION OF TERMS**101.07 Central Bureau of Construction (BC)**

The Central Bureau of Construction is responsible for providing policies that result in quality construction, approving modifications in contracts, providing uniform contract interpretation, prequalifying Contractors and prequalifying consultants for construction engineering, processing contractor payments as well as other responsibilities associated with state highway construction.

The Bureau determines Contractors financial prequalification and work ratings for various types of construction and analyzes Contractors requests for authorization to bid on Department lettings. The Bureau bills Local Agencies, processes change orders, approves alterations in contract work and approves requests for extensions of contract time limits. Additionally, the Bureau coordinates the activity of the IDOT/Industry Joint Cooperative and chairs and/or participates in various task forces and training programs.

Construction Reviews by the Central Bureau of Construction. General construction policies and uniform practices are developed and administered in cooperation with the district Construction offices through the Project Review Engineers of the Bureau of Construction. Active construction contracts are inspected by the Bureau of Construction personnel at intervals during the construction season.

Uniform Construction Practice. With nine districts in immediate charge of construction work certain differences in the interpretation of the specifications and in construction policies may develop. In order to secure uniformity, the Central Bureau of Construction provides general review of construction work performed in all districts. This is accomplished by Project Review Engineers who are assigned and rotated among the various districts. They inspect the work at various intervals during completion. This is entirely a cooperative matter and is intended to improve the uniformity of administration of policies, interpretation of the specifications and improve the overall quality of work performed by the Department. Suggestions concerning interpretation of policies and contract requirements may be given to district construction supervisors by representatives of the Bureau of Construction. This is a sound policy and as such should be welcomed. When the suggestions conflict with the District's viewpoint as to the proper method of handling the work and cannot be resolved, a memorandum will be sent to the District clarifying the interpretation.

101.14 District Construction Engineer

The State is divided into five Regions and further divided into nine Districts as shown on the [map](#) in the [Administration](#) Section of this manual. All functions within the District are performed under the direction of the Regional Engineer, in accordance with established policies. Each Central Bureau has a counterpart function in the District. The Regional Engineer delegates to the Project Implementation Engineer the authority for supervision and administration of all highway contracts within the District from the time of execution until construction and final papers are completed. This is accomplished through the District Construction Engineer who has the responsibility to ensure the work is performed in accordance with the contract documents which consist of the contract, special provisions, plans, recurring special provisions, supplemental specifications, and the Standard Specifications for Road & Bridge Construction. To accomplish this responsibility, a Resident and staff are assigned to each contract.

The District Construction Engineer is assisted by Supervising Field Engineers. Each Supervising Field Engineer is assigned to a geographical area and some Districts have a Field Engineer assigned specifically to local Federal-aid contracts. The Supervising Field Engineers periodically review all contracts in their area to monitor progress, assist the Residents with construction problems and approve additional work within policy limits. They also conduct preconstruction conferences and perform final inspections.

District Construction Engineers and Field Engineers motivate, evaluate, organize, train, assign and equip construction personnel to properly perform their assigned duties. They also keep the public informed of the progress of construction projects and of changes in traffic staging. They ensure that public complaints are handled quickly and judiciously for all concerned parties.

SECTION 102. PREPARATION OF BID

SECTION 103. AWARD OF CONTRACT

Sections 102 and 103 were eliminated from the Standard Specifications starting with the 2002 edition. The requirements in these two sections dealt with topics prior to the actual execution of the contract and were largely duplicated in the Transportation Bulletin Notice of Letting and the department's Procurement Rules. Both of these documents are part of the contract by reference, per Article 101.09, Contract.

SECTION 104. SCOPE OF WORK

104.01 Intent of the Contract

The department, or more specifically, the Secretary of Transportation, is given authority by the Legislature, to enter into contracts for the purpose of constructing and maintaining highways, airports, and other transportation facilities. The general powers of the Secretary and the department are enumerated in [20 ILCS 2705](#), Civil Administrative Code of Illinois. The laws governing the methods of procuring highway construction and making changes to existing contracts are [30 ILCS 500 Illinois Procurement Code](#), [30 ILCS 105 State Finance Act](#), and [720 ILCS 5 Criminal Code](#). Additionally, [44 Illinois Administrative Code Section 660](#), Contract Procurement, promulgated under the authority of the [Illinois Procurement Code](#), further refine the provisions for contract procurement as applied to the Department of Transportation.

Once the contract is executed (signed) by both the contractor and the department, it becomes a binding, legal relationship in accordance with the terms set out in the contract. Ultimately,

enforcement and interpretation of contract language could be determined by the Court of Claims, the final arbiter of all contract disputes.

Through the various procurement laws, the Legislature made it clear that as much as practicable, all construction contracts are to be entered into through a competitive bidding system, with awards to be made to the lowest responsive and responsible bidder. Cost-plus and force account bids are prohibited by both state and federal (when federal money is involved) law. Although specific work efforts within a contract may be paid for on a force account basis, as specified in the contract, the clear intent is to pay for as much work as possible on the basis of competitively bid unit prices.

104.02 Alterations, Cancellations, Extensions, Deductions and Extra Work

This article is the basis for the department's right to direct changes in the work. This article also states how such changes will be administered and paid.

Authorization of Contract Changes – Construction Memorandum 4

Department policy concerning approval and processing of contract changes is discussed in Construction [Memorandum No. 4](#). This policy is designed to conform department procedures to the [Illinois Procurement Code](#), the [State Finance Act](#), the [Criminal Code](#), department Procurement Rules promulgated in accordance with the [Illinois Procurement Code](#), and Departmental Orders.

The laws and directives mentioned above apply particularly to the approval and publication of contracts and contract changes. Some of the terms used in the above mentioned laws are used in a different sense than they are in [Construction Memorandum No. 4](#). For the purposes understanding the policy contained in this memorandum, the following terms are defined and discussed.

Contract. As defined in [Art. 101.09](#), the contract is "the written Agreement between the Department and the Contractor setting forth the obligations of the parties thereunder. . ." The contract includes the invitation for bids, proposal, letter of award, contract form and contract bond, [Standard Specifications for Road and Bridge Construction](#), [Supplemental Specifications](#), [Special Provisions](#), general and detailed plans, and any Agreements required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument."

[Art. 104.01](#) further states that "the intent of the contract is to prescribe a complete outline of work which the Contractor undertakes to do in full compliance with the plans and specifications. The Contractor shall perform all earthwork, construct all base and surface courses, structures, and such additional, extra, and incidental construction as may be necessary to complete the work to the finished lines, grades and cross sections in an acceptable manner."

Contract Quantity. The total quantity of a pay item that has been approved for payment. Contract quantities may be further delineated as either "original contract quantities" or "adjusted contract quantities" to distinguish between the pay items and quantities shown on the original contract proposal (in the bid schedule) and those pay items that have been added or pay item quantities that have been increased or decreased by authorization above or below the original contract quantities.

Obligation of Funds. After a contract is executed, the funds necessary to pay for the work contemplated in the contract are available by appropriation. An appropriation is a portion of the state budget set aside by the Legislature to pay for defined goods or services. IDOT must file a Contract Obligation Document (COD) with the Comptroller in order to obligate State funds for the future payment of work under the terms of the contract. The obligation reserves a portion of the appropriation for the specific contract. The total value of this obligation is equal to the total value of the contract, as determined by multiplying the contract quantity of each pay item by the respective unit prices and summing the products.

All payments to the Contractor are made against this obligation. Total payment to the Contractor will not, in any case, be allowed to exceed the obligated amount. If the value of work performed under the contract is increased, the value of the obligation must also be increased. When final payment is made to the Contractor, the value of the obligation must be adjusted, up or down, to match the value of the final payment. The Form [BC 22](#), Authorization of Contract Changes, is the instrument for initiating this adjustment in the obligation.

Contract Change. A contract change is a formal, written directive or agreement which amends a contract in order to address contingencies affecting the performance and completion of the contract including but not limited to such matters as extra work, increases or decreases in quantities, additions or alterations to plans, special provisions or specifications, and adjustments or alterations specifically provided for in the contract.

All contract changes that affect the pay items or pay item quantities are submitted to the central office on form [BC 22](#), Authorization of Contract Changes. There are four broad categories of contract changes submitted on a [BC 22](#). First, balancing quantities adjust the contract pay quantities, but do not change actual quantities needed to perform the work shown on the plans. Second, extra work is an addition of work that is not included in the original contract. Extra work would also include modification of the specifications for the work included in the original contract. Third, work that is included in the original contract may be deleted from the contract. Fourth, payment for the contract work may be adjusted based on the performance of the work, as provided for in the contract.

A contract change has three parts. The first part is the written approval of the change. The second part is the written directive to the contractor to perform the work involved in the change. The third part is the obligation of funds necessary to pay for that work.

To help the Department with the administration and approval of contract changes, each change requested by the districts will be classified as either Major change or a Minor change. A single contract change includes all of the various pay item quantity and funding changes involved in the changed work effort.

Approval Authority. The [Illinois Procurement Code](#) grants authority to the Secretary of Transportation, as the Chief Procurement Officer of the Department, to enter into contracts and, within limits, to modify the terms of contracts already executed. The [Illinois Procurement Code](#) allows the Secretary to delegate part of this authority. Only those persons to whom sufficient authority has been delegated may legally approve changes to the contract. This delegation of authority is in terms of the scope, type and value of the change contemplated.

Written Approval of Contract Changes. Before the contractor can be directed to perform any work, the work must be approved. The work included in the original contract is already approved and directed. The [Illinois Procurement Code](#) requires that when the total value of contract changes reaches a certain threshold, all subsequent approvals of contract changes will

be made in writing; the threshold varies based on the original contract value. The [Criminal Code](#) requires that when a change order, or series of change orders, increases or decreases the contract value by \$10,000, or changes the contract time limit by 30 days or more, all subsequent approvals of change orders will be made in writing. [Art. 104.02](#) requires that all changes in the physical work or the contract quantities shall be authorized in writing by the Engineer before the work is started.

Therefore, all work to be performed under the contract will be approved in writing before any work is performed. The written approval must be signed by a person with sufficient approval authority. While the instrument of this approval may take many forms, the most common are Form [BC 22](#), Authorization of Contract Changes, Form [BC 2256](#), Prior Approval Authorization of Contract Change, and Form [BC 329](#), Resident's Memo. As described later, state law requires that the written approval contain a description of the change, the reason for the change, and a statement that the change is germane and an explanation of why it is considered germane.

A special case occurs for balancing quantities, described below, in which the contract itself is considered the written approval to perform the work.

Written Directive to Proceed. The directive to the contractor to proceed with the work binds the Department to make good on the agreed payment for the work, when the work is completed in accordance with the agreement. However, those officials and employees approving the work so directed must do so with sufficient authority that will allow the obligation of additional funds, because the State cannot make payment on the work until sufficient funds have been obligated through the Comptroller.

The contract authorizes and directs the contractor to perform all the work shown on the plans, up to the contract quantity. The contractor will not be paid for any work that exceeds the lines, grades and dimensions given in the contract without direction to do so. Likewise, the contractor will not be paid for any quantities in excess of the contract quantities placed without direction to do so. Again, [Art. 104.02](#) requires that the directive to proceed with extra work or quantities be given in writing before the work starts.

Illinois court decisions have established the following principles in determining whether a contractor may obtain payment for any extra or additional work:

1. the work was extra, i.e. not within the original scope of the project,
2. the extra work was ordered by the owner or an authorized person,
3. before the extra work was begun, the owner agreed to pay for the additional work, either by the words or conduct of the owner or authorized person,
4. the extra work was not a voluntary contribution by the contractor, and
5. the extra work was not necessary due to any fault of the contractor.

An essential point here is the approval for the contractor to proceed with the work, and who is authorized to give that approval. When through word or action an authorized officer directs such work, the Department becomes obligated to pay the contractor for the extra work. However, care must be taken to comply with the various provisions mentioned above.

Except in the special case of balancing quantities, described below, all directives to proceed with extra work or quantities will be made in writing. The written directive must include, at a minimum, a sufficiently precise description of the work to be performed, including references to any Standard Specifications that govern the work, and the signature of the person issuing the directive. This directive may take many forms, the most common are Form [BC 22](#), Authorization of Contract Changes Form [BC 329](#), Resident's Memo, or a letter or memo from the person directing the change. The written approval and the written directive may, in fact, be the same document.

Balancing Quantities. The contract is, itself, the written approval to perform the work described by the contract, to the "lines and grades shown on the plans," etc. However, the contract specifies the amount of work not only in terms of the final dimensions for the work, but also in terms of the contract quantities of the various pay items necessary to complete that work.

As stated in [Art. 102.04](#), "the quantities appearing in the bid schedule are approximate and are prepared for the comparison of bids. Payment to the Contractor will be made only for the actual quantities of work performed and accepted or materials furnished according to the contract."

The difference between the contract quantity and the actual quantity of a pay item is referred to as a balancing quantity. Because the contract quantities are recognized as estimated, as long as the balancing quantity is of a magnitude that reasonably represents, under the circumstance, the actual amount of work required by the contract, the directive to perform an additional, balancing quantity in excess of the contract quantity may be given verbally or by physical layout of the work, without the need of a separate, written directive to the contractor.

Before the contract can be closed, contract quantities must be adjusted up or down to match the final quantity of work performed, so that the obligation of State funds matches the final payment to the contractor. [BC 22](#)'s that include only such balancing adjustments to the pay items are frequently referred to as balancing authorizations. Note, however, that even though the contractor may be directed verbally or by action to perform additional, balancing quantities, payment cannot be made for such quantities until an authorization (form [BC 22](#)) is submitted and approved to adjust the contract quantities.

Any contract change that affects the work to be performed under the contract, other than that needed to balance quantities, requires a specific, written directive to the contractor. The directive may be to perform extra work. The directive may also be to not perform work which is already authorized by the contract.

Plan Quantity Error. Technically, any difference between the estimated contract quantities and the actual quantity of pay items needed to perform the work specified by the contract is a balancing quantity. However, for the purpose of the approval authority and procedures, a quantity is considered balancing only when the estimated quantity reasonably represents the actual amount of work to be performed. The reasonableness of a quantity estimate depends on many factors, including the type of the work, the circumstances of the work, the methods used to determine the plan quantities, and, possibly, the value of the difference in quantities. Determining the reasonableness of a balancing quantity requires good judgment on the part of the Resident.

If a balancing quantity exceeds a reasonable magnitude, then this quantity is considered a plan quantity error. Dealing with plan quantity errors requires special attention.

If the error involves a significant overestimation of the actual quantity needed, the contractor is still limited to placing the work to the lines, grades, etc. specified in the contract. Two potential problems may still arise. First, even though the contractor is limited by the contract specification of the work, the Resident must be especially careful to not give any word or action that may be construed as giving the contractor sufficient direction to proceed with the extra, unneeded quantities. This implies that the Resident must be aware at all times of the progress of the work and the quantity of work that is necessary. Second, in some cases the work is not specified by dimensions in the contract but, rather, by the quantity. For example, an estimated quantity of patching or repair work may be included in the plans, without specifying the location of that work. In this case, the Resident must make sure that the scope of such work is that which was intended by the designer.

Conversely, if the error involves a significant underestimation of the actual quantity needed, the contractor is still limited by the contract quantity in the amount of work to be performed without additional direction. The main problem with this situation is that authorizing the additional quantities necessary to perform the entire work may involve increasing the value of the contract beyond what was expected when the original contract was executed. In this case, the Department will carefully consider whether the additional quantities work will be authorized, or the scope of work involved will be "deleted" from the contract. Payment for the additional quantities is governed by [Art. 104.02](#). For significantly underestimated quantities, the Resident must again be especially careful not to give any work or action that may be construed as giving the contractor sufficient direction to proceed with the additional, unauthorized quantities.

In either case, authorization of quantities involved in a plan quantity error are governed by the levels of delegated approval authority, and require additional written approval and direction to proceed with such work.

Extra Work. As defined in [Art. 101.17](#), extra work is "an item of work not provided for in the contract as awarded but found essential to the satisfactory completion of the contract within its intended scope as determined by the Engineer." Extra work includes both the addition of new types of work for which pay items were not included in the original proposal, as well as additional quantities of existing pay items, to pay for work at locations not included in the plans. As discussed later, work categorized as anticipated additions and unpredictable additions is also considered extra work.

Cancellation of Work. Although most of the discussion of contract changes in this memorandum deals with adding value to the contract, it should be noted that canceling work included in the contract also requires written approval and written direction. Cancellation of work is considered a change order, and is also covered by the [Criminal Code](#). Unless otherwise directed in writing, the contractor is authorized to perform work included in the contract. Payment for partially completed work that has been canceled is covered by [Art. 109.06](#).

Extra Work Effort. An extra work effort includes all of the various types of work necessary to produce a defined change in the project. An extra work effort may include work paid under one or more pay items.

Many of the dollar limits set by the new laws are in relation to an entire work effort, rather than the value of the individual pay item quantities that are necessary to produce the result that is the object of the extra work effort. Limits on delegation of approval authority from the Secretary of Transportation are also in relation to the type or value of an extra work effort. Because of this, judgment is required in defining the scope of a single extra work effort.

A question arises when the same type of extra work is performed at more than one location. One guideline for determining the scope of the extra work effort is that if the description and reason for the change is the same for extra work at different locations, then the work may be considered as part of the same work effort. It must be kept in mind that the law states that contract changes shall not be artificially divided so as to avoid the provisions in the law.

Change Order. As defined by the [Criminal Code](#), a change order is "a change in a contract term, other than as specifically provided for in the contract, which authorizes or necessitates any increase or decrease in the cost of the contract or the time to completion." A change order is a type of contract change that either modifies the requirements for a pay item already included in the contract, or adds a new type or scope of work that was not included in, or anticipated by, the original contract.

For example, increasing the diameter of a storm sewer is a change in specifications and is, therefore, a change order. The pay items and quantities involved in this work effort include the addition of the new, larger pipe, the deletion of the quantity of the original pipe, and, possibly the increase in trench backfill quantity required for the larger trench.

In the past, the terms change order and authorization have been used interchangeably. To help administer contract changes, the term change order will be used to refer only to such contract changes which modify the work called for in the contract, or that increase or decrease the contract completion time by 30 days or more (as noted in the [Criminal Code](#)). The term authorization is used more generically to refer to all the contract changes (not just change orders) submitted on a [BC 22](#).

Contract Adjustment. All contract changes that are not considered change orders are referred to as contract adjustments. A contract adjustment is a change in pay items or pay item quantities needed to pay for either the actual work required to be performed to complete the work called for in the plans, or extra work provided for in the contract.

For example, contract changes to balance as-built quantities against plan quantities are considered contract adjustments. The addition of a new pay item, such as Subgrade Repair, which is called for as a contingency in the Specifications would also be considered a contract adjustment.

Change Category. To help manage the large number of changes that occur on all construction projects, the Residents will begin assigning to each authorization line item a category code representing a change category which describes the type or reason for the change. These change categories are described in detail at the end of [Construction Memorandum No. 4](#) (see Attachments 1 and 2).

The purpose of designating the category codes is to allow statewide summary reports on the causes of contract changes. Individual authorizations already fully describe the descriptions and reasons for the changes. However, when management desires to get a sense of changes for statewide authorizations, it is impossible, practically speaking, to review and tabulate the thousands of authorizations that are approved every year. The change categories, then, provide that information in a way that allows for computer summarization and reporting, and are an important tool for managing trends in plan quality (state plans only) and state spending.

Germaneness. This is defined in the Department's rules promulgated under the [Illinois Procurement Code](#): "In relationship to the modification, alteration or amendment of the terms of a contract by [contract change], the term 'germane' means a change that is related to the

original terms of the contract but that is not so substantial a departure from the original as to constitute a new contract."

There is no exact definition of what is, or is not, germane. The whole idea behind a germaneness requirement is to promote careful planning by the person or agency before entering into a contract to purchase goods or services. The state Legislature mandates that, as much as possible, goods and services (in this case, construction contracts) be procured under a competitive, sealed, bidding system. Additional work added to an existing contract is not subject to competitive bidding. Therefore, the purpose of the germaneness requirement is to limit the amount of additional work that is uncompetitively procured.

It is clear that different people will have different opinions about what is, or what should be considered to be, germane. In reality, a judgment of germaneness is an attempt to conform to the Legislature's intent in establishing the germaneness requirement based on the various procurement requirements written into law, the specific procurement rules approved for the department by the legislative [Joint Committee on Administrative Rules](#), and legal opinions offered by the [Attorney General](#), and audit results from the [Auditor General](#). As a point of reference, prior to the current [Illinois Procurement Code](#), the [Criminal Code](#) required that all change orders be germane or in the best interest of the State or not have been determinable at the time the contract was advertised for bid. With the [Illinois Procurement Code](#), the Legislature required simply that changes were germane. (As discussed below, the [Illinois Procurement Code](#) allows two exceptions: emergency work and small purchases.)

A contract change is considered germane if the change is within the intended scope and quantity of the original proposed contract. In this sense, germaneness determinations have a "nature of the work" aspect and a "value" aspect. A contract change is also considered germane if the change is needed to complete the work directed by the contract.

Generally, types of work that are not shown on the plans or included in specifications, and that are not required to complete the work as bid, are not germane to the contract. For example, regrading a ditch is not germane if no work of this type is included in, or needed to complete, the original contract. On the other hand, modifying the excavation quantities for regrading work included in the plans is germane, if those additional quantities are necessary to produce the drainage result clearly intended by the contract. In the same line, adding a second entrance to an adjacent property may not be germane. On the other hand, adding a field entrance that was unintentionally omitted from the plans is germane, if the entrance is necessary to allow for egress to the property, as required by law.

Work outside the physical limits of the contract is not considered germane, if the work is not necessary to complete the work in the original contract or if the work is not necessary to provide the proper performance of the work in the original contract.

Extra work efforts that significantly increase the cost of the contract may also not be germane, even though the work might otherwise be considered necessary to complete the work in the contract.

Likewise significant changes in quantities may or may not be considered germane. Modifying contract quantities to account for plan quantity errors is germane, as long as the magnitude of the change does not alter the nature of the work.

Emergency Contracts. The [Illinois Procurement Code](#) requires that all contract changes be germane to the original contract. However, the Code also provides for non-germane additions

that are determined to be of an emergency nature. For most emergencies, the emergency work must be ordered and approved by the Regional Engineer, and the departmental policy governing the change is published by the central Bureau of Operations. However, it is conceivable that during the course of an ordinary construction contract an event will occur that poses an immediate hazard to public health or safety in the vicinity of the contract, and it is the intent of this policy to empower the Resident to order immediate action if the Resident is unable to contact and district supervisory personnel. This empowerment is with the understanding that the Resident will contact supervisory personnel as soon as possible following the event. All emergency contract work requires the Regional Engineer to submit an Emergency Affidavit within ten days of ordering the work.

A non-germane contract change may be considered as an emergency change, as defined by law, if:

1. the situation which necessitates the change poses a threat to public health or safety, or
2. there is an immediate need to repair State property in order to prevent or minimize further loss or damage to State property, or
3. the change is needed to prevent or minimize serious disruption in State services
4. the change is needed to preserve public records.

To prevent abuse of this emergency clause, the [Illinois Procurement Code](#) and Department Orders require the Regional Engineer to fill out, sign and notarize Form [BoBS 04](#), Emergency Affidavit. The Emergency Affidavit is reviewed and signed by the Secretary of Transportation. If the change exceeds \$30,000 the affidavit is also published in the Transportation Procurement Bulletin, and within 10 days of the start of the work be sent to the Auditor General for review who, in turn, reports it to the Legislature.

Emergency work constitutes a separate contract, and will ordinarily be paid for under a separate obligation of funds. However, subject to central office approval (per Bureau of Operations policy), in some cases the emergency work may be conveniently paid under an existing construction contract. In this case, the cost of the emergency work will be added to the contract using the same Authorization of Contract Change (Form [BC 22](#)).

Small Purchase Contracts. The [Illinois Procurement Code](#) defines a small purchase limit below which new contracts and contract changes will be exempt from the advertisement requirements of the Code. The Code sets the small purchase limit at \$30,000 as of July 1, 1998, and provides for adjustments for inflation to be issued on July 1 of each subsequent year. The Department rules, based upon authority in the Code, adjust this figure in reliance on the germaneness determination also set out in the Code.

In some sense, the Legislature provided a means to accomplish “small” additions to existing contracts without a requirement for germaneness. A Small Purchase is, in a technical sense, a separate contract which is conveniently paid for under the mechanisms of an existing contract. From the contractor’s perspective, a Small Purchase is indistinguishable from any other change ordered under the contract and paid for in accordance with [Article 104.02](#). However, [Article 101.18](#) defines Extra Work as “an item of work not provided for in the contract as awarded but found essential and germane to the satisfactory completion of the contract within its intended scope as determined by the Engineer.” (Emphasis added.) Taken together, these two

provisions (in the law and in the contract) allow for changes that are still within the realm of work that was bid on by the contractor but do not meet the stricter germaneness standards of the [Illinois Procurement Code](#).

In point of fact, the majority of changes performed each year fall below the current \$30,000 Small Purchase threshold. Since all departmental spending is subject to the oversight of the Legislature, it is not within the best interest of the department and its mission to be seen as abusing the Small Purchase exemption as a way around meeting the overall intentions of the competitive bidding requirements. It is for this reason, that central office approval is required for approval of Small Purchases.

Now, while the [Illinois Procurement Code](#) allows non-germane Small Purchases to be added to an existing contract, these additions are still subject to the requirements of the [Criminal Code](#) and the [State Finance Act](#). The [Criminal Code](#) still requires that for change orders a written determination be made that the change is germane or in the best interest of the State or not contemplated at the time the contract was signed. (There is a minimum threshold for this determination requirement, but as a matter of department policy all changes require a written determination.) So, if a contract change is procured as a Small Purchase (because of non-germaneness) there is still a requirement for a written determination.

FHWA Exempt vs. Non-Exempt (Full-Oversight). All State and Local Agency contracts which include Federal-Aid participation must follow all the requirements of the [Federal Highway Administration](#) (FHWA). The FHWA has active involvement in all Federal-aid (FA) projects during Phase I (planning) and Phase II (design), and they approve federal authorization for each FA project prior to the letting. On the other hand, during Phase III (construction), the department is exempt for direct federal oversight on most projects. On such "exempt" contracts, Federal law requires the State to administer the contract for the FHWA, in accordance with Federal regulations and any agreements between IDOT and the FHWA. The terms "exempt" and "non-exempt" are used to describe the FHWA's oversight role.

For FHWA-exempt projects, the department is solely responsible for ensuring that all work and procedures conform to department policy and specifications.

On non-exempt (full-oversight) contracts, the FHWA takes active involvement in all stages of planning and construction of the project. On exempt contracts, the Department administers all aspects of the contract without direct FHWA oversight.

For non-exempt (full oversight) projects, by written agreement between the department and the FHWA, the FHWA must give prior written approval of all major changes before work on the subject change is begun. (The department's agreement with the FHWA also stipulates that all time extensions must be approved by the FHWA as well as by the central Bureau of Construction.)

On non-exempt (full oversight) FA projects, prior approval of the [Federal Highway Administration](#) is required for all major changes and for all additional work efforts over \$100,000. The central bureau will advise the districts as to which contracts are non-exempt. The FHWA approval will be obtained as early as possible in the contract change development process. The district should keep the FHWA Engineers aware of pending major changes during project visits or through telephone calls. The FHWA approval must be in writing (an email or fax from the FHWA Engineer is sufficient written documentation) and the approval is to be documented on the [BC 22](#) or on a [BC 2256](#) submitted with the [BC 22](#). The central bureau will send a copy of

all authorizations on non-exempt projects to the FHWA (including [BC 22](#)'s that did not require prior approval by the FHWA).

[State Finance Act \(30 ILCS 105/9.02\)](#). The Illinois [State Finance Act](#) requires that when a single or cumulative contract change results in a net change that is equal to or greater than \$250,000 in a fiscal year, before funds may be obligated for such a change, the [BC 22](#), Authorization of Contract Changes, must have the signatures of the Secretary, Director of Highways, Director of Finance & Administration and Chief Counsel. (Departmental Order 2-2)

To give full force to the intent of the [State Finance Act](#), the Secretary has also ordered that for contracts with an awarded value in the range of \$200,000 to \$1,000,000, a single or cumulative change order resulting in a net change that is equal to or greater than 25% of the awarded contract amount in a fiscal year will also require the four signatures.

The [State Finance Act](#), places direct responsibility of oversight for large changes in the value of a contract on the chief executive officers of the Department. Because this law contemplates the total value of contract changes, rather than the specific objects of the changes, it would be extremely burdensome to stop the work to obtain these signatures on the particular authorization which triggers this law. The approval procedures noted above are intended to assure full review and oversight of all changes at an appropriate level of oversight which provides assurance to these officers that valid and lawful approvals have been given. It is absolutely essential, therefore, that all persons invoking delegated authority follow these procedures meticulously, to ensure that all legal requirements and Department regulations are followed.

Therefore, the central Bureau of Construction will coordinate with the chief executive officers to obtain these signatures. It is understood that these signatures may be obtained after the work has already been ordered, when the [BC 22](#) includes only minor changes approved at the district level. The central Bureau of Construction will obtain these signatures for all major changes before the work is approved.

Determination Statement. The [Criminal Code](#) requires that when a change order exceeds \$10,000 or adds 30 days to the duration of the work, a written determination must be made at the time of approval of the change order. The written determination must state one of the following:

- “The undersigned determine that the circumstances said to necessitate the change in performance were not reasonably foreseeable at the time the contract was signed” or
- “The undersigned determine that the change is germane to the original contract as signed” or
- “The undersigned determine that the change order is in the best interest of the unit of State or local government and authorized by law.”

On the other hand, the [Procurement Code](#) requires that all additions to a contract be germane. In addition, when the value of an addition – that is, the net value of an additional work effort – exceeds certain thresholds (depending on the value of the original contract), the [Procurement Code](#) requires that a written determination be made as to why the change is considered germane.

SECTION 105. CONTROL OF WORK

105.03 Conformity with Contract

Article 105.03 states "The Department reserves the right to accept work produced by the Contractor if the Engineer finds the noncompliant materials, the finished product in which the noncompliant materials are used, or the nonconforming work are in close conformity with the contract. In this event, the Engineer will document the basis of acceptance by contract modification which may provide for an appropriate adjustment in the contract price for such work or materials as the Engineer deems necessary to conform to the determination. The determination of the Department will be based on the best engineering judgment of the Engineer and shall be final and binding."

In determining close conformity with the contract, engineering judgment is based on a resulting service life that is not diminished. In the event an appropriate adjustment in the contract price is warranted, the following areas are recommended for consideration but are not considered as all inclusive.

- Engineering Costs

Undue engineering time incurred by the Department to review unacceptable work or material, and time to inspect corrective work may warrant an adjustment in the contract price. This situation may occur when there is the repeated review of unacceptable work or material or a lengthy structural engineering analysis is performed.

When Consultants are used, documentation is straightforward by invoice. In the case of the Department, which involves District and/or Central Office personnel, it is recommended to contact the Bureau of Design & Environment, Preliminary Engineering Section for the hourly rate and multiplier to use.

- Future Inspection and Monitoring Costs

Undue future inspection and monitoring time incurred by the Department may warrant an adjustment in the contract price. This may occur for repairs performed to new construction, such as a bridge. Biennial inspections of a bridge may take longer because of extra time to check the performance of a repair. Calculation of the additional time may include an adjustment to the hourly rate for inflation.

- Future Maintenance Costs

A repair on new construction may not be sufficient to last the entire service life. Thus, timely maintenance may be needed. If the probability of a future repair is high, an adjustment in the contract price may be warranted. Calculation of the future repair cost may include an adjustment for inflation.

105.07 Cooperation with Utilities

Many underground and overhead utilities may be located within the right-of-way. The utilities may be there by prior right or they may be there by permit. (The subject of permits is fully discussed in the Department's publication, *Accommodation of Utilities on Right-of-Way of the Illinois State Highway System*.)

As part of the design process for a highway improvement, the District will investigate and determine the presence of existing utilities within the right-of-way. All utilities within the proposed limits of construction that are to be adjusted will be adjusted either prior to or concurrent with the Department's contract construction. All known utilities are indicated on the plans.

105.07a Delays Caused by Unknown Utilities

Unknown utilities are defined as active or inactive underground transmission facilities (excluding service connections) which are not shown on the plans, not included in the proposal, or identified in writing by the Department to the Contractor prior to the letting. When the Contractor notifies the Resident of a delay caused by an unknown utility, immediate action is required. The Resident should promptly notify the district Construction office of the facts of the delay and notify the utility owner, if known.

Depending on the length of the delay, the Contractor may be entitled to compensation for labor, equipment, traffic control, increases in material or labor costs, and overhead. When such a delay is occurring, the Resident must keep accurate time records on idled labor, equipment, and additional traffic control. The use of form [BC 635](#), Extra Work Daily Report is recommended during all minor and major delays. See the Standard Specifications, Article 105.07, for specific instructions, definitions and payment procedures.

105.07b Paying for Utility Adjustments

When the utility is on the right-of-way by prior right, the Department may enter into an agreement to pay for the adjustment of utilities that will interfere with construction. The agreement will specify the method of payment (lump sum, force account, or unit price basis). The Resident should become thoroughly familiar with the approved agreement, detailed estimate of cost, letter of authorization to proceed, and work drawings prepared by the utility. The Resident should also review Construction [Memorandum No. 46](#), Field Control of Railroad and Utility Adjustment, for detailed instructions pertaining to the administration of the agreement.

105.10 Authority and Duties of Resident

The Resident, including all of his/her staff, is responsible for the administration of the construction and documentation requirements for the contract. S/he reports directly to the Supervising Field Engineer or District Construction Engineer. The Resident is expected to accept delegated responsibility and to make decisions within the authority delegated to him/her. A Resident's first duty is to enforce the contract and specification requirements. S/he assigns and schedules the staking and inspection and must maintain daily contact with the Contractor's personnel to efficiently provide the engineering services necessary for the Contractor's continued progress.

The Resident assures contract compliance with respect to payrolls, pay estimates, erosion control, EEO bulletin boards, traffic control, documentation, inspection and various other items. In addition, the Resident is authorized and expected to make the day-to-day decisions to the extent that his/her experience and construction knowledge permit. However, the Resident is not authorized nor shall s/he attempt to revise, delete, or change the contract provisions.

The Resident must present proposed contract, plan or specification changes or interpretation issues to his/her supervisor for review. Other involved bureaus and the [Federal Highway Administration](#) can then be notified and their approval obtained before changes are authorized.

The Resident is responsible for the accuracy of the field records and inspection reports as they are recorded. Each pay estimate approved by the Resident assures the Department that the materials and procedures used were in accordance with the specifications for each pay item paid for on that estimate.

The Resident is responsible for providing the District with an "As-built" set of plans at the completion of a contract. "As-built" plans shall fully document all field revisions, including any changes by the Bureau of Bridges and Structures, made during the construction phase of the contract. The importance of this set of plans can not be overemphasized. Maintenance activities and plans for future contracts are prepared using this set of "As-built" plans. If the "As-built" plans do not fully reflect the actual constructed conditions, additional time and money may be needlessly spent on future improvements. This is especially true of changes made on bridges and structures. The "As-built" set of plans should be so marked, dated and sent to the District Bureau of Operations. The District will transmit the plans to the Central Bureau of Bridges and Structures so that any structure changes can be verified before the plans are sent to the Microfilming Unit. The plans and a copy of the microfilm will be returned to the District.

105.10a Assignment to Field Work

- A. Supplies. When assigned to a project, the Resident will receive from the District office the necessary equipment, construction forms, record books and other office supplies. The District Construction Engineer, or an assistant, will instruct the Resident in all matters pertaining to the work and explain the proper use of the material and equipment assigned.

You may be required to sign for State equipment given to you. If you receive instructions to transfer all or a part of it to someone else, do not neglect to have a proper transfer signed by him/her. You will be held responsible for equipment not returned or not properly accounted for. Employees to whom Department-owned equipment is assigned, and who through carelessness or neglect cause unreasonable depreciation or need of repairs or losses, may be charged all, or a portion, of the resulting expense as may be determined by the Regional Engineer.

When an employee leaves the Department, all Department-owned property must be returned before final warrant is delivered. This includes identification cards, Construction Manual, and all equipment which has been assigned to the employee by the District office.

Establishing Headquarters. The District office should be notified immediately of the Resident's project mailing address and telephone numbers.

- B. The Public. The Resident is the Division of Highways' public relations person when dealing with the members of the general public that the contract may involve or inconvenience. The development of good public relations may avoid complaint letters written to the Governor and the Department of Transportation concerning highway construction problems. It is important that complaints be handled as soon as possible in a tactful and considerate manner. The number of complaints can be minimized if the District and Resident keeps the public informed of the status of the work in progress.

Address comments and concerns from the public in a manner that will convey a favorable impression of yourself and the Department. Explain the work to the public insofar as necessary but carefully refrain from providing information which might be misconstrued. Refrain at all times from loose talk, gossip, or comments with respect to Departmental policies, highway program and particularly improvements which are pending or proposed.

- C. News Media Publicity. It is Departmental policy that District offices will release information directly to local news media on items of local interest in connection with highway work. It is desirable that the publication of such information be encouraged. The Regional Engineer will determine the procedure to be followed in each District for the handling of news releases.
- D. Magazine Articles. Project personnel may be approached by technical magazines for articles pertaining to construction and the writing of such articles is encouraged. All such articles must be submitted to the Regional Engineer for approval before they are sent in for publication.
- E. Letters of Endorsement. The Department receives requests for letters of endorsement of Contractors or individuals, or recommendations for machinery, materials, etc. Under no circumstances shall any employee give any letters of endorsement or recommendations of this character. Requests of this character must be referred to the Regional Engineer, along with any comments you might have, who will see to it that they go through the proper channels.
- F. Investigational Work. Field personnel assigned to investigational work must understand that investigational work of any kind is confidential and you are not authorized to discuss it with anyone outside the Department.
- G. Presence on the Job. Remember that your presence on the job is essential. When you are unable to be at the jobsite, your whereabouts should be known so that you may be contacted when needed. Situations occur where immediate contact is necessary by your office, the Contractor or your family.

105.10b Project Personnel Operation and Safety

- A. General. On construction contracts, particular attention to safety is necessary when the work being performed is near traffic or in the vicinity of construction activities. It is essential that all employees and particularly those in supervisory capacities keep their safety and the safety of the employees under their direction constantly in mind and recognize the hazards that may exist in the performance of their duties. When a condition exists in which the use of protective equipment is required, it is the responsibility of the supervisor to see that the employee is furnished such equipment and that its use is enforced. It should be pointed out that it is also incumbent on the employee to use the safety devices provided, since any benefit provided under the Workmen's Compensation Law may be jeopardized where injury is caused by the willful failure of the employee to use safety devices provided. The chief of party is responsible at all times for safety procedures on survey work and s/he must ensure proper use of safety devices such as warning vests, warning devices, cones, etc. Where the work, as performed, is not adequately protected by the contract traffic control, it will be necessary to provide supplemental safety devices and measures. When on or near the pavement, red flags should not be used for waving signals between the instrument person and the other workers. Such use might confuse the traveling public.

- B. **Safe Practices.** Before starting work involving exposure to vehicular traffic, the supervisor in charge of the work should warn their employees of the potential traffic hazards. The supervisor should instruct all employees, and especially new employees, in the safe manner of performing the work and in the proper use of warning signs and devices. During the course of the work the supervisor will require all employees to conform to safe practices.

All employees must be constantly on the alert. They should face approaching traffic as much as possible. Never enter or cross a traffic lane without first watching for approaching cars and waiting until the way is clear.

All survey work, to the extent possible, should be conducted clear of the travel lanes. Exposure to traffic may be substantially reduced by making surveys from offset lines run on the shoulders, or at some greater distance from the pavement. Crossing of traffic lanes may be minimized by taking measurements on only one side of the highway at a time.

The taking of measurements in a traffic lane should be performed as quickly as possible and standing in or adjacent to a traffic lane should be avoided while discussing the work or while transmitting or recording readings.

Hazards associated with peak traffic volumes may be avoided by adjustment of working hours to take advantage of off-peak traffic conditions.

Necessary protection shall be provided for personnel performing such work as surveying, painting numbers on pavement, or taking of measurements from or on the pavement where the individual is unable to watch for traffic. Appropriate traffic control shall be used to direct traffic past individuals when on the pavement or within 2 ft of the pavement.

Vehicles of employees shall be legally parked 15 ft from the edge of the traveled way. Such vehicles should never be left where they may be an actual or potential hazard due to their proximity to a lane of moving traffic or by obstructing sight distance. All vehicles shall be parked on one side of the pavement. Vehicles parked 2 ft to 15 ft from the pavement edge must have strobe light operating.

The work shall be conducted in such a manner that vehicular traffic is not subjected to unnecessary inconveniences or accident hazards. When it is necessary to stop traffic, delays should be held to an absolute minimum.

The Department's *Employee Safety Code* and the [Illinois Work Site Protection Manual](#) (Other than Highway Maintenance and Traffic Crews) have additional information on this subject.

105.10c Traffic Control for State Construction Personnel

When State work forces are exposed to the hazards of traffic, the Resident shall assure their safety by providing the appropriate traffic control protection. For the specific information and current Departmental policies pertaining to personal protective equipment, traffic control and flagging, refer to the Department's *Employee Safety Code*, the *Flaggers Handbook* and the [Illinois Work Site Protection Manual](#) (Other than Highway Maintenance and Traffic Crews) for specific additional information on this subject.

105.11 Duties of the Inspector

It is the responsibility of the Inspector to enforce the requirements specified in the contract documents.

It is the Inspector's job to review all phases of the work periodically including various operations being performed by the Contractor to ensure that his/her instructions are being followed and to keep the Resident well informed of progress, problems and instructions to the Contractor. Unless field inspection is aggressively carried out and well documented, the completed contract may well be of unknown quality, a potential for high maintenance costs, and an embarrassment to the Department.

The Inspector is responsible for seeing that the work is executed in full accordance with the contract documents and requirements. The Inspector is responsible for having a thorough understanding of the contract documents and requirements and for exercising good judgment. Often the Inspector's work is the deciding factor in whether or not the specified level of quality is attained. A competent Inspector is thoroughly conscious of the importance and scope of his/her work and is fully informed in regard to the contract documents and contract requirements. Armed with this knowledge and with sound judgment gained through experience, s/he will be able to insure that a high level of quality is attained in the finished work.

Fairness, courtesy and cooperativeness, coupled with practicality, firmness and a business-like manner will encourage respect and cooperation. A good Inspector and a good job of inspecting will ensure work is done in accordance with the contract requirements and will allow the Contractor to perform the work in an efficient and economical manner.

SECTION 106. CONTROL OF MATERIALS

The ultimate responsibility for the acceptance of materials lies with the Resident. Materials may be delivered with an inspection report, [LA 15](#), Illinois OK stamp or tag or be stamped CERTIFIED by a manufacturer who has been approved by the Bureau of Materials and Physical Research. The Resident should inspect all materials to ensure that they have not been damaged in shipment and in fact have been properly manufactured. Materials which have been damaged or do not meet specifications should be rejected even though there is evidence of inspection.

Manufacturers who continually ship unacceptable material with a certified stamp should be reported to the District Bureau of Project Implementation, Materials Section.

SECTION 107. LEGAL REGULATIONS AND RESPONSIBILITY TO PUBLIC

107.11 Insurance Requirements for Railroad - Highway Crossings

The Contractor shall not be permitted to perform any work, on or over the right-of-way of a railroad, until the District Office has given the Resident Engineer evidence that the required railroad protective liability insurance has been approved by the Railroad(s) and has provided the expiration date of each policy. It is the responsibility of the Resident to ensure that the railroad protective liability insurance has been approved by the railroad(s) before work begins and that work does not continue past the expiration date without evidence of policy renewal.

107.12 Protection of Railroad Traffic and Property

A Overheads. When the grade separation is an overhead highway structure, the Department designs the plans and ensures that the concerns of the Railroad are provided for. The

main concerns usually are that their standard clearances are provided for, that drainage conditions are not interfered with, and any necessary changes of communication and signal lines and signals are given due consideration. Department plans are always submitted to the Railroad for its approval insofar as it is affected. In the case of open abutments, the Railroad will object to having the toe of the slope approach too close to any ditches or drainage. It has been necessary, in a few cases, to build small retaining walls parallel to the tracks, or place proper drainage facilities in the Railroad ditches, but any design change shall not be implemented until after consultation with your supervisor. Plans developed by the Department are checked by the Railroad for design and clearances. An authorized representative of the Railroad shall be invited to attend the preconstruction conference. The Contractor's progress schedule, falsework arrangement and proposed equipment shall be made known to the Railroad representative at the preconstruction conference so that s/he may have full knowledge of the work.

- B. Subways. The Railroad is more vitally interested in subway structures than in overheads and usually puts a full-time or part-time engineer on the work. Plans for subway structures are sometimes designed by the State, though more often they are designed by the Railroad. Plans designed by the Railroad are checked for design and clearances by the Department.

The specifications used shall be:

1. Those of the Railroad taken bodily (AREA specifications);
2. area specifications;
3. a modification of these; or
4. a modification of the State's specifications.

In any case, Section 100 of our [*Standard Specifications for Road and Bridge Construction*](#), General Requirements and Covenants, is always included if the State is a party to the contract. The building of the structure is done in accordance with the provisions of the agreement between the railroad company and the Department in the following ways:

1. The State may award a contract in the usual way, the Railroad not participating at all;
2. the State may award a contract for a portion of the work, arranging with the Railroad to do the remainder either by contract or with its own forces on a force account basis;
3. the Railroad may do the entire job with its own forces on a force account basis;
4. the Railroad may award a contract for a portion of the work, doing the remainder with its own forces on a force account basis, the State doing none of the work; or
5. the Railroad may award a contract for all the work involved, the State not participating.

The Contractor's working plans, etc., if a State contract, should be made known to the proper railroad company's official as stated above for overheads.

- C. Grade Crossings.

1. Approach Grades. The design of approach grades to railroad crossings should have been discussed with and accepted by the Railroad prior to the letting of a contract. A considerable length of time usually elapses between the field checking of the plans and the awarding of the contract. During the time lapse the railroad may have adopted changes of policy. Wherever our highway crosses a railroad at grade you should get in touch with the Railroad Division Engineer and mutually agree whether or not any changes in the grade of the track are to be made. You should be familiar with the drainage situation in the area of the crossing, so that any anticipated changes can be discussed with the Railroad.
2. Surfacing and Drainage. There may be cases where the State is obligated to assume the expense involved in changing the grade of the Railroad tracks and to provide a surface over the tracks. Normally, resurfacing of the grade crossing proper (that portion of the grade crossing over the crosstie area plus an additional 24 inches outside the outer rail) for the full width of the pavement, plus usable shoulder, remains an obligation of the railroad in accordance with General Order No. 138 issued by the [Illinois Commerce Commission](#), effective August 22, 1973. ([92 IL Admin. Code Chapter III 1535](#))

The riding quality of the grade crossings proper should be equal to the adjacent highway surface. This depends almost entirely upon the original construction or any major reconstruction of the surface. It is important that quality materials and approved methods of construction be used.

Adequate drainage is essential. This may involve the use of additional drainage structures or other facilities as the work progresses. The drainage configuration is usually specified in the Railroad agreement. Any changes in the drainage configuration from the Railroad agreement will require written approval by the Railroad.

3. Types of Surfacing. The actual surfacing of a grade crossings proper is usually accomplished by one of the two following methods: (a) the use of prefabricated rubber or concrete surface materials or (b) the use of timber and/or asphalt crossing materials.

Surfacing should be given the same careful inspection required in the State specifications to ensure proper materials, thorough mixing and compaction, and satisfactory smoothness. The [Bureau of Design & Environment Manual, Chapter 7, Section 3.02\(f\)](#) states – “Where the roadway traffic equals or exceeds 1000 ADT, use prefabricated rubber or concrete surface materials. For ADT less than 1000, timber and/or asphalt crossings may be used.” The Resident Engineer can obtain a list of approved grade crossing materials for a specific grade crossing from the District Project Support Engineer. The Resident Engineer can also obtain valuable information relative to the acceptable methods of installing the grade crossing material from the District Project Support Engineer.

These suggestions apply to all grade crossing surface installations paid for by the State, however the Railroads are making the improvements at their expense, every effort should be made to secure their cooperation in the use of Department approved materials and to perform the work in a manner that provides lower crossing maintenance costs and greater safety.

- D. Inspection. In addition to having a set of plans and a copy of the contract for either overheads or subways, you must have a copy of and be familiar with the Commerce Commission Order, the agreement between the Railroad and the Department; and the detailed estimate prepared by the railroad company showing the work which is to be performed by the railroad and its estimated cost. If you do not have copies of these papers, ask the district office for them. You cannot properly inspect or approve any of the work without being familiar with the content of the papers mentioned. All of the items in this section are covered only in a general way and it must be understood that each construction section is governed by whatever is set forth in the documents mentioned above.

The Railroad's Engineer. The Railroad Engineer's will probably keep in close touch with the work. S/he should be welcome at all times and given your full cooperation in all matters pertaining to construction. It is your duty to see that all work performed under your contract on the railroad company's right-of-way is done in such a manner as not to interfere with the movement and safety of trains. Wherever the safety of railroad traffic during construction is concerned, the Railroad Engineer will have jurisdiction, and his/her decision as to methods, procedure and measures used shall be final. The Contractor should submit sheet piling designs, demolition plans, beam erection plans, etc. for the Railroad Engineer's review and approval well in advance of performing the work to allow ample review time.

Subways. In the case of a subway where the railroad company's design and specifications, either in whole or in part, are used, the Railroad may have a full-time or part-time Engineer on the work. Your inspections in this case, if a State contract, will be the same as on regular State work, except that your interpretation must be based on the Railroad specifications, as set forth, in the contract and not on the Department's specifications.

Railroad's Contract. If the railroad company makes the contract, its Engineer is in responsible charge and will give the construction detailed inspection. It is important for you to keep in touch with all phases of the work. You should work in harmony with the Railroad Engineer and offer them your full cooperation, but in case of serious differences of opinion, objectionable practices or violations of the specifications, you should report immediately to your supervisor. You should be careful to give the Railroad's Engineer definite information as to the alignment and grade of our roadway. Occasionally, there are instances where the railroad starts work before receiving this information, with the result that the structure is not laid out in harmony with the entire design. As soon as the district office has received notice of a railroad grade separation, arrangements should be made with the proper Railroad officials to discuss the location. Arrangements should be made to set permanent stakes and bench marks as may be necessary for the structure to be built in harmony with the pavement plans. An occasional check on these lines and grades is suggested.

State's Responsibility. When the Federal Government participates in the cost of the work, they look solely to the State for proper inspection and execution of the work, as well as for compliance with all Federal restrictions and regulations, even when the State is not a party to the contract. They will not deal directly with the Railroad.

Change from Specifications. The question arises as to how much deviation you should permit from the Railroad specifications and how closely the work should conform to them. You should follow their specifications as closely as if they were our own, and on the question of minor details you are permitted to use your own judgment in variations encountered by either yourself or the Railroad Engineer, a decision should be obtained in writing from the Regional Engineer and the Railroad's Division Engineer. We will cooperate with the Railroad representative and will

be willing to consider suggestions, but in no case shall major changes in the approved plans or specifications be made without the consent and approval, in writing, of the Regional Engineer and the Railroad's Division Engineer.

State's Contract. When the contract is between the Department and the Contractor, the Railroad Engineer has no authority to overrule you or the Specifications. Matters pertaining to the safety of the railroad company should be brought to attention of your supervisor. The Railroad cannot grant concessions or make any change in the contract without the approval of the Department. In this case, the Railroad has no authority over the Contractor except through the Department.

Temporary Crossing. In case it is necessary to construct a temporary Railroad grade crossing for the convenience of the Contractor, it is the Contractor's responsibility to obtain an agreement with the Railroad concerning its construction, maintenance, and protection. The cost of providing the flaggers for use on this crossing shall be paid by the Contractor.

Bills. Refer to Construction [Memorandum No. 46](#), Field Control of Railroad and Utility Adjustments, to familiarize yourself with the proper procedures for recordkeeping for railroad adjustments.

When the Railroad does any part of the work with its own forces or provides flagging protection, excepting for a temporary crossing, it is necessary that you have such records which will enable you to check all items when the bill is sent to the district office for approval. Such work is usually done on an actual cost basis not expected to exceed the estimated sum. Use the detailed estimates, as prepared by the Railroad, in checking the work performed by them. The railroad should not be

permitted to perform any work not shown in the railroad agreement or on these estimates with the expectation of being reimbursed by the Department unless the Railroad agreement is amended to reflect the additional or changed work. If the Railroad insists on improvements not indicated in the Railroad agreement or in the estimate, they must be made to understand that the work will be at their own expense. Railroads have only the actual costs of construction of the work described in the Railroad agreement available to them and the Department will pay only the actual costs even though it underruns the estimated cost. Most Railroads have approved schedules for the allowable rates for service and supplies. The district office should give you a copy of this.

Federal Participation. Agreements between the State and the Railroad covering work which is to be done by the railroad at State expense on projects in which the Federal government participates; usually stipulate that the Railroad will be paid only those charges which are approved by the Federal Highway Administration for reimbursement to the State. When the work is to be paid entirely from State funds, reimbursement to the Railroad is determined by the terms of the agreement.

Resident's Responsibility. The particular responsibility of the Resident in connection with railroad bills is to keep a record of materials used and labor employed, including non-temporary crossing flagging costs, as the work progresses, so that when the bill is presented to him/her for checking, s/he will be in a position to approve the charges as to the amount of materials and labor used. The cost of materials and the rates paid for labor will be determined by an audit of the Railroad's books and need not be checked in detail in the field. The Railroad should be instructed to submit to the district office copies of all bills on their letterhead. If the agreement provides for progress payments before the work is completed, the bills should be consecutively

numbered and should show clearly the dates of the period of time covered by each billing. The final bill should be marked "Final."

State Audit. Before final reimbursement is made for Railroad force account work, in excess of the original estimated cost, representatives of the Bureau of Accounting and Auditing will make an audit of the Railroad accounts which support the bill. Such accounts must be kept in a manner that may be readily audited and actual costs readily determined. The Bureau of Accounting and Auditing makes an extensive check of all force account bills which are submitted by the Railroad or public utilities. You should have enough information to check all of the items in the Railroad bill. If enough information is not available, you should check the quantities of such items on which you do have information, and forward the bills along with a letter of explanation covering the items for which you are unable to check to the district office. This will be forwarded to the Central Office for verification.

107.32 Furnishing Right-Of-Way

- A. Unacquired. When the right-of-way is not clear, the contract proposal calls attention to the fact and lists the tracts not clear, giving their station numbers. It states definitely that the Contractor shall not undertake any work which would encroach upon private property until after s/he has been notified by the Department that the necessary right-of-way has been acquired. You should see that the Contractor's operations are in accord with these instructions.
- B. Agreements. The district office should have in its file all right-of-way stipulations and agreements. These papers frequently provide that certain definite things are to be done by the Department for the owner at the time the road is built. You should be given a copy of all such special agreements when you are assigned to the job. Property owners should be notified in writing to move fences, buildings, etc. This should be done as soon as possible after the contract is executed and the Contractor should be cautioned not to enter property before the owners have been notified nor before the expiration of the time limit as noted in the conveyance statements. Most Districts have a standard form of notification to property owners.

SECTION 108. PROSECUTION AND PROGRESS

108.01 Subletting of Contract

The Resident should be aware of all subcontractors which are to do work on the project. S/he should retain a copy of the Request for Approval of Subcontractor, Form [BC 260A](#), in the project file. S/he should also be aware if the subcontractor is a Disadvantaged Business Enterprise. No subcontractor should be allowed to start work until Form [BC 260A](#) is approved. A subcontractor cannot be approved without a current Subcontractor Registration Number. Review Construction [Memorandum No. 30](#), Policies and Procedures for Approval of Subcontractors.

108.02 Progress Schedules

The progress schedule is the contractor's statement of how he or she intends to complete all of the contract work within the contract time limits. The initial schedule (also referred to as the "original" or "baseline" schedule) should reflect all of the contract requirements and existing conditions as known at the time of bid. The amount of detail included in the schedule should correspond to the complexity of the project work or conditions. The schedule is an essential

tool for the proper charging of working days by the Resident during the work, and it will also be essential if any issues of delays develop during the work.

When the contractor submits the initial schedule for approval, the district will be responsible for reviewing and approving the schedule. The schedule does not in any way modify any other requirements of the contract. However, as a practical matter, an improper schedule approved by the district can bias any later discussions concerning delays, so it is important for the reviewer to carefully consider all aspects of the work involved in the contract and whether the schedule adequately accounts for all of that work. Since the contractor is fully responsible for scheduling his or her resources to complete all of the work, the contractor has considerable latitude in preparing his schedule with respect to the sequence of work, rates of progress, etc., subject to any specific contract requirements. Obviously, though, items of work that are physically dependent on a particular sequence of work, must be shown in a logical sequence on the schedule (e.g. typing rebar before placing concrete).

For administering the progress of the work and the contract time limits, the schedule is most useful if it is an accurate

108.03 Working Days (and Weekly Reports)

The proper charging of working days is one of the most important duties of the Resident. Equally important is the review by the Contractor of your Weekly Report to determine if an objection exists. Working day charges (for working day contract) and Workable days (for completion date contract) are to be shown on your Weekly Report, Form [BC 239](#). It is a contract requirement for the Contractor to submit a progress schedule for every working day contract or calendar completion date contract. The progress schedule lists the controlling items and the expected daily rate of progress to complete the work on time. To properly monitor the progress on both types of contracts, working day charges must be shown on the Weekly Report. Be sure to familiarize yourself with Construction [Memorandum No. 28](#), Administration of Contract Time for Working Day Contracts - [Articles 108.03, 108.04, 108.05](#) and [108.08](#). If the Contractor's work is more than 10 working days or 14 calendar days behind the Progress Schedule, a new Progress Schedule must be submitted.

Generally, the Resident Engineer is required to make entries in the Project Diary and submit Weekly Reports of the Resident from beginning to end of the physical work on the project (see Documentation Section). However, the Resident can suspend preparation and submission of the Weekly Reports if all work on the project is officially suspended by the department per [Article 108.07](#), Suspension of the Work, or during contractor-initiated winter shutdowns. To suspend Weekly Reports, the Resident should enter the date of suspension in the "Suspension" field of Form [BC 239](#), Weekly Report of Resident, and make a note in the summary of operations area of the report such as "Weekly Reports suspended during contractor's winter shutdown." When normal work resumes, submittal of Weekly Reports should also resume, and the Resident should enter the date in the "Resumed" field of the Weekly Report. Weekly Reports do not have to be submitted after the work is reported as 100% complete.

Some contract work items have establishment or performance period that may extend beyond the completion of all of the physical work on the project. The specifications for these establishment or performance periods typically allow the contractor to submit a performance bond in order to allow the rest of the contract to be finalized out.

Per [Article 105.13](#), Final Inspection, the "date of final inspection" is the date that all work, including cleanup and punch list, is completed. Per [Article 107.30](#), Contractor's Responsibility

for Work, "the Contractor shall protect and maintain the work until the date of final inspection is provided in writing to the Contractor" on the Weekly Report of the Resident, if the contractor does not provide a performance bond for those work items.

108.06 Labor, Methods and Equipment

The approval of any type of equipment or a new method of construction shall not be given by the Resident without first referring the matter to the Central Office through his/her district office. This policy enables the Engineer of Construction to assure uniform construction practices. The Department may have the proposal under consideration and may not be in a position to render a decision until more information is available. When new equipment and methods have been approved, the Resident will keep a record of the performance of the equipment and the results obtained. This information will then be incorporated into a detailed report which will be sent to the Regional Engineer, who will send a copy to the Central Bureau of Construction. This report will also contain any conclusions or recommendations that the Resident and District may have.

SECTION 109. MEASUREMENT AND PAYMENT

109.04 Payment for Extra Work

The Department reserves the right to require the performance of extra work in order to satisfactorily complete the contract work. It is in the best interest of both the Department and the Contractor to anticipate extra work whenever possible. The Resident should try to discuss options for completing any extra work with both the Contractor and Field Engineer. In no way shall a Contractor begin this work without written authorization from the Engineer. Refer to [Article 104.02](#) Payment for extra work:

- A. Lump Sum or Agreed Unit Price. Either you or the District office shall receive a letter from the Contractor proposing payment for extra work at a Lump Sum Price or an Agreed Unit Price. This request is forwarded to an estimator who either approves or rejects the price. If the Lump Sum or Agreed price is approved, the Contractor shall be given written confirmation of the approved method of payment and permission to proceed with the work. If the request is denied, one of two things will happen. Either, the Contractor may resubmit the proposal with changes or the Department will direct the Contractor to proceed under a force account basis.
- B. Force Account Basis. If it becomes necessary to do extra work under a force account basis, the Contractor shall do the work in the most expedient and economical manner possible. This shall be discussed before the work actually begins. In this discussion the labor force required, equipment to be used, as well as any material needed, will be decided upon. After these issues are resolved, the extra work may proceed. Each day that the Contractor proceeds working on the extra work an Extra Work Daily Report, Form [BC 635](#), shall be filled out. The [BC 635](#) shall then be signed by both the Contractors and Department's representatives. The original shall be given to the Contractor for future billing and a copy retained in the job file. Upon receiving the force account billing from the Contractor, the Resident shall check it for accuracy with the Extra Work Daily Report, Form [BC 635](#), in the job file. The Contractor billing should resemble that shown in the [Documentation Section](#) of this manual. Once checked, processing for payment may proceed. An authorization or prior approval for an estimated amount shall be processed before the work is to begin.

SURVEY SECTION (METRIC)**ELEMENTS OF HIGHWAY CONSTRUCTION LAYOUT**

In order to properly construct a project, it is essential that the field layout work be done accurately. The following discussions give field personnel some guidelines to assist in the staking operation. When the layout work and staking is done by the Contractor as a contract pay item, the Resident should review the Special Provisions to identify his/her responsibilities with regard to staking and checking.

Care of Department Owned Property

The Department has a considerable investment in vehicles, surveying and laboratory equipment. When this property is assigned to you for your use in the field, you become personally responsible for its care and condition. If damages occur to the equipment because of negligence or carelessness, the employee may be responsible for the cost of making repairs or replacements. Contractor-furnished equipment should be given similar care.

When you receive an instrument from the office you should take the time to read the instruction manual that comes with it. Take extra time to read the section on the proper care of the instrument. Proper care of equipment will extend its life and accuracy. Survey equipment is expensive and fragile, below are a few items to keep in mind when using any piece of survey equipment.

- A. Handle the instruments carefully and cushion them against vibration and shock.
- B. When taking the instruments out of their carrying case, handle them firmly until secured onto the tripod.
- C. When carrying a transit, make sure both plates are locked and the telescope is also locked in the vertical position.
- D. Before picking up the instrument and tripod, always check the centering screw to make certain the instrument is secured to the tripod.
- E. Never over tighten the locking screws.
- F. When carrying the instrument, on the tripod, carry it in a vertical position.
- G. Never leave the instrument unattended for any length of time.
- H. Clean the lenses only as specified in the owner's manual.
- I. Keep the instrument and carrying case dry. If they become wet, allow them to air dry before closing the carrying case. Extend level rod and let air dry overnight.

Field Notes

Field notes are the written record of pertinent layout information , measurements and inspection of the contract work. They should be kept according to uniform practices and conform as a minimum to the following general requirements:

- A. Neatness. Use a sharp pencil of at least 3-H hardness. Avoid crowding. Keep the book as clean as possible.
- B. Legibility. Use standard symbols and abbreviations to keep notes compact. Use plain lettering to avoid confusion.
- C. Clarity. Plan work ahead so that data can be clearly indicated. Do not make ambiguous statements. Provide adequate descriptions and make sketches for clarity. Record data in a consistent manner. Assume that the person who will use your notes has no familiarity with the work.
- D. Completeness. Show all pertinent measurements and inspection data. Use the degree of accuracy consistent with the survey requirement. If in doubt about the need for the data, record it. Review data before leaving the field. All entries must include:
 - 1. The date and weather conditions.
 - 2. Title of survey.
 - 3. Names (or initials) of all persons in the party and their assignments.

The title page must be completed when the book or contract is started. The District's return address must be noted on the title page in case the book is lost. The book must be adequately indexed, pages numbered and cross-referenced to contents.

- E. Permanence. All entries should be made directly into bound books. At completion of the contract, they should be filed as part of the permanent record in keeping with Department policy.
- F. Accuracy. Record exactly what was done at the time it was done rather than depending on memory at a later time. Never erase. If an item is incorrectly entered, draw a line through the item and insert the corrected value immediately above. When it is necessary to add data to notes previously prepared, the additional item should be dated and initialed. Always enter notes directly into the record.
- G. Self-checking. Notes should be so kept that the work can be checked without returning to the field. Any person familiar with the contract should be able to verify the accuracy of the work from the information contained in the notes. Use positive controls.
- H. Examples of proper field notes are in the [Documentation Section](#) of this manual.

Setting & Recording Layout Stakes

- A. Accuracy is the essential in setting vertical and horizontal control stakes. Remember that when you have set stakes the Contractor assumes they are correct. In order to avoid complaints from the Contractor that stakes were improperly set or that s/he incurred additional expense because of an error in setting a grade, instruct the Contractor to notify you at once if at any time they consider a grade stake to be in error. This will give you a chance to check the elevation in a timely manner

Service to the Contractor is another essential feature of the work. Do not wait for the Contractor to ask for stakes, but take the initiative and confer with him/her to determine the portions of the work to be staked first. Agree upon the lines and grades desired, the clearances required for construction equipment, and other matters relative to the layout work. Arrange your work so you will always have sufficient stakes set ahead so the Contractor will not be delayed in prosecuting the work.

Before stakes can be set, the survey line must be established and verified. It is advisable to tie in all control points, such as P.I.'s, P.O.T.'s, P.C's, and P.T.'s to reference points outside the area of construction. Benchmarks for use in construction should be set and checked before stakes are set. All level circuits used for setting stakes must be accurately closed on benchmarks before stakes are used. Once stakes are set they should be guarded with lath and high visibility flagging. The lath should clearly identify the stake and its use in order to avoid confusion.

Check, Check, Check. Whatever the method of surveying used, the more checking you do, the possibility of errors or mistakes is greatly reduced. Grade elevations, curve data, etc., must be checked before being used. All measurements, level notes, and computed distances must be rechecked frequently. Check with the plans in hand instead of relying on memory. It is an embarrassment to the Department when a bridge is built to the wrong elevation or when the distance between bridge seats is too short or too long. These things have happened in the past, but they will be less likely to occur if the work is carefully checked.

Choice of Methods:

1. Methods optional. The field methods outlined below are acceptable methods for construction surveying. The Resident does not have to follow these methods and may use their own method. However, each suggested method is a good method to use if the Resident is in doubt as to how to proceed. Each method should be read carefully.
 2. A standard method of staking should be followed but may be varied to meet topographical conditions, type of construction, equipment used and the Contractor's preference. This is a convenience to Contractors who work in more than one district, and also reduces the chance of confusion and misunderstanding between Residents in the field and the district office.
- B. The Resident must keep a complete legible record of all stakes set. The description and elevation of all new benchmarks and the new ties for all points must be recorded and completely described. Grade changes and other changes from the original design must be recorded and carefully described. All records must be clear and complete so that any stake

can be replaced easily, at any time, with a minimum amount of effort. It should never be necessary to rerun several hundred meters (yards) of line to replace one or two stakes.

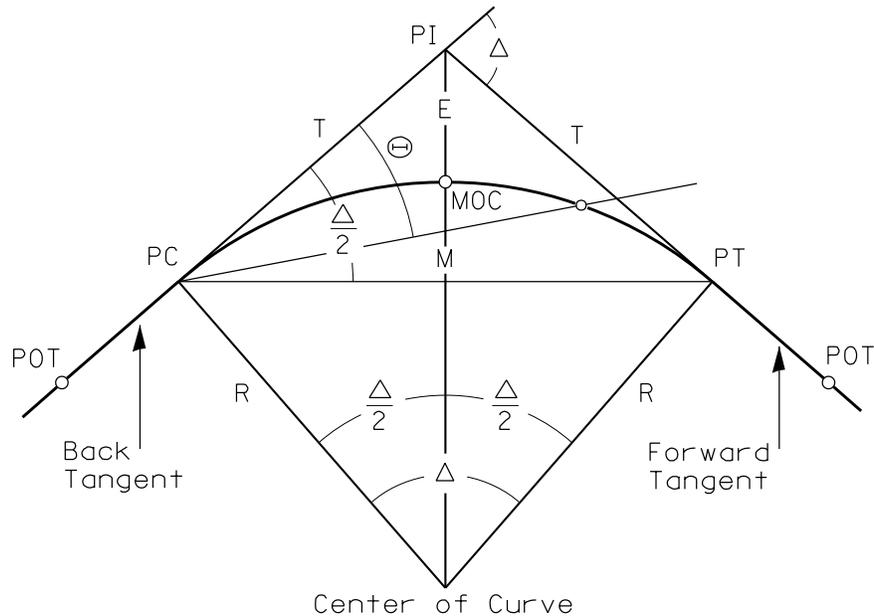
- C. Prepare in Advance. It is essential that field books containing the necessary grades, sketches, tie points, benchmarks and other data be prepared in advance. Delays and inconvenience result if it is necessary to refer to the plans often for layout information. Notes and sketches should be independently checked. The books should contain grade elevations at the intervals required, survey line ties, benchmarks, curve data and any other data required for frequent use.

Horizontal Curvature in the Metric System

In previous highway work in Illinois, the degree of curve definition was used to lay out and calculate curve parts. The degree of curve is defined as the change in direction of a central angle per arc length of 100 feet. The relationship between the degree of curve and the radius in feet is stated by the following equation:

$$R = \frac{5729.58}{D}$$

For projects in which metric units will be used, the radius defines horizontal curvature only, and in this case, curves will be described in meters. The following figure illustrates the fundamental principals of a simple circular curve.

FORMULAS & EXAMPLES - SIMPLE CIRCULAR CURVE

DEFINITIONS Be sure the instrument and carrying case are kept dry. If they become wet, allow them to air dry before closing the carrying case. Extend level rod and let air dry overnight.

Back Tangent	=	Tangent from which the curve starts
Forward Tangent	=	Tangent on which the curve ends
POT	=	"Point on Tangent" - Any point on the tangent portion where the curve starts or ends
PC	=	"Point of Curvature" - Station on centerline where the curve starts
T	=	"Tangent" - The distance on a straight line from the PC to the PI or the PT to the PI
MOC	=	"Mid-Point of Curve"
PT	=	"Point of Tangency" - Station on centerline where the curve ends
L	=	"Length of Curve" - The distance <u>along the curved centerline</u> from the PC to the PT
PI	=	"Point of Intersection" - The point where the back tangent and the forward tangent intersect
R	=	"Radius of the Curve"
E	=	"External Distance" - Distance from the MOC to the PI
M	=	"Middle Ordinate" - Distance from the MOC to the mid-point of the straight line between the PC and the PT (the LC)
LC	=	"Long Chord" - Straight line distance from the PC to the PT
Δ	=	The Central Angle of the Curve - The angle between a radial line from the center of the curve to the PC and a radial line from the center of the curve to the PT; also equals the angle of intersection of the forward tangent with the back tangent

The following definitions can be written from the figure on the previous sheet:

$$\text{Tangent distance (T)} = R \tan \frac{\Delta}{2}$$

$$\text{External distance (E)} = R \left(\sec \frac{\Delta}{2} - 1 \right) = R \operatorname{exsec} \frac{\Delta}{2} = T \sin \frac{\Delta}{2} - M$$

$$\text{Middle Ordinate (M)} = R \left(1 - \cos \frac{\Delta}{2} \right) = R \operatorname{vers} \frac{\Delta}{2} = R - R \cos \frac{\Delta}{2}$$

$$\text{Long Chord (L.C.)} = 2R \sin \frac{\Delta}{2} = 2T \cos \frac{\Delta}{2}$$

$$\text{Length of Curve (L)} = \frac{\Delta 2\pi R}{360^\circ} = \frac{\Delta R}{57.2958^\circ}$$

To find the deflection angle to a point on the curve, the following proportion can be written, where Θ is the deflection angle:

$$\frac{2 \times \text{deflection angle}}{\text{arc length}} = \frac{360^\circ}{2\pi R} \text{ where } R \text{ and the arc length are in meters.}$$

$$\text{deflection angle (minutes)} = \frac{1718.873}{R} \times \text{arc length}$$

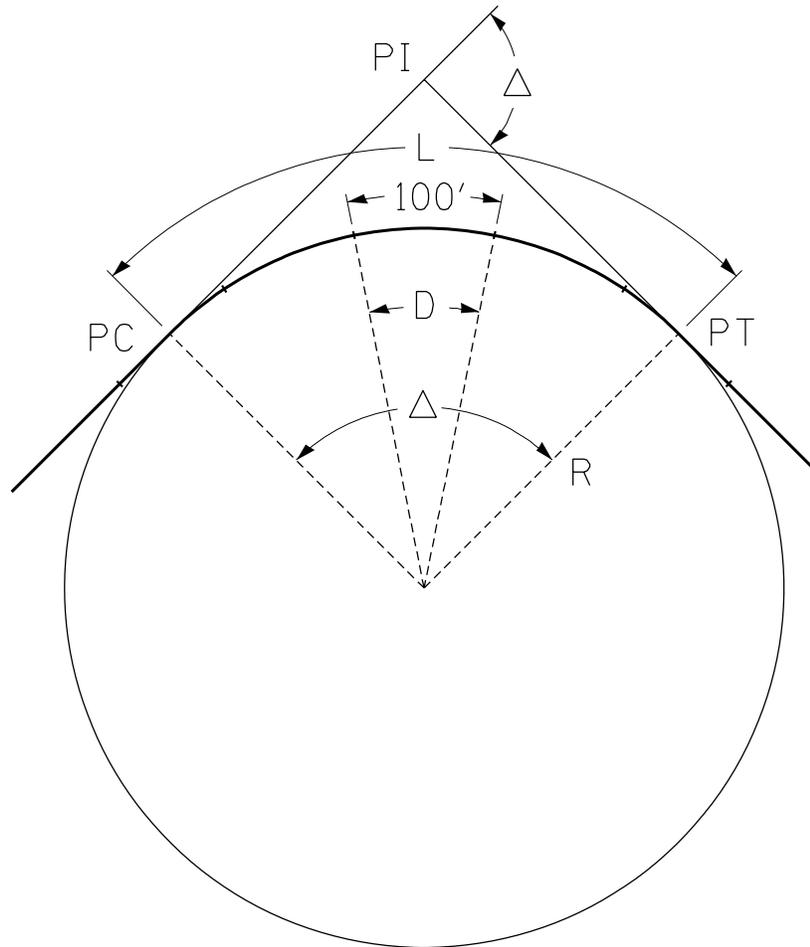
$$\text{deflection angle (degrees)} = \frac{28.648}{R} \times \text{arc length}$$

When laying out a horizontal curve in the metric system, the following guidelines are recommended for measuring chord distances around a curve. Where the radius is greater than 600 meters, use 25 m chords. For radii between 600 meters and 250 meters, use 15 m chords, and for radii between 250 meters and 125 meters, use 10 m chords. The chord distance between two points on a curve may not always equal the arc distance. The following equation is used to determine the chord distance for any arc length:

$$\text{Chord distance} = 2R \sin \left(\frac{90}{\pi R} \times \text{arc length} \right) = 2R \sin \Theta$$

In addition to the preceding definitions, the following term is used in the English system of surveying.

D = Degree of Curve – The angle formed by 100 ft segment (100 ft arc) of the curve



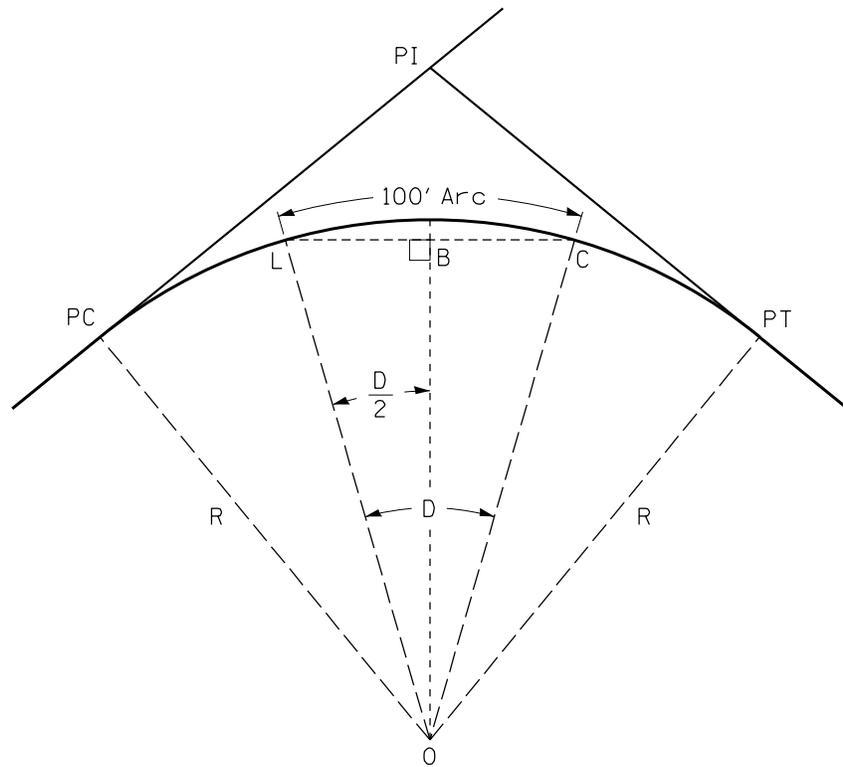
FORMULAS:

By Proportion: $\frac{\Delta}{360} = \frac{L}{2\pi R}$

$$\frac{D}{360} = \frac{100}{2\pi R} \quad \left[D = \frac{5729.58}{R} \right]$$

$$\frac{D}{\Delta} = \frac{100}{L}$$

SIMPLE CIRCULAR CURVE
DERIVATION OF FORMULAS



Using triangle O-L-B:

$$\sin \frac{D}{2} = \frac{LC_{100}}{\frac{2}{R}}$$

$$R \sin \frac{D}{2} = \frac{LC_{100}}{2}$$

$$LC_{100} = 2R \sin \frac{D}{2}, \text{ where } LC_{100} = \text{the chord distance for a 100' Arc}$$

$$LC_{50} = 2R \sin \frac{D}{4}, \text{ where } LC_{50} = \text{the chord distance for a 50' Arc}$$

$$LC_{25} = 2R \sin \frac{D}{8}, \text{ where } LC_{25} = \text{the chord distance for a 25' Arc}$$

CALCULATIONS FOR A CIRCULAR CURVE**Given**

$$\text{P.I. Sta. } 107+67.90 \quad \Delta = 11^{\circ}00'00'' \text{D} = 2^{\circ}30'00''$$

Calculate**Radius**

$$R = 5729.58/D$$

$$R = 5729.58/2^{\circ}30'00''$$

$$R = 2291.83'$$

Tangent Distance

$$T = R(\tan \Delta / 2)$$

$$T = 2291.83(\tan 11^{\circ}00'00''/2)$$

$$T = 220.68'$$

Length of Curve

$$L = 100 (\Delta/D)$$

$$L = 100(11^{\circ}00'/2^{\circ}30'00'')$$

$$L = 440.00'$$

External Distance

$$E = T(\tan \Delta/4)$$

$$E = 220.68(\tan 11^{\circ}00'00''/4)$$

$$E = 10.60'$$

P.C. Station

$$\text{P.C.} = \text{P.I. Station} - \text{Tangent Dist.}$$

$$\text{P.C.} = 107+67.90 - 220.68$$

$$\text{P.C.} = 105+47.22$$

P.T. Station

$$\text{P.T.} = \text{P.C. Sta.} + \text{Length of Curve}$$

$$\text{P.T.} = 105+47.22 + 440.00$$

$$\text{P.T.} = 109+87.22$$

Deflection for 100' Arc

$$100' \text{ Arc} = D/2$$

$$100' \text{ Arc} = 2^{\circ}30'00''/2$$

$$100' \text{ Arc} = 1^{\circ}15'00''$$

Deflection for 50' Arc

$$50' \text{ Arc} = D/4$$

$$50' \text{ Arc} = 2^{\circ}30'00''/4$$

$$50' \text{ Arc} = 0^{\circ}37'30''$$

Deflection for 25' Arc

$$25' \text{ Arc} = D/8$$

$$25' \text{ Arc} = 2^{\circ}30'00''/8$$

$$25' \text{ Arc} = 0^{\circ}18'45''$$

Deflection for 1' Arc

$$1' \text{ Arc} = D/200$$

$$1' \text{ Arc} = 2^{\circ}30'00''/200$$

$$1' \text{ Arc} = 0^{\circ}0'45''$$

Chord Length 100' Arc

$$100' \text{ Arc} = (2)(R)(\sin \text{Deflection Angle})$$

$$100' \text{ Arc} = (2)(2291.83)(\sin 1^{\circ}15'00'')$$

$$100' \text{ Arc} = 99.99$$

Chord Length 50' Arc

$$50' \text{ Arc} = (2)(R)(\sin \text{Deflection Angle})$$

$$50' \text{ Arc} = (2)(2291.83)(\sin 0^{\circ}37'30'')$$

$$50' \text{ Arc} = 50$$

CALCULATE THE DEFLECTION FOR THE FIRST STATION FROM P.C. OR
ANY ODD STATION ALONG THE CURVE

1. Take the distance from the last point with a known deflection to the station you are calculating.
2. Multiply this distance by the deflection of a 1' arc ($D/200$); this will give you the deflection between these two points

Example: Find deflection angle at Sta. 108+55.

$$(108+55 - 105+47.22) = 307.78'$$

$$307.78'(0^{\circ}0'45'') = 3^{\circ}50'50''$$

As discussed in the above paragraphs, angular measurements in the metric system will continue to be expressed in degrees, minutes, and seconds. However, the radius definition of horizontal curves will be used rather than the degree of curve. For example, a proposed 3-degree horizontal curve on new a location (Radius = 1909.86 ft or 582.125 m) shall be referred to as a 580 meter radius curve. Metric radii for new horizontal curves shall always be expressed in multiples of 5 meter increments for simplicity.

Conversely, alignments that incorporate a previously defined horizontal curve should continue to use the same existing radius, and the radius would be re-defined to the nearest 0.001 meter. If the 3 degree curve noted above is a re-creation of a previously established curve, it would be assigned a 582.125 meter radius.

Shown below are three possible cases defining horizontal curvature. In all three cases, it is assumed the curve starts at P.C. STA 300+59.41 (English units) or the equivalent P.C. station in metric units of kilometer STA 9+162.108.

Case A: English curve definition

Case B: Metric definition assuming that Case A curve data defines the roadway centerline from a previous survey and is to be retained. All curve data is a direct or soft conversion from English to metric units.

Case C: Metric definition of a paper relocation on mapping. The P.C. location will start at kilometer STA 9+162.108 and have approximately the same curvature as the Case A curve. Therefore, R will be set at 580 m.

CASE A	CASE B	CASE C
PI STA = 302+68.57	PI STA = 9+225.860	PI STA = 9+225.628
$\Delta = 12^\circ 30'$	$\Delta = 12^\circ 30'$	$\Delta = 12^\circ 30'$
$D = 3^\circ 00'$	R = 582.125 m	R = 580.000 m
T = 209.16 ft	T = 63.752 m	T = 63.520 m
L = 416.67 ft	L = 127.001 m	L = 126.535 m

To aid technical staff in laying out horizontal curves in the field, the following [Tables of Deflections for Various Radii and Arc Lengths](#) has been developed.

RADIUS (meters)	DEFLECTION IN MINUTES Per Meter of Arc	DEFLECTIONS FOR ARCS OF								
		10 meters			15 meters			25 meters		
		Deq	Min	Sec	Deq	Min	Sec	Deq	Min	Sec
10	17.1887	2	51	53	4	17	50	7	9	43
150	11.4592	1	54	35	2	51	53	4	46	29
200	8.5944	1	25	57	2	8	55	3	34	52
250	6.8755	1	8	45	1	43	8	2	51	53
300	5.7296	0	57	18	1	25	57	2	23	14
350	4.9111	0	49	7	1	13	40	2	2	47
400	4.2972	0	42	58	1	4	27	1	47	26
450	3.8197	0	38	12	0	57	18	1	35	30
500	3.4377	0	34	23	0	51	34	1	25	57
550	3.1252	0	31	15	0	46	53	1	18	8
600	2.8648	0	28	39	0	42	58	1	11	37
650	2.6444	0	26	27	0	39	40	1	6	7
700	2.4555	0	24	33	0	36	50	1	1	23
750	2.2918	0	22	55	0	34	23	0	57	18
800	2.1486	0	21	29	0	32	14	0	53	43
850	2.0222	0	20	13	0	30	20	0	50	33
900	1.9099	0	19	6	0	28	39	0	47	45
950	1.8093	0	18	6	0	27	8	0	45	14
1000	1.7189	0	17	11	0	25	47	0	42	58
1050	1.6370	0	16	22	0	24	33	0	40	56
1100	1.5626	0	15	38	0	23	26	0	39	4
1150	1.4947	0	14	57	0	22	25	0	37	22
1200	1.4324	0	14	19	0	21	29	0	35	49
1250	1.3751	0	13	45	0	20	38	0	34	23
1300	1.3222	0	13	13	0	19	50	0	33	3
1350	1.2732	0	12	44	0	19	6	0	31	50
1400	1.2278	0	12	17	0	18	25	0	30	42
1450	1.1854	0	11	51	0	17	47	0	29	38
1500	1.1459	0	11	28	0	17	11	0	28	39
1550	1.1090	0	11	5	0	16	38	0	27	43
1600	1.0743	0	10	45	0	16	7	0	26	51
1650	1.0417	0	10	25	0	15	38	0	26	3
1700	1.0111	0	10	7	0	15	10	0	25	17
1750	0.9822	0	9	49	0	14	44	0	24	33
1800	0.9549	0	9	33	0	14	19	0	23	52
1850	0.9291	0	9	17	0	13	56	0	23	14
1900	0.9047	0	9	3	0	13	34	0	22	37
1950	0.8815	0	8	49	0	13	13	0	22	2
2000	0.8594	0	8	36	0	12	53	0	21	29
2050	0.8385	0	8	23	0	12	35	0	20	58
2100	0.8185	0	8	11	0	12	17	0	20	28
2150	0.7995	0	7	60	0	11	60	0	19	59
2200	0.7813	0	7	49	0	11	43	0	19	32
2250	0.7639	0	7	38	0	11	28	0	19	6
2300	0.7473	0	7	28	0	11	13	0	18	41
2350	0.7314	0	7	19	0	10	58	0	18	17
2400	0.7162	0	7	10	0	10	45	0	17	54
2450	0.7016	0	7	1	0	10	31	0	17	32
2500	0.6875	0	6	53	0	10	19	0	17	11
2550	0.6741	0	6	44	0	10	7	0	16	51
2600	0.6611	0	6	37	0	9	55	0	16	32
2650	0.6486	0	6	29	0	9	44	0	16	13
2700	0.6366	0	6	22	0	9	33	0	15	55
2750	0.6250	0	6	15	0	9	23	0	15	38
2800	0.6139	0	6	8	0	9	12	0	15	21
2850	0.6031	0	6	2	0	9	3	0	15	5
2900	0.5927	0	5	56	0	8	53	0	14	49
2950	0.5827	0	5	50	0	8	44	0	14	34
3000	0.5730	0	5	44	0	8	36	0	14	19

RADIUS (meters)	DEFLECTION IN MINUTES Per Meter of	DEFLECTIONS FOR ARCS OF								
		10 meters			15 meters			25 meters		
		Dea	Min	Sec	Dea	Min	Sec	Dea	Min	Sec
3050	0.5636	0	5	38	0	8	27	0	14	5
3100	0.5545	0	5	33	0	8	19	0	13	52
3150	0.5457	0	5	27	0	8	11	0	13	39
3200	0.5371	0	5	22	0	8	3	0	13	26
3250	0.5289	0	5	17	0	7	56	0	13	13
3300	0.5209	0	5	13	0	7	49	0	13	1
3350	0.5131	0	5	8	0	7	42	0	12	50
3400	0.5056	0	5	3	0	7	35	0	12	38
3450	0.4982	0	4	59	0	7	28	0	12	27
3500	0.4911	0	4	55	0	7	22	0	12	17
3550	0.4842	0	4	51	0	7	16	0	12	6
3600	0.4775	0	4	46	0	7	10	0	11	56
3650	0.4709	0	4	43	0	7	4	0	11	16
3700	0.4646	0	4	39	0	6	58	0	11	37
3750	0.4584	0	4	35	0	6	53	0	11	28
3800	0.4523	0	4	31	0	6	47	0	11	19
3850	0.4465	0	4	28	0	6	42	0	11	10
3900	0.4407	0	4	24	0	6	37	0	11	1
3950	0.4352	0	4	21	0	6	32	0	10	53
4000	0.4297	0	4	18	0	6	27	0	10	45
4050	0.4244	0	4	15	0	6	22	0	10	37
4100	0.4192	0	4	12	0	6	17	0	10	29
4150	0.4142	0	4	9	0	6	13	0	10	21
4200	0.4093	0	4	6	0	6	8	0	10	14
4250	0.4044	0	4	3	0	6	4	0	10	7
4300	0.3997	0	3	60	0	5	60	0	9	60
4350	0.3951	0	3	57	0	5	56	0	9	53
4400	0.3907	0	3	54	0	5	52	0	9	46
4450	0.3863	0	3	52	0	5	48	0	9	39
4500	0.3820	0	3	49	0	5	44	0	9	33
4550	0.3778	0	3	47	0	5	40	0	9	27
4600	0.3737	0	3	44	0	5	36	0	9	21
4650	0.3697	0	3	42	0	5	33	0	9	14
4700	0.3657	0	3	39	0	5	29	0	9	9
4750	0.3619	0	3	37	0	5	26	0	9	3
4800	0.3581	0	3	35	0	5	22	0	8	57
4850	0.3544	0	3	33	0	5	19	0	8	52
4900	0.3508	0	3	30	0	5	16	0	8	46
4950	0.3472	0	3	28	0	5	13	0	8	41
5000	0.3438	0	3	26	0	5	9	0	8	36
5050	0.3404	0	3	24	0	5	6	0	8	31
5100	0.3370	0	3	22	0	5	3	0	8	26
5150	0.3338	0	3	20	0	5	0	0	8	21
5200	0.3306	0	3	18	0	4	57	0	8	16
5250	0.3274	0	3	16	0	4	55	0	8	11
5300	0.3243	0	3	15	0	4	52	0	8	6
5350	0.3213	0	3	13	0	4	49	0	8	2
5400	0.3183	0	3	11	0	4	46	0	7	57
5450	0.3154	0	3	9	1	4	44	0	7	53
5500	0.3125	0	3	8	0	4	41	0	7	49
5550	0.3097	0	3	6	0	4	39	0	7	45
5600	0.3069	0	3	4	0	4	36	0	7	40
5650	0.3042	0	3	3	0	4	34	0	7	36
5700	0.3016	0	3	1	0	4	31	0	7	32
5750	0.2989	0	2	59	0	4	29	0	7	28
5800	0.2964	0	2	58	0	4	27	0	7	25
5850	0.2938	0	2	56	0	4	24	0	7	21
5900	0.2913	0	2	55	0	4	22	0	7	17
5950	0.2889	0	2	53	0	4	20	0	7	13
6000	0.2865	0	2	52	0	4	18	0	7	10

Layout of Horizontal Curves

The curve data listed in the plans must be carefully checked, including the P.I.'s and the P.O.T.'s. You will encounter considerable difficulty in running the curves if the intersection angles do not check and new curve data must be calculated. Usually, this is done when verifying the transit line. Any discrepancies found, which you do not know how to correct, should be discussed with your Supervisor.

If practical, reestablish P.I.'s and the necessary P.O.T.'s. Record intersection angles, reference all P.I.'s and P.O.T.'s and record their stations and reference points.

Setting Stakes. Where practical, set up on the P.I. having as a foresight and backsight the P.I. or P.O.T. on either side of the P.I. over which you are set. Using the transit for line, measure accurately the tangent distance in each direction and set substantial hubs at the P.C. and P.T. of your curve. The station number of the P.C. is the station of the P.I. minus the tangent distance. The station of the P.T. is the station of the P.C. plus the curve length.

Before running curves, the notebook table of stations, deflection angles and chord lengths (including chord corrections if needed) must be set up and checked. See example in this Section. Curve data from computer programs should be spot-checked. After the P.C. and P.T. are established, set up over the P.C. and proceed to run in the curve. Offset the stakes the proper distance each way from the centerline.

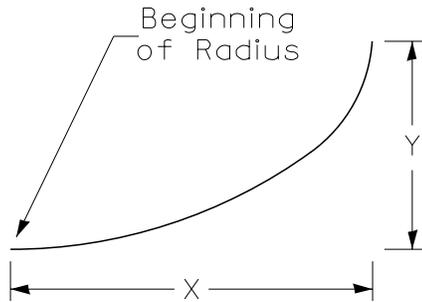
It is often necessary to run curves in the reverse direction to that of the stationing. On long curves where the view is obstructed, it is necessary to turn at one or more points on the curve.

Curves should close within about 75 mm per 300 m (0.25 ft per 1000 ft) of length. The error of closure should be proportionally distributed over sufficient length so that the eye can detect no break in the alignment. On flat curves having an external distance of 600 mm (2 ft) or less, it is faster to run in the curves by tangent offsets using the equation on the next page:

Horizontal Curve Layout Using Tangent Offsets:

Beginning of Radius

$$Y = R - \sqrt{R^2 - X^2}$$



R = Given

X = Distance from beginning of radius to point in question

Y = Distance from projected line (tangent at beginning of radius) to curve

Example

Given: R = 15 m

<u>X</u> (meters)	<u>Y</u> (meters)
0	0
1	.033
2	.134
3	.303
4	.543
5	.858
6	1.252
7	1.734
8	2.311
9	3.000
10	3.820
11	4.802
12	6.000
13	7.517
14	9.615
15	15.000

HORIZONTAL CURVE EXAMPLE

Information on the plans: P.I. Station 8+533.835

$$\Delta = 3^\circ 24' 29'' \text{ (LT)}$$

$$R = 1,513.073 \text{ m}$$

Find: T, E, L.C., L, PC Station and PT Station

$$\text{Tangent distance (T)} = R \tan \frac{\Delta}{2} = 1,513.073 \tan \frac{3^\circ 24' 29''}{2} = 45.013 \text{ m}$$

$$\text{External distance (E)} = R \left(\sec \frac{\Delta}{2} - 1 \right) = 1513.073 \left[\frac{1}{\cos \frac{3^\circ 24' 29''}{2}} - 1 \right] = 0.669 \text{ m}$$

$$\text{Long Chord (L.C.)} = 2R \sin \frac{\Delta}{2} = (2) \left(1513.073 \sin \frac{3^\circ 24' 29''}{2} \right) = 89.987 \text{ m}$$

$$\text{Length of Curve (L)} = \frac{\Delta R}{57.2958} = \frac{(3^\circ 24' 29'')(1513.073)}{57.2958} = 90.000 \text{ m}$$

$$\text{PC Station} = \text{PI Station} - T = 8+533.835 - 45.013 \text{ m} = 8+488.822$$

$$\text{PT Station} = \text{PC Station} + L = 8+488.822 + 90.000 \text{ m} = 8+578.822$$

FIELD BOOK FOR HORIZONTAL CURVE (metric)

<u>Station</u>	<u>Distance</u>	<u>Chord Distance</u>	<u>Deflection Angle</u>	<u>Total Deflection</u>	<u>Remarks</u>
8+578.822	3.822	3.822	0°04'21"	1°42'15"	PT
8+575	25	25	0°28'24"	1°37'54"	
8+550	25	25	0°28'24"	1°09'30"	
8+525	25	25	0°28'24"	0°41'06"	
8+500	11.178	11.178	0°12'42"	0°12'42"	
8+488.822	0	0	0	0	PC
8+475					

Note: Total deflection @ PT should equal $\Delta / 2$

FIELD BOOK FOR HORIZONTAL CURVE (English)

Deflections For Curve #1

Sta.	Dist	Chord Dist	Defl. Angle	Total Defl	
105+00					
+47.22	0	0	0	0	P.C.
+50	2.78'	2.78'	0°02'05"	0°02'05"	
106+00	50	50.00	0°37'30"	0°39'35"	
+50	50	50.00	0°37'30"	1°17'05"	
107+00	50	50.00	0°37'30"	1°54'35"	
+50	50	50.00	0°37'30"	2°32'05"	
108+00	50	50.00	0°37'30"	3°9'35"	
+50	50	50.00	0°37'30"	3°47'5"	
109+00	50	50.00	0°37'30"	4°24'35"	
+50	50	50.00	0°37'30"	5°2'5"	
+87.22	37.22	37.22	0°27'55"	5°30'00"	P.T.
Calc by KAB 7-20-93 Checked by AN 7-21-93					

$\Delta = 11^{\circ}00'00''$ $D = 2^{\circ}30'00''$
 P.C. P.K. Nail

Deflection Angles

100' Arc = $D/2 = 2^{\circ}30'00''/2$
 = $1^{\circ}15'00''$
 50' Arc = $D/4 = 2^{\circ}30'00''/4$
 = $0^{\circ}37'30''$
 1' Arc = $D/200 = 2^{\circ}30'00''/200$
 = $0^{\circ}0'45''$

Chord Lengths

100' Arc = $(2)(R)(\text{SIN DEFL. } \angle)$
 = $(2)(2291.83)(\text{SIN } 1^{\circ}15'00'')$
 = 99.99'
 50' Arc = $(2)(R)(\text{SIN DEFL. } \angle)$
 = $(2)(R)(\text{SIN } 0^{\circ}37'30'')$
 = 50.00'

P.T. (Note: Total Deflection Should equal $\Delta/2$)

CHANGING DECIMAL TO DEGREE OR DEGREE TO DECIMAL

The following calculations illustrate the proper method for converting degrees (sometimes referred to as "hours") to degrees, minutes and seconds ($0^\circ 0' 0''$) and vice versa.

- To find the degree equivalent of 88.461111°

- 1) Everything left of the decimal is the whole degree.

$$8^\circ 00' 00''$$

- 2) Multiply everything right of the decimal by 60.

$$0.46111 \times 60 = 27.66666$$

- 3) Everything left of the decimal in step 2 are now the minutes. Add this to step 1.

$$88^\circ 27' 00''$$

- 4) Multiply everything right of the decimal in step 2 by 60. These are now the seconds.

$$0.66666 \times 60 = 40$$

- 5) Add the answer in step 4 to the answer in step 3. This is the degree equivalent.

$$88^\circ 27' 40''$$

- To find the decimal equivalent of $88^\circ 27' 40''$

- 1) Take the number of seconds and divide them by 60

$$40 \div 60 = 0.66666$$

- 2) Add the number of minutes to the answer from step 1 and divide them by 60 again.

$$0.66666 + 27 = 27.66666 \div 60 = 0.461111$$

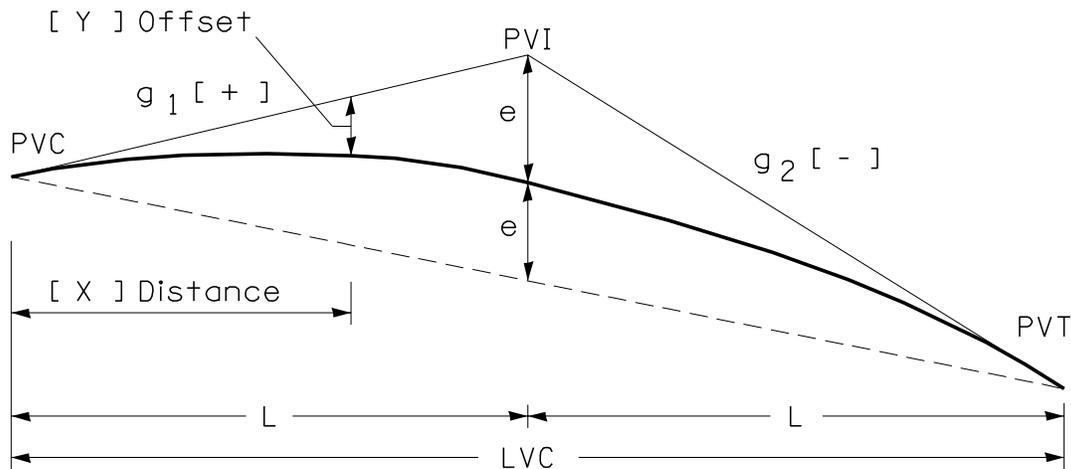
- 3) Add the number of degrees to the answer from step 2.

This is the decimal equivalent.

$$88 + 0.461111 = 88.461111^\circ$$

Layout of Vertical Curves

Vertical curves are used to provide smooth transitions between tangent grade changes. The figure below shows the various relationships of a simple vertical curve in the metric system.



LVC Length of Vertical Curve, meters

L $\frac{\text{Length of Vertical Curve}}{2}$

PVC Point of Vertical Curve - station where the vertical curve starts

PVT Point of Vertical Tangency

g Grade in Percent

A Algebraic difference in grades, $\% = g_2 - g_1$

e Tangent offset of the midpoint of the curve $= \frac{AL}{400} = (g_2 - g_1)L/400$

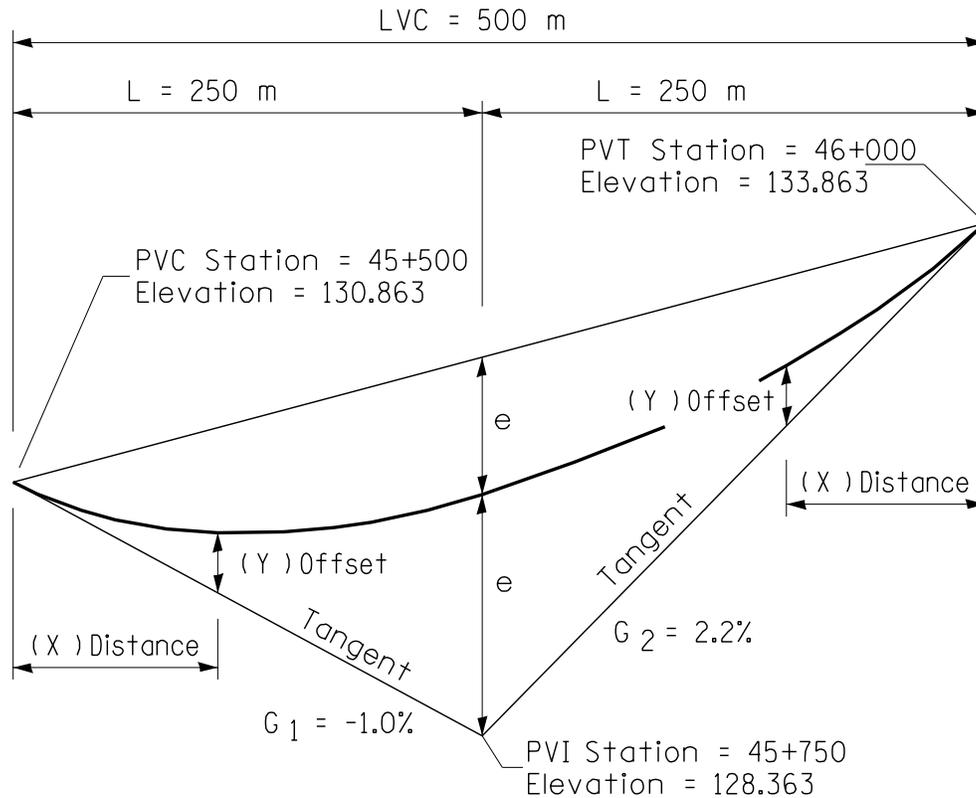
X Distance from PVC or distance from PVT (never greater than L)

y Other tangent offsets which vary as the square of their distance from the start or the

end of the curve $= \frac{\left(\frac{AL}{400}\right)X^2}{(L)^2}$ or $e\left(\frac{X}{L}\right)^2$

Elevation @ $x = \text{Elev. @ PVC} + (g_1)(x) + e x^2/L^2$

EXAMPLE CALCULATION OF A VERTICAL CURVE



For the above example find e, centerline profile elevations along the curve, and the station and elevation of the low point.

- $e = A L/400 = (2.2 - (-1.0)) 250/400 = 3.2(250)/400 = 2.0$

- $(Y)\text{Offset @ a given station} = e \left(\frac{(X)\text{Distance}}{L} \right)^2$

Example: @ 45 + 850 (X) Distance = 150; (Y) Offset = $2.0 (150.00/250)^2 = 0.720$ m

Tangent elevation at a given station =

$$\left[(X)\text{Distance} \times \left(\frac{g_1}{100} \right) \right] + \text{PVC elevation}$$

or

$$\text{PVT elevation} - \left[(X)\text{Distance} \times \left(\frac{g_2}{100} \right) \right]$$

Example: @ 45 + 850 Tangent Elevation = $133.863 - [150 \times (.022)] = 130.563$ m

CENTERLINE PROFILE ELEVATIONS

Station	(X) Distance	Tangent Elevation	(Y) Offset	Elevation on Curve
45+500		130.863		130.863
45+525	25.00	130.613	0.020	130.633
45+550	50.00	130.363	0.080	130.443
45+575	75.00	130.113	0.180	130.293
45+600	100.00	129.863	0.320	130.183
45+625	125.00	129.613	0.500	130.113
45+650	150.00	129.363	0.720	130.083
45+675	175.00	129.113	0.980	130.093
45+700	200.00	128.863	1.280	130.143
45+725	225.00	128.613	1.620	130.233
45+750	250.00	128.363	2.000	130.363
45+775	225.00	128.913	1.620	130.533
45+800	200.00	129.463	1.280	130.743
45+825	175.00	130.013	0.980	130.993
45+850	150.00	130.563	0.720	131.283
45+875	125.00	131.113	0.500	131.613
45+900	100.00	131.663	0.320	131.983
45+925	75.00	132.213	0.180	132.393
45+950	50.00	132.763	0.080	132.843
45+975	25.00	133.313	0.020	133.333
46+000		133.863		133.863

STATION AND ELEVATION OF LOW POINT

The lowest point on a sag curve or the highest point on a crest curve lies at a distance Z from the end of the curve with the flatter gradient. This point is at a distance $Z = \frac{2|g|L}{A}$

$$Z \text{ (In meters from PVC)} = \frac{2|g|L}{A} = \frac{2(1.0)(250)}{(2.2 - (-1.0))} = \frac{2.0(250)}{3.2} = 156.25 \text{ m}$$

$$\text{Station of Low Point} = \text{PVC} + Z = (45+500) + (156.25) = 45+656.25$$

$$\text{Elevation of Low Point} = \text{Tangent Elevation} + (\text{Y}) \text{ Offset}$$

$$(\text{X}) \text{ Distance} = 156.25 : \text{Tangent Elevation} = 130.863 + (156.25)(-0.01) = 129.301$$

$$(\text{Y}) \text{ Offset} = (156.25/250)^2 (2.0) = 0.781$$

$$\text{Elevation of Low Point} = 129.301 + 0.781 = 130.082$$

Tying Out Control Points

As stated before, it is very critical that control points are tied off and recorded accurately. There are basically two methods for tying off a point. 1) Swing ties; this is when a tape is used to measure between the point and a permanent object. 2) Transit ties; this method is used when there are no topographical features to measure to.

Qualities of a Good Tie Point

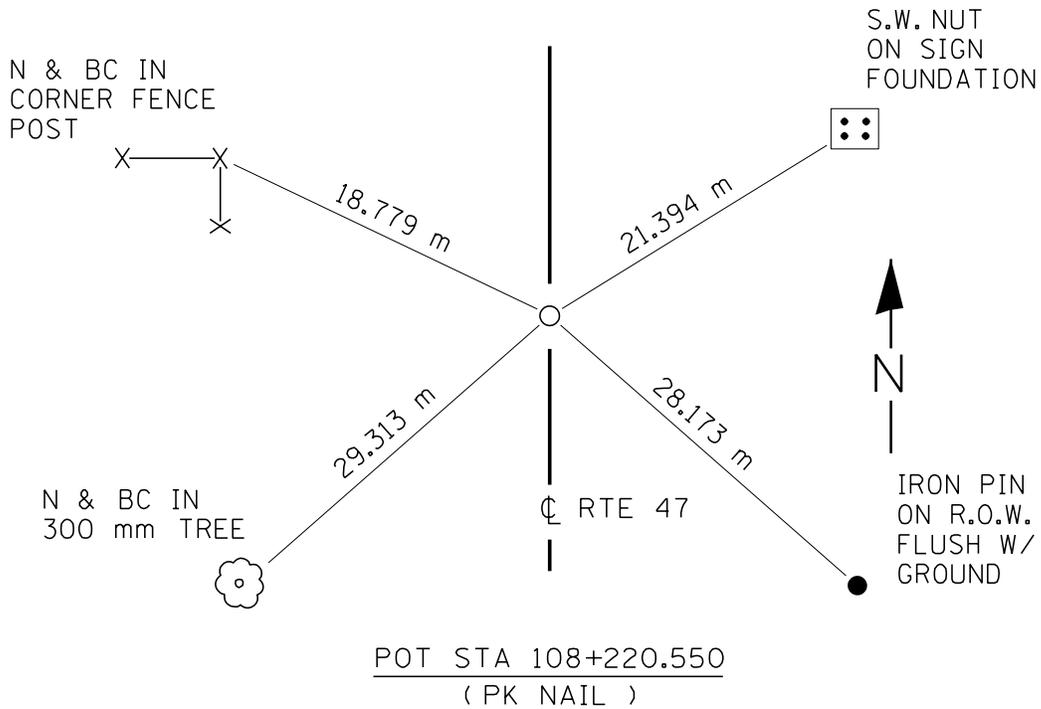
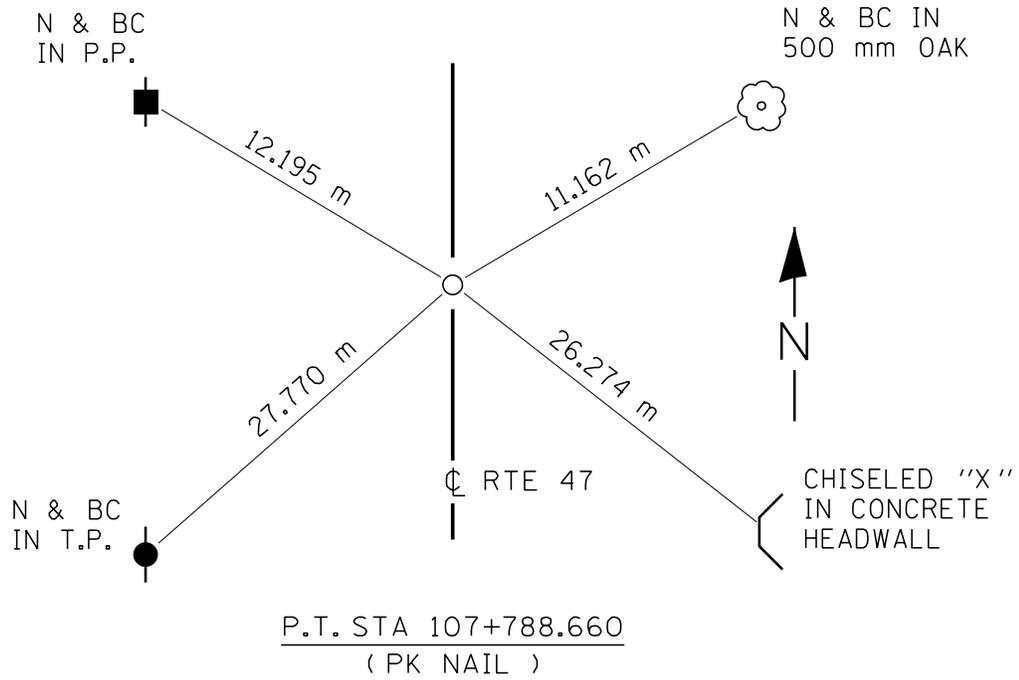
Swing Ties

- 1) They should not exceed 30 m (100 ft) in length.
- 2) There should be at least four ties for each point.
- 3) They should be something permanent and out of the construction zone. For example, a nail and a bottle cap in a tree, fence post or utility pole or a chiseled "X" on a concrete headwall.
- 4) Must be able to pull the tape straight between the two points.
- 5) Try not to have the ties straight across from each other. Doing this would cause the arcs to cross each other twice in a very short distance making it difficult to determine which point is the correct one.

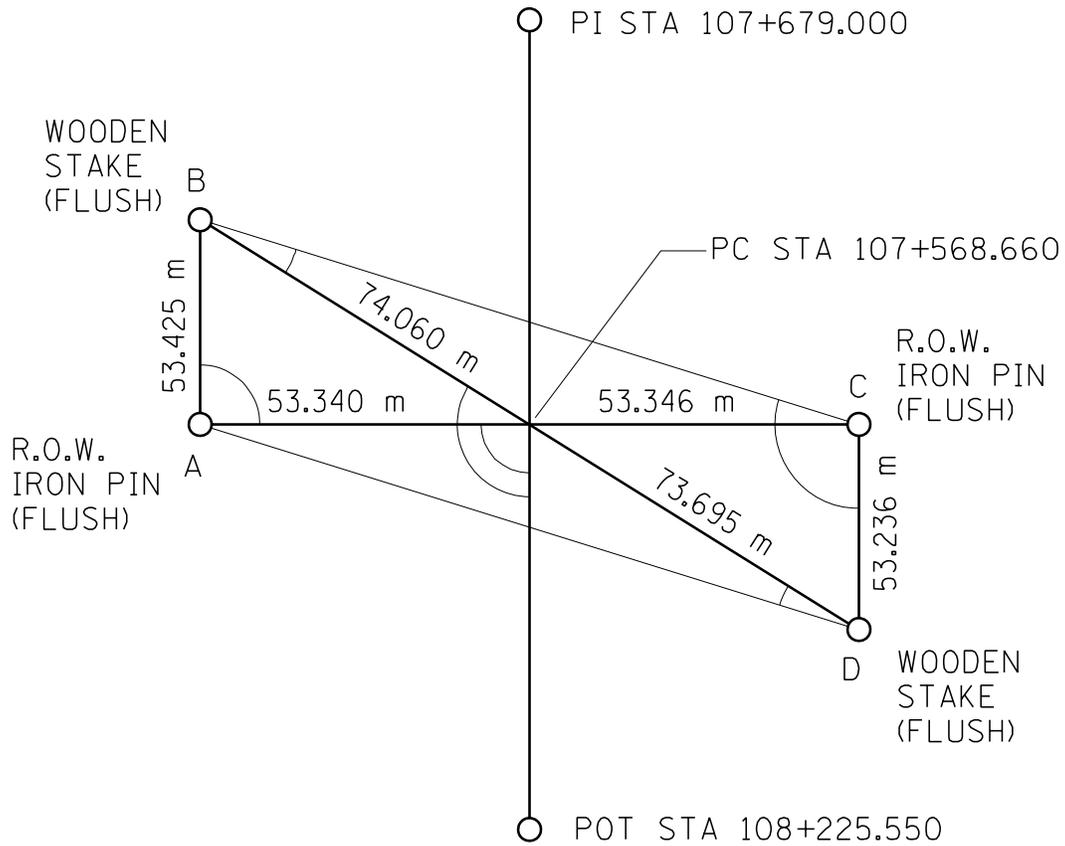
Transit Ties

- 1) If using a solid pin or a hub as your sight points, be sure to mark the exact point on them with a center punch or a tack.
- 2) Drive your sight points flush with the ground at the R.O.W. and lath them. This will ensure that they will not be damaged by mowers and will be easy to find when the time comes to untie the point.
- 3) When finished turning the angles, check to make sure that all the proper angles add up.

EXAMPLES OF CROSS TIES



EXAMPLE OF TRANSIT TIES

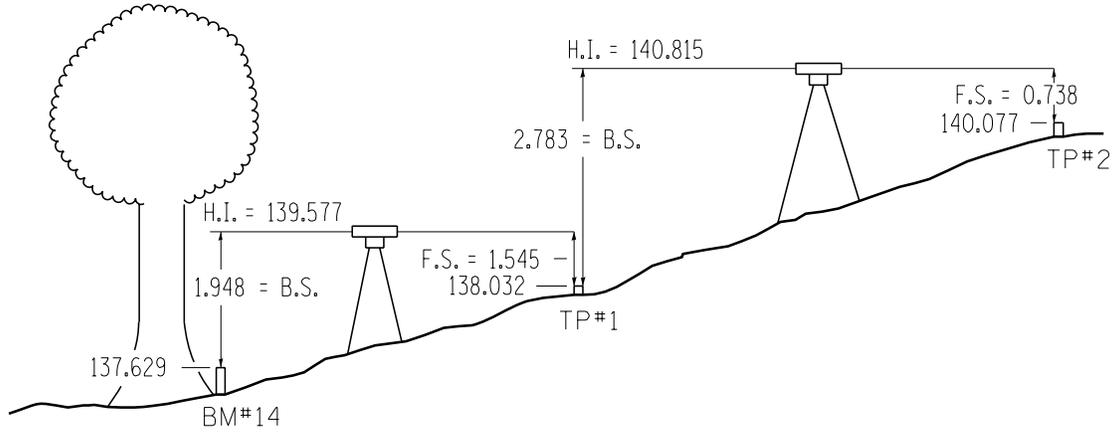


TIE POINTS FOR P.C. STA 107+568.66

@ PC, SIGHT POT, TURN TO A	90°00'00"
@ PC, SIGHT POT, TURN TO B	135°00'00"
@ A, SIGHT PC, ESTABLISH C	
@ A, SIGHT C, CHECK PC, TURN TO B	90°31'00"
@ B, SIGHT PC, ESTABLISH D	
@ B, SIGHT D, CHECK PC, TURN TO A	44°29'00"
@ B, SIGHT D, CHECK PC, TURN TO C	18°28'00"
@ C, SIGHT A, CHECK PC, TURN TO B	26°32'00"
@ C, SIGHT A, CHECK PC, TURN TO D	88°32'00"
@ D, SIGHT B, CHECK PC, TURN TO C	46°28'00"
@ D, SIGHT B, CHECK PC, TURN TO A	18°33'00"

CHECK C-PC-D, $180°00'00" - 88°32'00" - 46°28'00" = 45°00'00"$

TYPICAL LEVEL LINE



STA.	(+) B.S.	H.I.	(-) F.S.	ELEV.
BM#14	1.948	139.577		137.629
TP#1	2.783	140.815	1.545	138.032
TP#2			0.738	140.077

Setting Stakes for Bridges

- a) General. Prior to staking a bridge, plan dimensions and elevations must be checked. It is extremely important to check the bottom of footing elevations by working down from the profile grade line at each pier and abutment, using plan dimensions, beam depths, etc.

The entire structure must be staked before construction operations begin. Remember that the stakes you set are going to be used over and over again from the time you stake the footing excavation until the bridge is finally completed. As the work progresses, you will not be able to see from one stake to another as you did in the beginning and you should give this fact consideration when staking the bridge. It is better to have a few extra points than not to have enough. A substantial number of stakes located out of the way of Contractor's equipment and material should be used. At least three stakes on each line should be set each way from the site. Check all elevations and be sure all the stakes are protected, well referenced and clearly identified.

When you have completed the staking, notify your supervisor so that someone assigned to your office may make an independent check of your calculations and layout work before the Contractor starts work on the structure. When the layout work and staking is done by the Contractor as a contract pay item, the Resident must review the Special Provisions to identify his/her responsibilities with regard to staking and checking.

Thorough and accurate layout work that is checked by an independent party is essential for structures, however, the checking should not stop here. It is important to have positive control points on each pier and abutment, so as the bridge cone embankments are being constructed, instrument checks can be made easily to determine any movement. Be particularly careful when the embankment toes out near the bottom of tall piers, as frequently happens with railroad structures.

Each stake set should be recorded, as well as all elevations that are given to the Contractor. It is good practice to sketch each feature of the bridge and show the stakes with the references and distances of their respective locations. See the end of this section for a sample staking diagram. It is also a good practice to share staking diagrams and information with the Contractor to avoid possible future disputes.

Triangulation and E.D.M. System. On multiple or long span bridges, especially bridges with steel superstructures where the width of the stream or other conditions prevent direct measurements, the location of abutments of piers must be measured with an electronic distance measuring (E.D.M.) system and/or by triangulation methods. Precise methods are required in such work

and are necessary for long structures. This E.D.M. system or triangulation should be supervised by the Resident in charge of the work.

In triangulating locations for long bridges, concrete monuments, large stakes set deep and cut off near ground level, etc. should be used. Remember that the location may be affected by freezing and thawing, floods, driftwood and ice. Measurements should be corrected for temperature and a scale should be used to set the pull that is standard for the tape that is used. Long measurements should be made with an E.D.M. When possible, intersection lines should be set for each pier at an angle of 45 degrees with the base line, and the base line should extend both sides from the centerline of bridge. The intersection lines should be run out to points above high water on both sides of the river so that the locations can be set when the low ground is flooded. Angles should be set using repetition and should be checked by measurements. Guard stakes should be placed at each hub and the layout should be marked so that no confusion may result.

In some cases it is desirable to establish a low water and a high water base line. A base line that is above low water elevation can usually be placed nearer the bridge site and will be found very convenient.

Span Length. In staking the abutments, an allowance must be made for any anticipated deflection of the abutments so that the span length after deflection will be as shown on the plans. Theoretically, the amount of deflection can be figured, but practically it is somewhat indeterminate because of the variable conditions of the footings and backfill. It is assumed that the pressure of the backfill will move the top of a closed abutment or a concrete pile abutment horizontally 5 mm for each meter (1/16 inch for each foot) of height measured from bridge seat to bottom of footing. For open abutments, the assumed movement is 3 mm per meter (1/32 of an inch per foot).

In the case of a single span, if a correction is necessary for the deflection of the abutments, add the total deflection of both abutments to the span length shown on the plans to get the length for locating the abutments. In case of a multiple span bridge, add the deflection of one abutment to the length of the end span only.

Locating Centerline. Care must be exercised in locating the centerline of structure. The centerline of roadway and structure are not always the same. From the road plans or original survey notes, establish at least two P.I.'s or P.O.T.'s in each direction from the bridge and tie them in permanently. This should be done to ascertain if the intersection angle in both directions from the bridge is correct. If the P.I. or P.O.T. in each direction cannot be seen from the bridge, establish a P.O.T. on each side of the bridge and as close to the original P.I. or P.O.T. as possible. Place a permanent hub on centerline each side of and as close to the bridge as possible without interfering with the Contractor's operation. The Contractor should be requested to assist you by keeping equipment and materials clear of the line between these hubs. When possible, a permanent foresight should be set on centerline of bridge as high as the ground permits. It should be possible to set centerline from either side of the stream.

Establish hubs on centerline of bearing or back of abutments and on the centerline of each pier. These hubs should be heavy stakes and nails should be used for line. It is very important that the Resident and Contractor clearly understand and agree on what lines are staked. You may provide the Contractor with a sketch of all lines and stakes set.

Establish permanent bench marks close to the bridge. The benchmarks on the plan or original survey must be checked before establishing your benches at the bridge site. Transfer your benchmarks to permanent concrete or piling on the structure. Use the benchmarks established on the structure for the remaining work. Do not set temporary benchmarks on newly constructed embankments since they may settle. Be sure that your transit and levels maintain proper adjustment.

- b) **Staking Abutments.** On the hub that is set on centerline of bearing or the back of abutment with the centerline of structure set up and turn the skew angle; on this line, set hubs; one close to the bridge and two at distances of 60 and 120 m (200 and 400 ft). If this cannot be done, set them as far as possible from the bridge. Check skew angle by repetition before proceeding.
- c) **Staking Piers.** From the hubs established on centerline of structure turn the skew angle and set additional hubs in each direction, the same as you did for the abutment. Care must be exercised in establishing this line since the centerline of bearing and centerline of pier are not always the same. The vertical alignment of piers should be monitored with a transit during concrete placement.

Measure the distance from centerline to each hub and record it. Measurements for bridge layouts are often made on rough, uneven ground. It is necessary to have the chain horizontal and to use a plumb bob for accurate measurements on such terrain. Check your measurements often. Whenever possible, physical measurements should be made as the work progresses.

- d) **Staking Cofferdams.** In fixing the location of cofferdams, it is usually best to give the Contractor only the center of the pier and centerline of structure. The Contractor can then determine the width and length, knowing what allowance is needed for footing forms, drainage outside the forms, size of walers and struts, etc. Cofferdams in deep water may be located by triangulation. Proper alignment may be secured by placing marks at the intersection of the centerlines with each edge of the frame to be spotted and moving the frame until both marks are on the transit line.
- e) **Staking Footings.** Check carefully the elevation of the bottom of footing as shown on the plans and compare it with the distance below streambed that you actually find. If there is a discrepancy of 300 mm (1 ft) or more, consult your Supervisor.

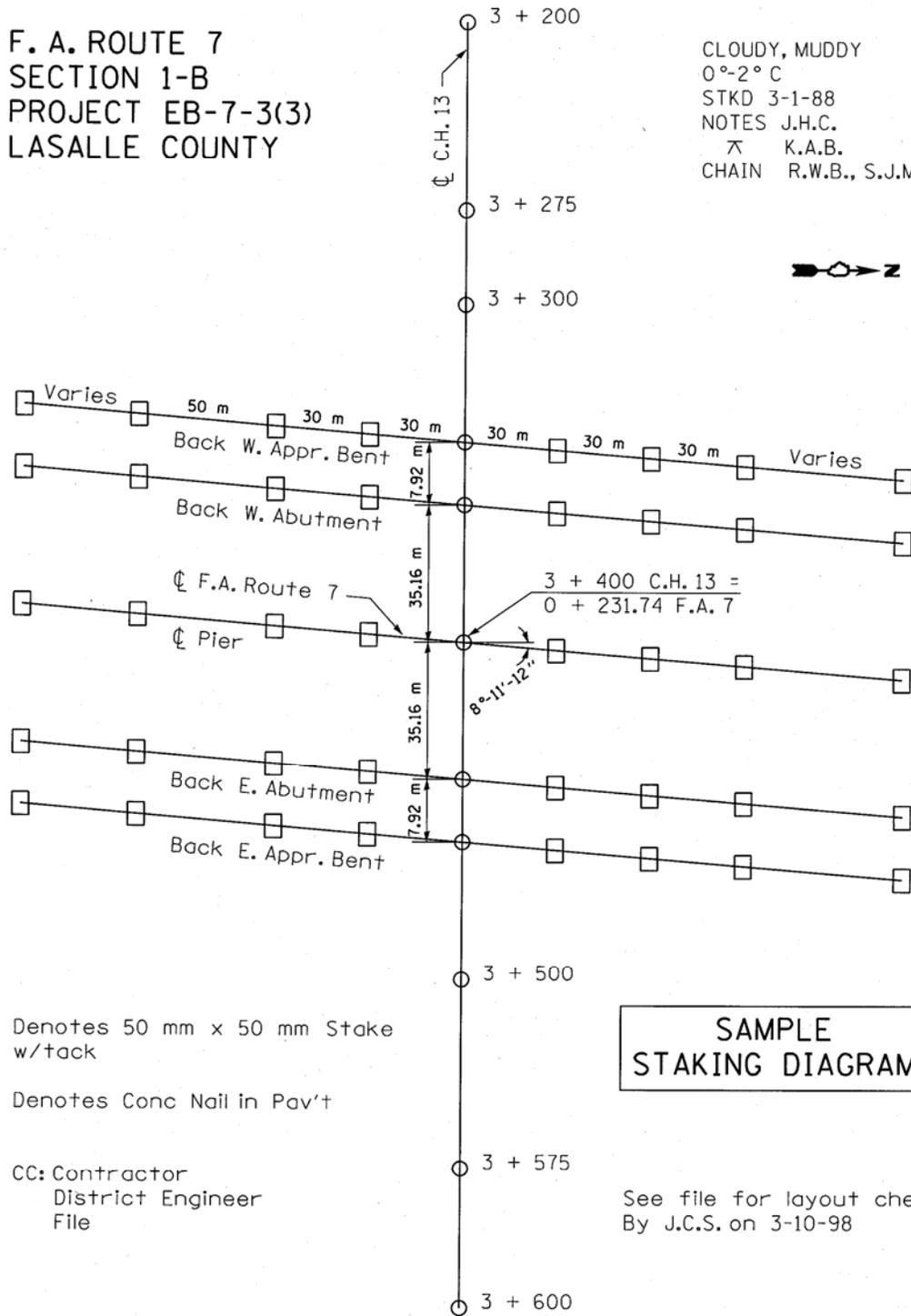
Keep the contractor informed at all times as to the work you are doing, and give him/her a record of all stakes set. When the neat line forms of the footing are in place, the top of footing should be established by setting nails with an instrument at convenient points around the footing. When footings are too deep to set elevations directly, turns may be established by measuring down to a nail from a point of known elevation.

- f) **Miscellaneous Elevations.** After the forms for either an abutment seat or pier cap have been built, grade points for the bridge seat elevations should be set with an instrument. The level circuit for setting the bridge seat elevations should be checked by using one of these set elevations as a turning point. Elevations at tops and wings should also be set with an instrument. Seat elevations should be checked after the concrete is placed. Bridge seat elevations should be checked by subtracting the deck thickness, minimum fillet, permanent camber (if any), beam heights and bearing heights from the finished deck elevations before laying out the bridge seat elevations in the field.

On steel truss spans supported by falsework, it is essential that each panel point of support be set at the exact camber elevation before any connections are made.

F. A. ROUTE 7
SECTION 1-B
PROJECT EB-7-3(3)
LASALLE COUNTY

CLOUDY, MUDDY
0°-2° C
STKD 3-1-88
NOTES J.H.C.
K.A.B.
CHAIN R.W.B., S.J.M.



□ Denotes 50 mm x 50 mm Stake w/tack

○ Denotes Conc Nail in Pav't

CC: Contractor
District Engineer
File

SAMPLE STAKING DIAGRAM

See file for layout check
By J.C.S. on 3-10-98

Setting Stakes for Borrow Pits and Cross Sections

Although setting stakes and running cross sections for a borrow pit seem to be a simple matter, it is, nevertheless, a matter that calls for more than ordinary accuracy. Inaccuracy or lax procedures anywhere from start to finish will almost certainly result in confusion and possibly in a dispute with the Contractor over the volume involved.

If the borrow pit is furnished by the State, it should be staked before construction starts so that the Contractor will not encroach upon private property. If the Contractor furnishes the pit, s/he should obtain the necessary approval and show you the location of the boundaries in sufficient time to take cross sections.

When the pit is furnished by the State, establish its location from the plans. For pits adjacent to the right-of-way, it is often convenient to use the centerline as a base line, if on a tangent. Usually the base line should be chosen parallel to the long dimension of the pit, which means that it may not always be parallel to the centerline of the roadway. In all cases, the base line must be readily reestablished or preserved until all work is finished. If the centerline is not used, the base line chosen should be tied accurately. Base lines should always be straight line regardless of the shape of the borrow pit. It is often convenient to locate the base line in a fence line or other location where hubs on the line will not be destroyed. The base line should be referenced to points which will remain after borrow is completed.

See the drawing of a typical borrow pit layout following this section.

Stakes for Base Line. The drawing indicates the pit is parallel to the centerline. The base line is parallel to the centerline and is as close to the borrow pit as can conveniently be placed without being disturbed by the Contractor's operations. From the base line run a parallel line on the opposite side of the borrow pit and reference it, locating it close to the pit (perhaps within 3 m (10 ft)) but out of the way of the Contractor's operation. Use an instrument to turn angles and a steel tape for all measurements, and be sure to have the lines on each side of the borrow pit well hubbed and referenced. Base line stakes should be marked with the station numbers and driven solidly. Borrow pits often stand over the winter season before borrow is completed. You must be able to reestablish any line easily, at any time, at its exact original location.

If the boundary of the borrow pit is a curved line, this curvature must be taken into consideration in taking cross sections and computing final quantities.

Stakes for Cross Sections. The base line and its parallel line on the opposite side of the borrow pit are marked lines "A" and "B". The borrow pit limits as staked out are to be visible, carefully referenced, and accurately measured from the centerline.

On line "A" at 8 m (25 ft) intervals (or not more than 30 m (100 ft)), and at all breaks in the grade, set stakes. Record the distance to each stake. Set a corresponding stake on line "B" by turning an angle of 90 degrees from line "A". In placing stakes on the original ground surface, keep in mind the contour of the finished pit and take enough points to cover breaks in both the original and final ground lines. Do this along the base line, its parallel line and along each cross section. It is often convenient to use a range pole or flag, set at the far end of the sections to be taken, as a foresight to ensure that the sections are taken on a straight line and in the proper location.

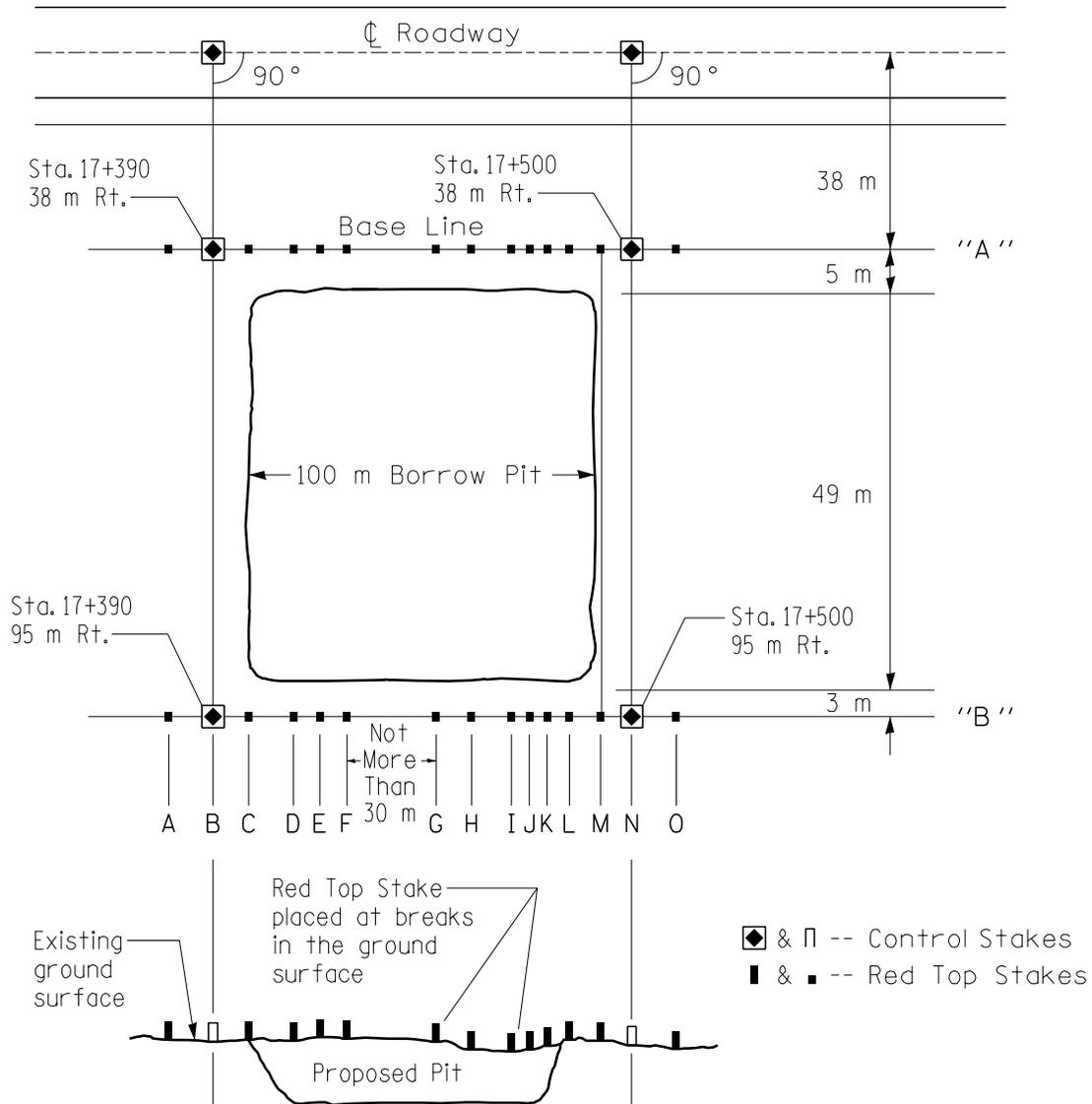
Original Cross Section: Cross sections must be taken before excavation starts. Establish a permanent bench mark close the borrow pit, using plan datum if possible. Then take readings along each cross section established between line "A" and "B", making those readings often enough to get all the breaks in the grade on each section measuring the distance to each point accurately. Have the cross section reading extend several meters (feet) outside of lines "A" and "B". It is a good idea to take a few cross sections beyond the ends of the borrow pits also, as it may be necessary to enlarge the pit after excavation starts. Be sure to check cross section distances against stakes previously set in the base line and offset line. Close the level circuit on a benchmark of known elevation.

Final Cross Section. After the excavation is completed and the borrow pit shaped, you should recross section the pit at the identical locations used previously. In addition, cross sections should be taken at the breaks between the back slopes and level parts of the pit. Original sections at these points may be interpolated. Usually, it is not possible to determine such points in advance. The recross sectioning should be done as soon as possible. It may be necessary to take cross sections before the borrow pit is leveled off, if the Contractor delays this finishing very long, because of the danger of the contour of the pit being changed by heavy rains. It is convenient to check borrow pit drainage in connection with the final cross sections.

Pits Subject to Overflow. If the borrow pit is subject to overflow and the Contractor suspends work for any considerable length of time, the pit should be cross sectioned immediately after work stops. If overflow occurs, the pit must again be cross sectioned before work starts as alluvial deposit may appreciably affect the quantities.

Computations. Plot your notes and compute the volume used on the project by the Contractor. If computations are to be made in the District Office Computer Section, retain a copy of your cross section notes. It is a good idea to spot check the cross sections yourself to make sure they close.

STAKES FOR BORROW PIT EXAMPLE



Location	Station	Location	Station
A	17+385	I	17+460
B	17+390	J	17+470
C	17+400	K	17+475
D	17+410	L	17+485
E	17+415	M	17+495
F	17+420	N	17+500
G	17+440	O	17+505
H	17+445		

Setting Stakes for Grading

Usually, three sets of stakes will be used for controlling a construction contract; (a) Right of Way, Control and Structure (b) Preliminary Grade, and (c) Finish Grade.

Before you start setting stakes consult the Contractor to learn whether your proposed method will suit his/her convenience. As much as possible adjust your method to his/her wishes. After you have come to an agreement, make a note of it in your fieldbook, and make certain that the Contractor understands just what method of staking you will use, at what points stakes will be set, and how they will be marked. It is best to give him/her this information in writing as this may avoid a future controversy. A 1.5 m (5 ft) offset, if possible, will permit satisfactory distances from the toe of slope or edge of ditch to permit the Contractor sufficient workroom for his/her operation. Each cut or fill entered on the grade stakes should be recorded in the fieldbook. Prior to the Contractor beginning dirtwork operations, the original ground elevations should be spot checked for accuracy.

After the earthwork is roughed in, the Contractor will request a line of stakes, usually down the centerline of the roadway, to establish the completed crown grade. This line of stakes should be set with an instrument and the grade shown as requested by the Contractor. When the roadway is built as close to grade as possible with the previous stakes, it will then be necessary to set line stakes and paving stakes at 15 m (50 ft) intervals, closer intervals are required on a tight horizontal or vertical curve. These stakes should be of hardwood, preferably a 1 in x 2 in or 2 in x 2 in size, or metal and of sufficient length to penetrate the grade far enough that the movement of equipment will not cause variations once the grade is established.

The subbase and pavement can be built from these paving stakes. The Contractor should be cautioned against destroying the stakes. If this condition is encountered, the Specifications permit a fee that can be assessed for replacing the stakes.

Curve Superelevation. Review the curve data and typical sections shown on the plans for superelevation rates, transition lengths, and points of rotation. In some instances, this superelevation may create drainage problems, especially in flat terrain and with wide pavements. Review the curve data shown on the plans for superelevation limits and rate.

Within Cities. Superelevation within the limits of villages or cities is designed for the slower speed required and is, therefore, generally less than found in rural areas where higher speeds prevail. The difference in superelevation is, as a rule, the result of the difference in speeds, although there may be specific instances where good judgment or local conditions call for some modification of our standard practice. If you have any doubt as to whether you should follow our standard practice, discuss the matter with your Supervisor.

Layout of Entrance Culverts

Location. All entrance culverts should be set such that they match the roadway ditch both line and grade.

Staking. The only stakes that are necessary to be set for an entrance culvert are two stakes on the centerline of the culvert barrel. On these stakes should be marked with the cut to the ditch flow line.

Elevations of Headwalls. If the headwalls are built, it is essential that the top elevation of the two headwalls be made parallel to the grade of the shoulder, even though the gradient of the ditch is not the same as that of the pavement.

Layout of Across-Road Culverts

Location: Prior to staking out an across-road culvert determine whether the location as shown on the plans will fit the channel to the best advantage. See the following page for How to Check Plan Pipe Culvert Lengths. If you think the culvert line or grade should be relocated or the skew angle changed, take the matter up with your supervisor. Channel locations should not be revised without approval from your supervisor.

Staking. The centerline of the culvert barrel should be staked first by placing a stake on the centerline not closer than 1.5 m (5 ft) outside of each headwall. Nails should be set in the stakes giving the exact line. The cut to flow line should be marked on the stake, measured from the top of the stake. Also, always check the plan length for accuracy.

Elevation of Headwalls. After the forms are built, it is sometimes necessary to set the elevation to be used for the top of headwalls and give the Contractor elevations on the forms at which to set the chamfer. Remember that the tops of the headwalls must be parallel to the grade of the centerline of the roadbed.

HOW TO CHECK PLAN PIPE CULVERT LENGTHS

When checking a culvert for length the following information is given:

W = Right angle distance from centerline to shoulder point. This may be found on the typical section sheet or from cross sections.

K = Difference in elevation between centerline elevation and shoulder point. Also given on typical section sheet (Special case superelevated curves).

Centerline Elevation: Given on plans or may be calculated.

Invert Elevation: The flowline of pipe culvert at inlet or outlet end. Given on plan sheet and cross sections.

N = Slope: Defined as the number of meters (feet) vertical per 1 meter (ft) horizontal (at right angle to centerline).

Skew Angle = α : The angle between the centerline of the pipe and a perpendicular line to the centerline of the roadway.

C = Distance from top of headwall to invert elevation found under Standard or Special Headwall Sheet listed for particular pipe. (See typical pipe data below).

t = Thickness of Headwall. (See typical pipe data below).

TYPICAL DATA GIVEN ON PLAN SHEETS FOR PIPE CULVERTS (metric)

STA 395+000
 Double Pipe Culv Ty 2A
 RCCP CL II 900mm 103 m
 Hdwls Std 2102-D-900-2
 Both Hdwls:
 4.00 cu m Class SI Concrete
 104 kg Reinf Bars
 D.A. 1.6 ha
 Method II Installation

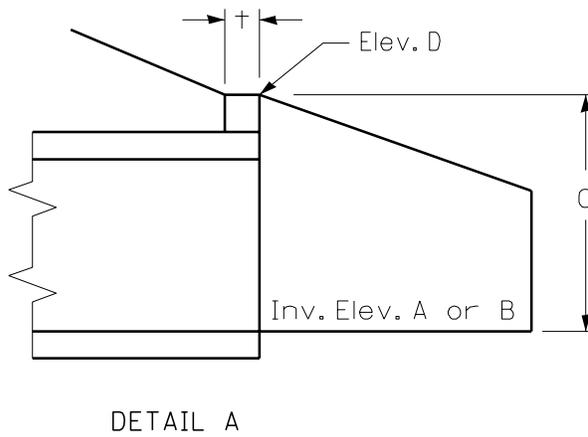
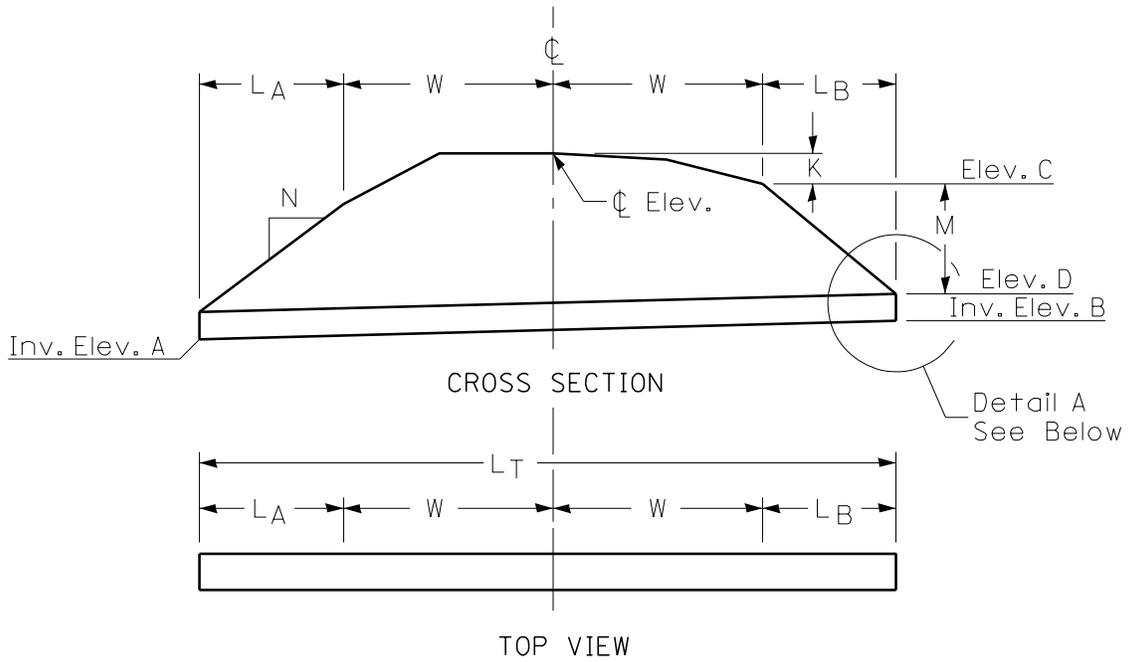
STA 390+055
 Pipe Culvert Ty 2 A
 RCCP CL II 900 mm 59 m
 (Lt 29 m & Rt 30 m)
 Hdwls Std 2051-DS-900-2
 Both Hdwls
 4.3 cu m Class SI Concrete
 68 kg Lbs. Reinf Bars
 Skew Angle = 25°
 D.A= 0.9 ha

TYPICAL DATA GIVEN ON PLAN SHEETS FOR PIPE CULVERTS (English)

STA. 1395+00
 Double Pipe Culv Ty 2A
 RCCP CL II 36" 338 lin. ft
 Hdwls. Std. 2102-D-36-2
 Both Hdwls.:
 5.00 Cu. Yds. CL "X" Conc (Hdwl)
 230 Lbs. Reinf. Bars
 D.A. 40AC
 Method II installation

STA 1286+54
 Pipe Culv Ty 2A
 RCCP CL II 36" 192 lin. ft
 (Lt 94' & Rt 98')
 Hdwls. Std. 2051-DS-36-2
 Both Hdwls.
 5.6 Cu. Yds. CL "X" Conc (Hdwl)
 150 Lbs. Reinf. Bars
 Skew Angle = 25°
 DA = 22AC

RIGHT ANGLE INSTALLATION



THE PROCEDURE IS AS FOLLOWS:RIGHT ANGLE CULVERT (Skew Angle = 0)

- A. Total Length $L_T = 2W + L_A + L_B$
- B. For L_A or L_B
 Elev C = C_L Elev - K
 Elev D = Inv Elev (A or B) + C
 M = Elev C - Elev D
 $L_{AB} = N(M_{AB}) + t$
- C. $L_T = 2W + L_A + L_B$

EXAMPLE RIGHT ANGLE CULVERT @ STA 10+000

$$W = 6.70 \text{ m} \quad K = 0.300 \text{ m} \quad C = 1.000 \text{ m} \quad t = 0.150 \text{ m} \quad N = 1:3$$

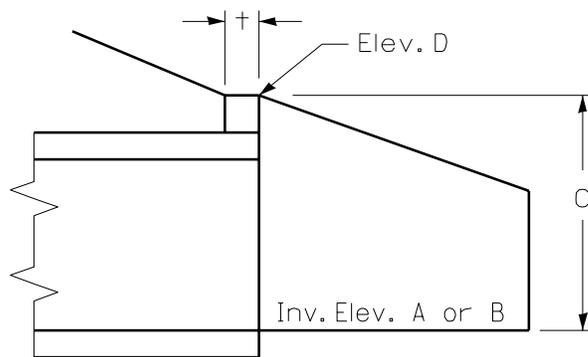
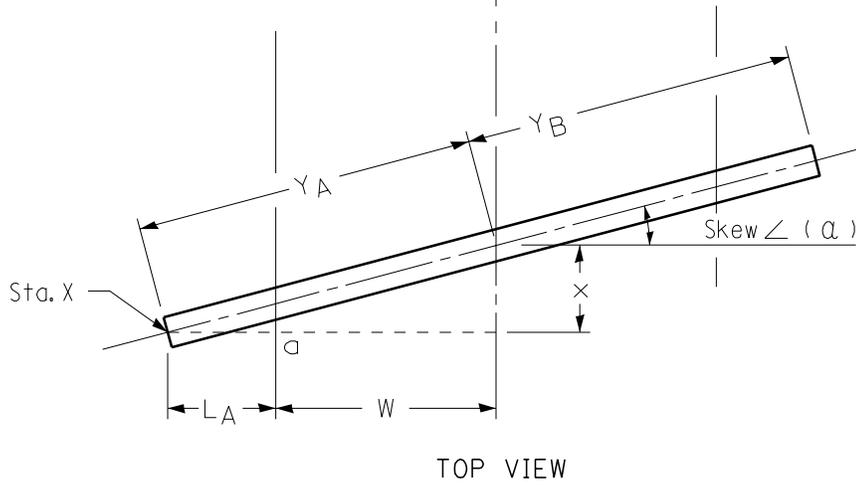
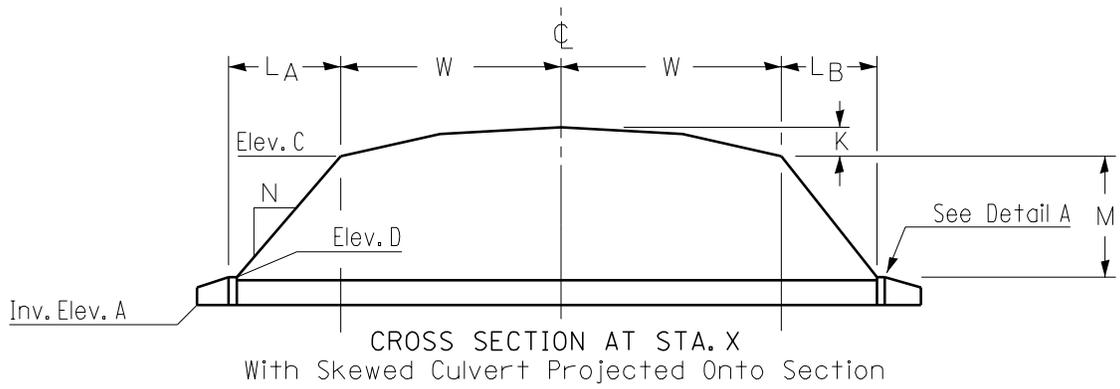
$$C_L \text{ Elev} = 46.000 \text{ m} \quad \text{Inv Elev A} = 31.000 \text{ m} \quad \text{Inv Elev B} = 32.000 \text{ m}$$

$$\begin{aligned} L_A \quad \text{Elev C} &= 46.000 - 0.300 = 45.700 \text{ m} \\ \text{Elev D} &= 31.000 + 1.000 = 32.000 \text{ m} \\ M &= 45.700 - 32.000 = 13.700 \text{ m} \\ L_A &= N M_A + t = 3(13.700) + t = 41.100 + .1500 = 41.250 \end{aligned}$$

$$\begin{aligned} L_B \quad \text{Elev C} &= 45.700 \text{ m} \\ \text{Elev D} &= 32.000 + 1.000 = 33.000 \text{ m} \\ M &= 45.700 - 33.000 = 12.700 \text{ m} \\ L_B &= N M_B + t = 3(12.700) + .150 = 38.100 + .150 = 38.250 \end{aligned}$$

$$L_T = 2W + L_A + L_B = 13.400 + 41.250 + 38.250 = 92.900 \text{ m}$$

SKewed CULVERT INSTALLATION



SKEWED PIPE CULVERT

1. Assume Y_A is correct.
2. $X = Y_A \sin \alpha$
3. Sta X = Sta of Pipe \pm X
4. Calculate Centerline Elev of Sta X
5. Calculate shoulder break elevation at point "a" = Centerline Elev Sta X-K = Elev C
6. Elev D = Invert Elev A or B + C
7. $M = \text{Elev C} - \text{Elev D}$
8. $L_A = [N \times M] + t$
9. $Y_A = \frac{L_A + W}{\cos \alpha}$
10. Does Y_A (calculated) = Y_A (assumed)?
11. If No. 10 is not true, then a new Y_A must be assumed and the procedure repeated.

EXAMPLE SKEWED CULVERT

Same data as above with Skew Angle = 45° RT Forward

Given: $Y_A = 67.000\text{m}$ $Y_B = 61.000\text{ m}$ (Assumed correct but not checked for this problem -
Check left side only.)

1. $Y_A = 67.000\text{m}$ (assumed correct)
2. $X = 67.000 (.70711) = 47.376\text{ m}$
3. Sta X = 10+000 - 47.376 = 9 + 952.624
4. Elev Sta X = 46.000 - 47.376 (.01) = 45.526
5. Elev C = 45.526 - 0.300 = 45.226

6. Elev D = 31.000 + 1.000 = 32.000
7. M = 45.226 - 32.000 = 13.226
8. $L_A = NM + t = 3(13.226) + 0.500 = 40.178$
9. $Y_A = \frac{40.178 + 6.700}{\cos 45^\circ} = \frac{46.878}{0.70711} = 66.296$
10. Y_A (calculated) $\neq Y_A$ (assumed) , therefore repeat procedure

Recalculation

1. $Y_A = 66.296$
2. $X = 66.296(\sin 45^\circ) = 46.878$
3. STA X = 10 + 000.000 - 46.878 = 9 + 953.122
4. Elev STA X = 46.000 - 46.878(0.01) = 45.531
5. Elev C = 45.531 - 0.300 = 45.231
6. Elev D = 31.000 + 1.000 = 32.000
7. M = 45.231 - 32.000 = 13.231
8. $L_A = NM + t = 3(13.231) + 0.500 = 40.193$
9. $Y_A = \frac{40.193 + 6.700}{\cos 45^\circ} = \frac{46.893}{0.70711} = 66.317$
10. Y_A (calculated) $\approx Y_A$ (recalculated) , therefore OK -- Use $Y_A = 66.317$

$$\frac{\text{Total Length of Culvert}}{Y_A + Y_B}$$

Layout of Pavement

Alignment and Grade. The essentials of a good paving section, alignment and grade, should be kept in mind continually when setting stakes for the work.

Field Book. Before setting any stakes, you should prepare your field book, check all computed grades shown on the plans as well as your calculated grades for other points. If the proposed pavement is to tie into existing pavement, the existing pavement elevations must be checked. Review the District Computer Programs for assistance. In addition to elevations, it is desirable to include the following data in your field book:

- A. Elevations of each edge of pavement on superelevated curves and on superelevated transitions at ends of curves, at 15 m (50 ft) intervals;
- B. Ties to all survey line control points, points of curve and tangent, bench mark elevations and locations;
- C. Tables of curve deflection angles and chords;
- D. Tables of offset from survey line to form stake line when required;
- E. Your return address (in case book should be lost).

It is a convenience, and will save time, if all necessary information from the plans is carefully transferred to the field book.

Notes for Setting Grade Stakes and Stringlines for Automatic Grade Control Equipment

General Information. Automatic grade control equipment automatically transfers the accuracy of the predetermined plane, such as a stringline, to the subgrade, base or surface, resulting in a neat line profile.

Automatic grade control equipment makes the transfer by the use of sensing units that contact the stringline on either side of the grade.

Normal Stringline Setting. The Contractor will usually set metal stakes which are 1 m (42 in) long and are driven into the ground, normally at 15 m (50 ft) intervals along one side of the roadway when using a machine equipped with automatic slope control or along both sides of the roadway when using a machine with sensors installed on both the right and left sides of the machine. The metal stakes are set to the hubs (grade stakes set for the roadway) for both dual lane and single lane machines. On superelevated sections and ramps, the metal stakes should be set at 8 m (25 ft) intervals to gain a greater degree of accuracy.

Factors to Consider for Stringline Installation. The following factors should be considered before any preparation for setting the stringline is started, to determine the most feasible location for the stringline:

1. Other work that may be performed either between the stringlines, when two are used, or along the shoulders.
2. The amount of material to be wasted near the stringline and the disposition that will be made of the material.

3. Obstructions along either side of the roadway.
4. The limit of the autograde sensor arm supports.
5. The percent of fall from the centerline of the roadway to the hubs or edge of pavement.
6. The grade stakes should be set directly below the stringline, if possible, but could be offset by up to four feet in small areas.

Location of the stringline may vary with each section of the roadway, due to supers, crowns and offsets. Each section should be evaluated separately to determine the proper location or position of the stringline.

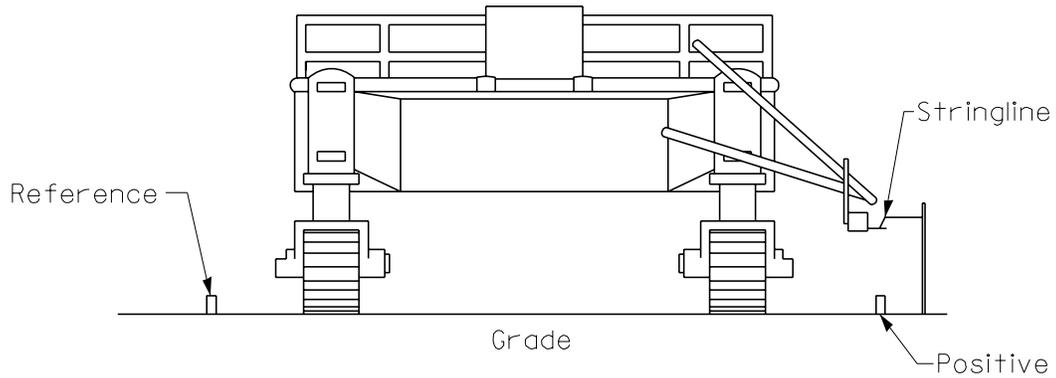
Stringline Hubs. Accurate operation of automatic grade control equipment depends on the correct installation of the stringline and the precise setting of the line and grade hubs. Considerable effort can be saved in the initial engineering if the Resident and Superintendent discuss the proper offset distance of the hubs and the specific machine to be used for each operation.

For autograde equipment with only one grade sensor and an automatic cross slope grade control, only one set of grade hubs is needed. See [Figure A](#).

For automatic equipment operating from two stringlines, two sets of grade hubs are needed to work the roadway from the initial subgrade to the finished slab. See [Figure B](#).

Each stringline must be set at a constant distance from the roadway centerline or a theoretical edge of the pavement. Each stringline must also be suspended at a constant height above the plane passing through the lower corners of the proposed slab.

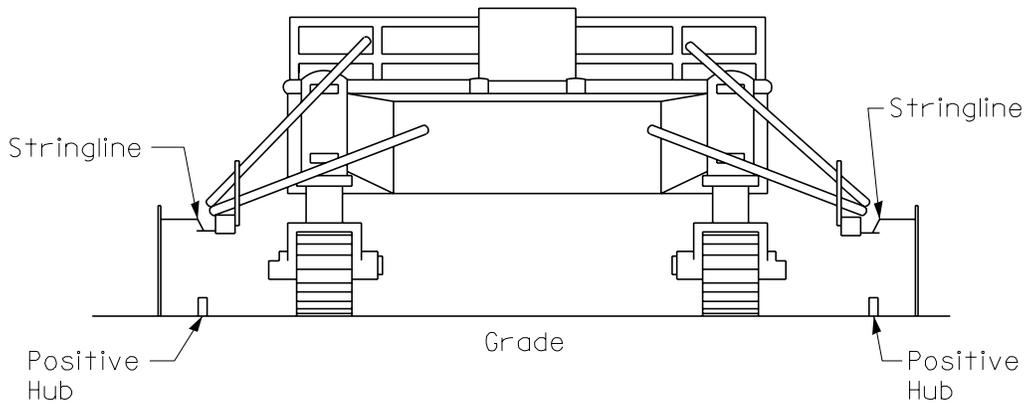
AUTOGRADE WORKING FROM 1 POSITIVE HUB, WITH CROSS SLOPE SYSTEM



Note: All Autograde equipment equipped with cross slope system needs only one set of positive hubs

FIGURE A

AUTOGRADE WORKING FROM 2 STRINGLINES, WITH 2 POSITIVE HUBS



Note: When operating from two stringlines, two sets of positive hubs are needed

FIGURE B

Superelevation

On many horizontal curves, the cross-slope of the pavement is modified to provide greater comfort and safety to the motorist. For the majority of the length of the curve the pavement will be uniformly sloped toward the center of the curve. This uniform cross-slope is called the superelevation rate.

In order to change from the normal crown on the tangent portion of the pavement to the full superelevation portion of the curve (and vice versa) the cross-slope must undergo superelevation transition.

Superelevation transition length is defined as the distance required to transition the pavement or traveled way from a normal crown section to the full superelevation (e). The superelevation transition length is the sum of the tangent runout distance (TR) and superelevation runoff length (L).

The tangent runout distance is the length required to bring the outside lane(s) up to a flat cross-slope. The superelevation runoff length is the remaining portion of the superelevation transition length.

For a detailed discussion of Superelevation, including design criteria and sample calculations, see [Chapter 32 of the Bureau of Design and Environment Manual](#).

COMPUTER APPLICATIONS

The Resident should be aware of and optimize the use of the Department's computer service. The following programs are available at the District level.

Field Control

Coordinate Geometry - An ICES subsystem of solving geometric problems, determining coordinates for triangulation, and locating control points by station/offset values.

Roadway Analysis and Design System - An ICES subsystem capable of computing earthwork quantities, plotting cross sections, and producing printed tables of slope stake locations.

Offset Line Elevations - This program is capable of producing tables of offset line elevations for paving stakes. These tables may optionally be printed on field book size pages.

Circular Curve Deflection Angles - Produces, in tabular form, deflection angles for staking of circular curves in the field.

Three Point Problem - Determines plane coordinates for a point based upon sightings of three non-collinear points whose coordinates are known.

Bridge Deck Elevations - Provides a listing of bridge deck elevations along each beam of a bridge and can adjust these elevations to reflect dead local deflections.

Field Quantities

Bridge Fillet Quantities - Computes fillet quantities, based upon plan values and field measurements.

Borrow Pit, Embankment and Excavation Computations - Computes cut and/or fill, along with end-area for each cross section, as well as accumulated totals. Plotting of cross sections is available.

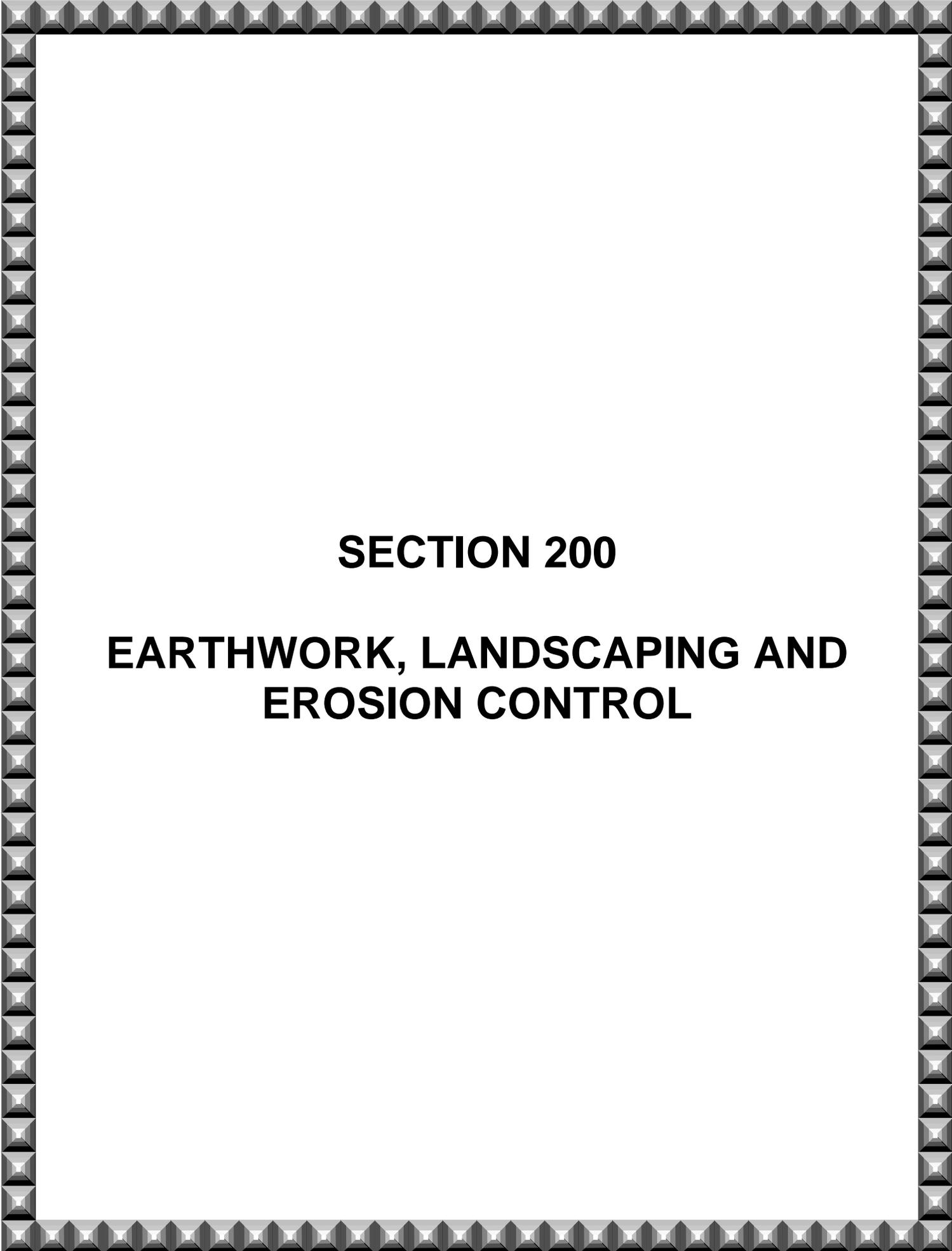
Reinforcing Steel Quantities - Tabulates total weight of reinforcing steel.

Quality Control

PCC Proportioning - Designs concrete mix for user specified material specific gravities.

Bearing Tables for Pile Hammers - Provides a table of bearings versus blows-per-meter (foot). Also computes blows-per-meter (foot) to reach a specific bearing.

Slope Stability Analysis Series - These programs analyze the stability of slopes using various test methods.



SECTION 200

**EARTHWORK, LANDSCAPING AND
EROSION CONTROL**

SECTION 200. EARTHWORK, LANDSCAPING, EROSION CONTROL

General. Contact your District Office and Environmental Coordinator, check the Commitment File, read any permits (e.g. Section 404 or 401) and determine if there are any special right-of-way agreements that will restrict the Contractor's operation. Such agreements may include saving or removal of certain trees, hedges, or plantings, the moving or disposition of particular buildings, fences, walls or other structures or objects or protection of features within the ROW.

Before construction starts, arrange to have your supervisor go over the work with you. A Storm Water Pollution Prevention Plan (SWPPP), Form [BDE 2342](#) may need to be developed or adjusted to accommodate the Contractor's operations and Form [WPC 623](#), Notice of Intent, submitted to the [Illinois Environmental Protection Agency](#) (IEPA) to be in compliance with Illinois Laws. At the preconstruction conference, a jobsite inspection shall be scheduled with the Contractor. An Erosion Control Plan indicating the erosion control measures to be implemented on the project should be included in the plans. If not, one must be developed from a jobsite inspection with the Contractor. Any plans to preserve natural points of interest that may be incorporated in the ultimate development of the road for the convenience and comfort of the public can be reviewed at this time. Some erosion control measures, particularly perimeter barriers and those protecting sensitive areas or special items, must be installed before construction activities disturb existing ground conditions. Other measures will be installed as the work progresses.

SECTION 201. CLEARING, TREE REMOVAL AND PROTECTION, CARE AND REPAIR OF EXISTING PLANT MATERIAL**201.04 Tree Removal**

You can determine which trees may be saved by studying the limits of the cut and fill slopes on the cross sections. Review the design files for right-of-way agreements that may require certain trees to be saved. The District Landscape Architect should be contacted for advice on tree removal questions. Identify each tree to be saved by a method acceptable to you and the Contractor. Record in your field book the location by stations, and the diameter in millimeter (inches), of each tree to be removed and paid for on the diameter basis. The plan locations and limits for Tree Removal, Hectare, (Acre), will be laid out in the field to assure the plan locations fit the field conditions.

Tree Removal, Special. This item is generally specified when trees are located in urban sections or present a special removal problem due to locations of houses, power lines, etc. Under this item the specific location of each tree should be shown.

201.05 Protection of Existing Plant Material

It is Departmental policy to preserve as many plantings as possible. In the event that any plantings designated to be saved are damaged by the Contractor, they shall be repaired or replaced by the Contractor at his/her expense.

The resident will review commitments to see which trees are to be saved, and discuss these requirements at the pre-construction meeting. Fencing or other appropriate protective barriers

shall be placed around trees or other sensitive areas, as noted in the plans, prior to beginning construction activities.

It may be possible to accommodate haul roads and staging areas through additional clearing or have the trees and shrubs replaced at the Contractor's expense. However, Residents will not permit Contractors to remove trees and shrubs, outside of designated clearing areas, for haul roads or staging areas without the review and approval of the District Landscape Architect. Questions regarding plant removal involving utility relocations should also be brought to the attention of the District Landscape Architect.

201.09 Disposal of Materials

Refer to Article 202.03 of the Standard Specifications before disposing of waste materials. Article 107.22 requires the contractor to designate all such areas for approval by the Engineer prior to their use. The contractor shall submit Form [BDE 2289](#) with supporting documentation to the District Office for this purpose.

SECTION 202. EARTH AND ROCK EXCAVATION

Rock Cuts. Rock encountered in cut sections will require special attention. Consideration is to be given to modifying the typical cross section and profile grades to minimize the excavation. Each case must be considered individually. Safety, drainage and maintenance costs as well as construction costs are to be considered. Care is to be taken to excavate the rock at least 75 mm (3 inches) below the subgrade in a manner that will avoid water pockets.

Prior to adjusting the cross section when rock is encountered or variances are discovered in the plan elevations discuss the situation with your supervisor.

202.03 Removal and Disposal of Surplus, Unstable, and Unsuitable Materials and Organic Waste

1. A. Unstable or Unsuitable Material. If there is any question in your mind as to whether or not material is unstable or unsuitable, whether found in ordinary excavation or in the finished grade, refer the matter promptly to your supervisor.

Article 107.22 requires the contractor designate all borrow, use and/or waste areas for approval by the Engineer prior to their use. The contractor should submit Form [BDE 2289](#) with supporting documentation to the District Office for this purpose. It is essential that the Contractor file a written proposal for disposal of surplus waste materials along with the property owners' written permission. The Department, as generator of this waste, is liable even after removal from our property for all environmental statutes, archaeological and zoning requirements.

The Contractor shall follow all State and Federal solid waste disposal laws, regulations and solid waste determinations of the [Illinois Environmental Protection Agency](#).

- B. Contaminated Soil. Should you encounter waste which may be considered a contaminate i.e. petroleum based products, paint material, pesticides, asbestos, herbicides, acids etc., it is imperative that your supervisor be contacted immediately.

The Contractor shall follow the guidelines as set forth by the IEPA in their removal and/or disposal.

Refer to Section 669 of the Standard Specifications addressing Removal and Disposal of Regulated Substances.

- C. Make certain the Department has been issued an Open Burning Permit from the IEPA. Become familiar with the conditions of the permit. The Contractor shall follow the conditions as required. If the Contractor proposes to deviate from the conditions of the Departments permit, s/he shall secure a specific permit for any open burning on the contract.

202.05 Drainage

Refer to Construction [Memorandum No. 60](#), Erosion and Sediment Control.

The condition of existing drainage lines may be valuable for future reference if noted on the as-built plans. Drainage outlets will be considered when establishing the flow line of culverts and ditches. It is advisable to replace all tile lines that extend across the roadway. If it is decided to replace the tile, it should be replaced with pipe conforming to the requirements for storm sewers. However, you will be required to locate the lines and then consult your supervisor before authorizing any replacement work.

202.07 Method of Measurement

Surplus or Deficiency of Excavation. The contract is to be constructed to the lines and grades shown on the plans. However, occasionally, either too much or an insufficient material is encountered on the contract. When this occurs, check the cross section as shown by the plans with the cross sections of the road as built before making your decision as to what should be done.

- A. Excavation Beyond Plan Limits. The Specifications provide that any material excavated beyond the limits of the required slopes or excavated material used for purposes other than those designated, shall not be measured for payment. When excavating material that can be easily handled, a grading Contractor will sometimes make cuts wider and ditches deeper than called for on the plans. This should not be permitted unless the additional material is actually required and is approved by your supervisor.
- B. Grading Sections. You must verify the plan cross sections prior to starting grading operations. Cross sections will be taken at all even stations, at points where there is a transition from cut to fill or vice versa, and wherever there is an abrupt change in the original ground line. When grading is completed, cross sections must be taken again at the same stations to complete the data for computation of quantities. During finishing operations, the Resident must require strict conformance with the 50 mm (2 in) tolerance contained in Article 212.02.
- C. C. Previously Graded Sections must be recross-sectioned before they are paved.

SECTION 203. CHANNEL EXCAVATION**203.03 Clearing, Tree Removal, and Protection of Existing Plant Material.**

Prior to starting any excavation involving waters of the U.S., check the Section 404 permits to determine the extent of work permissible under the conditions of the permit.

203.05 Method of Measurement

Measured quantities require cross sections before starting work and upon completion of the work. If the channel excavation is of sufficient length, segments of the work should be cross sectioned upon completion. This will avoid discrepancies in the amount of cubic meters (yards) removed due to changes which might occur during heavy rains or high water.

SECTION 204. BORROW AND FURNISHED EXCAVATION**204.02 Borrow Pits**

Environmental reviews (Art. 107.22) are required for all borrow pits. You will forward the Contractor's submittals of Form [BDE 2289](#) and other supporting documents to the District Office to obtain the necessary clearances. The contractor shall not disturb the borrow pit area, other than the minimum necessary to obtain samples, until clearance has been received.

SECTION 205. EMBANKMENT**205.04 Placing Material**

If the embankment freezes during delays in the Contractor's operation, all frozen material must be removed from the embankment prior to resumption of the earth placing operation. The frozen material may be bladed over the slopes or placed in areas designated by the Engineer until the material can be reincorporated into the work after it has thawed. Any stockpiling should be protected in accordance with [Section 280](#).

Large Rocks, Boulders, and Broken Concrete. Considerable care is required to place rocks, broken concrete or boulders in a fill to obtain satisfactory results. The fill must be deep enough to accommodate this material and the material must be distributed as widely as possible. The material shall be placed in specified lifts and distributed to permit the compaction of earth around and between the various pieces, and the filling of all voids. If material of this character is incorporated into the embankment, close inspection of the placement and compaction is required.

Shrinkage Factor. In computing the amount of excavation or borrow required to build an embankment, a percentage of excess material is allowed to account for volume differentials resulting from the effects of compaction. This percentage will vary greatly, depending on the character of the soil and the height of the embankment. All of the District Offices have tabulations of percentages of excess which cover the conditions in their particular District. However, the shrinkage factor for Furnished Excavation will be 25% or as stated in the contract, regardless of any tests which may be conducted at the time of construction.

Erosion and sediment control measures must keep pace with the construction of the embankment. Areas should be final graded and seeded at the earliest possible date, and all necessary maintenance regularly performed on perimeter and other control measures as required in Construction [Memorandum No. 60](#), Erosion and Sediment Control.

205.05 Compaction

Disking. Note that the use of a disk is required on all material with the exception of sand or gravel. The function of the disk is primarily to mix the material, assist in the distribution of moisture and to pulverize the soil. Disking must at least penetrate through the entire depth of the currently placed material to be effective.

Moisture Content. Moisture plays an important part in successful compaction. Without the proper moisture content, the density required by the Standard Specifications may not be secured even though the embankment is subjected to additional rollings. When the moisture content of the material exceeds its optimum moisture content, to the extent that the required density cannot be obtained, it shall be allowed to dry out before additional material is placed, or the wet material may be incorporated with drier material provided satisfactory results obtained.

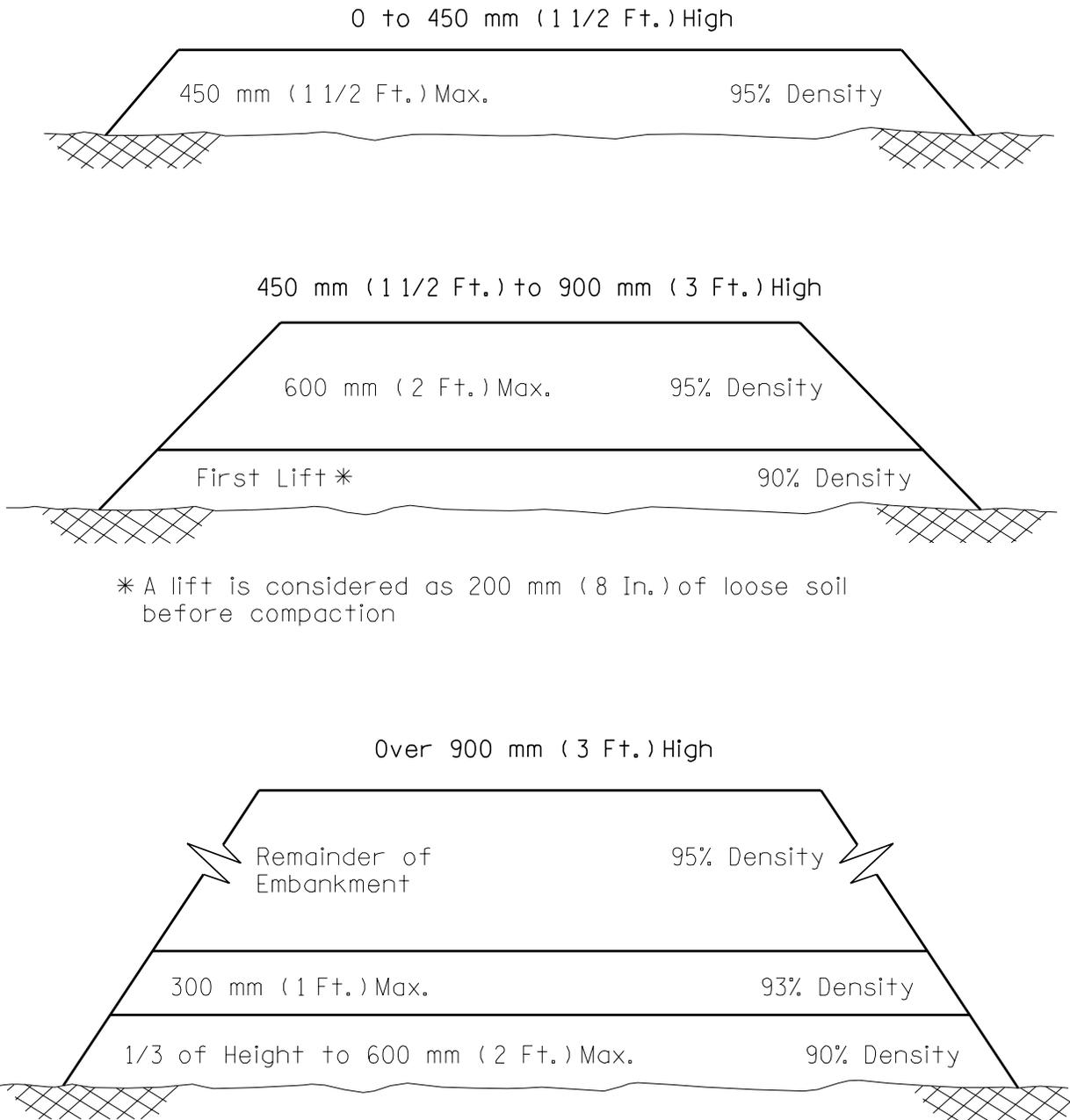
Density Requirements. Read Article 205.05 concerning density requirements. All density tests shall meet at least the minimum requirements of Article 205.05. If tests do not meet the minimum requirements, additional compactive effort shall be applied to bring the density up to the minimum Standard Specification requirements. No additional earth placement shall be permitted until the questionable areas are re-tested and approved by the Engineer.

Tests. The District Materials Engineer will acquaint you with the procedure in making density tests.

Compaction Around Culverts, Bridges and Retaining Walls. The manner of placing embankment material around or behind structures may result in excessive pressure or settlement. To guard against displacement or undue settlement, material placed adjacent to structures must be properly compacted at a moisture content not in excess of 110 percent of optimum. You should carefully inspect the placement and compaction of material in places inaccessible to the roller method of compaction. The Contractor must place sufficient, properly compacted embankment over pipe culverts before crossing with earth moving equipment to prevent damage.

EMBANKMENT

Density Requirement



EQUATIONS

$$\begin{aligned}\text{Shrinkage Factor (SF)} &= \frac{\text{bank volume} - \text{compacted volume}}{\text{bank volume}} \\ &= \frac{1 - \text{compacted volume}}{\text{bank volume}}\end{aligned}$$

Unless otherwise stated in the contract, use SF = 0.25. Suitable Excavation is defined to be all Earth Excavation, Rock Excavation, and all other on-site excavation that is suitable to be used as Embankment for the contract.

To determine quantity of Embankment that will result from the suitable Excavation:

$$\text{Excavation to be used as Embankment} = \text{Suitable Excavation} \times (1 - \text{SF})$$

If the quantity of Excavation to be used as Embankment is less than the Embankment quantity required, the designer used one of the following equations to establish plan quantities:

$$\text{Furnished Excavation} = \text{Embankment} - [\text{Suitable Excavation} \times (1 - \text{SF})]$$

$$\text{Borrow Excavation} = \frac{\text{Embankment} - (\text{Suitable Excavation}) \times (1 - \text{SF})}{1 - \text{SF}}$$

The designer will show all areas of suitable material on a schedule in the plans. If any area cannot be used on a project containing Furnished Excavation or additional jobsite removal is done, the quantity of suitable Excavation and Furnished Excavation must be adjusted. On projects using Borrow Excavation, this is not required since payment is made for all material from the pit used on our project.

EXAMPLESExample 1: Earthwork Schedule

1 Location	2 Earth Excavation	3 Earth Excavation Adjusted for Shrinkage	4 Embankment	5 Earthwork Balance Waste (+) or Shortage (-)
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard
Sta. 100+00 to 105+00	500	375	100	+275
Sta. 105+00 to 110+00	400	300	100	+200
Sta. 110+00 to 115+00	500	375	200	+175
Side Road A	<u>200</u>	<u>150</u>	<u>300</u>	<u>-150</u>
Total	1600	1200	700	+500

Column 1, 2 & 4 – Location and Quantities from cross sections

Cut = Earth Excavation

Fill = Embankment

Column 3 - Quantity of Earth Excavation (Cut) Adjusted for a shrinkage factor of 0.25%

Column 5 - Earthwork required. (-) = Quantity of Fill or Embankment needed

(Furnished or Borrow Excavation), (+) = Quantity to be wasted

Since the Earth Excavation quantity is greater than Embankment needed, the only pay item is for Earth Excavation. No pay item for Borrow or Furnished Excavation is needed.

Pay Item

EARTH EXCAVATION = 1600 cubic yards

Example 2: Earthwork Schedule

1 Location	2 Earth Excavation	3 Earth Excavation Adjusted for Shrinkage	4 Embankment	5 Earthwork Balance Waste (+) or Shortage (-)
	Cubic Yard	Cubic Yard	Cubic Yard	Cubic Yard
Sta. 320+00 to 325+00	100	75	275	-200
Sta. 325+00 to 330+00	200	150	125	+25
Sta. 330+00 to 335+00	150	112.5	300	-187.5
Side Road X	<u>50</u>	<u>37.5</u>	<u>250</u>	<u>-212.5</u>
Total	500	375	950	-575

Column 1, 2 & 4 – Location and Quantities from cross sections

Cut = Earth Excavation

Fill = Embankment

Column 3 - Quantity of Earth Excavation (Cut) Adjusted for a shrinkage factor of 0.25%

Column 5 - Earthwork required. (-) = Quantity of Fill or Embankment needed

(Furnished or Borrow Excavation), (+) = Quantity to be wasted

The Earth Excavation quantity is not great enough to account for all Embankment (Fill) needed. Therefore, additional earth is required from off-site either as Borrow or Furnished Excavation.

Furnished Excavation is measured in its final (compacted) state. Borrow Excavation is measured at the borrow site and therefore the Borrow quantity must allow for shrinkage (0.25%).

$$\text{Borrow} = \frac{575 \text{ CY}}{(1 - .025)} = 766.67$$

Pay Items

EARTH EXCAVATION = 500 cubic yards
 FURNISHED EXCAVATION = 575 cubic yards

OR

EARTH EXCAVATION = 500 cubic yards
 BORROW EXCAVATION = 767 cubic yards

SECTION 208. TRENCH BACKFILL

208.03 Method of Measurement

If the trench has been excavated wider than the maximum width permitted by the specifications, the backfill material required for the excess excavation will not be measured for payment. The Contractor shall backfill this excess excavation with the same backfill material s/he uses for the pay portion of the trench. As an aid in computing the quantity of Trench Backfill refer to the [Trench Backfill Table](#) in the [Documentation Section](#) of this Manual. If the material excavated from the trench is used for backfilling, it is not measured for payment as Trench Backfill.

- * These tables may be used only when the trench is at least as wide as allowed by the Standard Specifications. The volume of trench backfill will be less for narrower trenches. If any portion of the trench width, as required by the Standard Specifications, falls within the limits of the pavement or sidewalk for longitudinal runs, the entire width of the trench, up to the maximum width allowed by the Standard Specifications, will be paid for as Trench Backfill.

SECTION 211. TOPSOIL AND COMPOST

211.03 Furnishing and Excavating Topsoil

Do not assume the top of soil within the right-of-way is always suitable for topsoil.

Necessity for Topsoil. Topsoil will be specified on the plans if required. The purpose of topsoil is to provide a covering over the slopes that will support vegetation or protect a more erodible material. Review your plans and Special Provisions prior to starting excavation to determine the areas for topsoil removal. Stockpiles of top soil must also be treated in accordance with the Department's Erosion and Sediment Control policy.

211.04 Placing Topsoil and Compost

On slopes, in addition to raking and breaking of clods on the existing surface, to prevent slippage and to provide adequate bond, it is necessary to scarify the area preferably at right angles to the slope.

The time of placement of topsoil should be as close as possible to the time of the seeding operations.

SECTION 212. FINAL SHAPING, TRIMMING AND FINISHING

212.01 Description

You will note different types of surfacing require different operations in regard to shaping and trimming. Most of the operations are mentioned in the Specifications and others may be listed in the Special Provisions. Where the contract calls for surfacing on a pre-graded section, the shaping of backslopes is not required unless it is covered in the Special Provisions or the original slopes are disturbed.

SECTION 280. TEMPORARY EROSION CONTROL

Construction [Memorandum No. 60](#) details the requirements of our Erosion and Sediment Control practices, including timely use of temporary and permanent measures. *All* projects which disturb soil, regardless of acreage of disturbance, require an Erosion and Sediment Control Plan. Weekly inspections, and supplemental inspections following 13 mm (0.5 inch) rain events, of the erosion control measures and areas subject to erosion are required on all projects. These inspections are to be documented on Form [BC 2259](#) and included in the Erosion Control file. Most contracts will include pay items which the designers felt would adequately address the control of erosion on the project. The lack of pay items, however, does not relieve the Resident of responsibility for erosion control. When sufficient pay items are not included, the Resident will pay for necessary measures in accordance with Article 109.04. On projects disturbing more than 0.4 hectares (1 acre), Form [BDE 2342](#), Storm Water Pollution Prevention Plan (SWPPP), will be included in the plans. Even on projects disturbing less area, an Erosion and Sediment Control Plan should be included in the plans. If an Erosion and Sediment Control plan is not present, the Department's representative and the Contractor are to cooperatively develop an erosion control plan using good engineering practices. (The Department is usually represented by the Landscape Architect, or the Erosion Control Coordinator, and the Resident.)

National Pollutant Discharge Elimination System (NPDES)

In compliance with the provision of the Illinois Environmental Protection Act, the [Illinois Environmental Protection Agency](#) (IEPA) has developed a general permit (ILR10) which addresses NPDES requirements for storm water discharge from construction site activities. This permit is required whenever a project results in the disturbance of 0.4 hectares (1 acre) or more of total land use. A Storm Water Pollution Prevention Plan will be supplied by Program Development to the Resident. The Resident is responsible for reviewing the plan and completing the sections which reflect the Contractor's specific operations. These sections include: Section 3. Maintenance; Section 5. Non-Storm Water Discharges.

The Contractor and all subcontractors involved with work items subject to the SWPPP are to certify that they understand and will comply with all the requirements of the permit by signing [BDE 2342A](#), Contractor Certification Statement, included with the SWPPP.

The Resident must submit form [WPC 623](#), Notice of Intent (NOI) (i.e., intent to use the general permit) form to the IEPA at least 48 hours before any disturbance of land commences and post a copy of the notice at the jobsite.

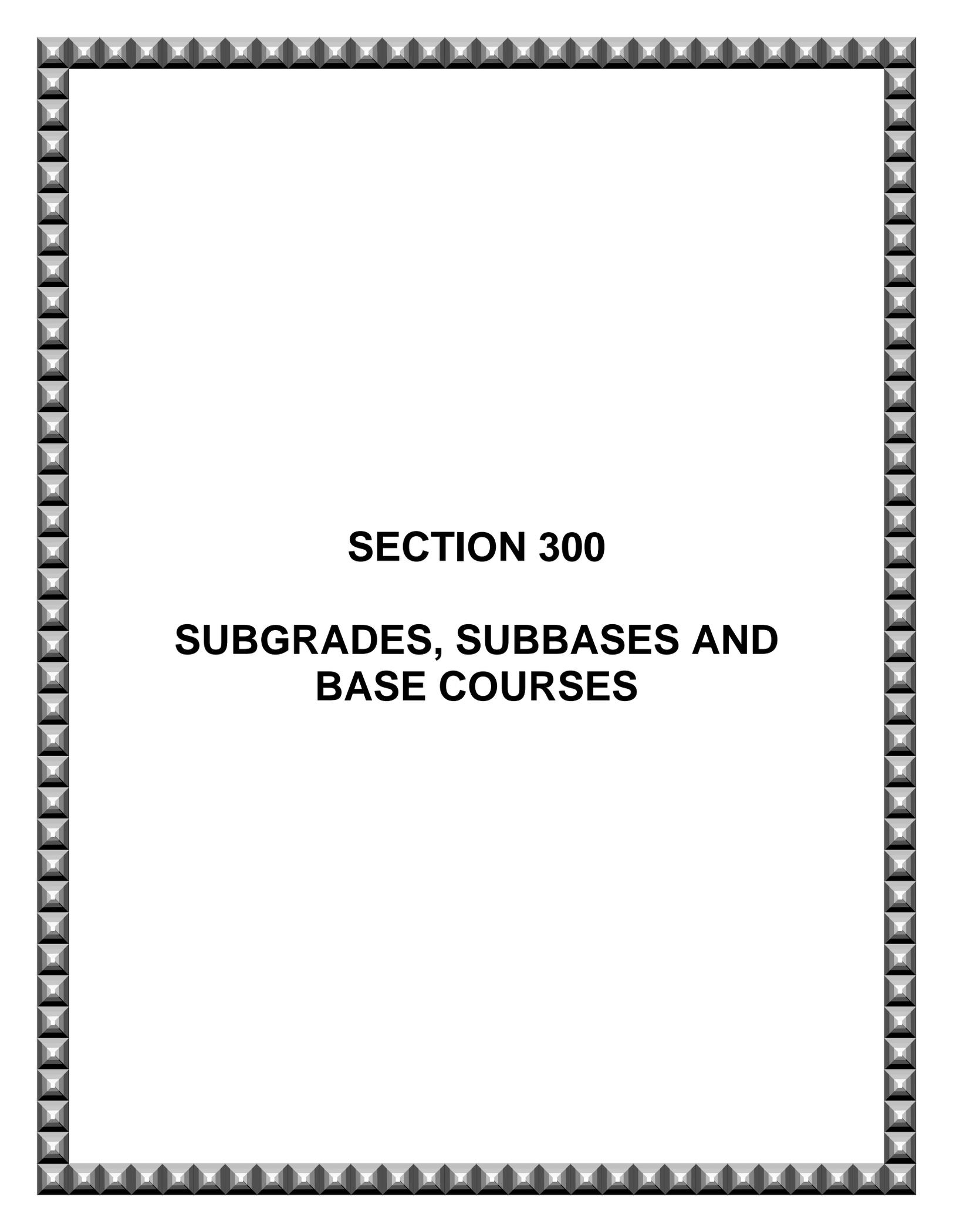
The Resident will conduct periodic inspections at least once every seven calendar days and within 24 hours of a storm that is 13 mm (0.5 inch) or greater, and record observations of the inspection on form [BC 2259](#), NPDES/Erosion Control Inspection Report. Timely completion of these forms documents, in a manner acceptable to regulatory agencies, the department's efforts at permit compliance in the event of a failure of any portion of the Erosion and Sediment Control Plan. Send a copy of this form to the contractor. This provides evidence you notified the contractor of areas requiring maintenance.

In the event a failure of the erosion control system occurs, the Resident must complete and mail to the IEPA, within 5 days, a [WPC 624](#), Incident of Non-compliance form. This form notifies the IEPA that a discharge of sediment into the surrounding area has occurred and the actions we took to mitigate this discharge. A copy of each ION must be kept with the Erosion Control file.

The Resident must complete the Form [WPC 621](#), Notice of Termination (NOT) when final erosion control measures in accordance with the NPDES requirements are established. It is very important, therefore, that your Supervisor be kept informed.

A project which is designed with less than 0.4 hectares (1 acre) of disturbance but through added work or carelessness exceeds 0.4 hectares (1 acre) of disturbance during construction phase will require immediate implementation of NPDES provisions including NOI, ION and NOT submittals. These requirements become effective as soon as it is discovered that more than the threshold will be disturbed. The Resident does not wait until the contractor disturbs more than 0.4 hectares (1 acre).

Please review Construction [Memorandum No. 60](#), Erosion and Sediment Control and Form [BC 2259](#), NPDES/Erosion Control Inspection Report. Your District Landscape Architect or Environmental Coordinator can also assist with these requirements.



SECTION 300

**SUBGRADES, SUBBASES AND
BASE COURSES**

SECTION 300. SUBGRADES, SUBBASES AND BASE COURSES**SECTION 301. SUBGRADE PREPARATION****301.01 Description**

The preparation of the subgrade for any type of subbase, base and surface course is governed by the specifications in this section.

301.03 General

The final finish of the subgrade must be constructed in accordance with the requirements for the type of base, subbase or surface course being placed. The subgrade shall be compacted to a minimum 95% density and stable to prevent rutting and shoving during construction, provide support for the placement and compaction of paving lifts, limit pavement resilient deflections and rutting of the subgrade during the service life of the pavement. To ensure adequate stability, required minimum levels of strength and stiffness must be achieved in the subgrade soil to a depth determined by both construction traffic and pavement design requirements.

Subgrades may be divided into two different categories. The first is the subgrade constructed on an embankment. The second is the subgrade that is constructed in a cut section or very near the existing ground surface. A stable subgrade can be constructed by controlling moisture and density as the embankment is constructed. However, the stability of a subgrade in a cut or on or very near the existing ground surface is greatly affected by the insitu soil conditions.

An exposed cut section should be examined as soon as possible. This is important in order to determine whether or not conditions in the exposed cut are those predicted on the basis of the preliminary soil survey. Since even the most thorough soil survey gives information only at point locations, often separated by considerable distances, careful examination of the roadway will assist in locating problem foundation materials or faulty drainage conditions which must be corrected. Corrective action may be required for foundation materials which are exceedingly weak, those which appear to be much weaker than originally thought, and materials which differ significantly from adjacent material with respect to frost susceptibility. If the inspection reveals excessive seepage into the cut, problems of instability, often including frost action, may result in future rapid deterioration of the pavement and/or slopes unless special corrective measures are taken.

The stability of an earth subgrade is critical for the construction of subsequent pavement lifts and the future performance of the pavement structure. The Resident should make a careful inspection and evaluation of the entire subgrade for stability prior to placement of the subbase or base course.

The stability of the subgrade can easily be evaluated by inspecting the amount of deflection and/or rutting which takes place under the wheels of heavy construction equipment. The *Subgrade Stability Manual* provides requirements for subgrade stability and outlines the following remedial procedures for unstable subgrades:

1. undercut and backfill
2. lime treatment
3. moisture density control

It is not always apparent which remedial procedure should be used for a particular situation. The Resident responsible for the subgrade should make the District Soils Engineer aware of

any subgrade stability problems so s/he can evaluate the condition and make the appropriate recommendation for corrective action.

301.05 Aggregate Surface Course, Type B

Although no rolling is required, the provisions of Article 301.03 apply and the subgrade must be approved by the Engineer before the surfacing material is placed.

301.06 Bituminous Concrete Base Course and Pavement (Full-Depth) and Portland Cement Concrete Base Course and Pavement

The subgrade shall be compacted with a pneumatic-tired roller, three-wheel or tandem roller. In small street returns and tapers, hand tamping may be necessary due to the limited space. Close inspection is important where mechanical equipment is not used.

Preparing Subgrade Ahead. When the subgrade operation gets too close to the paving operation, there is a tendency to overlook some details in the subgrade preparation in an effort to get ahead. This may result in poor workmanship or neglect of important features of the work. Therefore, the preparation of the subgrade shall be ahead of the paving operation by one day's paving production rate.

Moisture Content. When concrete surface or base courses are to be constructed, the subgrade shall be in a moist condition to prevent moisture from being drawn from the concrete. It may become necessary to re-wet the subgrade by sprinkling

Checking Subgrade Planer (or Subgrade Machine). The cutting blades on the subgrade planer (or subgrade machine) should be checked and set to cut the subgrade to the required depth and crown. It is the responsibility of the Contractor to set the equipment to obtain the required crown and thickness and to keep it properly adjusted.

Subgrade or Subbase Template. All finished subgrades or subbases shall be checked for crown and proper elevation prior to starting paving. Electronically-controlled subgrade machines may be used as the template for slipform or form paving or the heavy subgrade template with forms.

301.08 Drainage

A stable subgrade is essential and it can be secured only if adequate attention is given to surface drainage. Water pockets create soft or spongy spots in the subgrade or make it muddy or otherwise unfit to receive the surfacing material. The Contractor shall make provisions for surface drainage.

SECTION 302. LIME MODIFIED SOILS

302.01 Description

Used to prepare a working platform in conjunction with the mechanistic pavement design for the subsequent pavement structure. It is also used as a construction expedient.

302.04 General

Prior to Lime Modification, the soil should be brought to approximate final grade. This will help assure a uniform thickness of stabilization following final trimming.

SECTION 310. LIME STABILIZED SOIL MIXTURE**310.01 Description**

As a subbase layer, the lime treated soil is a part of the pavement structure, and thus must provide permanent improvement to the treated soil.

SECTION 312. STABILIZED SUBBASE**312.01 Description**

This work consists of furnishing, placing and compacting a Bituminous Aggregate Mixture (BAM), Cement Aggregate Mixture (CAM), Pozzolanic Aggregate Mixture (PAM), or a Cement Aggregate Mixture (CAM II) on a prepared subgrade.

312.02 General

No stabilized subbase should be constructed that cannot be surfaced during the current construction season. The reason for this requirement is that stabilized subbases and the respective subgrades upon which they are placed tend to deteriorate when left exposed to the elements over the winter months.

Refer to the Stabilized Subbase, BAM, CAM, PAM & CAM II checklist for requirements of the various types of subbase.

SECTION 351. AGGREGATE BASE COURSE**351.01 Description**

Aggregate Base Course is generally used as a foundation for flexible surfaces. Ensure that the crown and superelevation have been constructed as shown on the plans.

351.02 Materials

You should inspect the aggregate as it is delivered and placed. Watch for foreign substances such as chunks of wood, weeds and particularly clay balls and lumps of dirt. Be sure the material has been inspected and approved. If you have any doubts as to the quality of the material that is being delivered or find that segregation is quite prominent, consult your supervisor.

351.05 Base Course

- A. The Contractor should begin the aggregate placing operations with lifts that will not be greater than 100 mm (4 in) when compacted. Generally, a loose measurement of about 150 mm (6 in) will result in a compacted thickness of 100 mm (4 in). If tests show that the specified density is obtained, the compacted thickness may be increased to 200 mm (8 in).

The spreader must be capable of placing the aggregate the full width of one lane and to the desired thickness for one lift. Do not permit the aggregate to be deposited in excessive

thicknesses in one lane with the top half of the material then bladed to the adjacent lane. The Specifications require a minimum of blading and manipulation. If blading and manipulation is necessary to achieve proper crown you should make sure there is sufficient moisture present in the material to prevent segregation.

- B. Type A. Visit the plant and inspect the mixing operation. Assure yourself that the water and aggregate are being mixed to provide a uniformly moist product. Material that is either too dry or too wet will not compact well when rolled.

It is possible to get density (but not stability) at a moisture content higher or lower than optimum. The Inspector should be aware of appropriate ranges from optimum s/he should be trying to achieve. In case the material was deposited on the subgrade or prior lift of base, and the desired density was not obtained, the aggregate can be aerated or wet down in place so as to obtain required density of 100 percent. This is only for those isolated cases when material was inadvertently placed in a too wet or too dry condition. It must not become an accepted part of the normal operation.

Inspect the rolling operation. For best results, the roller should follow as closely behind the spreader as possible. If you find that the base is pumping, cracking or is showing other signs of failure, determine the magnitude of the failure. It may be something easily corrected. If not, discuss the difficulty with your supervisor. Placing multiple lifts without proper cure time on the previous lift(s) could be the source of the problem.

- C. Type B. Water for Type B Base Course may be added after aggregate has been placed on the grade. You will have more difficulty obtaining uniform moisture content by this method than by the pug mill method; however, close inspection throughout the operation will help provide the desired product.

There is no numerical density requirement for Type B Base Course. The compaction is to the satisfaction of the Resident.

351.06 Tolerance in Thickness

Obtaining the thickness shown on the plans depends primarily on the inspection control you exercise. Anything less than 90 percent of plan thickness is not permitted. Excess thickness is permitted except as limited by the 108 percent maximum for the tonnage pay item.

351.11 Method of Measurement

The method of measurement will determine your inspection and quantity control procedures and ultimately the documentation you will need to substantiate payment for this item.

If the unit of measurement is the metric ton (ton), the aggregate must be weighed on scales approved annually by the [Department of Agriculture](#). A weight ticket must accompany each load of material delivered to the job from the quarry, pit, or stockpile. A copy of the ticket must be given to the Inspector, who must initial the ticket for purposes of documentation.

The Resident should review the [Documentation Section](#) of this Manual for additional information.

SECTION 352. SOIL-CEMENT BASE COURSE**352.01 Description**

The Soil-Cement Base Course is generally used as a foundation for a bituminous surface. The construction of a Soil-Cement Base Course consists of processing soil, cement and water either mixed in place on the roadbed or by a traveling mixing plant.

352.09 Dry Mixing

When using multiple base mixing equipment, the soil and cement should be satisfactorily mixed prior to the addition of water. Once the dry mixing process has started, all operations through the compaction of the mixture should be continuous without interruption.

352.10 Moist Mixing

- A. With equipment other than a traveling mix plant. Processing the soil-cement mixture with a multiple pass mixer may require the addition of water in several increments in order to provide the optimum moisture required for mixing and compaction. The Specifications limit the range of moisture content for various soils used in the soil-cement mixture and should be followed to obtain a satisfactory result.
- B. With a traveling mix plant. A traveling mixing plant is so designed that the addition of water and the mixing of soil, cement and water are obtained in one pass of the equipment. If proper mixing is not obtained in one pass, the forward speed of the machine should be reduced to improve the mixing.

352.11 Compaction and Finishing

Compaction of the soil-cement mixture is a continuation of the moisture mixing operation and should be conducted uninterrupted after moist mixing is completed. It is important that the edges of the Soil-Cement Base Course be compacted as well as the remaining portions of the base course to prevent failures along the edges.

352.12 Protection and Cover

The Soil-Cement Base Course, after being finished, is provided with a protective cover of bituminous material to protect against loss of moisture or abrasion by traffic during the 7 day curing period. Any damage to the protective coat by construction equipment or other traffic is to be corrected by the Contractor.

If the air temperature is expected to reach the freezing point during the curing period, straw should be used to protect against freezing.

SECTION 353. PORTLAND CEMENT CONCRETE BASE COURSE**353.03 Equipment**

Prior to starting the placing of any concrete, be sure the required equipment is available and in good working condition. It should be checked to be sure the plan cross section of the pavement can be obtained. The finishing machine should be carefully checked to be sure the screed is adjustable and will go in and out of superelevation accurately and give the desired pavement slope at all times. You should also insist a subgrade template be available and used

continuously ahead of the paving train to be assured that the proper thickness of the pavement will be attained.

353.11 Surface Test

Usually, Portland Concrete Cement Base Course is overlaid with a bituminous material. In order to obtain reasonable control of the quantities specified for the bituminous material and a satisfactory finish, you should insist that the concrete base course be placed to the plan grade. Periodic inspection on your part will be necessary to be sure the required results are being obtained.

SECTION 354. PORTLAND CEMENT CONCRETE BASE COURSE WIDENING

354.04 General

During excavation care should be taken to avoid damaging the existing edge of pavement. The existing edge of pavement should be carefully checked to ensure that the edge is clean of all loose material before rolling and checking of the subgrade for the required thickness.

354.05 Subgrade

After the subgrade has been excavated it should be checked with a stringline or a template to be sure the specified thickness can be obtained. The subgrade should not be disturbed during the paving operation.

354.06 Constructing Without Forms

It is important that the consistency be as uniform as possible so the edges will not slump with the movement of the equipment.

354.07 Constructing With Forms

Prior to placing the paving forms, the grades should be checked to be sure that proper slope of the base course widening is being attained. A form line should be smooth and the forms inspected before the concrete is placed.

354.09 Tolerance in Thickness

After the forms have been properly graded and set, the subgrade should be checked with a stringline or template so the plan thickness of the paving course will be obtained. Before and after cross sections are still required for base course thickness determinations when using a template.

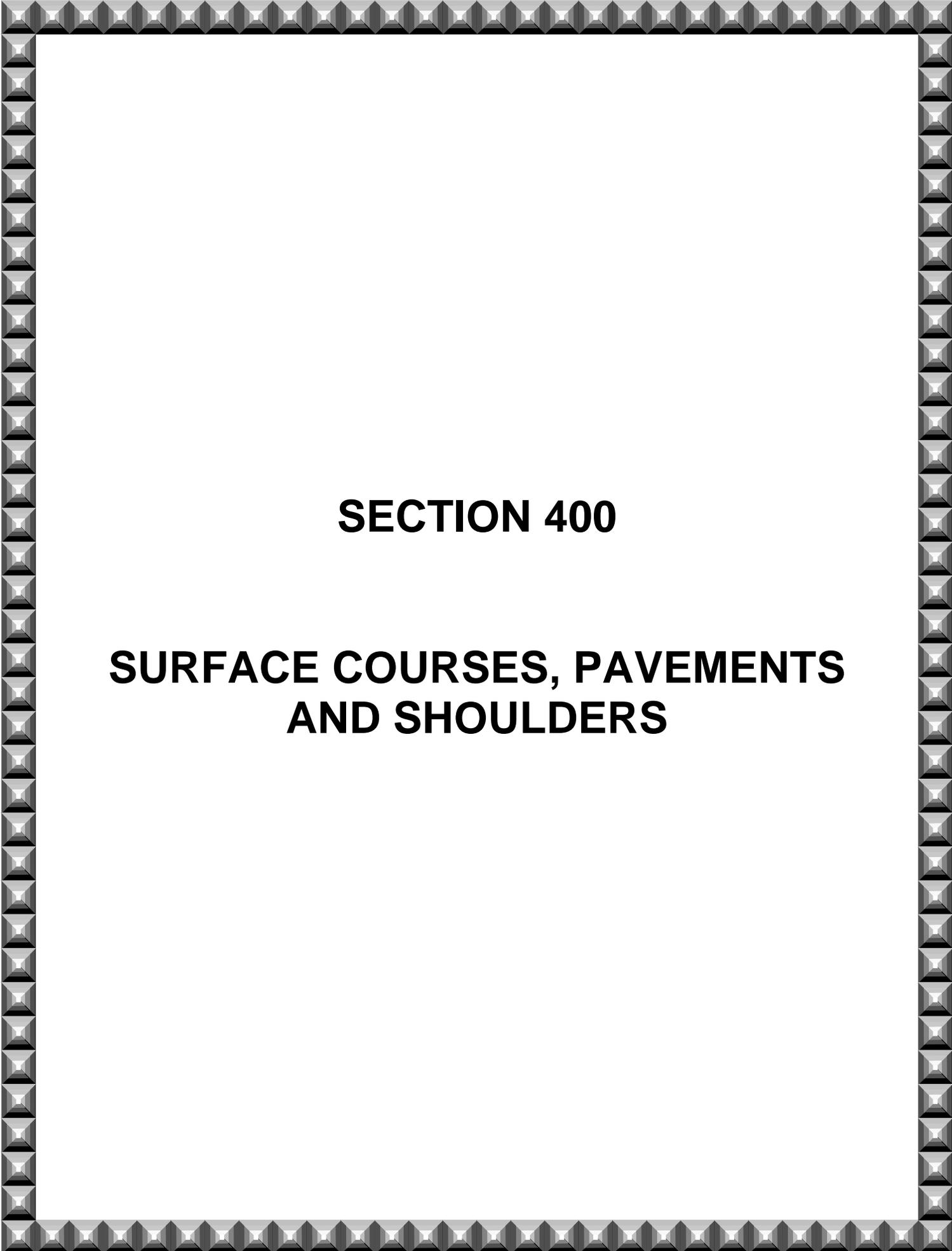
SECTION 356. BITUMINOUS CONCRETE BASE COURSE WIDENING

356.05 Subgrade

Prior to starting any placing of bituminous material, the subgrade should be rolled and the widening depth checked with a stringline or template to verify that the necessary depth will be obtained.

356.06 Base Course Widening

The existing edge of pavement should be carefully checked to ensure that the edge is clean of all loose material before rolling and checking of the subgrade for the required thickness. It is necessary to keep traffic off the newly-completed widening until it has cooled sufficiently to support traffic.



SECTION 400

**SURFACE COURSES, PAVEMENTS
AND SHOULDERS**

SECTION 400. SURFACE COURSES, PAVEMENTS, REHABILITATION AND SHOULDERS

SECTION 403. BITUMINOUS SURFACE TREATMENT (CLASS A-1, A-2, A-3)

403.10 Application of Bituminous Material

Hand spraying of the bituminous material will be permitted in inaccessible areas such as narrow driveways, mail box turnouts and sidewalks. Hand spraying is more difficult to control than pressure spraying from the distributor and you will find a tendency to overrun the application amount of material. Precautions should be taken prior to starting the application of the bituminous material to see that the equipment is functioning properly and will give uniform distribution. Unless the roadway is closed to traffic, the bituminous material should be blotted immediately with prime coat aggregate. This will prevent pick up of the material by traffic and permit the curing of the prime coat. Excess aggregate in gutters and driveways should be removed prior to placing the surface course.

403.12 & 403.13 Cover and Seal Coats

It is very important for embedment of the aggregate into the bituminous material. The aggregate must be spread and rolled immediately following the bituminous application. The aggregate spreader should be checked to ensure it is operating properly.

SECTION 406. HOT-MIX ASPHALT (HMA) BINDER AND SURFACE COURSE

406.04 Keeping Road Open to Traffic

Unless specified in the contract, one-way traffic shall be maintained during the priming and placing of the HMA course. Traffic control to handle the one-way traffic is required by the contract and shall be in place prior to moving the equipment on to the pavement to start operations.

Traffic control should be discussed at the pre-construction conference. Due to the relatively fast movement of paving operations, most of the traffic hazards are concentrated around the paving area. Traffic shall be directed through the construction area in accordance with the contract traffic control in a manner that provides maximum safety for the workers and traveling public.

406.05 Preparation, Priming and Leveling of Brick, Concrete or HMA Bases

On two lane highways open to traffic only one lane shall be primed at a time, and the adjacent lane shall not be primed until prime on the first lane has cured or fine aggregate has been applied so that it will not pick up under traffic. De-bonding of the subsequent layer can result if the prepared surface is not cleaned and kept clean. It is important that the correct amount of prime is applied.

1030.08 Transportation

Trucks hauling the hot mix material shall be insulated and covered in accordance with the Standard Specifications and/or project provisions. The covering shall be rolled back prior to the truck starting to dump so the material can be inspected before it is actually placed. The material should be visually checked in the trucks to see if there is any sign of segregation.

406.06 Placing

Prior to the delivery of the mixture, the base shall be prepared or constructed to the correct grade, cross section and compacted to the density specified.

If the paving operation sequence is not set forth in the contract, the Contractor should discuss a proposed sequence of paving operations with the Engineer.

Prior to Paving. The Resident and Inspectors should be thoroughly familiar with the plans and Specifications for the project. Review first day start-up procedures, they may vary depending upon location and mix. Refer to Construction Memorandum No. 55, Placement of Bituminous Mixtures. In addition, they must have the equipment necessary to check all phases of the paving operations. They should check with the Superintendent on the paving sequence to see that the construction equipment on the project is of the number, size and condition required by the Specifications. Prior to paving operations, the Inspector should thoroughly check the surface on which the pavement is to be placed. If the surface is a base or subgrade, a prime coat, when required shall be applied and thoroughly cured. The surface should be checked for correct grade and cross section, and all work areas, depressions or potholes shall be repaired to give a firm and unyielding paving base. When an existing surface is to be resurfaced, the surface shall be cleaned of dirt and other extraneous matter and all base failures repaired. If a leveling course is to be applied, the existing surface should be checked and the roughest areas marked for level binder. A light fog coat of prime may be required on surfaces when there has been a long delay in the paving operations.

Inspection of Paving Equipment. The Inspector should make a personal inspection of the Contractor's paving equipment, checking the condition and adjustment of the component parts of the paving machine and rollers. By making this inspection prior to beginning paving operations, obvious deficiencies in the condition of the equipment may be discovered and corrected, thus avoiding delays once the work is under way and to ascertain that the best possible surface can be obtained. Listed below are some of the more important details the Inspector should check during the inspection of the paving equipment.

Paving Equipment. Refer to Construction Memorandum No. 11, Bituminous Spreading and Finishing Machines Approved for Use in Illinois - Article 1102.03. The inspector should be familiar with the mechanical features on the type of paver to be used on the project

Spreading and Finishing. The bituminous mixture is spread and finished by a self-propelled paver. In irregular areas, the mixture may be spread and finished by hand.

The Inspector routine duties are to collect load tickets and control the location and length of spread of each load, however, their principal duty is to construct a pavement to the correct grade and cross section and with a surface texture and riding surface proposed in the contract. To achieve these results, the Inspector must continually check the base, the mixture, surface texture, rolling operation, and paved surface. The finished surface should be checked for crown and smoothness by using a carpenter's level and string line.

As the trucks arrive with the mixture, the Inspector should collect and initial each ticket and visually inspect each truck for leaking fluids which could contaminate the mat. The Inspector should check each truck load of mixture for uniformity and occasionally the temperature of the mixture.

An effective and timely means of communication between jobsite and plant personnel is essential to placing a workable and uniform mix on the road. The depth should be checked frequently to ensure the proper amount of mixture is being placed. Yield should be checked frequently to ensure there is not an excessive amount of overrun or under-run of plan quantity.

As the paver proceeds, the grade or thickness control device shall be adjusted to give the thickness required by the plans. Because continuity of paving operations is essential to securing a quality pavement surface, the optimum paver speed is controlled by the coordination of roller capabilities and plant production, within specification limits. By inspecting the surface texture behind the machine, and checking the surface with a straightedge, a malfunction in the paver operation or segregation of mixture may be detected.

In addition to the maximum paver speed specified in Article 406.06, paver speed is further constrained by the maximum roller speed to the extent that the vibratory roller is able to perform the required number of passes and still keep up with the paver. A pass of the roller is defined as one trip of the roller in one direction over any one spot.

Whenever a vibratory roller is in the paving train, the vibratory roller speed required to produce no less than 10 impacts per foot (30 impacts/m) controls the paver speed. The paver speed shall be mated with the required roller speed, not to exceed 50 ft/min (15 m/min). Maximum speed of the vibratory roller, in the static mode, should not exceed 3 mph (5 km/h) or 264 ft/min (80 m/min).

$$\text{Maximum Vibratory Roller Speed} = \frac{\text{Measured Frequency}}{10}$$

$$\text{Maximum Paver Speed} = \frac{\text{Measured Frequency}}{10 \times \text{No. Required Passes}} \times .9$$

Example: Measured frequency 2200 VPM @ 5 passes to cover the full mat width

$$\text{Max. Vibratory Roller Speed} = \frac{2200}{10} = 220' / \text{min.} = 2.5 \text{ mph}$$

$$\text{Max. Paver Speed} = \frac{2200}{10 \times 5} \times .9 = 39.6' / \text{min}$$

406.07 Compaction

Refer to Construction [Memorandum No. 55](#), Placement of Bituminous Mixtures

Rollers of the type and number set forth in the Standard Specifications shall be used in compacting the mixture.

Effective use of vibratory rollers for compaction of HMA depends on the following major factors:

1. Lift Thickness
2. Roller and Paver Speeds
3. Total Applied Force (Sum of Static and Dynamic)
4. Frequency
5. Amplitude
6. Condition of Equipment

To obtain optimum results of density and smoothness requires an understanding of the interaction of the above factors. For example, an improper balance of amplitude and frequency can result in a marginal density and/or a rough surface.

The total applied force is the sum of the dynamic force and the static weight force. The formula

for dynamic force is $\frac{wrf^2}{35235}$

w = weight of eccentric

r = radius of weight

f = velocity of frequency of eccentric

The amplitude is adjusted by changing the weight of the eccentric. Frequency is controlled by engine speed.

Frequency Control

The frequency vibration is controlled by engine speed not roller speed. Manufacturers show frequency as a function of engine rpm and it is normally shown on the rpm dial. A vibrating Reed Tachometer should be available from the Contractor or your supervisor so that you can measure the operating frequency of the roller.

Maximum Roller Speed

To determine the proper roller speed divide the measured frequency by 10 impacts/ft (30 impacts/m) (Article 406.07).

Thus a roller with 2400 vpm/10 impacts/ft (30 impacts/m) = 240 ft/min (80 m/min) roller speed. If a roller was operated at 400 ft/min (122 m/min) with a 1600 frequency the spacing would be 3 in (75 mm) which would result in ripples and lower density because the dynamic energy into each square yard (square meter) would be reduced by two-thirds.

Paver Speed Conversion Factors

Inches x 25.40	=	Millimeters
Feet x 0.3048	=	Meters
Miles x 1.6093	=	Kilometers
Pounds x 0.4536	=	Kg
PLI x 0.1786	=	N/mm

SECTION 407 HOT-MIX ASPHALT PAVEMENT (FULL DEPTH)

The specifications for the construction of Hot Mix Asphalt Pavement (Full Depth) are the same as that for the construction of binder and surface courses. The main difference of a full depth pavement is the construction of the pavement in multiple lifts with there being a maximum thickness for each lift.

407.05. Preparation of Subgrade or Subbase

The subgrade or subbase must be checked to ensure that it is at the proper grade and cross section. The riding quality of the new pavement will depend largely on the smoothness of the grade on which it is placed.

407.08. Hauling on Partially Completed Full-Depth Pavement

The first lift placed for the full depth pavement is not designed to withstand the loading of a truck, whether empty or fully loaded with asphalt or other materials. But the staging of the work may require that the trucks drive on the initial lift and subsequent intermediate lifts of pavement to deliver the asphalt. Hauling on the partially completed pavement must be strictly limited to that allowed by specification to avoid damage to the underlying lifts of pavement.

407.09. Surface Tests

See the section below titled Pavement Smoothness.

407.10 Tolerance in Thickness

Pavement shall be constructed to full plan thickness. Although thick pavement is not detrimental to the performance of a full depth asphalt pavement, thin pavement will lead to a shorter life than that anticipated by the pavement design. Pavement placed to a varying thickness could indicate poor workmanship by the contractor. The Tolerance in Thickness specification is designed to encourage the contractor to employ the quality control required to construct the pavement to the proper thickness with minimal variation.

Special care must be exercised in super elevation transition areas to avoid thin pavement.

Refer to Construction Memorandum 43 for tolerance of pavement thickness and subsequent payment for work.

SECTION 420. PORTLAND CEMENT CONCRETE PAVEMENT

The following information, as it applies, is also relative to Continuously Reinforced Concrete Pavement.

Prior to starting any concrete work, it is necessary that you review the contract documents.

420.04 Preparation of Subgrade or Subbase

The subgrade or subbase must be checked to ensure that it is at the proper grade and cross section. The riding quality of the new pavement will depend largely on the smoothness of the grade on which it is placed.

420.10 Surface Tests

See the section below titled Pavement Smoothness.

420.14 Slipform Method

Preparation to Paving. The original paving stakes used for checking the earth grade and the placing and checking of the subbase material should not be disturbed prior to starting the slipform paving. This will prevent any error in reestablishing the pavement grades.

The subbase material must be checked for thickness, density, line and grade prior to placing the continuously reinforced pavement steel. Once the subbase material is approved and paving has started, it is important to continually check the thickness of the pavement behind the slipform paver, the condition and location of the reinforcing steel ahead and behind the slipform paver and the edge slump while the pavement is being placed.

Edge slump can be controlled by using a uniform mix with consistent slump and proper adjustment of the edge plates on the slipform paver. If excessive edge slump over that permitted by the Standard Specifications is evident, either wood planks or metal forms should be placed against the pavement immediately and the pavement brought to the proper grade. Metal forms usually work better than wood planks as they will lock together and will not cause variations in the pavement edge. As the paving progresses, a metal probe can be inserted in the pavement to determine the thickness.

Refer to the [Project Procedures Guide](#) in this manual for types and frequencies of tests.

Review the contract documents in advance to determine the locations of joints, tie bars, wide flange beam terminal joints or lug end anchorages and super elevations. These locations must be adequately staked or marked. The wide flange beams at the pavement ends and structures are constructed in advance of the paving operations and the slipform paver then paves through the wide flange beams.

Do not permit the Contractor to use bricks or other similar material under the reinforcing steel. Sand plates are required for all bar supports.

Provisions should be made prior to starting formless paving to take care of any sudden rain that may occur. The Standard Specifications require sufficient polyethylene or burlap be on the job to cover such emergencies. You should discuss this issue with the Contractor prior to the start of paving operations.

Split header boards must be used on continuously reinforced pavement so that the reinforcing steel may be extended past the header board at the proper elevation. The pavement standards in the contract require additional reinforcing bars at each header. There is a minimum distance from the laps of the steel where a header may be placed. A portable vibrator must be used for vibrating the concrete adjacent to header board at the end of the day's paving and also at the start of the following day's paving. The internal vibrators on the slipform paver will not cover this area. Failures on continuously reinforced pavement are usually the result of improper consolidation at the header boards or improper placement of the reinforcement. Excess mortar carried by the paver should not be placed in the pavement but should be wasted. All concrete protruding between the header boards should be chipped off flush with the pavement face prior to the next pour.

420.15 Tolerance in Thickness

Pavement shall be constructed to full plan thickness. For continuously reinforced pavement, the ratio of the steel area to the concrete area is a critical design factor for the pavement structure. It is neither desirable to have thin pavement nor thick pavement as the ratio of steel to concrete is correspondingly increased or decreased depending on the pavement thickness. Special care must be exercised in super elevation transition areas to avoid thin pavement.

Refer to Construction Memorandum 43 for tolerance of pavement thickness and subsequent payment for work.

SECTION 424. PORTLAND CEMENT CONCRETE SIDEWALK

Your plans should include details addressing the treatment of sidewalk accessibility ramps and the placement of detectable warnings for disabled persons in order to comply with the [Americans with Disabilities Act](#) Accessibility Guidelines (ADAAG) and the Illinois Accessibility Code. Be sure you are familiar with these details, the related standards and specifications and inform the Contractor of the requirements as well.

Crosswalks require detectable warnings in the form of truncated domes where the sidewalk/curb ramp meets the curb or pavement. The contractor must supply written certification from the manufacturer that the truncated domes meet the requirements of the ADAAG and a written manufacturer's 5 year warranty.

The Americans with Disabilities Act (ADA) requirements are law and must be implemented on roadway improvements. If a problem exists relating to implementing ADA requirements, contact your supervisor.

SECTION 442. PAVEMENT PATCHING

442.05 Pavement Removal

You should review the contract documents for the requirements relating to patching prior to beginning patching operations. Prior to patching, mark out the required patch locations and contact your supervisor for a field review of the locations you have determined.

SECTION 483. PORTLAND CEMENT CONCRETE SHOULDERS

Prior to construction of PCC shoulders, the subgrade must be properly prepared. Tangents, superelevations and transitions must be calculated and constructed properly so the shoulder surface and thickness will conform to that shown on the plans.

PAVEMENT SMOOTHNESS (Pertains to Sections 407, 420 and 421)

The smoothness of mainline pavement will be tested using the California Profilograph. The specifications allow the contractor to supply an approved equivalent. Approval of this option should be coordinated with the Bureau of Materials and Physical Research.

Testing will be according to the California Test Method 526, Operation of California Profilograph and Evaluation of Profiles. The version dated April 2002 is included after this section of the Construction Manual, but the most recent version should always be used. The most recent version may be located at http://www.dot.ca.gov/hq/esc/ctms/CT_ChooseVersion.html#526.

California Test 526
April 2002

Additionally, vertical calibration is required after every profile wheel change and each re-assembly of the profilograph. The air pressure of the profile wheel shall be checked daily. A log of the tire pressure and the calibration information shall be kept with the profilograph.

The horizontal calibration standard is a straight roadway section at least 160 m (528 ft) long, measured accurately to within 0.32 m (1.05 ft), or 0.2% of the length. The roadway test section shall be measured by a measuring tape or wheel or other means acceptable to the Engineer.

Proof of calibration shall be in the form of a recording on a chart for the manual devices or a printed document for the automated devices.

Horizontal calibration shall be accepted when the following procedures have been successfully completed:

Perform horizontal calibration by pushing the profilograph over a measured test section at least 160 m (528 ft) long.

With manual devices determine the scale factor by dividing the length of this test section in meters (feet) by the length of the recording on the chart, measured to the nearest 1.27 mm (0.5 in.)

This factor must be 300.00 with a tolerance of 2.4 (0.8%).

For the automated devices the profilograph shall be rerun over the same calibrated distance to assure that the diagnostic was performed correctly. The tolerance is 1.28 m (4.20 ft)

The vertical deflection standards are flat plates of known thickness or a single device with graduated thickness. The initial plate will be used to place the profile wheel on a flat surface and establish a baseline value in which to measure subsequent elevations. The initial thickness may not exceed 25.4 mm (1.0

in.). Ensure that the initial plate is firmly seated so that it cannot flex or tilt. Subsequent measurements shall be at 25.4 mm (1 in.) and 50.8 mm (2 in.) and accurate to within 0.254 mm (0.01 in) in thickness.

Vertical calibration shall be accepted when the following procedure has been successfully completed:

Perform vertical calibration on a flat, level area using the standard plates of known thickness or a single device with graduated thickness.

Elevate the profile wheel and place the initial plate or initial step of the graduated device under the wheel to establish the baseline elevation value.

When the wheel has been lowered onto the plate mark the recorder pen elevation on the manual device or record the elevation displayed on the automated device.

Elevate the wheel again and insert another plate on top of the initial baseline plate under the wheel or slide the graduated device to the next elevation. Again mark the recorder pen elevation on the manual device or record the displayed elevation on the automated device

Elevate the wheel again and insert another plate on top of the second plate under the wheel or slide the graduated device to the next elevation. Again mark the recorder pen elevation on the manual device or record the displayed elevation on the automated device

Reverse this process, by removing the two individual plates one at a time or stepping down the graduated device and marking or recording the change in elevation after the removal of each successive plate

The calibration is considered complete, if the marking pen or recorded elevation returns to the original position, obtained from the initial plate used to establish a baseline value, +/- 0.76 mm (0.03 in.)

Adjust chart deviations in excess of 0.76 mm (0.03 in.) according to the manufacturer's recommendations.

The profilograph shall also be able to demonstrate an acceptable repeatability level, the acceptable level is defined as, "after three tests, difference in the measured PI shall not exceed a PI of 1 between any two tests, when testing pavements with a PI of up to 15.

If required by the Engineer, all model test results must correlate to those generated by the Department's profilograph to within a Profile Index (PI) of 1 for pavement surfaces up to a PI of 15.

PART 2. DETERMINATION OF THE PROFILE INDEX

A. EQUIPMENT

The Profile Index can be determined by the use of an automated or manual profilograph model. Both models will create a profile trace or profilogram. The profile trace or profilogram shall indicate the Profile Index (PI) for the required distance as well as the location of all scallops in excess of 7.5 mm.

The Profile Index is defined as "millimeters per 0.1km in excess of the 5 mm blanking band,"

A.1 AUTOMATED PROFILOGRAPH

An automated profilograph device collects data by means of a digital response resulting from the vertical movement of the profile wheel. The data collected shall be processed by a software program capable of generating a computerized profile trace or profilogram. The computer software shall be set with the following settings:

Data Filters

- Filter Type: 3rd Order Butterworth
- Filter Length: 610 mm (2.0 ft)
- Blanking Band: 5 mm
- Bump Locator: On
- Bottom Bump: Off

Alternative settings will only be allowed with the approval of the Engineer.

A.2 MANUAL PROFILOGRAPH

A manual profilograph collects data by measuring with a pen-recording device on a paper reel resulting from the vertical movement of the profile wheel.

The Profile Index from the manually generated profilograph trace can be determined by using a scanning device or by a manual count.

To determine the Profile Index manually, use a plastic scale 40 mm wide and 333.3 mm long representing a pavement length of 100 m or 0.1 km at a scale of 1:300. A plastic scale for the profilograph may be obtained by the districts from the Transportation Laboratory. Near the center of the scale is an opaque band 5 mm wide extending the entire length. On either side of this band are scribed lines 2 mm apart and parallel to the opaque band. These lines are used to measure deviations or excursions of the graph above or below the blanking band. The deviations are called "scallops".

B. METHOD OF COUNTING

Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. When this is done, scallops above and below the blanking band usually will be approximately balanced. See Figure 1.

The profile trace will move from a generally horizontal position when going around super elevated curves making it impossible to blank out the central portion of the trace without shifting the scale. When such conditions occur, the profile should be broken into short sections and the blanking band repositioned on each section while counting, as shown in the upper part of Figure 2.

Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the blanking

band, measuring each scallop to the nearest 1 mm. Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may be visible outside the blanking band, but unless they project 0.6 mm or more and extend longitudinally for 0.6 m (2 mm on the profilogram) or more, they are not included in the count. See Figure 1 for illustration of these special conditions.

When scallops occurring in the first 0.1 km are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made, and proceed with the counting in the same manner. The last section counted may or may not be an even 0.1 km. If not, its length should be scaled and the counts proportioned to an equivalent 0.1 km section. For example, 9 counts in 0.07 km = 12.9 or 13 per 0.1 km.

C. LIMITATIONS OF COUNT IN 0.1 KM SECTIONS

When the specifications limit the amount of roughness in "any 0.1 km section", the scale is moved along the profile and counts made at various locations to find those sections if any, that do not conform to specifications. The limits are then noted on the profile and can be later located on the pavement preparatory to grinding.

D. LIMITS OF COUNTS — JOINTS

When counting profiles, a day's paving is considered to include the last portion of the previous day's work, which includes the daily joint. The last 5 to 10 m of a day's paving cannot usually be obtained until the following day. In general, the paving contractor is responsible for the smoothness of joints if he places the concrete pavement on both sides of the joint. On the other hand, the contractor is responsible only for the pavement placed by him if the work abuts a bridge or a pavement placed under another contract. Profilograph readings, when approaching such joints,

should be taken in conformance with current specifications.

PART 3. DETERMINATION OF HIGH POINTS IN EXCESS OF 7.5 MM

A. EQUIPMENT

Use a plastic template having a line 25 mm long scribed on one face with a small hole or scribed mark at either end, or a slot 7.5mm from and parallel to the scribed line. See Figure 2. (The 25 mm line corresponds to a horizontal distance of 7.5 m on the pavement.) The plastic template may be obtained from Transportation Laboratory.

B. LOCATING HIGH POINTS IN EXCESS OF 7.5 MM

At each prominent peak or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on the template need not be horizontal. With a sharp pencil draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the deviation in excess of 7.5 mm.

There may be instances where the distance between easily recognizable low points is less than 25 mm. In such cases a shorter chord length shall be used in aligning the scribed line on the template tangent to the trace at the low points. It is the intent of this requirement that the baseline for measuring the height of bumps will be as near to 25 mm as possible, but in no case exceed this value. When the distance between prominent low points is greater than 25 mm make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. Examples of the possible positions are shown in Figure 2.

PART 4. SAFETY AND HEALTH

Use leather gloves when assembling and storing the profilograph frame. Use proper lifting methods and be aware of pinch points and sharp edges.

Prior to handling gasoline, or operating equipment, operators are required to read Caltrans Laboratory Safety Manual Part A, Section 5.0, Hazards and Employee Exposure; Part B, Section 5.0, Safe Laboratory Practices; and Part C, Section 1.0, Safe Laboratory Practices and Section 2.0, Field Operations and Testing. Users of this method do so at their own risk.

**End of Text (California Test 526 contains 8
Pages)**

EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILOGRAMS

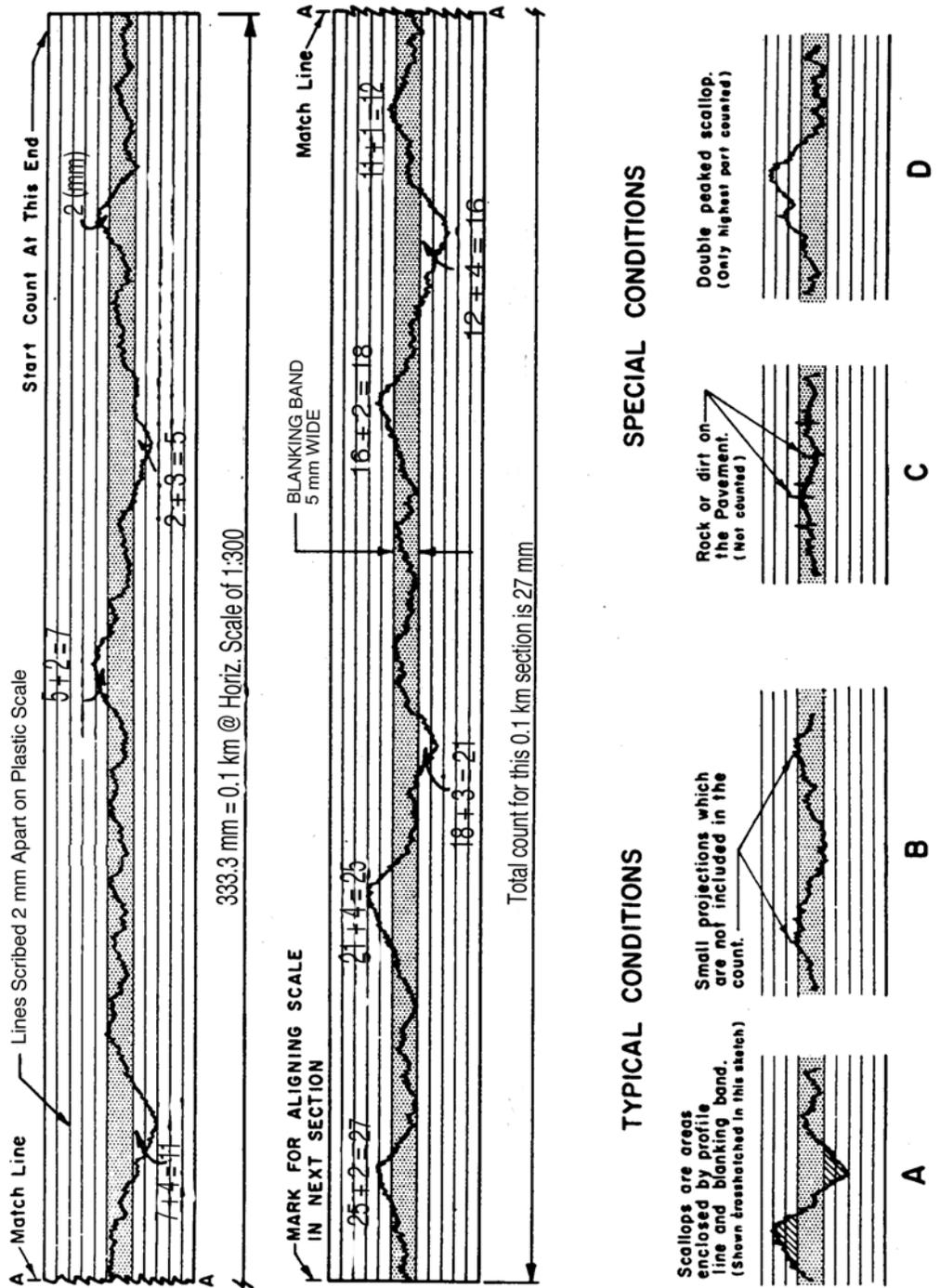
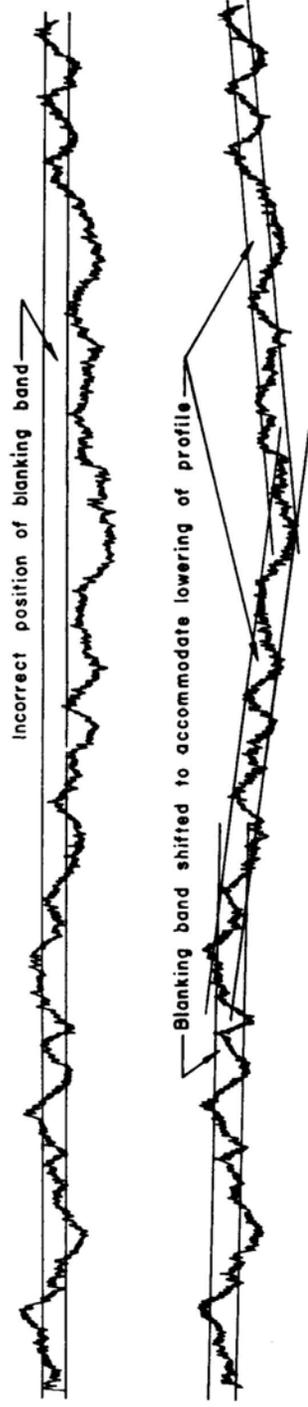


FIGURE 1

**METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY
WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION**



METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED

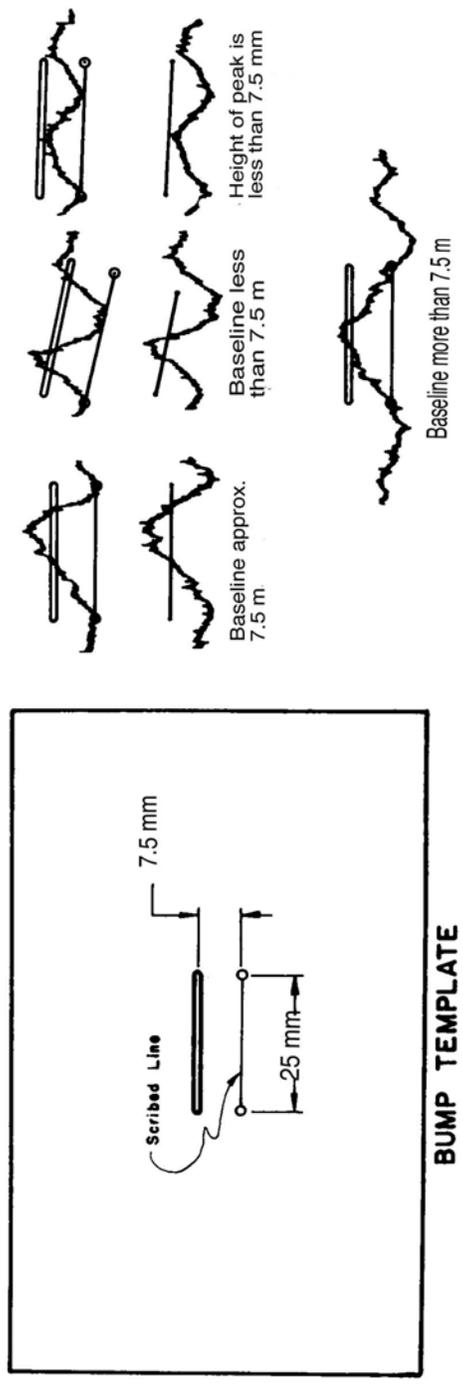


FIGURE 2

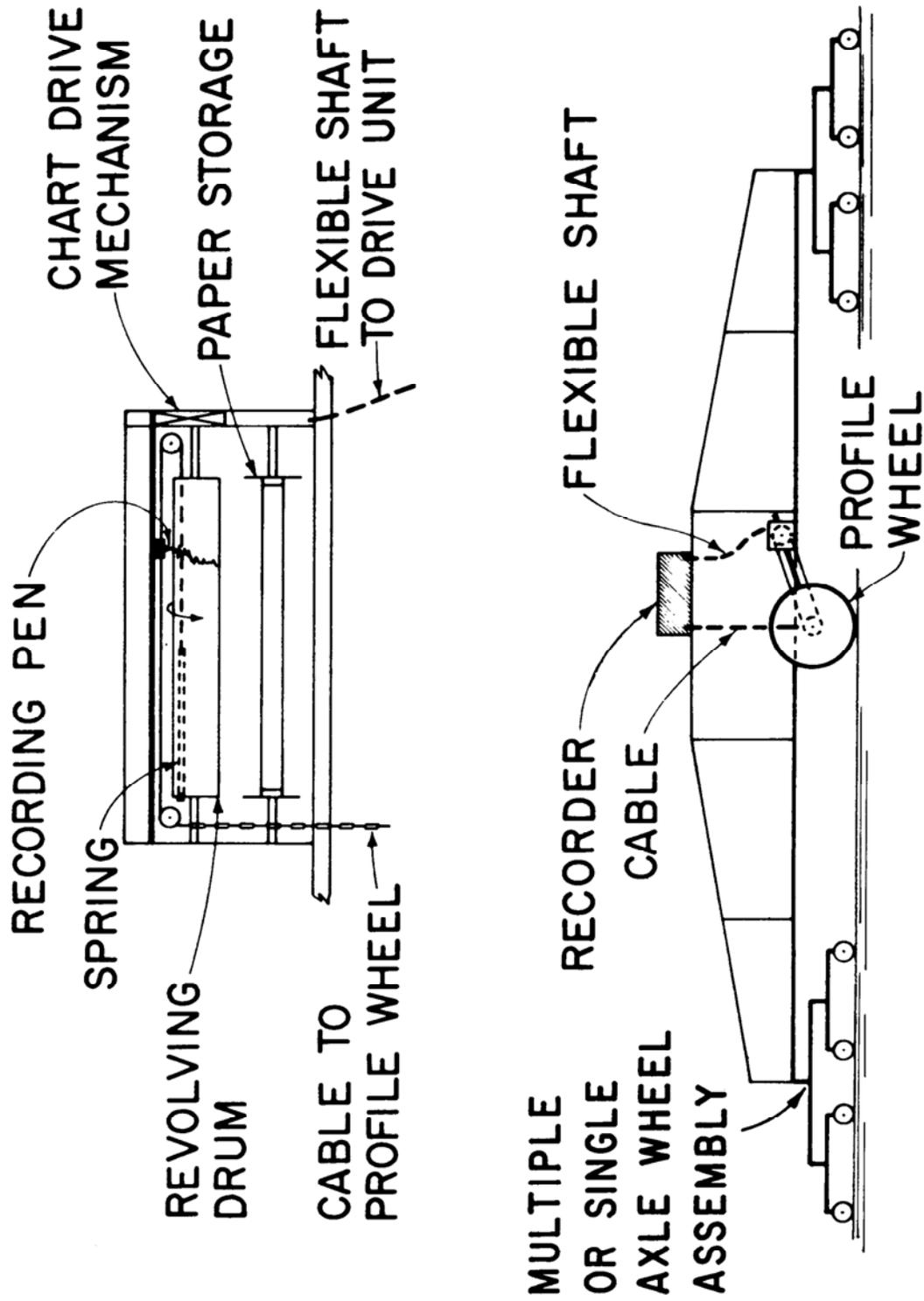
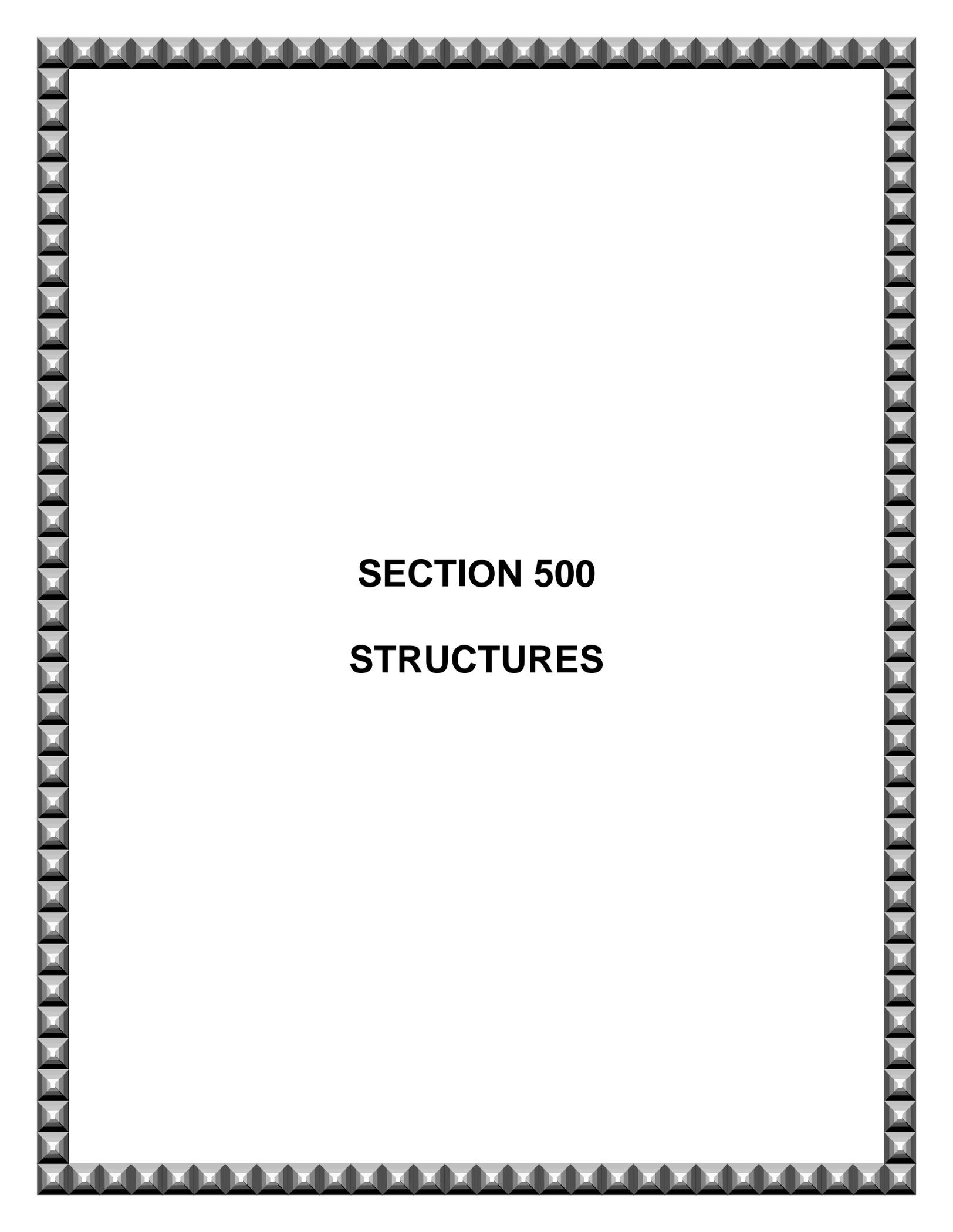


FIGURE 3



SECTION 500

STRUCTURES

SECTION 500. STRUCTURES**SECTION 501. REMOVAL OF EXISTING STRUCTURES****501.02, 501.03 Complete and Partial Removal of Structures**

Caution should be taken when the plans require removal of existing structures or portions of existing structures. Reinforced concrete structures may require additional shoring if portions of the superstructure are to be removed.

Structural steel that is to remain must be protected from jackhammer notches and gouges as well as from concrete saw cuts. This type of damage results in stress concentrations that could result in fatigue cracking or failure of a member. Should damage occur, contact your supervisor. No repairs should be undertaken without the recommendations of the Bureau of Bridges and Structures and with concurrence of the Bureau of Construction.

Extreme caution should be exercised when blasting to prevent damage to underground utilities or other public and private property. Thoroughly discuss the removal plans with the Contractor and your supervisor. If materials are to be removed and disposed of away from the site, the work should be done in accordance with Article 202.03 and District policy.

SECTION 502. EXCAVATION FOR STRUCTURES**502.03 General**

Structure and Rock are the classifications of excavation for bridges.

When piles are driven, the displaced material usually causes a swelling in the surface of the footing excavation. To keep the bottom of the footing at plan elevation, either this displaced material must be removed after the piles are driven, or the original excavation must be carried enough below plan grade to allow for the swelling.

The Designer prepares the plans based on information obtained from a limited number of soil borings made at the site. It is not uncommon for conditions to vary from those shown in the plans. This may result in encountering rock or other hard supporting material for a spread footing at a different elevation than shown in the plans. Familiarize yourself with the soil boring information and the foundation details. If during excavation for the footing or pile driving, the site conditions do not seem to match those shown in the plans, contact your supervisor. This must be done promptly to minimize expensive delays which may be caused by a foundation redesign.

502.06 Cofferdams

As described in the Standard Specifications, cofferdams are "watertight enclosures surrounding excavations" to be used for "placing concrete or other required construction". The required construction includes the excavation and construction of structure foundations below the design or prevailing water elevation. These enclosures normally consist of sheet piling driven around the perimeter of the excavation with or without one or more "rings" or wales placed at specified elevations within the sheet pile enclosure. The wales are often needed, together with a concrete seal coat, to provide structural stability for the cofferdam when it is dewatered. The cofferdam must be built in accordance with the plans and/or drawings submitted by the

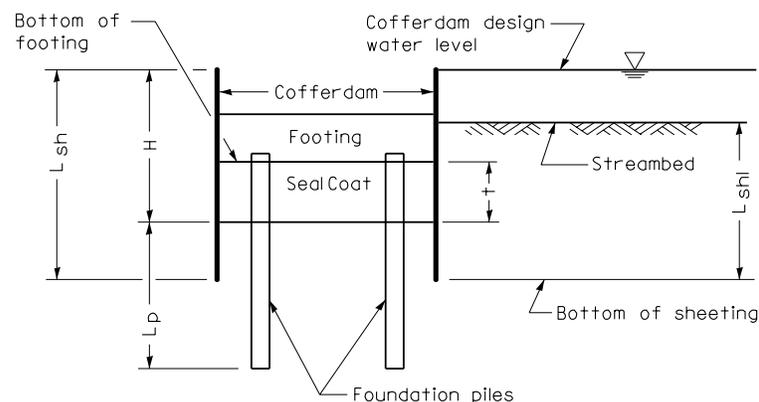
Contractor and approved by the Engineer before construction is started. Bracing and other supports can not extend into the substructure concrete without written approval of the Engineer.

Foundation Seal. Dewatering the Cofferdam. The purpose of the concrete seal is to permit dewatering of a cofferdam and to maintain the cofferdam in a stable state with respect to boiling and/or buoyancy problems during the dewatering period. Concrete seal coats are designed for a specific water elevation on the outside of the cofferdam. When the preliminary information clearly indicates that a seal will be required, it will be taken care of in the design phase and shown on the plans. There are border line cases, however, where there is doubt as to whether a seal is necessary. If the available data, studied in the light of previous experience, make it appear probable that the cofferdam can be dewatered without a seal, none will be shown on the plans. In such cases, the success of the Contractor in pouring the footing without a seal coat will depend to a great measure on the penetration of the steel piling and on the Contractor's pumping capacity.

Ordinarily, the sheet piling must be long enough to go well below footing elevation.. Even with a satisfactory cofferdam, lack of pumping capacity may prevent successful dewatering. It is not practicable to set a fixed limit for minimum requirements because of the variable conditions encountered, but when the plans do not call for a seal coat, we expect the Contractor to use such methods and to employ such equipment as will give evidence of an understanding of the problem s/he faces and of his/her serious effort to do the work according to the plans. In some places, well points have been very successful and should be tried if other methods fail. Only after the Contractor has met full requirements under the contract and has been unable to dewater the cofferdam, will we consider authorizing a seal coat. Seal coat design parameters may be obtained from the Bureau of Bridges and Structures.

Confined Space. A cofferdam is considered a confined space. Special tests and equipment are needed to determine if conditions are safe before Department personnel enter a confined area. Contact your supervisor before entry to determine current requirements.

Construction of Cofferdam Seal. The manner of placing the concrete, the use of tremies, etc., are discussed in the Standard Specifications, Article 503.15.



I. UPLIFT FORCE (P_b)

II. WEIGHT OF SEALCOAT (P_{sc})

III. SHEETPILING RESISTANCE

- (a) Weight of Sheet Piling (P_{sh}) _____
- (b) Miscellaneous Weight (P_m) (a)+(b)+(c)
- (c) Sheetting/Soil Anchorage (P_{shsoil}) _____ smallest
- (d) Sheetting/Seal coat Anchorage (P_{shseal}) _____

IV. PILING RESISTANCE

- (a) Weight of Piles (P_p) _____ (a)+[(b) or (c)]
- (b) Weight of Soil Mass (P_{soil}) smallest smallest
- (c) Pile/Soil Anchorage ($P_{pilesoil}$) _____
- (d) Pile/Seal coat Anchorage ($P_{pileseal}$) _____

FACTOR OF SAFETY, SF. This factor of safety is defined as:

$$SF = \frac{\text{RESISTING FORCES(II + III + IV)}}{\text{BUOYANT FORCE(I)}}$$

The minimum value for the factor of safety shall be 1.2

The minimum thickness of the seal coat shall be 3 ft (0.9 m).

502.08 Pumping

Sufficient pumping shall be utilized to maintain a dry footing. Water must not be permitted to flow over or in contact with the fresh concrete to prevent cement loss. The sump from which water is pumped shall be outside of the footing form. The location of the sump and the procedure in pouring the concrete shall be arranged so that any water entering either within or outside of the form will flow to the sump without washing cement out of the concrete until set.

502.09 Inspection

Regardless of whether piles are used or not, concrete shall never be placed directly on mud. The Contractor is required to notify the Engineer when an excavation is completed and ready for placing the footing. You should check the elevation of the bottom of the excavation and its condition. If it is soft and muddy it must be covered with a 75 mm (3 inch) layer of gravel, crushed stone or other suitable material at the Contractor's expense. The Contractor's method of handling water should also be considered, so that water will not be permitted to flow over or through the concrete as it is being placed.

502.10 Backfilling

Backfilling as discussed in this article includes not only the backfill up to the original ground line but also the embankment material that is placed on one or both sides of the structure and immediately adjacent to it above the original ground line. It includes that part of the approach fill which lies next to the structure.

Care Necessary. Too much emphasis cannot be made on the importance of properly constructed backfills. This work calls for careful inspection and requires the constant presence of the inspector during the entire operation. Particular attention must be paid to tamping the areas next to the structure and areas which cannot be reached with the motorized equipment. Backfill material shall be dry before placing it in back of closed abutments or walls.

When specified, weep holes shall be placed so that the outlet on the front face is above the completed fill. The Standard Specifications are clear in regard to this requirement and the Contractor shall use such methods as will result in the required amount of this material properly placed. Be careful that dirt is not intermixed with the coarser material, interrupting the flow of water before it reaches the weep holes. When the 600 mm (2 ft) cube of gravel is used, 360 kg (800 lbs), the bottom of the cube should be placed 50 mm (2 in) below the weep hole. This will make allowance for the dirt that may become mixed with the bottom gravel in cube, and will avoid making a reservoir for the water immediately below the weep hole. When the backfill material is an impervious clay, gravel or crushed stone cubes may not be sufficient. In this case, consult your supervisor for a possible alternative. It is not intended that weep holes should be placed in the wings of small culverts, because the area is so small that no appreciable hydrostatic pressure can be built up behind them. Weep holes must be cleared of all obstructions as the fill is placed, and that they remain clear after the fill is completed.

Failure of the weep holes to work properly may result in thoroughly saturating the earth back of the abutment, thus producing stresses beyond those for which the structure is designed.

502.14 Method of Measurement

Before excavation is started for classified excavation pay items is, you must take cross sections or other appropriate measurements of the existing ground elevation so that you will be able to calculate the quantity of each class of excavation actually performed. The Standard Specifications provide the maximum dimensions allowed for calculation of the maximum pay item quantity. Any excavation made outside of the limiting dimensions is not paid for.

SECTION 503. CONCRETE STRUCTURES

503.05 Falsework

Dead Load Deflection. The appearance of the completed structure depends to a large extent on the lines obtained, especially along the outer edges of the superstructure and the top of the handrail. The attainment of good lines depends largely on the care and accuracy with which the falsework and forms are constructed.

The plans will show the profile grade line throughout the length of the structure and the theoretical dead load deflection. The dead load deflection shown on the plans is computed so as to include not only the immediate deflection which will take place when the falsework is removed but an allowance for long term deflection due to future wearing surfaces placed on the deck.

With the exception of the handrail, the elevation to which the forms should be built is the plan elevation adjusted for dead load deflection shown on the plans plus an allowance for compression and settlement of falsework.

Falsework Compression and Settlement.

This settlement may be due to compression of timbers that are too light or may be the result of settlement of the bents supporting the form work. Or it may be caused by oblique cuts on the tops of piles supporting caps, or by the use of small softwood shims which crush or compress under the superimposed load. The estimated compression within the falsework will vary considerably with the use of different materials, spacing, number and type of joints and other factors, and will be a matter of judgment based on previous data and experience.

The dead load deflection shown on the plans should be added to the amount estimated for falsework compression, and the result used for setting the falsework.

Superimposed Loads. The question of placing equipment or materials on a bridge before the falsework is removed has been frequently raised. The Standard Specifications prohibit the placement of superimposed loads, either dead or alive, prior to removal of the falsework. The reason is the possibility of damaging the concrete, or of destroying the bond between the concrete and the steel, even though the falsework is in place.

Backfill and Embankment. If the superstructure is to be built before the backfilling and placing of the embankment, ensure that the expansion devices are free to move when the backfilling and embankment are started. Although the falsework may still be in place, ensure that any restraints against abutments, bents and piers are cut off so that the superstructures can move freely.

Sidewalks and Handrails. Handrails or sidewalks separated from the floor slab by a construction joint, should not be poured until after the falsework has been removed. Otherwise, the deflection of the span may set up detrimental stresses or distort the vertical alignment.

503.06 Forms

Tightness. The individual dressed lumber or sections of plywood composing the forms should be drawn up against each other and be mortar-tight. Special care should be taken with all floor forms as the mortar in the concrete next to the cracks may leak through. Even though wood forms have been built mortar-tight, if they are allowed to stand in the sun for several days before the concrete is poured, the wood forms may shrink and cracks up to 6 mm ($\frac{1}{4}$ in) may develop. When mortar is lost in this way, the face of the concrete immediately back of the crack will be more porous. Even though the forms have shrunk, causing cracks between the panels, they may be restored to mortar-tight condition by being kept wet for several hours before pouring.

Footings. Where the excavation for footings is in rock, footing forms are not used, but the concrete is placed directly against the rock which is excavated to the footing line. If the excavation is not rock but is in material which is firm enough to be excavated to the neat line (plan dimension) of the footing, and will stay in place, and if pumping is not required, the Resident may permit the Contractor to omit the forms. In this decision, the Resident should be guided by his/her judgment as to the result that will be obtained. If the sides of the excavation can be cut so as to form the edges of the footing, and will not crumble or break off until the concrete is poured, they will furnish good lateral support for the footing. It should be understood

that payment will be limited to the neat line quantities with no extra compensations being allowed for any additional concrete used unless authorized in writing by the Resident.

Alignment and Bracing. Where practicable the alignment of all forms should be checked with a transit. A waler should always be placed at the top of abutments, piers and wing walls, and the forms shall be well braced. Forms shall not be braced in a way that will interfere with required deflections or expansion and contraction resulting from changes in temperature. All forms should be rechecked during placement and realigned or otherwise adjusted if necessary.

Molding. Molding should be used at all sharp corners (90° or less). The molding should have a uniform size and a smooth face. Molding which has not been planed to uniform dimensions will produce unsightly lines on the finished concrete.

503.07 Placing and Compacting

The rate of placement of the concrete will determine the number of vibrators required. No hard and fast rule can be given for the amount of vibrating necessary, as it will vary with different mixes, with the amount of reinforcement present, and the complexity or simplicity of the form work. After a little experience, the Resident can judge as to whether the concrete has settled into place and the reinforcement properly bonded. Failure to vibrate the whole area uniformly may result in porous areas. This will require considerable attention by the Inspector to obtain satisfactory results. The frequency of the vibrator may be measured with a tachometer.

The Specifications require a minimum rate of delivery of concrete to the forms. This is especially important when ready-mixed concrete is used. You should ensure that the Contractor has made satisfactory arrangements for the continuous delivery before a concrete pour is started.

Depositing Concrete Under Water. The placing of concrete under water is usually done in the construction of seal coats for bridge foundations. When the interior framing of the cofferdam divides the area into bays, it is necessary to hoist the tremie out of the water when changing from one bay to another. Concrete should be placed as far as possible in one bay before moving the tremie to adjacent bays, to prevent forming mud or sand pockets. The outlet end of the tremie must be equipped with a gate which must be tightly closed when being moved. The it must be moved about within the bay as needed to obtain minimum thickness of seal at all points.

Two major concerns to remember in constructing seal coats under water are:

- A. Prevent washing the cement out of the concrete by mixing it with the water; and
- B. Avoid enclosing pockets of mud pushed up from the bottom into the mass of concrete.

To prevent washing out of the concrete, the bottom end of the tremie should always be in the concrete when concrete is being discharged, and care should be taken to avoid spilling concrete into the water when filling the tremie.

Placing should be started at one end of the cofferdam and should proceed continuously for full depth so that any loose mud on the bottom will be pushed ahead of the mass of concrete and up over the concrete at the end of the pour.

The level of the concrete surface should be checked frequently by soundings, and the water level should be compared with a fixed mark set in advance, since the water level often rises due to displacement by the concrete. Be sure that the seal has at least the required thickness at all points, checking in particular at the corners of the cofferdam and around the piles. Use the delivery tickets to check the weight of the total volume placed. Ten percent excess cement should be added to the mix design to allow for loss under water. The slump should be large enough to permit the concrete to flow evenly

503.09 Construction Joints

See Construction [Memorandum No. 64](#) for Sequential Deck Pours. Construction joints at locations other than those provided for on the plans should be avoided in the superstructure of any bridge. However, because of occasional breakdown of equipment, or sudden storms, emergency construction joints are sometimes necessary. When it is necessary to provide construction joints because of a large amount of concrete, the Bureau of Bridges and Structures will show construction joints on the plans.

Preferred Location of Emergency Joints.

A. Simple Spans.

1. Vertical Construction Joints in Slab Bridges. A longitudinal joint may be placed on the centerline of the roadway. A transverse joint may be placed parallel to the supports as near the third point of the span as practicable but preferably not within the middle third of the span.
2. Vertical Construction Joints in Reinforced Concrete Girder, Plate Girder, or I-Beam Spans. Longitudinal joints in the slab should be made parallel to the centerline of the roadway as near the third point of the slab span between beams, as practicable, but preferably not within the middle third of the span. Transverse joints through reinforced concrete girders should be made as for simple slab spans. Transverse joints through concrete slabs carried on steel girders or beams may be made on any line parallel to the main reinforcement.

B. Continuous Spans (Concrete Slab, Girder, and I-Beam Spans).

1. Longitudinal joints should be made parallel to the centerline of the roadway. For slabs carried on girders or beams, the longitudinal joint may be placed as given above in paragraph for Simple Spans.
2. For continuous slab or reinforced concrete girder spans, transverse joints should be placed parallel to the supports and preferably at the points of dead load contra flexure, but they may be placed between these points and the third points of that portion of the span between points of dead load contra flexure.
3. For continuous steel girder or beam spans, transverse joints in the slab should be placed parallel to the transverse bars and preferably at the points of dead load contra flexure. These points are usually near the quarter points of the spans and at the splices. If necessary they can be located in span segments between the points of contra flexure that are not over interior piers. The District Office should be contacted by telephone for concurrence of the location of emergency joints whenever feasible.

4. For end spans, one point of contra flexure shall be considered to be at the free end.
- C. Rigid Frame Structures. Vertical construction joints should be placed in accordance with instruction given above for continuous slab concrete girder bridges.

Other Locations Permissible. It should be understood that the above discussion refers only to the preferred location of emergency construction joints. Construction joints are permissible at other locations on the superstructure if it is necessary to make them in cases of real emergency. However, they should be avoided. As an example, the preferred location of an emergency construction joint in the superstructure of a simple slab bridge should be at some location outside of the middle third of the span. However, if the concrete had been placed to approximately the center of the span and the mixer should break down, it would be permissible to place a joint at or near the center of the span and at right angles to the main reinforcement and it would not be necessary to remove any of the concrete already placed in order to make the joint outside of the middle third. Sound judgment must be used when making an emergency construction joint. If the Contractor desires to make a construction joint which is not of an emergency nature, you should consult your Supervising Engineer before granting permission to make such a joint.

Bonded Construction Joints. The Standard Specifications provide for two kinds of construction joints: bonded and unbonded. Unbonded joints are used where bonded joints are not needed. Bonded joints are typically used where shear transfer or water tightness are needed. Construction joints will be shown on the plans.

In making a bonded construction joint, the objective is to get as good a bond as possible between the concrete being placed and that already in place. A good bond will provide for transmission of some stress across the joint and will prevent any infiltration of water into the joint.

503.16 Surface Finish

The rubbed finish required under Article 503.16(b) will only be required when specified by the plans or Special Provisions.

All other exposed concrete will be given a normal finish. The amount of work which the Contractor will need to do to obtain a satisfactory job will be determined by the condition of the forms which s/he uses and the manner in which the concrete is placed. The Contractor should be aware of the fact that good forms along with extra care taken in construction and tying the forms can result in reduced costs in obtaining a satisfactory normal finish. The placing of concrete in the forms should be accomplished in a manner that will permit mortar to work against the forms to produce a smooth finish free of honeycomb and with a minimum of water and air pockets. Discoloration of the concrete between successive panels may require additional work to obtain a uniform color.

SECTION 504. PRECAST CONCRETE STRUCTURES

504.06 Precast, Prestressed Concrete Members

Damage Inspection

Precast prestressed concrete (PPC) products are inspected at the production facility using a quality control / quality assurance (QC / QA) program described in the Department's Manual for

Fabrication of Precast Prestressed Concrete Products. This program does not require a Department QA inspector to be present or directly involved with every aspect of the product fabrication process. As a minimum, a Department QA inspector will examine the finished product for cracks and conduct a brief visual inspection. The brief visual inspection shall consist of examining the product for placement of reinforcement or other hardware protruding from the product, overall dimensions, sweep, camber, chips, spalls, or anything else out of the ordinary.

The Manual for Fabrication of Precast Prestressed Concrete Products is referenced by the Standard Specifications (Std. Spec.) for Road and Bridge Construction and is a contract document. Per the Manual, products are to be stamped ILL OK by the Department QA inspector to release them for shipment. Per the Manual, the ILL OK stamp is evidence of the validation of the Producer's quality control activities by the inspector's quality assurance activities. The ILL OK stamp is also evidence of materials inspection per the Project Procedures Guide.

After an ILL OK stamp is applied, there is potential for product damage during loading at the plant, during transportation, and during handling at the jobsite. Thus, it is important that all products be evaluated at the jobsite by Department personnel. The following summarizes the minimum jobsite evaluation that should be performed:

Prior to Delivery to the Jobsite

1. Ensure an approved final set of shop drawings is in the project file and available for reference when the products are delivered to the jobsite.
2. Review the Manual for Fabrication of Precast Prestressed Concrete Products. In particular see Section 1.2 and Appendix A for maximum allowable dimensional tolerances, Section 3.5 for allowable damage and repairs, and Appendix A for procedures to remedy unacceptable products. The Manual for Fabrication of Precast Prestressed Concrete Products can be found at <http://www.dot.il.gov/materials/guidesmanuals.html>
3. Verify with the District Materials Engineer if any product was declared unacceptable and if a remedy for the unacceptable product has been approved. If a remedy for any product declared unacceptable has been approved, obtain a copy of the "Notice of Unacceptable Product at Plant or Jobsite" form (BMPPR PS02) and the remedy approval notification for the project file.
4. Verify with the District Materials Engineer if the fabricator has developed an alternate transportation loading configuration (in lieu of the configuration specified in Std. Spec. Art. 504.06 (c). (Note, Art. 504.06 (c) may not apply in all cases because of the length and depth of the beams, the transportation route to deliver the beams, or other circumstances.) If the fabricator has developed an alternate transportation loading configuration, its design must be sealed by a licensed Illinois structural engineer and approved by the Bureau of Bridges and Structures. The approved transportation loading configuration is to be used for checking the location of bolsters or other supports.

Arrival at Jobsite and Before Unloading

1. Verify the product has an ILL OK stamp. If the product doesn't have the ILL OK stamp, issue a notice of unacceptable product (BMPR PS02) to the contractor and contact the District Materials Engineer. (See Std. Spec. Art. 106.02 for additional guidance regarding unacceptable materials and Section 3.6.3 of the Manual for Fabrication of Precast Prestressed Concrete Products for more information on the ILL OK stamp.)
2. Verify bolsters or other supports are at the correct location, per Std. Spec. Art. 504.06 (c) or an approved alternate (project specific) loading configuration, for transporting the product. If bolsters or supports are located incorrectly, subsequent inspection will be required to verify that the product did not incur crack damage. It is recommended the product be returned to the Producer for this inspection. If it is not feasible to return the product to the Producer, access to the entire beam is required for inspection. Note, it may not be feasible (or possible) to perform this inspection after the product is placed in its final location. Thus, an immediate inspection will likely be required. This immediate inspection may delay the contractors operation. (See item 2 in the "After Placement at the Jobsite" section below for additional discussion regarding crack inspection.)
3. Verify wood blocks or other suitable material, per Std. Spec. Art. 504.06 (c), were placed under the tie chains to prevent chipping of the concrete. If shipping damage is identified, issue a notice of unacceptable product (BMPR PS02) to the contractor.

Unloading/Handling

Per Std. Spec. Art. 504.06(d), never allow the contractor to lift a product without fully engaging all the lifting loops as shown on the shop drawings. The products are designed for fully engaged lifting loops to prevent product damage. Be advised that extra lifting loops may be used by the Producer at the plant because of their handling equipment. These loops are supposed to be removed at the plant, but sometimes they are not. Thus, it is important to review the shop drawings.

Per Std. Spec. Art. 504.06(d), ensure the contractor is utilizing an adequate spreader beam and slings to prevent the development of detrimental horizontal forces in the product. Note, the minimum sling angle should be shown on PPC beam plan sheet(s). When the sling angle exceeds (i.e. is steeper than) the minimum angle shown in the plans, the horizontal force developed in the product will not have detrimental effects.

After Placement at the Jobsite

- A. Perform a brief visual inspection as follows:
 1. Examine beams for excessive sweep (i.e. horizontal curvature). This should be performed during or as soon as practicable after placement. Be advised that as the sun shines on the beams it will cause temperature differentials that may cause the beams to temporarily warp. Thus, it may be necessary to examine the beams for sweep early in the morning when temperature differentials are minimized. If visual inspection warrants further investigation, use a string line to check maximum dimensional tolerance. The dimensional tolerance information is provided in Section 1.2.4 and Appendix A of the Manual for Fabrication of Precast Prestressed Concrete

- Products. In rare instances, beams may be in tolerance for sweep but still cannot be placed properly. In this situation it is important to contact the Bureau of Bridges and Structures.
2. Examine beams for unusual camber (i.e. vertical curvature). Unusual camber includes no camber, negative camber, excessive differential camber with adjacent deck beams and excessive camber contributing to thin wearing surfaces on deck beams or negative fillets on I – Beams/Bulb T – Beams. The recommendations of Article 504.06 (d) may help alleviate differential camber problems between deck beams.
 3. Examine for anything else that is out of the ordinary.

Contact the Bureau of Bridges and Structures if you have questions regarding the above inspection, and issue a notice of unacceptable product (BMPR PS02) if the beam is unacceptable.

- B. Examine the product for cracks, per Section 3.5 of the Manual for Fabrication of Precast Prestressed Concrete Products, using a crack comparator and tape measure. (Do not drill, or allow drilling, into PPC products without prior consultation with the Bureau of Bridges and Structures.) As an aid to the inspection, it is suggested to spray the concrete surface with water to help locate cracks. If cracks not exceeding the Department's limits are located, verify if repairs per Section 3.5.6 of the Manual for Fabrication of Precast Prestressed Concrete Products were performed. This may be seen visually or you can contact the Department's QA plant inspector. If cracks exceeding the Department's limits are located, issue a notice of unacceptable product (BMPR PS02) to the contractor.
- C. Verify that no chips, spalls, or other damage occurred to the concrete during handling at the jobsite. It is not uncommon for beam torsion (twisting) to occur during handling which may cause damage or spalling of concrete. If handling damage is identified, issue a notice of unacceptable product (BMPR PS02) to the contractor.

When a notice of unacceptable product (BMPR PS02) is issued, follow the "procedure to remedy an unacceptable prestressed product at the jobsite" outlined in Appendix A of the Manual for Fabrication of Precast Prestressed Concrete Products. It should also be mentioned that "Inspection Feedback to Precast Prestressed Concrete Producer" (BMPR PS03) is available for providing constructive feedback to the production facility if appropriate.

Minor plant repairs that didn't require the product to be declared unacceptable (i.e. didn't require a BMPR PS02) may be noticed in the field. Minor repairs frequently involve a small chip, spall, or cracks. The Department's QA plant inspector, at the production facility, should be contacted if any concerns with a plant repair are identified at the jobsite.

SECTION 505. STEEL STRUCTURES

General. Welding of structural members or accessories to structural steel should not be permitted unless specifically allowed in the contract. Refer to [Construction Memorandum No. 15](#), Welding of Construction Accessories to Structural Steel Bridge Members.

Long Span Bridges. The discussion under this article has to do primarily with long span bridges. The material was prepared by the Bureau of Bridges and Structures and with some

additions is presented here with the thought of stressing some of the important features of construction practice. Some of these features take on additional importance when the structure involved is a long span bridge. This is explained by the fact that the design involves features not found in the relatively simple short span structures. Improper procedure in the field or neglect of certain construction points may lead to serious consequences.

Substructures are discussed herein under the sections devoted to the various operations involved: [Section 501](#), Removal of Existing Structures; [Section 502](#), Excavation for Structures; [Section 503](#), Concrete Structures, and [Section 512](#), Piling. The Resident should keep complete records of the construction of foundations as they are actually built. These should include elevations of the bottom of the footing or seal coat, the nature of the material excavated and that under the foundation, the elevation of the top of the seal coat (if any), the actual alignment, position and elevation of tops of finished piers, etc. Any settlement of the piers during construction may be observed by taking periodical level readings on horizontal marks scribed on the sides of the piers at convenient elevations.

Falsework Bents. The Contractor must keep the structure to the proper line and elevation at all stages of construction. S/He should have perfect control of the position of the span at all times. This can most easily and definitely be done if steel jacks are used at points of bearing on the falsework. Review Article 503.05 Standard Specifications.

Setting Shoes, Grillages, etc. Particular care should be taken in setting shoes, grillages, pins, etc., so as to secure perfect fit and alignment. The axes of pins should be in the same horizontal straight line and perpendicular to centerline of roadway. Error in setting should not exceed an angle of 1 mm in 1.92 m ($1/32$ inch in 5 ft). Any greater error materially reduces the capacity of the bridge. For continuous trusses, after all steel has been set and all spans swung, adjustment must be made at both ends of each truss for the true reactions before concreting the bearings, and preferably before grouting the anchor bolts. Do not allow the bearings for one truss to be concreted before the bearings for the other truss have been adjusted. After bearings are in place for continuous trusses, accurate check measurements should be made for span length between bearings. This information should be sent to Springfield by the District Office so that the Bureau of Bridges and Structures may use it in determining the length of the closing members of the trusses.

Crookedness of Compression Members. Initial crookedness should not exceed 3 mm ($1/8$ in) plus $1/5000$ of the length of the member, measured center to center of the ends. This concerns shop inspection primarily, but the Resident should be acquainted with the limits permissible.

Milling of Compression Members. Milled surfaces of compression members are assumed to transfer load in bearing and so must conform closely to the angles shown on the plans. A deviation from the line of the finished surface, as shown on the plans, by more than an angle of 1 mm in 1.92 m ($1/32$ in in 5 ft) will materially reduce the capacity of the member.

Handling of Compression Members. Flanges of wide flanged rolled beams, having a short bend or crook of not more than $1/20$ the outstanding flange, may be straightened on the job or in the shop after heating around the bend to a temperature that gives a deep cherry red. After being heated in this manner, members should be annealed, but as this is not practicable in the field, they must be made to cool off as slowly as possible.

Top Laterals. High strength bolts for top laterals of compression members should not be tightened until all steel in the trusses is erected, in order to facilitate bringing the chords to proper alignment and to avoid overstressing the laterals.

Compression Chord Splices. Tighten bolts for main chord splices only after enough steel has been placed to ensure that chords may be brought as nearly as possible to their final relative positions.

Middle Cross Ties at Main Posts. The members connecting the middle of main posts over middle piers to portals should be cut loose at main posts or be bolted with bolts as least 10 mm ($\frac{3}{8}$ inch) smaller in diameter than bolt holes, in order to allow posts to take an unrestrained position. These connections should be tightened after all other steel has been erected.

Closure of Middle Span. See that the Contractor's plan for closing the middle span can be quickly and safely executed and that closure is made at a time when the temperature of the top and bottom chords is approximately equal, unless provision is made for the difference in temperature. As soon as high strength bolts in final connections are tightened, have blocking under rollers removed.

Floor Slabs. Care should be exercised in placing floor slabs to see that there is little or no overrun in slab thickness so as not to increase the dead load on the structure appreciably.

Information and Reports. The Supervising Engineer should keep in close touch with the Resident on projects of this sort and should be fully informed on all phases of the work as it progresses. The Resident should avail him/herself of the wider experience of the Supervising Engineer and should confer with him/her in regard to all the important features of the work. Any special information desired from Springfield should normally be secured through the Bureau of Construction.

The District organization should make definite arrangements to keep the Engineer of Construction constantly informed in regard to the more important details of the work. The regular weekly report covers progress satisfactorily, but is it not designed to give information in regard to such items as test piles, seal coats, triangulation, and other important details in the normal progress of the work. Special report should be made promptly on any feature that does not proceed in a normal and satisfactory way or of any unusual or unexpected conditions or results encountered. On structures of this character, it is essential that there should be very close contact between the District organization, Engineer of Construction and Engineer of Bridges and Structures. The latter two may readily interchange information received from the field but they must receive the closest cooperation from the District organization.

505.01 Description

Items of field work common to all bridges, such as staking, location, high water, etc., are discussed in the [Survey Section](#) of this Manual.

505.07 Marking and Shipping

When the structural steel is furnished and fabricated under a contract which does not include erection, it is important that each the bill of lading for each shipment be inventoried. . A complete inventory is required in case any member or fitting is mislaid or lost by the erection Contractor. Assign an inspector check each piece as it is unloaded.

505.08 Erection

Handling and Storing Materials. Mishandling of structural steel can result damage to the paint or to the steel. When the fabrication and erection are performed under separate contracts, the

responsibility of the fabricator may terminate when the shipment reaches its destination and the erection contractor assumes responsibility, it is important that the condition of each individual item be checked upon arrival and while being unloaded. This will determine whether any abrasion or other damage occurred prior to delivery. It is important that the storage area be properly drained and safe from high water. Flood waters and mud cause rapid deterioration. The Resident must carefully check the items covered by this article.

Falsework. The discussion of falsework in Article 503.05 is pertinent here also.. The responsibility for suitable falsework lies entirely with the Contractor Bearings and Anchorage. Correction for Temperature.. Correction for temperature should always be considered, when setting rollers or rockers. In steel spans, changes in length due to temperature variations is critical.

The amount of expansion or contraction allowed for in a concrete or steel span is to account for the change in length that occurs due to variations in temperature. The amount of expansion or contraction allowed for is independent of any allowance necessary for movement in the substructure. The total expansion or contraction, due to temperature change, is calculated on the basis of a coefficient of expansion of .00001206 (.0000067) per degree C (F). for both steel and concrete. That is, the expansion end of a span moves .0000067 (.00001206) of its length between bearings for each degree change in temperature. For example, a rise of 4.44 °C (8 °F) lengthens a 30.48 m (100 ft) span: $4.44 \times .00001206 \times 30.48 \times 1000 = 1.63 \text{ mm}$ ($8 \times .0000067 \times 100 \times 12 = .0643 \text{ inch}$ (about $\frac{1}{16}$ inch)). Similarly a drop of 4.44 °C (8 °F) will shorten the same span a like amount.

The span length shown on the plans is the design length at 10 °C (50 °F). In setting anchor bolts, bearing plates, bed plates, pedestals, etc., which are in fixed positions with respect to the supporting masonry, it is necessary only to establish the correct span length at 10 °C (50 °F). This means applying a temperature correction to a steel tape, if one is used. (The steel tape used shall be a calibrated tape.)

Bearings must be positioned over the bearing lines as shown on the contract plans. This is accomplished at the time of erecting the span by adjusting the expansion bearings a distance determined by the difference between 10 °C (50 °F) and the existing air temperature. The most desirable time for setting or adjusting bearings is early in the morning. The temperature throughout the entire structure will be more uniform at this time than it will later in the day when the sun is higher and part of the structure is in shadow. Longer spans have the potential for greater temperatures differentials throughout the structure.

Example:

Suppose that pin rockers are to be placed at the expansion of a 54.86 m (180 ft) steel span when the air temperature is 1 °C (33 °F). The shortening of the span is, 10 °C (50 °F) minus 1 °C (33 °F) = 9 °C (17 °F), $9 \times .00001206 \times 54.86 \times 1000 = 5.92 \text{ mm}$ (6 mm) ($17 \times .0000067 \times 180 \times 12 = .246 \text{ inch}$ ($\frac{1}{4}$ inch)).

Example:

Bearings are to be adjusted under the expansion end of a 18.29 m (60 ft) reinforced concrete girder span when air temperature is 32 °C (89 °F). The temperature correction is, 32 °C (89 °F) minus 10 °C (50 °F) = 22 °C (39 °F), $22 \times .00001206 \times 18.29 \times 1000 = 4.85 \text{ mm (5 mm)}$ ($39 \times .0000067 \times 60 \times 12 = .188 \text{ inch (} \frac{3}{16} \text{ inch)}$).

Anchor Bolt Holes. In general, the Contractor for the substructure makes no provision for anchor bolts, simply bringing the bearing areas of the abutments, piers or bents, to proper elevation, and leaving it to the superstructure Contractor to drill holes for anchor bolts at the proper locations. This is desirable because of variations from theoretical span lengths due to deflection in the abutments from backfill and other causes.

In locating the abutments, the assumed deflection is added to the span length on the plan as explained in the [Survey Section](#) of this Manual.

Field Bolting. Bolts in continuous beams and girders shall not be tightened until the entire continuous length is in place on the substructure. Otherwise, excessive negative or positive fillets will result. Bolts shall be tightened in accordance with ASTM Specifications for Structural Joints. See [Field Installation and Inspection of High Strength Bolts and Fasteners for Slip Critical Connections](#) in this section for details.

Camber. Make certain all parts of the structure are properly aligned and that the structure is blocked up for the correct camber before tightening of bolts is started. It is possible for a structure to be distorted even though holes are well filled with bolts.

Article 505.08(h) states that splices in continuous beams or girders to be bolted shall not be torqued until the entire continuous length is in place on the substructure.

Standard practice in the fabrication of structural steel is to provide 2 mm ($\frac{1}{16}$ in) oversize holes for bolts and 5 mm ($\frac{1}{4}$ in) maximum spacing between adjoining webs. This allows possible rotation about the centerline of the beam or girder at the splice. The resulting small movement of the splice will cause a larger displacement at the opposite end of the member. The magnitudes of the displacement are illustrated in [Figure 1](#).

If the bolts are torqued after the continuous length is in place, the desired result of design positive fillets is obtained. ([Figure 2](#))

By torquing the bolts before the entire continuous length is in place, the undesired result of excessive positive and negative fillets will occur. ([Figure 3](#))

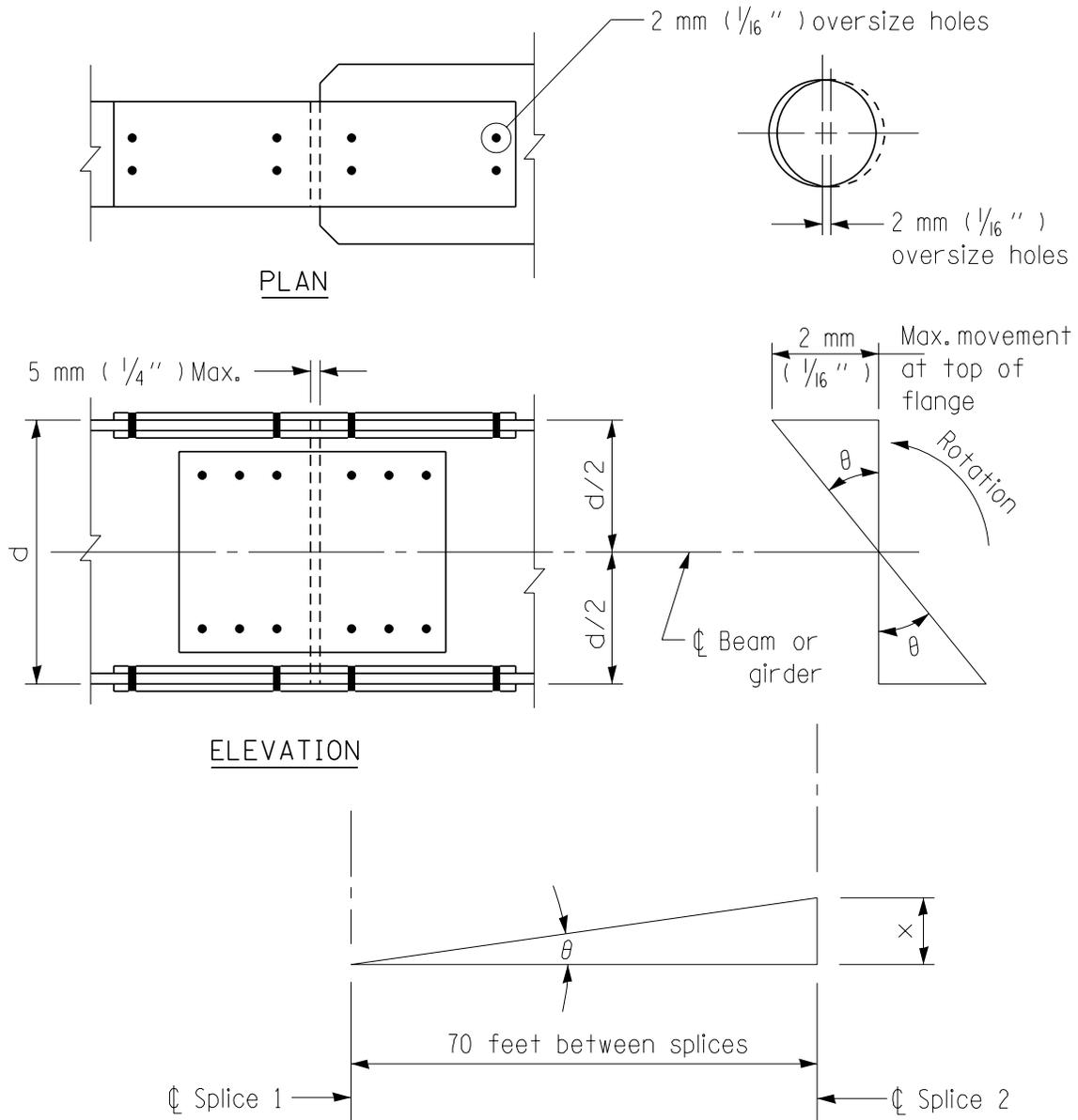


Figure 1

d m (in.)	d/2 m (in.)	0.8 mm (1/32") Movement	1.6 mm (1/16") Movement
0.61 (24)	.30 (12)	56 (2.19)	111 (4.38)
0.76 (30)	.38 (15)	44 (1.75)	89 (3.5)
0.91 (36)	.46 (18)	37 (1.46)	74 (2.92)
1.07 (42)	.53 (21)	32 (1.25)	64 (2.5)
1.22 (48)	.61 (24)	28 (1.09)	56 (2.19)
1.37 (54)	.69 (27)	25 (0.97)	49 (1.94)
1.52 (60)	.76 (30)	22 (0.87)	44 (1.75)

EXAMPLE OF 3 - SPAN CONTINUOUS GIRDER

Splices are bolted and or pinned but not torqued until the entire continuous length is in place on the substructure. See Article 505.08(h) of the Standard Specifications.

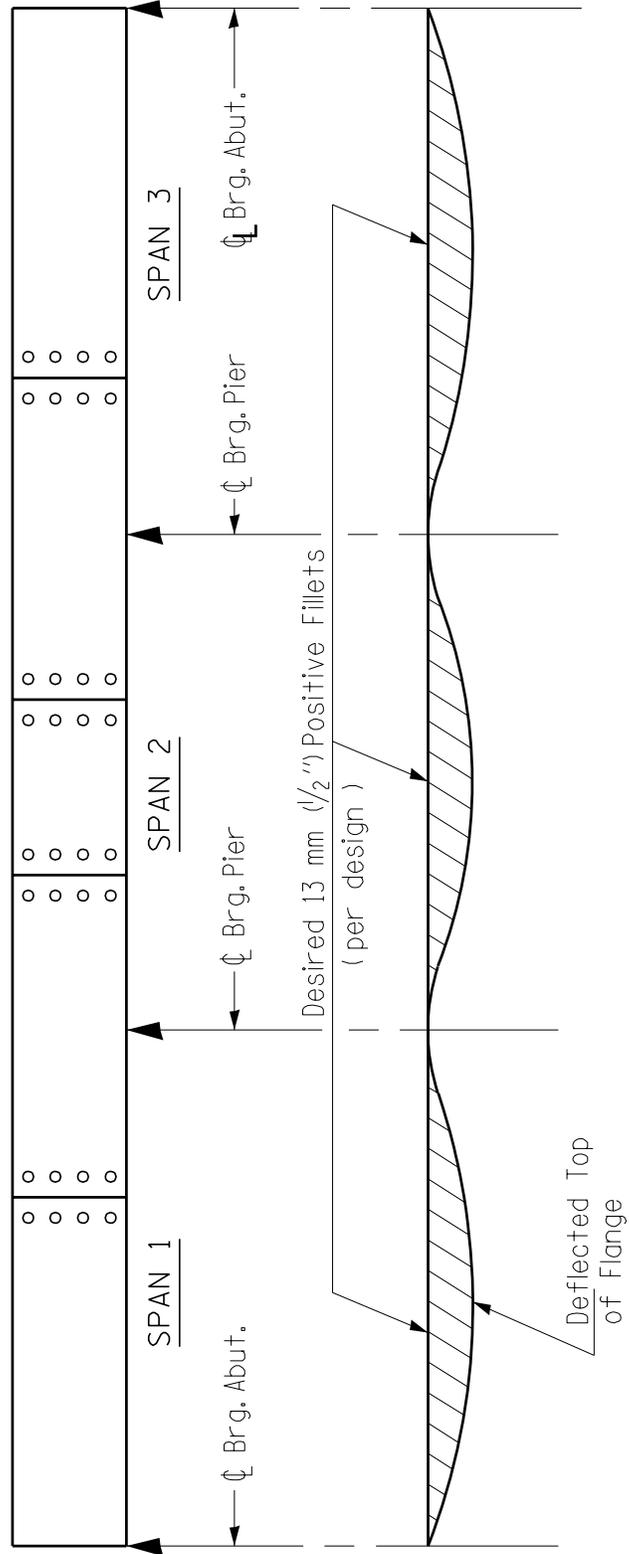


Figure 2

EXAMPLE OF 3 - SPAN CONTINUOUS GIRDER

Erected by torquing bolts before the entire continuous length is in place on the substructure.

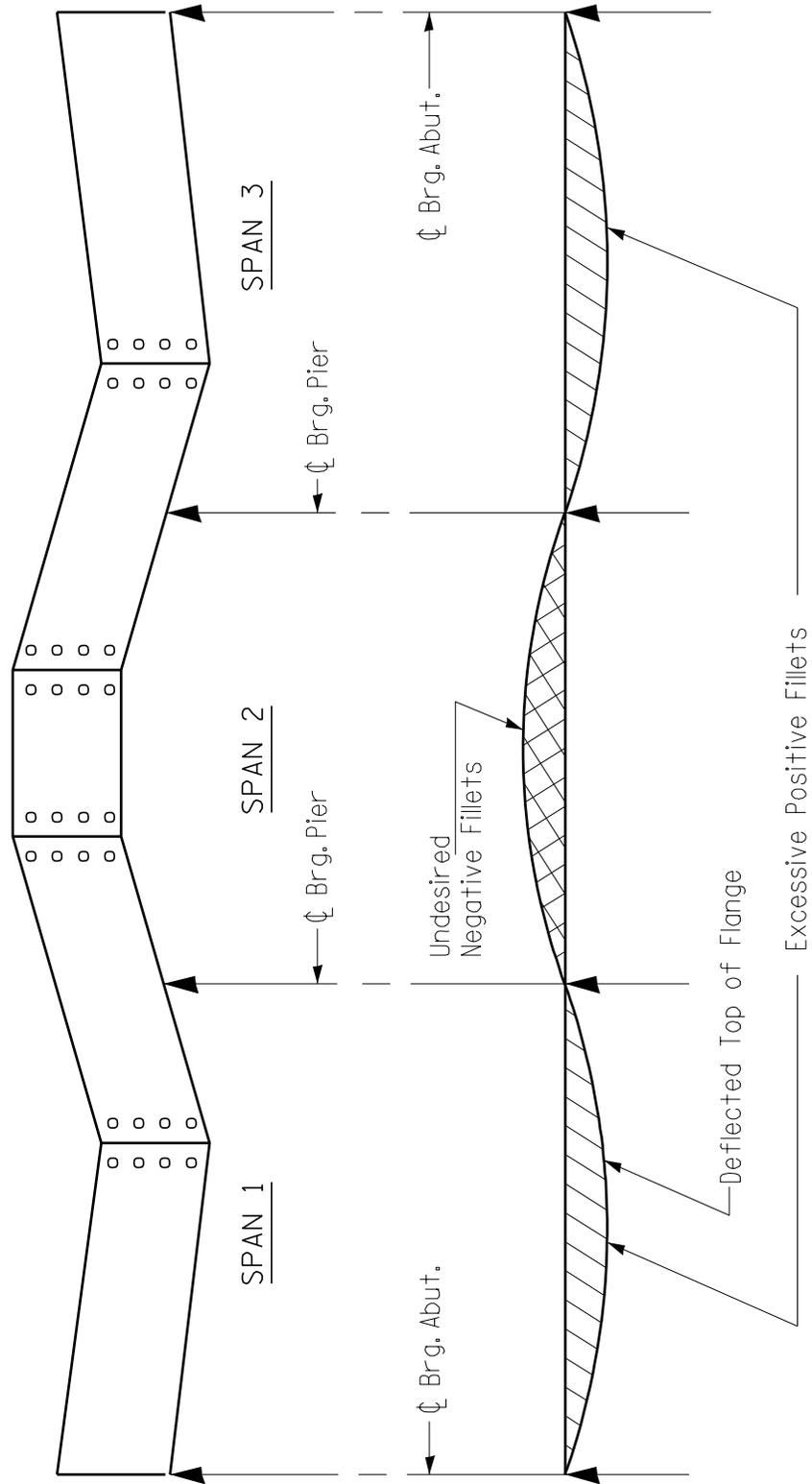


Figure 3

Field Installation and Inspection of High Strength Fasteners for Slip Critical Connections

Article 505.04(f)(2) requires that the installation, tightening and inspection of all high strength bolted connections shall conform to the latest issue of the Specifications for Structural Joints using ASTM A325M or A490M (A325 or A490) bolts for slip-critical connections as issued by the Research Council on Structural Connection Joints of the Engineering Foundation. This specification is quite lengthy and many parts are not pertinent to our needs. Therefore, it is the intent of this section to summarize, for the field inspector, the requirements for both the installation and inspection of high strength fasteners. All bridge connections are slip critical connections.

HANDLING AND STORAGE OF FASTENERS

Fasteners shall be protected from dirt and moisture at the jobsite. Only as many fasteners as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. Fasteners not used shall be returned to protected storage at the end of the shift. Fasteners shall not be cleaned of lubricant that is present in as-delivered condition. Fasteners for slip critical connections which must be cleaned of accumulated rust or dirt resulting from jobsite conditions, shall be cleaned, relubricated and have a rotational capacity test performed prior to installation.

LUBRICATION

During the tightening of galvanized high strength bolts A325M/ (A325/) increased friction occurs due to the galling of the galvanizing on the threads or face of the turned element (nut or bolt head) and the washer. This galling can cause seizing or binding of the bolt. This increased friction can result in bolt tension being out of specification. Dry or rusty black bolts and nuts will also result in bolt tension not meeting specifications.

It is essential that bolts and nuts be properly lubricated at the time of installation. It is not difficult to determine if bolts and nuts are properly lubricated. Black bolts must be oily to the touch. For galvanized fasteners, the nuts must be lubricated with lubricant that is clean and dry to the touch and must contain a visible dye for easy identification. Lubrication of bolt, washer and nut combinations shall be checked prior to job start up using the rotational capacity test. During installation, if improper lubrication is suspected and/or lubricant is added, the assembly shall be retested for rotational capacity.

The following lubricants have been used successfully in the field although other lubricants may be available that will work:

A milky looking liquid lubricant called Safety Film 616 manufactured by Chem-Trend, Inc., Howell, Michigan 48843 or Jon Cote 639 is very easy to use and requires little time to apply. Mix two parts water to one part lubricant in a plastic spray bottle and spray on threads and washer face just before nuts are installed. The lubricant is water soluble and cleans up easy.

A stick wax called Chem-Trend 140 (formerly Johnson's 140 stick wax) and also manufactured by Chem-Trend, Inc., will also work well but requires some clean up afterwards.

Lubricant not only aids in obtaining proper bolt tension but also increases the bolting production rate for the contractor which more than pays for the application of the lubricant.

STRIPPING

Stripping is thread failure of either the nut or bolt threads. Galvanized nuts are overtapped to allow for the thickness of galvanizing. Galvanized bolts thus strip more readily than black bolts. The amount of overtapping that can be allowed is dependent upon the strength of the nut and bolt. Stripping of the threads occurs when the strength of thread area engaged in the nut is not sufficient to develop the force generated in the bolt.

Often nuts and bolts are made by different manufacturers and shipped to the fabricator/distributor. The only way to know that one lot of nuts will properly assemble and fit with another lot of bolts is to test the bolt-nut combination for stripping. This is done with a rotational capacity test.

ROTATIONAL CAPACITY TEST

Article 505.04(f)(3) requires that rotational capacity tests will performed according to AASHTO M164M. As previously mentioned, bolts, nuts and washers are often made by different manufacturers at different locations and are not fitted as an assembly until they arrive at the fabricator/distributor. Due to bolts, nuts and washers never being preassembled and tested as a unit, inadequate combinations of variables such as; ductility, out of tolerance overtapping of nuts, zinc thickness (galvanized bolts), thread depth, lubrication, etc. can cause inadequate tension in the bolted connection as well as bolt failure.

The rotational capacity test checks all components as a complete assembly to assure:

1. Ductility
2. Adequate thread shear area to prevent stripping
3. Adequate lubrication

The FHWA now requires rotational capacity tests to be performed at the source where the nuts, bolts and washers are combined to form an assembly. This source (fabricator/distributor/manufacturer) is where the rotational capacity lot numbers are assigned. Rotational capacity tests must also be performed at the jobsite.

Jobsite rotational capacity tests shall be performed on all black or galvanized bolt, nut and washer assemblies of the same rotational capacity lot number as received from the manufacturer and/or distributor. The frequency of testing shall be two assemblies per each rotational-capacity lot. Jobsite rotational tests shall be performed in accordance with the following procedure and the results documented on Form [BC 2320](#).

FIELD VERIFICATION TESTING

Prior to any fastener installation on the structure, it is essential that each member of the tightening crew and the Engineer be familiar with the tightening procedure to be used on the structure. To accomplish this, the specification requires 3 assemblies of each diameter and length to be tested in the tension calibrating device.

This verification testing demonstrates that the Contractor's chosen tightening procedure will provide the minimum required tension in the fastener assembly and that each crew member understands and can properly apply the correct snug tightening and final tightening procedure.

Snug tight: The specifications define snug tight as the condition when all piles of the joint are in firm contact. This normally happens at a tension of approximately 10 kips. Only with all the piles in firm contact will the final tightening procedure produce the desired tension in the fastener. Crew members should demonstrate that their snug tightening procedure produces approximately 10 kips of tension, but does not produce more than 50% of the required final tension. Snug tight tensions above 50% of the final tension could result in fasteners failing when final tightening is applied.

Final tightening: Correct final tightening can only be applied to assemblies that have been properly snug tightened. Final tightening, whether measured by the rotation of the nut, the shearing off of a part of the fastener or the collapse of nodes on a washer, is only correct if it results in at least the required minimum tension in the fastener. In most instances, the amount of rotation of the nut from snug tight (given elsewhere in this section), the shearing off of a part of the fastener or the collapse of nodes to a certain thickness will produce tensions in the assemblies above the minimum specified. However, the only way to ensure this on your project is through verification testing. If the Contractor's procedure or the assembly does not produce the minimum tension, then the procedure must be revised until it results in the specified tension or the assemblies must be rejected. While the specifications do not directly address the maximum tension in fasteners, the minimum required tension is approximately 70% of the tension strength of the fastener. Therefore, it is important to realize that tension values considerably above the minimum tension should be avoided.

After the Contractor's tightening procedure has been shown to produce the specified tension in the fasteners, it is the inspector's duty to observe the tightening procedure used on the structure to verify it is the same procedure demonstrated. If the Engineer is satisfied the procedure used on the structure is the same as shown in the verification testing, s/he can be assured the required tension is present in the installed fasteners and the visual and minimum inspection requirements for each type of assembly discussed elsewhere in this section is all the further inspection needed.

PROCEDURE FOR PERFORMING ROTATIONAL CAPACITY TEST

EQUIPMENT REQUIRED:

1. Calibrated bolt tension measuring device of size required for bolts to be tested. Mark off a vertical line and lines $\frac{1}{3}$ of a turn, 120 degrees; and $\frac{2}{3}$ of a turn, 240 degrees, from vertical in a clockwise direction on the face plate of the calibrator.
2. Calibrated dial type torque wrench.
3. Spacers and/or washers with hole size no larger than $\frac{1}{16}$ inch greater than bolt to be tested.

4. Steel section to mount bolt calibrator. Flange of girder or cross frame accessible from the ground is satisfactory.

PROCEDURE:

1. Install nut on bolt and measure stick out of bolt when 3 to 5 full threads of the bolt are located between the bearing face of the nut and the bolt head. Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.
2. Install the bolt into the tension calibrator and install the required number of shim plates and/or washer (one washer under the nut must always be used) to produce the thread stick out measured in Step 1.
3. Tighten bolt using a hand wrench to the snug tensions listed below (Tolerance - 0 kips, + 2 kips).

Bolt Dia. (in.)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1-\frac{1}{8}$	$1-\frac{1}{4}$	$1-\frac{3}{8}$	$1-\frac{1}{2}$
Snug Tension (kips)	1	2	3	4	5	6	7	9	10

4. Match mark the nut to the vertical stripe on the face plate of the bolt calibrator.
5. Using the calibrated manual torque wrench, tighten the bolt to at least the tension listed below and record the torque required to reach the tension and the value of the bolt tension. Torque must be measured with the nut in motion.

Bolt Dia. (in.)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1-\frac{1}{8}$	$1-\frac{1}{4}$	$1-\frac{3}{8}$	$1-\frac{1}{2}$
Tension (kips)	12	19	28	39	51	56	71	85	103

6. Further tighten the bolt to the rotation listed below. The rotation is measured from the initial marking in Step 4. Record the bolt tension. Assemblies which fail prior to this rotation either by stripping or fracture fail the test.

Bolt Length (measured in Step 1)	4 x bolt dia. or less	Greater than 4 but no more than 8 x bolt dia.	Greater than 8 x bolt diameter
Required Rotation	$\frac{2}{3}$	1	$1-\frac{1}{3}$

7. The bolt tension measured in Step 6 after the required rotation must equal or exceed the values in the table shown below. Assemblies which do not meet this tension have failed the test.

Bolt Dia. (in.)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\text{-}\frac{1}{8}$	$1\text{-}\frac{1}{4}$	$1\text{-}\frac{3}{8}$	$1\text{-}\frac{1}{2}$
Tension (kips)	14	22	32	45	59	64	82	98	118

8. Loosen and remove nut, and examine the threads on the nut and bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies which have evidence of stripping have failed the test.
9. Calculate and record the value of $0.25 \times$ the tension (pounds=kips \times 1000) measured in Step 5 \times the bolt diameter in feet. The torque measured and recorded in Step 5 must be equal to or less than this calculated value. Assemblies with torque values exceeding this calculated value failed the test. This calculated torque value should not be exceeded at any point in Step 5 or the assembly has failed the test. The table shown below can be used for $\frac{3}{4}$ inch and $\frac{7}{8}$ inch bolts.

ROTATIONAL CAPACITY TEST/MAXIMUM TORQUE			
3/4 INCH BOLT		7/8 INCH BOLT	
TENSION (KIPS)	TORQUE (FT-LBS)	TENSION (KIPS)	TORQUE (FT-LBS)
28	437	39	711
29	453	40	729
30	469	41	747
31	484	42	766
32	500	43	784
33	516	44	802
34	531	45	820
35	547	46	839
36	562	47	857
37	578	48	875
38	594	49	893
39	609	50	911
40	625	51	930
		52	948
		53	966
		54	984
		55	1003
		56	1021

Rotational Capacity Maximum Torque (step 7 on front side)

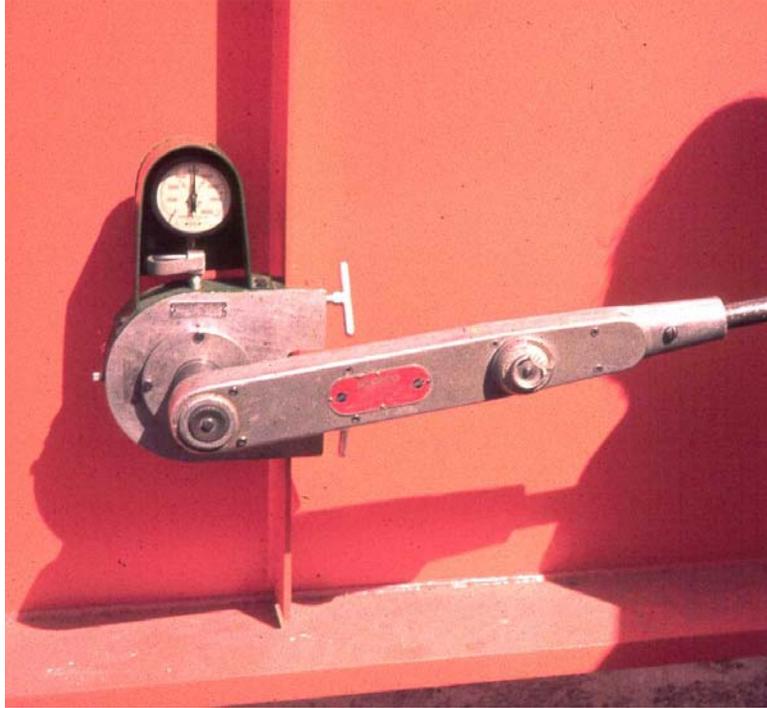
3/4 Inch		7/8 Inch	
Tension	Torque	Tension	Torque
kips	ft-lbs	kips	ft-lbs
28	437	39	711
29	453	40	729
30	469	41	747
31	484	42	766
32	500	43	784
33	516	44	802
34	531	45	820
35	547	46	839
36	562	47	857
37	578	48	875
38	594	49	893
39	609	50	911
40	625	51	930
41	641	52	948
42	656	53	966
43	672	54	984
44	688	55	1003
45	703	56	1021
46	719	57	1039
47	734	58	1057
48	750	59	1076
49	766	60	1094
50	781	61	1112
		62	1130
		63	1148
		64	1167
		65	1185

Minimum Measured Tension (step 9 on front side)

	A325 bolt	A490 bolt
3/4 inch	32	40
7/8 inch	45	56

TENSION CALIBRATING DEVICES

At the present time, there is no known economical means for determining the tension in an installed bolt. However, the tension calibrator is a hydraulic load cell which measures bolt tension created by tightening a bolt in the device.



As the bolt or nut is turned, the internal bolt tension or clamping force is transmitted through hydraulic fluid to a pressure gauge which indicates bolt tension directly in pounds, provided the device is properly calibrated.

Such a device is an economical and valuable tool that shall be readily available whenever high-strength bolts are to be installed. Although each element of a fastener assembly may conform to the minimum requirements of their separate material specifications, their compatibility in an assembly or the need for lubrication can only be assured by testing of the assembly. Hence, such devices are important for confirming the complete fastened assembly as it will be used with the method of tightening to assure the suitability of bolts and nuts, including lubrication, and the adequacy of impact wrenches and/or air pressure, to provide the specified bolt tension.

Testing before start of installation of fasteners in the work will identify potential sources of problems including, but not necessarily limited to, the need for lubrication to prevent failure of bolts by combined high torque with tension, under strength assemblies due to improper marking or heat treatment or quality control of fasteners, excessive overtapping of galvanized nuts, improper use of selected installation method by the bolting crews and/or improper or unreliable inspection technique by the inspectors. Such devices are essential for testing fasteners other than AASHTO M164 (ASTM A325M (A325)) or AASHTO M253 (ASTM A490M (A490)) bolts and direct tension indicators. They are also essential for assuring proper installation method by the bolting crews. Hydraulic tension calibrating devices capable of indicating bolt tension undergo a slight deformation under load. Hence the nut rotation corresponding to a given tension reading may be somewhat larger than it would be if the same bolt were tightened

against a solid steel member. Stated differently, the reading of the calibrating device tends to underestimate the tension which a given rotation of the turned element would induce in a bolt in an actual joint. This is the reason we calibrate at 105% of the minimum required bolt tension.

CONNECTIONS AND SNUG TIGHT

With any tightening method, it is important to install fasteners in all holes of the connection and bring them to an intermediate level of tension generally corresponding to snug tight in order to compact the joint. If individual fasteners are installed and tightened in a single continuous operation, fasteners which are tightened first will be subsequently relaxed by the tightening of the adjacent fasteners. The total of the forces in all fasteners will be reduced which will reduce the slip capacity of the entire connection. Even after being fully tightened, some thick parts with uneven surfaces may not be in contact over the entire faying surface.

This is not detrimental to the performance of the joint. As long as the specified bolt tension is present in all fasteners of the completed connection, the clamping force equal to the total of the tensions in all fasteners will be transferred at the locations that are in contact and be fully effective in resisting slip through friction.

With all methods, tightening should begin at the most rigidly fixed or stiffest point and progress toward the free edges, both in the initial snugging up and in the final tightening.

FIELD MATERIAL INSPECTION

Bolts, Nuts, Washers, Twist-Off Bolts - The Standard Specifications require the following certifications from the mill, the manufacturer and/or distributor:

(Note: The structural steel fabricator could also be the distributor)

Mill Test Report (MTR)

Manufacturer Certified Test Report (MCTR)

Distributor Certified Test Report (DCTR)

The information needed on the certification is outlined in the specifications.

Prior to shipment, the source which combines the nuts, bolts and washers into assemblies (manufacturer/supplier) is required to conduct rotational capacity tests on assemblies of known accepted production lots of bolts, nuts and washers. A rotational lot number is assigned to each assembly representing the bolts, nuts and washers which passed the rotational capacity test. Only bolts, nuts and washers from the same rotational capacity lot can be used together. Bolts, nuts and washers from different rotational capacity lots cannot be intermixed.

Bolts, nuts and washers from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be permanently marked (on the container, not only the lid) with the rotational-capacity lot number such that identification will be possible at any stage prior to and during installation.

When containers arrive on the jobsite, the MTR, MCTR/DCTR shall be provided by the Contractor. In addition, the containers must have an ILL OK stamp or a letter from the Bureau of Materials and Physical Research approving the respective lots of bolts, nuts and washers.

No bolt, nut or washer shall be permitted to be used in the structure unless the MTR, MCTR/DCTR certifications are received, the material has been approved by the Bureau of Materials and Physical Research and the jobsite rotational-capacity tests have passed. If the material does not have an ILL OK stamp or an approval letter from the Bureau of Materials and Physical Research, a minimum sample from each production lot consisting of 3 bolts of each diameter and length, 3 nuts of each size and 3 washers of each size shall be sampled and sent to the Bureau of Materials and Physical Research for testing.

Lockpin and Collar (Huckbolts, etc.)

The MTR and MCTR/DCTR requirements for lockpin and collar fasteners are the same as for bolts, nuts and washers except that rotational-capacity tests are not required.

Lockpin and collars can be accepted in the field if the following requirements are met:

1. Mechanical galvanizing shall be measured and shall be between 2 to 6 mm in thickness. Hot dipped galvanized lockpin and collars are not permitted.
2. From each production lot, 3 lockpins and collars of each diameter and length shall be tested in a tension measuring device. Each lockpin shall clamp at no less than 105% of the minimum required tension or the lot it represents shall be rejected.
3. The manufacturer has the option to ask the Bureau of Materials and Physical Research to test the lockpins and collars before they are shipped to the jobsite. If the containers arrive at the jobsite with an ILL OK stamp, the Bureau of Materials and Physical Research has sampled and approved the lockpins and collars. In this case, the galvanizing thickness check as per Item 1 will not be required. However, the field tension testing as per Item 2 will be required.

INSTALLATION METHOD

Regardless of the fastener type or method of tightening used, the following general provisions apply:

1. The Engineer shall check the marking, surface condition and storage of bolts, nuts and washers, alternate design fasteners and the faying surfaces of joints for compliance with the specification requirements.
2. When faying surfaces of slip critical joints (all bridge joints are slip critical) are specified to be painted in the field, the Engineer shall assure the coating has cured for the minimum time recommended by the paint manufacturer.
3. The Engineer must verify that all bolt tension measuring devices and torque wrenches have been calibrated within the last year and test certificates are available. The bolt tension measuring device must be capable of accepting the shortest bolts on the contract (Skidmore-Wilhelm, Model MS or equivalent).
4. The Engineer shall witness all rotational capacity tests performed at the fastener installation site to assure the tests are properly conducted at the required frequency and test results are in compliance with the specifications. Lockpin and collar fasteners (Huckbolts) require no rotational capacity test.

- 4.1 The rotational capacity test shall be performed as outlined on two representative bolt, nut and washer assemblies per rotational capacity lot.
- 4.2 Fasteners not passing the rotational capacity test shall be rejected. If lack of lubricant appears to be a problem, the entire rotational capacity lot of nuts/bolts can be relubricated with an approved lubricant and the rotational capacity test rerun. Select two of the relubricated assemblies as per paragraph 4.1 and perform the rotational capacity test. If the assembly passes the rotational capacity test, the rotational capacity lot they represent can be accepted.
5. The Engineer shall witness all, turn-of-nut verification testing, tension verification testing of all fasteners and direct tension indicator (DTI) calibration required by the specification requirements to assure the tests are properly conducted at the required frequency.
6. The Engineer will assure that each member of the bolting crew(s) is familiar with the procedural requirements for the tightening method selected by the Contractor. Each bolting crew member must also fully understand the procedure for snug tightening the joint and fasteners, and should have demonstrated this knowledge by tightening a fastener in a bolt tension calibrator.
7. Material within the bolt grip will be steel with no compressible material.
8. Slope of surface shall not exceed 20:1 (V:H). Correct with hardened beveled washers.
9. All surfaces free of loose scale, dirt or other foreign material.
10. Uncoated joints shall have no paint, including overspray, in the connection area.
11. All fastener components shall be properly lubricated and protected from contamination, dirt and moisture.
12. Hardened washers may be required for standard holes or special washers may be required for oversize or slotted holes. See specifications. Hardened washers are required to be used under the turned element.

TURN-OF-NUT METHOD

Consistency and reliability using turn-of-the-nut method is dependent upon assuring that the joint is well compacted and all bolts are uniformly tight to a snug tight condition prior to application of the final required partial turn. Under-tightened bolts will result if this procedure is not followed. Reliability is also dependent upon assuring that the turn that is applied is relative between the bolt and nut; thus the element opposite the turned end should be prevented from rotating while the required degree of turn is applied to the turned end. Reliability and inspectability of the method may be improved by having the outer face of the nut match-marked to the protruding end of the bolt after the joint has been snug tightened but prior to final tightening. Such marks shall be applied by the wrench operator using crayon or dab of paint. Such marks in their relatively displaced position after tightening will afford the inspector a means for noting the rotation that was applied.

Problems with turn-of-nut tightening have been encountered with galvanized bolts. Jobsite tests in the tension indicating device demonstrated the lubricant reduced the coefficient of friction between the bolt and nut to the degree that "the full effort of a man using an ordinary spud

wrench" to snug tighten the joint actually induced the full required tension. Also, because the nuts could be turned by application of lower torque than normally expected with non-galvanized bolts, they were erroneously judged improperly tightened by the inspector. Research confirms that lubricated galvanized bolts may require only one-half as much torque to induce the specified tension. In other cases of problems with galvanized bolts, the absence of lubrication or lack of proper overtapping caused seizing of the nut and bolt threads which resulted in twist failure of the bolt at low or no tension. For such situations, use of a tension indicating device and the fasteners being installed may be helpful in establishing either the need for lubrication or alternate criteria for snug tight.

**PROCEDURE FOR INSTALLATION AND TIGHTENING
OF HIGH STRENGTH FASTENERS
TURN-OF-NUT METHOD**

2.0 TENSION VERIFICATION TESTING

- 2.1 Equipment required - Calibrated bolt tension measuring device. Spacers and/or washers with proper hole size. Rigid mounting for bolt tension calibrator. Air impact wrenches which will be used to install fasteners in the structure.
- 2.2 Select at least 3 bolt, nut and washer (when required) assemblies of each diameter, length and grade to be used in the work.
- 2.3 Install and tighten each assembly in the bolt tension measuring device using the "snug tightening" procedure which will be used to snug tight the fasteners in the work. "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Assure the proposed "snug tightening" procedures does not produce more than 50% of required fastener tension as specified by Table 1. If so, revise snug tightening procedure as bolt stress may be near the bolt failure range when tightened. Too much lubrication can cause this problem.

TABLE 1 - REQUIRED FASTENER TENSION (Kips)

Bolt Dia. (in)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M164 (A325)	13	20	29	41	54	59	75	89	108
M253 (A490)	16	25	37	51	67	84	107	127	155

- 2.4 Following snug tightening, mark nut or drive socket to a reference point on bolt tension calibrator and further tighten to the rotation shown below.

Bolt Length	4 x bolt dia. or less	Greater than 4 but no more than 8x bolt dia.	Greater than 8 x bolt dia.
Required Rotation	1/3	1/2	2/3

- 2.5 At this rotation, the minimum bolt tension shall be as follows:

Bolt Dia. (in)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M164 (A325)	13	20	29	41	54	59	75	89	108
M253 (A490)	16	25	37	51	67	84	107	127	155

3.0 SNUG TIGHTENING PROCEDURE

- 3.1 Bolts shall be installed in all holes of the connection and brought up to a "snug tight" condition.
- 3.2 "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. The snug tightening procedure used in the work shall be the same snug tightening procedure used when conducting the TURN-OF-NUT VERIFICATION TEST in paragraph 2.3.
- 3.3 Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Start the pattern near the end of each member being spliced at the center of the pattern and work toward all edges of the splice plate.
- 3.4 Following this initial snug tightening, all bolts in the joint shall be again systematically tightened as necessary using a similar pattern until all bolts are simultaneously snug tight and the connection is fully compacted.

4.0 FINAL TURN-OF-NUT TIGHTENING

- 4.1 Following this snug tightening operation, all bolts in the connection shall be match-marked such that the subsequent relative rotation between the bolt and the nut can be inspected. All bolts shall then be tightened by the applicable amount of rotation as determined in Step 2.5.
- 4.2 During the tightening operation, there shall be no rotation of the part not turned by the wrench.
- 4.3 Tightening shall progress systematically from the most rigid part of the joint to its free edges. Start the pattern near the end of each member being spliced at the center of the pattern and work toward all edges of the splice plate.
- 4.4. When it is impractical to turn the nut, tightening may be done by turning the bolt with a washer under the bolt head while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

TWIST OFF BOLT METHOD

When high-strength bolts with mechanical properties equivalent to AASHTO M164 (ASTM A325M (A325)) or AASHTO M253 (ASTM A490M (A490)) but with different geometry which is intended to provide automatic control of installed bolt tension are used, the following shall apply. The bolts currently being used of this general type involve a splined end extending beyond the threaded portion of the bolt which is gripped by a specially designed wrench chuck which provides a means for turning the nut relative to the bolt. While such bolts are subject to many of the variables affecting torque/tension relationship, they are produced and shipped by the manufacturers as a nut-bolt assembly under good quality control which apparently minimizes some of the negative aspects of the torque controlled process.

While these alternate design fasteners have been demonstrated to consistently provide tension in the fastener meeting the specifications in controlled tests in tension indicating devices, it must

be recognized that this type of fastener may be misused and provide results as unreliable as those with other methods. They must be used in the as delivered, clean, lubricated condition. The requirements of this Specification as well as the installation requirements of the manufacturer's specification must be adhered to.

**PROCEDURE FOR INSTALLATION AND TIGHTENING
OF HIGH STRENGTH FASTENERS
ALTERNATE DESIGN FASTENERS (TWIST OFF BOLTS)**

2.0 TENSION VERIFICATION TESTING

2.1 Equipment required:

2.1.1 Calibrated bolt tension measuring device.

2.1.2 Spacers and/or washers with proper hole size to adjust bolt length in tension measuring device.

2.1.3 Rigid mounting for bolt tension calibrator.

2.1.4 Wrenches which will be used to install fasteners in the structure.

2.1.8 Adequate supply of hex head HS bolts, nuts and washers.

2.2 Testing Frequency - As a minimum, 3 fastener assemblies shall be checked from each fastener length, diameter and grade. The testing should be done immediately prior to start of installation of the fasteners in the work. Fasteners should be retested when any significant difference is noted in the surface condition or level of lubrication of the fastener threads, nuts or washers.

2.3.1 Select three (3) fastener assemblies from each diameter, length and grade.

2.3.2 Install each fastener assembly into the tension measuring device and install sufficient spacers and/or washers so that at least three (3) but no more than five (5) full threads are exposed between the nut face and the underside of the bolt head. The fastener manufacturer's installation procedure shall be followed for installation of bolts in the calibration device and in all connections.

2.3.3 Tighten each assembly using the "snug tightening" procedure which will be used to snug tight the fasteners in the work. "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Assure the proposed snug tightening procedure does not produce more than 50% of required fastener tension as specified by Table 3 below. If so, revise snug tightening procedure.

TABLE 3 - REQUIRED FASTENER TENSION (Kips)

Bolt Dia. (in)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M164 (A325)	12	19	28	39	51	56	71	85	103
M253 (A490)	15	24	35	49	64	80	102	121	148

- 2.3.4 Following the fastener manufacturer's procedure, further tighten each of the three (3) assemblies until the final twist-off of the control or indicator element. Each assembly must indicate a minimum tension as shown below or the lot the bolt represents shall be rejected.

Bolt Dia. (in)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M164 (A325)	13	20	29	41	54	59	75	89	108
M253 (A490)	16	25	37	51	67	84	107	127	155

3.0 SNUG TIGHTENING PROCEDURE

- 3.1 Fasteners shall be installed in all holes of the connection and brought up to a "snug tight" condition.
- 3.2 "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. The snug tightening procedure used in the work shall be the same snug tightening procedure used when conducting the Tension Verification Testing in paragraph 2.3.3.
- 3.3 Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Start the pattern near the end of each members being spliced at the center of the pattern and work toward all edges of the splice plate.
- 3.4 Following this initial snug tightening, all bolts in the joint shall be again systematically tightened as necessary using a similar pattern until all bolts are simultaneously snug tight and the connection is fully compacted.

4.0 FINAL TIGHTENING

- 4.1 Following the snug tightening operation, all fasteners shall be further tightened until the final twist-off of the control or indicator element. All tightening shall be done using equipment and procedures recommended by the fastener manufacturer.
- 4.2 Tightening shall progress systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, proper tensioning of the bolts may require more than a single cycle of systematic partial tightening prior to final twist-off of the control or indicator element of individual fasteners.

**PROCEDURE FOR INSTALLATION AND TIGHTENING
OF HIGH STRENGTH FASTENERS
LOCKPIN AND COLLAR (HUCKBOLTS,ETC.)**

2.0 TENSION VERIFICATION TESTING

- 2.1 Equipment required: Calibrated tension measuring device. Spacers and/or washers with proper hole size to adjust fastener length in tension measuring device. Rigid mounting for tension measuring device. Wrenches which will be used to install fasteners in the structure.
- 2.2 Adequate supply of lockpin and collar fasteners.
- 2.3 Select a representative sample of not less than 3 fasteners of each diameter, length and lot.
- 2.4 Tighten each assembly using the snug tightening procedure which will be used to snug tight the fasteners in the work. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. Assure the proposed snug tightening procedure does not produce more than 50% of the required fastener tension as specified in the table, Step 2.5, below. If so revise the snug tightening procedure.
- 2.5 Following the manufacturer's procedure, further tighten each representative fastener until the pintail shears and the collar is swaged around the pin. Each fastener shall develop a tension of not less than that in the following table:

Bolt Dia. (in)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M164 (A325)	13	20	29	41	54	59	75	89	108
M253 (A490)	16	25	37	51	67	84	107	127	155

If any fastener does not meet the required minimum tension, the lot it represents shall be rejected.

3.0 SNUG TIGHTENING PROCEDURE

- 3.1 Fasteners shall be installed in all holes of the connection and brought up to a "snug tight" condition.
- 3.2 "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. The snug tightening procedure used in the work shall be the same snug tightening procedure used when conducting the Tension Verification Testing.
- 3.3 Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Start the pattern near the end of each members being spliced at the center of the pattern and work toward all edges of the splice plate.
- 3.4 Following this initial snug tightening, all fasteners in the joint shall be again systematically tightened as necessary using a similar pattern until all fasteners are simultaneously snug tight and the connection is fully compacted.

4.0 FINAL TIGHTENING

- 4.1 Following the snug tightening operation, all fasteners shall be further tightened until the pintail shears and the collar is swaged around the pin. All tightening shall be done using equipment and procedures used when conducting the Tension Verification Testing.
- 4.2 Tightening shall progress systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, proper tensioning of the fasteners may require more than a single cycle of systematic partial tightening prior to final shearing of the pintail.

**PROCEDURE FOR VERIFICATION AND INSTALLATION
OF HIGH STRENGTH BOLTS
WITH DIRECT TENSION INDICATORS (DTIs)**

2.0 TENSION VERIFICATION TESTING

- 2.1 Equipment required: Calibrated bolt tension measuring device with a special flat insert in place of normal bolt head holding insert. Special insert required to allow access to measure DTI gap. Tapered leaf thickness (feeler) gages 0.001, 0.005 and 0.015 inch. Same gauges as to be used to inspect the bolts after installation. Bolts, nuts and standard washers to be used in the work with the DTIs. Test at least three assemblies of each diameter, length and grade of bolts used in the work. Impact and manual wrench to tighten bolts. Equipment should be the same as to be used in the work.
- 2.2 Install bolt, DTI, standard washer and nut into the bolt tension indicator using the equipment which will be used in the work. Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element.
- 2.3 Snug the bolt to no more than 50% of the required installation tension using the equipment which will be used in the work. Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element.
- 2.4 Further tighten bolt to tensions listed below. Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element. If an impact wrench is used, tighten to a load slightly below the required load and use a manual wrench to attain the required tension. The load indicating needle of the bolt calibrator cannot be read accurately when an impact wrench is used.

BOLT TENSION (Kips)

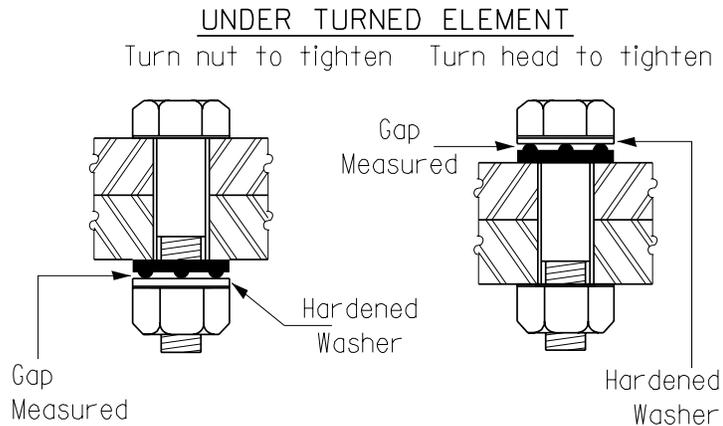
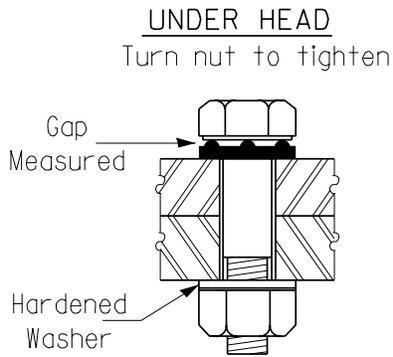
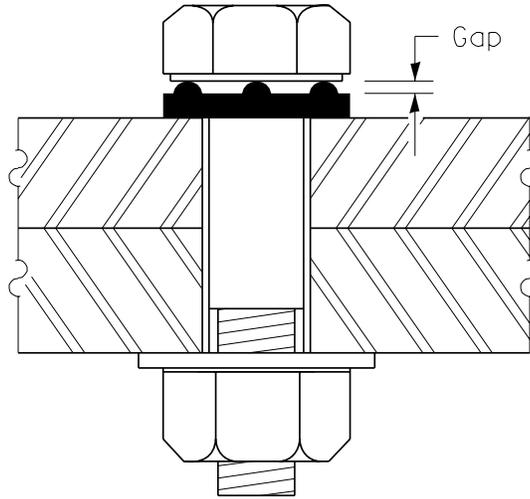
Bolt Dia. (in)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1 \frac{1}{8}$	$1 \frac{1}{4}$	$1 \frac{3}{8}$	$1 \frac{1}{2}$
M164 (A325)	13	20	29	41	54	59	75	89	108
M253 (A490)	na	na	37	51	67	84	107	127	Na

- 2.5 Determine the number of spaces between the protrusions on the DTI that a 0.005 inch (galvanized DTI) or 0.015 inch (Plain DTI) feeler gage is refused. If the thickness gage is refused in more than $\frac{1}{2}$ of the total spaces, the DTI fails the test and the lot is rejected.
- 2.6 The bolt should be further tightened to zero total gap. This is defined as the gap at which a 0.001 inch feeler gage cannot enter any space in the DTI, but a visible gap still exists in at least one space.
- 2.7 Remove the bolt from the calibrator and turn the nut on the threads by hand. The nut should be able to be turned on the complete length of the threads. If so, total zero gap is the minimum allowable gap for the job. If not, repeat the test with a larger minimum gap in Step 5, for example one space will accept a 0.005 inch feeler gage, to establish the minimum allowable gap for the job.

INSTALLATION:

Galvanized high strength A325M (A325) bolts shall always have the galvanized DTI under the bolt head with only the nut being permitted to be turned to tighten the bolt. There is no capability to measure the proper gap of a galvanized DTI when installed under the turned element with a hardened washer.

See proper installation below:



3.0 SNUG TIGHTENING PROCEDURE

- 3.1 Fasteners shall be installed in all holes of the connection and brought up to a "snug tight" condition.
- 3.2 "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. The snug tightening procedure used in the work shall be the same snug tightening procedure used when conducting the Tension Verification Testing.
- 3.3 Snug tightening shall progress systematically from the most rigid part of the connection to the free edges. Start the pattern near the end of each members being spliced at the center of the pattern and work toward all edges of the splice plate.
- 3.4 Following this initial snug tightening, all bolts in the joint shall be again systematically tightened as necessary using a similar pattern until all bolts are simultaneously snug tight and the connection is fully compacted.

4.0 FINAL TIGHTENING

- 4.1 Following the snug tightening operation, all fasteners shall be further tightened to their final required tension.
- 4.2 Tightening shall progress systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, proper tensioning of the bolts may require more than a single cycle of systematic partial tightening prior to final tightening.

INSPECTION OF FASTENER INSTALLATIONS

It is apparent from the commentary on installation procedures that the inspection procedures giving the best assurance that bolts are properly installed and tensioned is provided by inspector observation of the calibration testing of the fasteners using the selected installation procedure followed by monitoring of the work in progress to assure that the procedure which was demonstrated to provide the specified tension is routinely adhered to. When such a program is followed, no further evidence of proper bolt tension should be required.

GENERAL PROCEDURE FOR INSPECTION OF HIGH STRENGTH FASTENERS INSTALLATION

2.0 INSPECTION DURING INSTALLATION

- 2.1 The Engineer must constantly monitor the surface condition of fasteners in order to prevent accumulation of dirt or rust and to detect any change in the level of lubrication in the bolt, nut and washer assembly. Lack of lubrication will not affect the installation of lockpin and collar fasteners.
- 2.2 Allow only as many fasteners as are anticipated to be installed and tightened during a work shift to be removed from protective storage. Fasteners not used shall be returned to protected storage at the end of the shift.
- 2.3 At any time during the erection process, when the Engineer suspects there may have been a change in the level of lubrication of the bolt, nut and washer assemblies, s/he should immediately require the rotational capacity test to be conducted on two assemblies removed from the structure, as well as all calibration and verification testing.
- 2.4 The Engineer shall monitor the installation of the fasteners in the work to assure that the selected installation method, as demonstrated in the initial testing to provide the specified tension, is routinely properly applied. This monitoring shall also include verification that all plies of connected material have been drawn together and the procedure for snug tightening has been followed.

3.0 FIELD INSPECTION (TURN OF NUT METHOD)

In addition to the requirements of paragraphs 2.1 thru 2.4 above and the requirements of the turn-of-nut procedure, the Engineer shall visually inspect the match marks to assure that the required rotation has been achieved .

FIELD INSPECTION - TWIST OFF BOLTS

- 4.0 In addition to the requirements of paragraphs 2.1 thru 2.4 above and the requirements of the procedure for alternate design fasteners, the inspection of completed joints is required. The following inspection procedure shall be used unless a different procedure is specified in the contract documents.
- 4.1 Inspecting torque wrenches will not be required on the completed connections.
- 4.2 Installation inspection shall be performed in the following manner.
 - a. If the twist-off bolts are installed and tensioned in a single continuous operation, they will give a misleading indication to the inspector that the bolts are properly tightened. Therefore, the only way to inspect these fasteners with assurance is to observe the jobsite testing of the fasteners and installation procedure and then monitor the work while in progress to assure that the specified procedure is routinely followed.
 - b. Visually check that all spliced ends have been sheared off.
 - c. Tap each bolt with a hammer to assure there are no loose bolts.

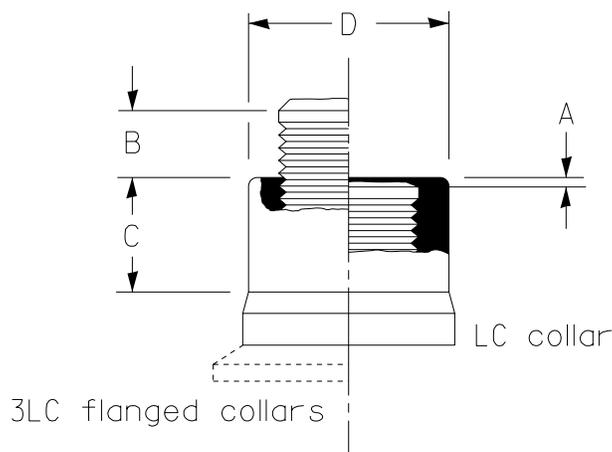
**FIELD INSPECTION
LOCKPIN AND COLLARS FASTENERS (HUCKBOLT, ETC.)**

5.0 In addition to the requirements of paragraphs 2.1, 2.2 and 2.4 above, inspection of completed joints shall be used unless a different procedure is specified in the contract documents.

5.1 Installation inspection shall be performed in the following manner:

- a. If the fasteners are installed and tensioned in a single continuous operation, they will give a misleading indication to the inspector that the bolts are properly tightened. Therefore, the only way to inspect these fasteners with assurance is to observe the jobsite testing of the fasteners and installation procedure and then monitor the work while in progress to assure that the specified procedure is routinely followed.
- b. Randomly measure and visually check each installed fastener for compliance with the dimensions in the following table. Remove and replace all fasteners with a new fastener which do not meet the dimensional requirements of the table. (Note: A hardened mechanically galvanized washer may be used under the head of the fastener to increase the grip so the A and B dimension is within the required tolerance of 1/16 in or 3/8 in respectively).

Dia.	Pin Part. No.	Collar Type C	Collar Type	A Max.	B. Max	C Min.	D Max.
1/2	C50L()-()16	LC-2R16G	3LC-2R16G	1/16	3/8	13/32	.733
5/8	C50L()-()20	LC-2R20G	3LC-2R20G	1/16	3/8	5/8	.916
3/4	C50L()-()24	LC-2R24G	3LC-2R24G	1/16	3/8	21/32	1.110
7/8	C50L()-()28	LC-2R28G	3LC-2R28G	1/16	3/8	3/4	1.282
1	C50L()-()32	LC-2R32G	3LC-2R32G	1/16	3/8	7/8	1.465
1 1/8	C50LR-BR36	LC-2R36G		1/16	3/8	29/32	1.646



FIELD INSPECTION DIRECT TENSION INDICATORS (DTIs)

- 6.1 In addition to the requirements of paragraphs 2.1 thru 2.4 above, the inspection of completed joints is required. The following inspection procedure shall be used unless a different procedure is specified in the contract documents.
- 6.2 All DTIs in the first two connections of each bolting crew must be checked. No more than 10 percent of the DTIs in any connection shall have the minimum allowable gap. The Contractor shall remove and replace any bolts which exceed the 10 percent allowed. No more than 10 percent of the bolts shall have gaps larger than 0.005 inch for galvanized DTIs or 0.015 inch for plain DTIs. Additional tightening will be required on any bolts which exceed the 10 percent allowed.
- 6.3 Testing of 100 percent of the bolts in a connection shall continue until the above requirements are met.
- 6.4 Once the requirements in Step 6.2 are met, a minimum of 20 percent (but not less than 10 bolts of each splice connection and not less than 1 bolt of each cross frame or diaphragm connection) shall be tested with feeler gages. The remainder of the bolts in a connection shall be visually inspected.
- 6.5 If more than 10 percent of the bolts tested in Step 6.4 are at the minimum allowable gap or at a gap greater than 0.005 inch (galvanized DTI) or 0.015 inch (plain DTI), the entire connection shall be tested.

Reuse. A490M (A490) bolts and galvanized A325M (A325) bolts shall not be reused. Other A325M (A325) bolts may be reused if approved by the Engineer. Retightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered as a reuse.

Oversize and Slotted Holes. Oversize, short slotted and long slotted holes require hardened washers under both the bolt head and the nut. Refer to RCSC Specifications for Structural Joints using A325M or A490M ASTM (A325 or A490) Bolts for requirements.

SECTION 508. REINFORCEMENT BARS

508.05 Placing and Securing

Placing. Reinforced concrete design is based on having the reinforcement bars set in accordance with the design. If the bars are not set in the exact positions shown on the plans and then held securely in position while the concrete is being placed, the design allowable loading capability may not be attained. The inspector must ensure that the reinforcement bars be placed in accordance with the plans.

Forms must be oiled before the reinforcing steel is placed so that no oil will come in contact with the bars.

508.06 Splicing

When mechanical reinforcing bar splicers or couplers are allowed, they shall be one of the systems on the current approved list published by the Bureau of Materials and Physical Research. Installation procedures and equipment should be performed in accordance with the manufactures' instructions. If test samples are fabricated, they shall be with the equipment, technique and conditions representative of the job site.

SECTION 512. PILING

Prior to the start of pile driving operations the Resident and/or the pile inspector must review the plans and Standard Specifications as well as the Construction Inspector's Checklist for Piling. If anything appears unclear or contradictory between the plans and Standard Specifications the Supervising Engineer should be notified and the matter resolved prior to the Contractor starting work.

512.07 Welding

It is not the intent of the specification for the inspector to qualify a welder for the purpose of splicing piles. All welders shall produce Evidence of Prequalification to perform the intended welding. The evidence should be appropriate for both the type of process (e.g. fillet) and weld position (e.g. horizontal, vertical or overhead) to be performed.

512.08 Storage and Handling of Piles

- A. Precast and Precast Prestressed Concrete Piles. The Specifications stress the importance of handling concrete piles with care. It is very easy to cause cracks by indifferent handling, and cracks which not only may open up under driving, but which may even spall and "powder" to such an extent as to seriously lessen the strength or life of the pile. Shock, vibration, or excessive deflection must be avoided. When piles are picked up with adjustable slings, blocking should be used to prevent breaking off corners of the pile. The pick-up points should be plainly marked on all piles before removal from the casting bed and all lifting shall be done at these points. All piles must be wetted at least 6 hours before being driven and shall be kept moist until driven.
- B. Steel Piles. In loading steel piles at the fabricator's plant, the individual piles must be placed with webs vertical and so blocked that the flanges will not be bent, nor permanent bends caused in the piles by lack of support. The Department's Inspector at the fabricator's plant

checks the loading into freight cars, but the inspector at the jobsite must check the piling for damage upon arrival.

- C. Material Inspection. If piles arrive on the jobsite without evidence of inspection, the Resident should contact the District Materials Office immediately. No piles shall be used unless there is evidence of inspection or approval from the District Materials Engineer.

In addition to with the materials inspection you must have evidence that all iron and steel products have been wholly manufactured in the United States. Both Federal and State laws require the use of domestically produced steel products in all our projects. Severe consequences included loss of federal participation can result from failure to document source of iron and steel products incorporated into our projects.

Identification of approved piles can be made as follows:

Precast Concrete Piles: Certified Producer List

Precast, Precast Prestressed Concrete Piles: ILL OK Stamp

Timber Piles: Hammer Mark and Tag from Approved Testing Agency or Certification

Steel H-Pile, Metal Shell Piles: ILL-OK Stamp, manufacturer's certification or LA15. If steel piles come from the Contractor's yard, the Contractor must be able to provide manufacturer's certification and heat numbers even if stamped ILL OK.

The heat numbers will be printed on the piles and must agree with the heat numbers shown on the certification. Otherwise, the piles must not be used. Maintain a record of the heat numbers of the piles as they are installed. A separate column in the field pile driving record book can be used for this purpose. (See [Example B](#))

512.09 Preparation for Driving

Prior to driving the production piles, the excavation or embankment in the immediate area of the piling must be complete. Although the area only had to be within two feet prior to driving the test pile, the remainder of the preparation must be completed before starting the remaining piles. The plans should be checked again to ensure any precoring is correctly performed to the depths indicated, and become aware of minimum elevations for the pile tips shown on the plans.

The Contractor shall provide the Resident with the make and model of the hammer. The hammer should be checked for compliance with the energy requirements for the Nominal Required Bearing of the pile being driven as required in Section 512.10 (See [Example A](#))

This is also an ideal time to set up the field pile driving record book or other means of recording the pile driving data which will be forwarded to the Bureau of Bridges and Structures at the end of the job (See [Example B](#)) and compute the required blow per inch (25mm) for the hammer which will be used to obtain 110% of plan bearing on the test pile and plan bearing on the vertical as well as battered pile (See [Examples C, D, & E](#)).

The typical procedure which should be followed to check for hammer compliance and set up charts for Nominal Driven Bearing for use in the field is:

1. The contractor provides hammer specification sheets for the hammer they have chosen.

2. The Resident computes the minimum and maximum energies to drive the piles at penetration rates of between 2 and 10 blows per inch.
3. Verify the hammer selected by the contractor can operate between those rates.
4. Develop a chart showing the relationship between various hammer energies and penetration rate.
5. Drive the piles to the point where the rate of penetration at the energy developed by the hammer equals or exceeds the Nominal required bearing shown on the plans.
6. Record the rate of penetration, energy developed by the hammer at bearing and the Nominal Driven Bearing (R_{NDB}) on your record for that pile.

512.10 Driving Piles

Selection of Hammer. The hammer must meet the energy requirements of the Standard Specifications. Regardless of the type of hammer or type of pile, the energy requirement remains the same. The hammer must develop enough energy to drive the pile to a Nominal Driven Bearing (R_{NDB}) equal to or greater than the Nominal Required Bearing (R_N) shown on the plans at a penetration rate of between two and ten blows per inch (blows per 25mm).

The formulas to check for this are:

Minimum

$$E \geq 0.082 \times [R_N + 100]^2 \text{ (English)} \qquad E \geq 0.005 \times [R_N + 550]^2 \text{ (Metric)}$$

Maximum

$$E \leq 0.193 \times [R_N + 100]^2 \text{ (English)} \qquad E \leq 0.012 \times [R_N + 550]^2 \text{ (Metric)}$$

Where: R_N = Nominal Required Bearing in kips (kN)

E = Energy Developed by the hammer per blow in ft lb (J)

Once the hammer is delivered and is being used, the Resident should check to make sure the required energy is actually being developed as the pile approaches bearing. The delivered energy of the hammer, regardless of the type selected is critical in determining if the pile has achieved a Nominal Driven Bearing at least as great as the Nominal Required Bearing. Consequently either the hammer fall or correctly correlated gages must be properly functioning and monitored during the pile driving operation.

Loss Due to Impact. The successful driving of a pile is dependent upon the weight of the ram with respect to the weight of the pile and the velocity of the ram at the moment of impact with the pile. The driving energy of pile hammers is expressed in foot-pounds (joules) of energy per blow. The blow should be struck by a ram possessing not only sufficient energy to overcome the inertia of the pile and the frictional and elastic resistance encountered, but also sufficient weight to reduce to a minimum the portion of this energy which is unavoidably dissipated during impact.

A considerable amount of the energy of the blow is lost during the impactation period. The percentage of loss depends primarily upon the ratio of the mass (weight) of the pile to the mass (weight) of the striking parts. To a lesser degree, the pile material is involved. Assuming the pile material to be inelastic (which is not strictly true), this loss of energy is about 50 percent when the ratio of the pile mass (weight) to ram mass (weight) is unity. As this ratio increases,

the loss becomes greater. The magnitude of this loss becomes so serious as the ratio increases that it is very important to keep the ratio as low as possible. Some manufacturers do not recommend the use of a hammer having a ram weighing less than one-fourth the mass (weight) of the pile.

In addition to the energy requirements of the hammer, some situations require additional considerations in selecting the hammer.

Gravity (Drop) Hammer. If a gravity hammer cannot be considered for driving precast piles or piles with a Nominal Required Bearing (R_N) greater than 120 kips (533kN). In selecting a gravity hammer, the ram weight (mass) must be equal to or exceed the combined weight (mass) of the Pile being driven and the drive head. A gravity hammer uses a falling weight. Gravity hammers are guided in their fall by riding in a set of leads. Powered by a hoisting engine having a friction clutch, the drop hammer is raised by an attached hoist line to the desired height. The engine is declutched, allowing the drop hammer to free-fall as the hoist line plays out.

The short time-duration forces exerted directly upon the head of a pile by a gravity hammer would surely destroy it. The pile head is thus always protected with a pile cap which the drop hammer strikes. The pile cap rests directly upon the pile head and descends with the pile upon each blow. When the pile has been driven, the cap is attached to the hammer and lifted with the hammer to set upon the next pile.

Remember, no drop is to exceed 15 feet (4.6 m), especially with the heavier hammers, as this may injure the pile. A greater penetration per blow with less injury to the pile head will usually be produced with a heavy hammer and a low fall than with a light hammer and a high fall. In either case, the theoretical amount of energy expended may be the same. With a low fall, more blows can be struck in the same time, and there is less chance for the soil to compact around the pile between the blows. Where hard driving is encountered, it may be necessary to reduce the length of the stroke in order to avoid injury to the pile.

Air/Steam Hammers. Consideration must be given to the weight of the pile in determining hammer size for this type hammer. The striking parts of the hammer must be at least one-third of the weight (mass) of the pile and drive cap combined, and in no case less than 1.4 tons (1.3 metric tons).

Steel H-Piles Driven to Hard Rock. When steel H-piles are driven to hard rock care must be taken to avoid damaging the tip of the pile. If it is observed that the penetration resistance and hammer energy has abruptly increased, the contractor should reduce the energy developed by the hammer and the Resident may calculate the penetration increment over a reduced increment (Less than 1 inch (25mm)) when determining the nominal driven bearing to assure the pile obtains the nominal required bearing without sustaining damage.

Caps and Collars. It is advisable to provide extra pile cushions and shock blocks so that they may be quickly replaced when damaged.

Leads. Ordinarily, the Contractor will use swing leads for driving piles. This is permitted by the Standard Specifications, provided enough guy ropes are used to hold the leads steadily in place and the toe of the leads is set securely in the ground.. It is necessary that the leads be tied rigidly enough to guide and hold the pile in correct position. This is especially important in difficult driving.

Followers. Rarely is it necessary to use a follower in driving piles. If the Contractor wants to use a follower, you should consult your Supervisor before giving permission. One pile in each group of 10 must be driven without a follower and the Nominal Driven Bearing of all the piles in the group determined from that one pile. The piles driven with the follower should be driven to the penetration found to be required for the pile on which the Nominal Driven Bearing was determined without the follower.

A follower, as the word is used in this Article, is a length of pile, timber, or other special material placed on top of the pile to be driven so that the driving can be done from a higher elevation.

Jets. An experienced operator should be able to secure satisfactory alignment of the pile by the use of only one jet. If this cannot be done, two jets may be necessary.

The pump serving the jet should have plenty of capacity at a moderate pressure. The volume and pressure must be sufficient to erode freely the material adjacent to the pile. Volume of water is more important than pressure except for penetration of gravel where both volume and pressure are necessary. For jetted piles, the formula for capacity will be applied after the jet is removed and driving is resumed.

512.11 Penetration of Piles

Records of Penetration. An accurate and complete record should be kept of the penetration and bearing data for all piles driven. This record must include a diagram of the location of piles in each foundation and a tabulation of the initial length, cut-off, length left in place of each pile and heat number of each steel pile. The final pile penetration rate (N_b) in blow per inch (25mm), blows per minute, make and model of hammer used, Energy developed by the hammer and nominal driven bearing must be recorded along with the Inspector's initials. (See [Example B](#)) Remember, unless shown on the plans foundation piles shall be driven to a penetration of at least 10 feet (3 m) below bottom of footing and other piles to a penetration of at least 10 feet (3 m) below undisturbed earth.

Complete and send your Test and production Piling diagrams and data to the District Office when pile driving is completed. They will be filed as a part of the permanent records on the job and kept with bureau of Bridges and Structures records along with other data for the structure.

It is recommended that you calculate the number of blows per inch (25mm) for several hammer energy levels near the Nominal Required Bearing (R_N) in advance of the pile driving operation. You will then know the Nominal Driven Bearing (R_{NDB}) as driving progresses and you may quickly determine when the pile has reached its required bearing.

By keeping complete records for driving test piles, the length of piles ordered, and the driving of production piles, including pile diagrams, you will have all the information needed to determine the payment due the Contractor for furnishing and driving piles.

Excess Penetration. When the pile has attained the required penetration and nominal driven bearing, the Contractor is not required to continue driving unless called for in the plans or Special Provisions.

512.14 Determination of Nominal Driven Bearing

- A. Formulas. The Standard Specifications (512.14) provide the required formula for determining Nominal Driven Bearing (R_{NDB}) based the FHWA modified Gates formula. See the typical bearing computations for vertical and battered pile in attached examples.
- B. Wave Equation. A Wave equation analysis is required to determine the nominal driven bearing of more heavily loaded piles. When this analysis is required, the Bureau of Bridges and Structures must be contacted to perform the analysis.
- C. LoadTests. Load tests are the most accurate method of determining the ultimate axial resistance or nominal driven bearing of piles. This test is used when the structure is complex or when a large number of foundation piles are required. If a load test is required, discuss the matter thoroughly with your supervisor. The procedure will be governed by the contract requirements.

512.15 Test Piles

The location of the test pile will be specified in the plans to be driven in a production location of a designated substructure unit. However, the Engineer may have to select which individual pile location shall be used as the test pile within the designated substructure unit. The test pile location should be as far away from the nearest soil boring location as possible in order to obtain more comprehensive subsoil data in the area of the structure.

If the Contractor elects to drive the test pile out of the footing area or in a non permanent location, written permission of the Engineer is required and, the replacement of production pile in the footing area will not be paid for. Where treated timber piles are specified, test piles not driven in a production location or driven outside the footing area may be untreated piles with the written permission of the Engineer..

In driving a test pile, be sure to keep a complete record of the driving data all the way down and report on Form [BC 757](#), Test Pile Driving Record. In doing this, you may delay the driving somewhat but a test pile is driven to help determine the itemized list of lengths to be furnished by the contractor. This is also the final check to the accuracy of the subsurface information upon which the estimated lengths of piling shown in the plans was based. You should notify your supervisor before driving the test pile.

Pile Driving Information Submittals

Submit pile data with accompanying authorization after all piling have been driven on your contract. The piling diagram should be neat, accurate and the piling numbers should correspond to the pile data tabulation for each pier, abut, etc. Show locations of all test piles. One copy of this information is required and prints will be made and returned for your files.

It is important that the summary of length sheet clearly indicate the total furnished quantity and total driven quantity. These quantities should correspond to those in your Quantity Book.

EXAMPLE A

Typical Calculations - Single Acting Diesel Hammer - H – Pile Driven

Given:

Type & Size: Steel HP12x74
 Nominal Required Bearing: 589 kips (2620 kN)
 Allowable Resistance Available: 163 kips (1870 kN)
 Est Length: 60 ft.

Contractor proposes to use a Delmag D12-32 hammer

Ram = 2820 lbs.

MAXIMUM operating energy of 32,881 ft-lbs. (44,553 J)

Check for the MINIMUM Energy requirement:

ENGLISH

Minimum

$$E \geq 0.082 \times [R_N + 100]^2 \text{ (English)}$$

METRIC

Minimum

$$E \geq 0.005 \times [R_N + 550]^2 \text{ (Metric)}$$

Hammer must develop be at least

$$0.082 \times [589 + 100]^2 = 0.082 \times [689]^2 =$$

38,927.1 ft-lbs Energy Hammer must develop be at least

$$0.005 \times [2620 + 550]^2 = 0.005 \times [3170]^2 = \mathbf{50,244.5 \text{ J Energy}}$$

The MAXIMUM operating energy of the hammer (32,881 ft-lbs. (44,553 J)) is LESS than the MINIMUM required energy (38,927 ft-lbs. (50,245 J)) for the Nominal Required Bearing.

∴ Inform Contractor the energy of the **hammer does not meet specifications.**

The Contractor subsequently proposes to use a **Delmag D16-32** hammer with a rated energy of 41,136 ft lbs (56,944 J) which exceeds MINIMUM specification.

Now we must check for the MAXIMUM energy:

ENGLISH

Maximum

$$E \leq 0.193 \times [R_N + 100]^2 \text{ (English)}$$

METRIC

Maximum

$$E \leq 0.012 \times [R_N + 550]^2 \text{ (Metric)}$$

Hammer Energy must not exceed

$$0.193 \times [589 + 100]^2 = 0.193 \times [689]^2 =$$

91621.1 ft-lbs Hammer Energy must not exceed

$$0.012 \times [2620 + 550]^2 = 0.012 \times [3170]^2 = 120,587 \text{ J}$$

The MAXIMUM operating energy of the hammer (41,136 ft-lbs. (56,944 J)) is LESS than the MAXIMUM allowable energy (91,621 ft-lbs.(120,587 J)) for the Nominal Required Bearing.

∴ Inform Contractor the energy of the **hammer meets energy requirements**, and the hammer should be able to meet requirement to drive the pile between 2 and 10 blows per inch (25mm) when the Nominal Driven Bearing (R_{NDB}) reaches the Nominal Required Bearing (R_N) shown on the plans.

Set up your Table of Nominal Driven Bearing values for this hammer:

589 Production Pile Nominal Required Bearing (kips)
 647.9 Test Pile Nominal Required Bearing (kips)

				blows/ft	120	108
	ft-lbs			H	11	11.5
Minimum Hammer Energy	38927.12	45867.06	42819.83	Nb	10.0	9.0
Maximum Hammer Energy	91621.15			W	3528	3528
				RNDB	589	589

Table of Nominal Driven Bearing at various blows/in v. hammer fall
 Fall (ft) / hammer Energy (ft-lbs)

Delmag D 16-32	Wt ram		3528 #						
Fall	4	4.5	5	5.5	6	6.5	7	7.5 Ft	
E	14112	15876	17640	19404	21168	22932	24696	26460 Ft-lbs	
Blow/in	206.2	133.3	92.1	67.1	50.8	39.8	32.0	26.3 Nb	
1	108	121	132	144	155	165	175	185	
2	170	187	202	217	231	245	258	270	
3	207	226	243	260	276	291	306	320	
4	233	253	272	291	308	325	341	356	
5	253	275	295	314	333	350	367	384	
6	270	292	313	333	353	371	389	406	
7	284	307	329	350	370	389	407	425	
8	296	320	342	364	385	404	423	442	
9	306	331	354	376	398	418	437	456	
10	316	341	365	388	409	430	450	469	

Delmag D 16-32	Wt ram		3528 #						
Fall	8	8.5	9	9.5	10	10.5	11	11.5	11.66 Ft
E	28224	29988	31752	33516	35280	37044	38808	40572	41136.48 Ft-lbs
Blow/in	22.1	18.8	16.2	14.1	12.5	11.1	10.0	9.0	8.7 Nb
1	194	203	212	220	229	237	245	252	255
2	283	294	306	317	328	338	349	359	362
3	334	348	361	373	386	398	409	421	424
4	371	386	400	413	427	440	452	465	469
5	399	415	430	444	458	472	486	499	503
6	423	439	454	470	484	499	513	527	531
7	442	459	475	491	506	521	536	550	555
8	460	477	493	510	526	541	556	571	575
9	475	492	509	526	542	558	574	589	594
10	488	506	524	541	557	574	589	605	610

This hammer meets requirements, but must be operated near it maximum energy to achieve Nominal Required Bearing

EXAMPLE B

TYPICAL COMPUTATIONS: Air/Steam Hammer - Precast Concrete Pile

Plan Piling: Type & Size: 14 in x 14 in x 50 ft Precast Concrete Pile
 Nominal Required Bearing 256 kips
 Allowable Resistance Available: 85 kips
 Est Length: 60 ft.

Vulcan 506 weight of striking parts: 6,500 pounds (2948 kg)
 Height of Fall 5 foot (1.5m)
 Rated Energy 32,500 ft-lbs. (44.1 kJ)

Weight of Drive Cap = 1080 lbs (491 kg)
 1 cubic foot concrete = 150 lbs (1 cubic meter concrete = 2403 kg)
 Check acceptability of chosen air/steam hammer.

Check minimum Air hammer size

Weight of Pile and Helmet =

ENGLISH

METRIC

$(14/12)(14/12)50ft * (150 \text{ lb/cu ft}) + 1080 \text{ \#}$
 (helmet) = 11,288 pounds

$(.352)(.352)(15m) * (2403\text{kg/cu m}) + 491 \text{ kg}$
 (helmet) = 4957 kg

$11,288/3 = 3,763 \text{ lbs}$
 $3763 \text{ \#} < 6500 \text{ \#}$ therefore hammer is OK

$4957/3 = 1652 \text{ kg}$
 $1652 \text{ kg} < 2948 \text{ kg}$ therefore hammer is OK

Minimum required hammer energy

$E \geq 0.082 \times [R_N + 100]^2$ (English)
 $32,500 \geq 0.082(256+100)^2$? Yes (10,392) OK

$E \geq 0.005 \times [R_N + 550]^2$ (Metric)
 $44.1 \geq 0.005(1139+550)^2$? Yes... OK

Maximum allowable Hammer energy

$E \leq 0.193 \times [R_N + 100]^2$
 $32,500 \leq 0.193 \times [256 + 100]^2$? (24,460) NO

$E \leq 0.012 \times [R_N + 550]^2$
 $44,100 \leq 0.012 \times [1139 + 550]^2$? (34,233) NO

Hammer exceeds MAXIMUM energy allowable

Determine Maximum allowable fall H

$E = WH \quad | \quad 24460 = 6500 * H \quad | \quad 34,233 = 2948(9.806) * h$

$H = 3.76' (1.18 \text{ m})$

Unless this hammer can operate at a fall of less than 3.76 feet (1.18 m), this hammer cannot be used.

EXAMPLE C

TYPICAL COMPUTATIONS – Drop Hammer – Timber Pile

Plan Piling: Type & Size: Timber Pile
 Nominal Required Bearing 153 kips
 Allowable Resistance Available: 51 kips
 Est Length: 24 ft.

Outside Rows to be driven on 12:2 V : H batter

Given: Drop (GRAVITY) Hammer
 Ram Weight = 2500 lbs
 Height of Fall = MAXIMUM 15 ft

Determine if hammer is correctly sized:

Energy Developed by the hammer (E) vertical Pile = Height Fall * Weight Ram
 $= 2500 * 15 = \underline{37,500 \text{ Ft lbs}}$ MAXIMUM

Energy Developed by the hammer (E) battered Pile =
 Height Fall * Weight Ram * Hammer Energy Reduction coefficient "U"
 U for 12:2 (V:H) = 94.5% (from Table in Section 512)

Determine Fall Heights to meet Energy requirements for Vertical Pile:

Minimum required hammer energy	Maximum allowable Hammer energy
Is $E > 0.082 \times [RN + 100]^2$? YES!	$E < 0.193 \times [RN + 100]^2$? NO!
$E > 0.082 \times [RN + 100]^2 = 5,248 \text{ ft-lbs}$	$E \text{ not } < 0.193 \times [153 + 100]^2 (=12,353 \text{ ft-lbs})$
Drop required to achieve MINIMUM energy	Must restrict Height of Hammer Fall
$5248 > Wt \text{ Hammer} \times \text{Height Fall}$	How much?
$5248 > 2500 \times \text{Ht Fall}$	Maximum Energy = 12,353 = Ht Fall * 2500 #
Minimum Height Fall = $5248/2500 = 2.1 \text{ feet}$	Maximum Ht Fall = 4.9 feet

Hammer must be operated at an average of between 2.1 and 5 foot fall at nominal driven bearing to meet energy requirements

Determine Fall Heights to meet Energy requirements for Battered Pile

Adjust the hammer energy above by the Hammer Energy Reduction coefficient "U" (The minimum and maximum energies requirements to drive the 153 kip pile remain the same, but the energy the hammer develops is reduced). The weight of hammer remains the same, so distance the hammer falls along the batter must increase to accommodate the loss of energy due to the batter.

Minimum hammer fall to achieve E	Maximum hammer fall to restrict E
$5,248 = 2500 \# * \text{Ht fall} * .945$	$12353 = 2500 \# * \text{Ht Fall} * .945$
$\text{Ht fall} = 5248 / (2500 \# * .945) = 2.22'$	$\text{Ht fall} = 12353 / (2500 \# * .945) = 5.23'$
Ht Fall = 2.22' average Ht Fall at R_{NDB}	Ht Fall = 5.23' average Ht fall at R_{NDB}

Hammer must be operated at an average of between 2¼ and 5¼ foot fall at nominal driven bearing to meet energy requirements

153 Production Pile Nominal Required Bearing (kips)				
168.3 Test Pile Nominal Required Bearing (kips)				
		blows/ft	25	X
		H	5	4
	Production Test	Nb	2.1	2.8
Minimum Hammer Energy (ft-lbs)	5248.74 5902.76	W	2500	2500
Maximum Hammer Energy (ft-lbs)	12353.74 13893.08	RNDB	158	153

Table of Nominal Driven Bearing at various blows/in v. hammer fall Plumb (Vertical) Pile
 Ht Fall (ft) / hammer Energy (ft-lbs)

Drop Hammer	Wt ram		2500							7 Feet
Fall	2	2.5	3	3.5	4	4.5	5	6	17,500 Ft-lbs	
E	5,000	6,250	7,500	8,750	10,000	11,250	12,500	15,000	1.2 Nb	
Blow/in	11.1	6.7	4.7	3.5	2.8	2.3	2.0	1.5	1.2 Nb	
1	24	38	52	64	75	86	96	114	132	
2	61	80	97	113	128	141	155	179	201	
3	83	104	124	142	158	174	189	217	242	
4	98	122	143	162	180	197	213	243	271	
5	110	135	157	178	197	215	232	264	293	
6	120	146	169	191	211	230	248	281	312	
7	128	155	180	202	223	242	261	295	327	
8	135	163	188	212	233	253	272	308	341	
9	142	170	196	220	242	263	282	319	352	
10	147	177	203	227	250	271	291	329	363	

Table of Nominal Driven Bearing at various blows/in v. hammer fall Batter 12:2 (V:H) Pile
 Ht Fall (ft) / hammer Energy (ft-lbs) 0.945 Hammer Energy Reduction Coefficient

Drop Hammer	Wt ram		2500							7 Feet
Fall	2	2.5	3	3.5	4	4.5	5	6	16,538 Ft-lbs	
E	4,725	5,906	7,088	8,269	9,450	10,631	11,813	14,175	1.3 Nb	
Blow/in	12.7	7.6	5.2	3.9	3.1	2.5	2.1	1.6	1.3 Nb	
1	20	34	47	59	70	80	90	108	125	
2	57	75	92	107	121	135	147	171	193	
3	78	99	118	135	151	167	181	208	232	
4	93	115	136	155	173	189	205	234	261	
5	104	128	150	170	189	207	223	254	282	
6	114	139	162	183	202	221	238	270	300	
7	122	148	172	194	214	233	251	284	315	
8	129	156	180	203	224	243	262	297	328	
9	135	163	188	211	232	253	272	307	340	
10	141	169	195	218	240	261	280	317	350	

EXAMPLE D

TYPICAL COMPUTATIONS – Metal Shell Pile – Double-Acting Hammer

Type & Size: Metal Shell – 12 in. dia x 0.179 in. walls
 Nominal Required Bearing: 256 kips
 Allowable Resistance Available: 85 kips
 Est Length: 65 ft.

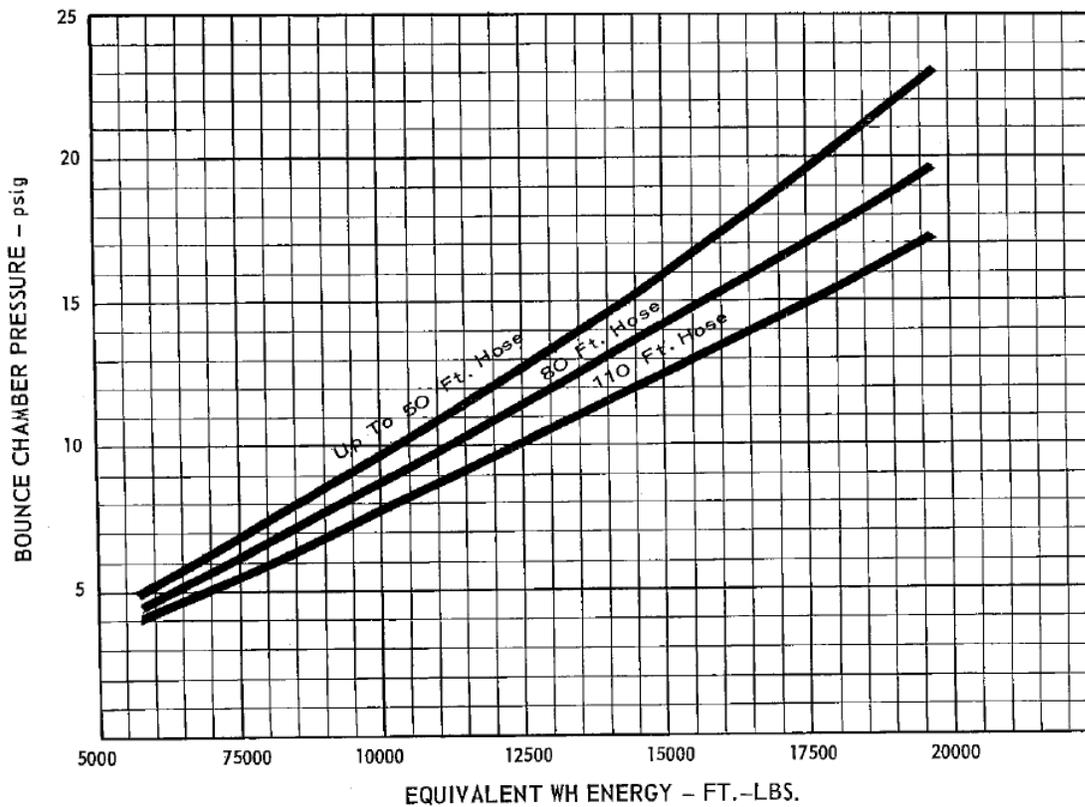
Proposed hammer is a: Link-belt 440 Ram Weight = 4000 lbs
 Maximum Energy Developed by the Hammer per blow (E) = 18,200 Ft-lbs.

LINK-BELT SPEEDER

MODEL 440 DIESEL PILE HAMMER

BOUNCE CHAMBER PRESSURE vs. EQUIVALENT WH ENERGY

SEA LEVEL TO 2000' ELEVATION



CAUTION – GRAPHS VALID ONLY FOR GAGE HOSE AS FURNISHED IN LENGTHS INDICATED

Energy developed by the hammer (E) = read via Bounce Chamber pressure gage based on length of hose. In this example, the contractor provided the following data sheet and is using an 80 foot hose. PLEASE NOTE Different hammers may have different charts. Use the chart for the hammer provided.

Determine if hammer is correctly sized:

Determine Energy for Vertical Pile:

Minimum required hammer energy

$$E \geq 0.082 \times [R_N + 100]^2$$

$$E \geq 0.082 \times [256 + 100]^2 = 10,392 \text{ ft-lbs}$$

$$18,200 \geq 10,392$$

Maximum allowable Hammer energy

$$E < 0.193 \times [R_N + 100]^2$$

$$E \leq 0.193 \times [256 + 100]^2 (=24,460 \text{ ft-lbs})$$

$$18,200 < 24,460 \text{ ft-lbs.}$$

Hammer is acceptable

From the provided chart, minimum pressure reading must be 9.0

Hammer meets energy requirements to set pile at between 2 and 10 blows per inch.

Chart R_{NDB} for various guage readings and blows per inch within the above range.

256 Production Pile Nominal Required Bearing (kips)

281.6 Test Pile Nominal Required Bearing (kips)

	ft-lbs	Test	blows/ft Nb	25 2.1	3.9
Minimum Hammer Energy	10392.35	11940.72	E	13000	16600
Maximum Hammer Energy	24460.05	28104.38	RNDB	163	259

Table of Nominal Driven Bearing at various blows/in v. hammer fall

Fall (ft) / hammer Energy (ft-lbs)

Delmag 36

Guage Rd	9	10	11	12	13	14	15	16	17	18
E	10200	11200	12100	13000	13900	14800	15700	16600	17500	18300
Blow/in	10.3	8.4	7.1	6.1	5.3	4.7	4.2	3.8	3.4	3.2
1	77	85	93	100	106	113	119	125	132	137
2	130	141	150	160	168	177	185	193	201	208
3	161	174	184	195	205	214	224	233	242	250
4	183	197	208	220	231	241	251	261	271	279
5	200	215	227	239	251	262	273	283	293	302
6	214	229	242	255	267	279	290	301	312	321
7	226	242	255	268	281	293	305	316	327	337
8	236	252	266	280	293	305	317	329	341	351
9	245	262	276	290	303	316	329	341	352	363
10	253	270	285	299	313	326	339	351	363	373

**Hammer Energy Reduction Coefficients
for
BATTERED PILES**

NOTE: If the hammer has internal ram velocity monitoring, no friction losses or stroke reductions should be used. Because the measured impact velocity is used to control the nominal energy delivered to the pile, losses are internally corrected by the hammer operating system.

u = A coefficient less than unity

m = Tangent of the Angle of Batter Horizontal dimension / Vertical dimension

	<u>Driven with Drop Hammer</u>	<u>Driven with All other Hammers</u>
	$u = \frac{0.25(4 - m)}{(1 + m^2)^{0.5}}$	$u = \frac{0.1(10 - m)}{(1 + m^2)^{0.5}}$
<u>Batter</u> V:H	<u>"u"</u>	<u>"u"</u>
12:1/2	0.989	0.995
12:1	0.976	0.988
12:1 ½	0.961	0.98
12:2	0.945	0.97
12:2 ½	0.928	0.959
12:3	0.91	0.946
12:3 ½	0.89	0.932
12:4	0.87	0.917

Example: Determine the Energy Developed by the Hammer per blow on a pile with a 12:2 (V:H) batter if the Energy Developed for vertical bearing is 25,000 ft-lbs and an air hammer is used:

$$25,000 \text{ Ft-lbs} \times 0.97 = 24,250 \text{ ft-lbs}$$

The Energy Developed by the Hammer on a pile battered at 2 in 12 is 24,250 ft-lbs

PILE HAMMER DATA (ENGLISH)

Mfgr.	Model	Type	Blows Per Min.	Stroke At Rated Energy, In.	Ram Weight, Lbs.	Rated Energy Ft. Lbs.
Link-Belt (Diesel) **	105	Dbl-Act	90-98	35.23	1,445	7,500
	180	Dbl-Act	90-95	37.60	1,725	8,100
	312	Dbl-Act	100-105	30.89	3,857	15,000
	440	Dbl-Act	86-90	38.40	4,000	18,200
	520	Dbl-Act	80-84	43.17	5,070	26,300
Vulcan (Steam-Air)	18C	Dbl-Act	150	10 1/2	1,800	3,600
	2	Sgl-Act	70	29	3,000	7,260
	30C	Dbl-Act	133	12 1/2	3,000	7,260
	1	Sgl-Act	60	36	5,000	15,000
	50C	Dbl-Act	120	15 1/2	5,000	15,100
	65C	Dbl-Act	117	15 1/2	6,500	19,200
	06	Sgl-Act	60	36	6,500	19,500
	0	Sgl-Act	50	39	7,500	24,375
	80C	Dbl-Act	111	16 1/2	8,000	24,450
	08	Sgl-Act	50	39	8,000	26,000
	OR	Sgl-Act	80	39	9,300	30,225
	010	Sgl-Act	50	39	10,000	32,500
	140C	Dbl-Act	103	15 1/2	14,000	36,000
	014	Sgl-Act	60	36	14,000	42,000
	016	Sgl-Act	60	36	16,250	48,750
	020	Sgl-Act	60	36	20,000	60,000
	030	Sgl-Act	55	36	30,000	90,000
400C	Diff	100	16 1/2	40,000	113,488	
McKiernan- Terry (Diesel)	DE-10	Sgl-Act	48-52	Var.*	1,100	8,800
	DE-20	Sgl-Act	48-52	Var.*	2,000	16,000
	DE-30	Sgl-Act	48-52	Var.*	2,800	22,400
	DE-40	Sgl-Act	48-52	Var.*	4,000	32,000
	DA-35	Sgl-Act	48-82	Var.*	2,800	22,400
	DA-35	Dbl-Act	48-82		2,800	21,000
	DA-55	Sgl-Act	48-82	Var.*	5,000	40,000
	DA-55	Dbl-Act	48-82		5,000	38,000
	DE-50	Sgl-Act	40-50	Var.*	5,000	40,000
	DE-70	Sgl-Act	40-50	Var.*	7,000	56,000
McKiernan- Terry (Steam-Air)	9-B-2	Dbl-Act	140	16	1,500	8,200
	9-B-3	Dbl-Act	145	17	1,600	8,750
	S-3	Sgl-Act	65	36	3,000	9,000
	C-3	Dbl-Act	130-140	16	3,000	9,000
	10-B-3	Dbl-Act	105	19	3,000	13,100
	10-B-2	Dbl-Act	115	20	2,500	15,000
	C-5	Dbl-Act	100-110	18	5,000	16,000
	S-5	Sgl-Act	60	39	5,000	16,250
11-B-3	Dbl-Act	95	19	5,000	19,150	
McKiernan-	11-B-2	Dbl-Act	120	20	3,625	22,080

Terry (Steam-Air)	C-826	Dbl-Act	85-95	18	8,000	24,000
	S-8	Sgl-Act	55	39	8,000	26,000
	C-8	Dbl-Act	77-85	20	8,000	26,000
	S-10	Sgl-Act	55	39	10,000	32,500
	S-14	Sgl-Act	60	32	14,000	37,500
Union (Stream)	00	Dbl-Act	85	36	6,000	54,900
	0A	Dbl-Act	90	21	5,000	22,050
	0	Dbl-Act	110	24	3,000	19,850
	1	Dbl-Act	130	21	1,850	13,100
	1A	Dbl-Act	120	18	1,600	10,020
	1 1/2A	Dbl-Act	125	18	1,500	8,680
	2	Dbl-Act	145	16	1,025	5,755
Delmag (Diesel)	D-5	Sgl-Act	50-60	Var.*	1,100	9,050
	D-12	Sgl-Act	50-60	Var.*	2,750	22,610
	D-15	Sgl-Act	50-60	Var.*	3,300	27,000
	D-22	Sgl-Act	50-60	Var.*	4,850	39,780
	D-30	Sgl-Act	39-60	Var.*	6,600	54,200
	D-36	Sgl-Act	37-53	Var.*	7,940	73,780
	D-44	Sgl-Act	37-55	Var.*	9,460	87,000
	D-55	Sgl-Act	36-47	Var.*	11,860	117,175
Conmaco	50	Sgl-Act	60	36	5,000	15,000
	65	Sgl-Act	60	36	6,500	19,500
	80	Sgl-Act	50	39	8,000	26,000
	100	Sgl-Act	50	39	10,000	32,500
	115	Sgl-Act	50	39	11,500	37,375
	125	Sgl-Act	50	39	12,500	40,625
	140	Sgl-Act	60	36	14,000	42,000
	160	Sgl-Act	60	36	16,250	48,750
	200	Sgl-Act	60	36	20,000	60,000
	300	Sgl-Act	55	36	30,000	90,000
Kobe	K-13	Sgl-Act	45-60	102	2,860	24,400
	K-22	Sgl-Act	45-60	102	4,850	41,300
	K-25	Sgl-Act	39-60	110	5,510	50,700
	K-32	Sgl-Act	45-60	102	7,050	60,100
	K-35	Sgl-Act	39-60	110	7,700	70,800
	K-42	Sgl-Act	45-60	102	9,260	79,000
	K-45	Sgl-Act	39-60	110	9,900	91,100
	K-60	Sgl-Act	35-60	102	13,200	112,600

* Use actual length of stoke as observed in field. Rated energy is determined by stoke which increases with driving resistance.

** Equivalent HW energy is obtained by plotting the observed bounce chamber pressure on the corresponding chart provided in the gage box.

PILE HAMMER DATA (METRIC)

Mfgr.	Model	Type	Blows Per Min.	Stroke At Rated Energy, mm	Ram Weight, kN	Rated Energy J
Link-Belt (Diesel) **	105	Dbl-Act	90-98	895	6.42	10,169
	180	Dbl-Act	90-95	955	7.67	10,982
	312	Dbl-Act	100-105	785	17.16	20,337
	440	Dbl-Act	86-90	975	17.79	24,676
	520	Dbl-Act	80-84	1,097	22.55	35,658
Vulcan (Steam-Air)	18C	Dbl-Act	150	267	8.00	4,881
	2	Sgl-Act	70	737	13.34	9,843
	30C	Dbl-Act	133	318	13.34	9,843
	1	Sgl-Act	60	914	22.24	20,337
	50C	Dbl-Act	120	394	22.24	20,473
	65C	Dbl-Act	117	394	28.91	26,032
	06	Sgl-Act	60	914	28.91	26,438
	0	Sgl-Act	50	991	33.36	33,048
	80C	Dbl-Act	111	419	35.58	33,150
	08	Sgl-Act	50	991	35.58	35,251
	OR	Sgl-Act	80	991	41.36	40,980
	010	Sgl-Act	50	991	44.48	44,064
	140C	Dbl-Act	103	394	62.26	48,810
	014	Sgl-Act	60	914	62.26	56,944
	016	Sgl-Act	60	914	72.27	66,096
	020	Sgl-Act	60	914	88.95	81,349
030	Sgl-Act	55	914	133.43	122,024	
400C	Diff	100	419	177.90	153,869	
McKiernan-Terry (Diesel)	DE-10	Sgl-Act	48-52	Var.*	4.89	11,931
	DE-20	Sgl-Act	48-52	Var.*	8.89	21,693
	DE-30	Sgl-Act	48-52	Var.*	12.45	30,370
	DE-40	Sgl-Act	48-52	Var.*	17.79	43,386
	DA-35	Sgl-Act	48-82	Var.*	12.45	30,370
	DA-35	Dbl-Act	48-82	Var.*	12.45	28,472
	DA-55	Sgl-Act	48-82	Var.*	22.24	54,233
	DA-55	Dbl-Act	48-82	Var.*	22.24	51,521
	DE-50	Sgl-Act	40-50	Var.*	22.24	54,233
	DE-70	Sgl-Act	40-50	Var.*	31.13	75,926
McKiernan-Terry (Steam-Air)	9-B-2	Dbl-Act	140	406	6.67	11,118
	9-B-3	Dbl-Act	145	432	7.12	11,863
	S-3	Sgl-Act	65	914	13.34	12,202
	C-3	Dbl-Act	130-140	406	13.34	12,202
	10-B-3	Dbl-Act	105	483	13.34	17,761
	10-B-2	Dbl-Act	115	508	11.12	20,337
	C-5	Dbl-Act	100-110	457	22.24	21,693
	S-5	Sgl-Act	60	991	22.24	22,032
	11-B-3	Dbl-Act	95	483	22.24	25,964

McKiernan-Terry (Steam-Air)	11-B-2	Dbl-Act	120	508	16.12	29,937
	C-826	Dbl-Act	85-95	457	35.58	32,540
	S-8	Sgl-Act	55	991	35.58	35,251
	C-8	Dbl-Act	77-85	508	35.58	35,251
	S-10	Sgl-Act	55	991	44.48	44,064
	S-14	Sgl-Act	60	813	62.26	50,843
Union (Stream)	00	Dbl-Act	85	914	26.69	74,435
	0A	Dbl-Act	90	533	22.24	29,896
	0	Dbl-Act	110	610	13.34	26,913
	1	Dbl-Act	130	533	8.23	17,761
	1A	Dbl-Act	120	457	7.12	13,585
	1 1/2A	Dbl-Act	125	457	6.67	11,769
	2	Dbl-Act	145	406	4.56	7,803
Delmag (Diesel)	D-5	Sgl-Act	50-60	Var.*	4.89	12,270
	D-12	Sgl-Act	50-60	Var.*	12.23	30,655
	D-15	Sgl-Act	50-60	Var.*	14.68	36,607
	D-22	Sgl-Act	50-60	Var.*	21.57	53,935
	D-30	Sgl-Act	39-60	Var.*	29.36	73,485
	D-36	Sgl-Act	37-53	Var.*	35.32	100,032
	D-44	Sgl-Act	37-55	Var.*	42.07	117,956
D-55	Sgl-Act	36-47	Var.*	52.75	158,868	
Conmaco	50	Sgl-Act	60	914	22.24	20,337
	65	Sgl-Act	60	914	28.91	26,438
	80	Sgl-Act	50	991	35.58	35,251
	100	Sgl-Act	50	991	44.48	44,064
	115	Sgl-Act	50	991	51.14	50,674
	125	Sgl-Act	50	991	55.59	55,080
	140	Sgl-Act	60	914	62.26	56,944
	160	Sgl-Act	60	914	72.27	66,096
	200	Sgl-Act	60	914	88.95	81,349
	300	Sgl-Act	55	914	133.43	122,024
Kobe	K-13	Sgl-Act	45-60	2,591	12.72	33,082
	K-22	Sgl-Act	45-60	2,591	21.57	55,995
	K-25	Sgl-Act	39-60	2,794	24.51	68,740
	K-32	Sgl-Act	45-60	2,591	31.36	81,485
	K-35	Sgl-Act	39-60	2,794	34.25	95,992
	K-42	Sgl-Act	45-60	2,591	41.18	107,110
	K-45	Sgl-Act	39-60	2,794	44.03	123,515
K-60	Sgl-Act	35-60	2,591	58.70	152,665	

* Use actual length of stoke as observed in field. Rated energy is determined by stoke which increases with driving resistance.

** Equivalent HW energy is obtained by plotting the observed bounce chamber pressure on the corresponding chart provided in the gage box.

PRECAST PRESTRESSED CONCRETE DECKS

The design of a precast prestressed concrete deck is predicated on the fact that several beams placed and grouted together will act as one unit.

Two very important items must be carefully checked prior to erecting any precast deck beams.

1. Check the precast deck beams keyways to be sure that there is no form of oil, grease, laitance or other foreign materials in the keyways. Cleaning, if necessary shall be done by sandblasting the keyway areas between top of beam and the bottom edge of keyway.
2. Check the bearing seats to be sure they are level in all directions. If they are not level, the bearing seats should be ground level. Shim pads may be used as required by the plans.

Erection of beams shall not begin until the bearing seats are level and the keyways are clean.

Erecting must start at the expansion joints and the beams set from the joint so that the minimum expansion width is obtained. The beams may need to be shifted or interchanged to obtain the best fit. After the beams are properly placed an approved non-shrink grout shall be used for grouting dowels at fixed ends of the deck beams. A 24-hour curing period is required for the dowels before keyway grout is placed. Retainer clips must also be in place at expansion end of beams prior to placing keyway grout. Once the beams have all been set and are ready for the keyways to be grouted, care must be taken to ensure that the grouting is performed in accordance with the Standard Specifications. Only approved non-shrink, non-metallic grout shall be used in the keyways. The manufacturer's directions for mixing and application of the grout must be followed with one exception. No coarse aggregate including pea gravel is to be added to the grout. The minimum grout temperature at time of placement shall be 10°C (50°F).

1. Check with a thin feeler gauge between the bottom of the precast beam and bearing pad to ensure that the beam is properly seated on the bearing. If a feeler gauge can be inserted in this area - Stop. By either grinding the bearing seats and/or using shim pads or inserting stainless steel shim plates as called for on the plans, the bearing pad should be leveled to provide 100% bearing contact.
2. If openings due to casting of the beams are evident below the keyways, caulking or a strip of compressible material to prevent the loss of water in the grout should be inserted between the beams below the bottom of the keyway. The compressible material must be placed continuously and below the lowest point of the keyway (wood is not considered to be compressible material).
3. Prior to the grouting of the keyways, the keyway surfaces must be soaked with water for one to two hours. This can be done by placing wet burlap in the keyway slot. The wet burlap should be removed from one keyway at a time. As the grout is placed and finished the wet burlap that was previously in the keyway can then be placed over the completed keyway as the work progresses. This will prevent the grout from drying before the curing is started. Since a three-day cure is required on the grouted keyways, polyethylene should be placed over the wet burlap to prevent its drying out before the curing period is over.

Stage Construction

On bridges where stage construction is specified, ensure that the keyway clamps are installed as detailed on the plans. Check the Special Provisions for Stage Construction PPC Deck Beams for additional requirements. The procedure for grouting the keyway is similar to the above, however, the clamping rods must be properly tightened and have adequate water soluble lubrication in the keyway area to allow easy removal of the rods after the grout is cured and the holes are properly filled. Traffic in the staged lanes shall be kept as far away as possible until the grout in the stage construction keyway is cured.

Equipment must not be allowed on the beams during the grouting and curing period.

CRITICAL CONTROLS IN THE CONSTRUCTION OF NEOPRENE EXPANSION JOINTS

Construction Problems and Controls

A. Forming and Control of Concrete Blockouts

1. Inaccurate construction of blockouts is the greatest single cause of joint failures.
2. The geometry of blockouts is critical (See shop drawings).
 - a. Dimensions are fixed and must be maintained - horizontal, vertical and anchor bolt placement.
 - b. Potential problems if dimensions are not maintained:
 - (1) Over-extension or compression of seal - tearing or pullout of convolution on strip seals, overloading and shearing of anchors,
 - (2) Inadequate seating area for seal - breakout of anchor bolts, edge and rotational load on neoprene type joints.
 - (3) Vulnerable to traffic and snowplow impacts if vertical depth of the expansion joint is not maintained.
3. Control of blockout profile is vitally important.
 - a. Non-parallelism of seats - problem most frequently encountered:
 - (1) Distortion of seal.
 - (2) Vulnerable to traffic and snowplow impacts.
 - (3) Destruction from slapping or banging under traffic.
 - b. Transverse alignment and elevation of seats.
 - (1) High or low spots on seats will allow leakage under seal.

- (2) If proper alignment is not maintained, unit ends could be high and susceptible to damage or ends will not properly fit together allowing joint leakage.

4. Inspection and Resident control of blockout placement is vital for effective sealing.

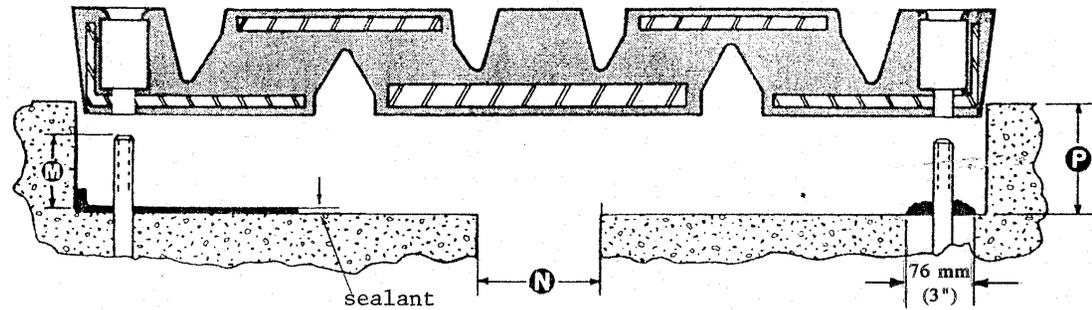
- a. The Standard Specifications require that Contractor not place the seal until the Engineer has inspected and approved the concrete blockout and bolt layout.
- b. The inspector must check the horizontal and vertical dimensions and anchor bolt placement prior to installing expansion devices.
- c. Engineer should check seat parallelism and transverse alignment with a straightedge prior to installing expansion devices.
- d. Non-parallelism and high spots must be corrected by grinding the concrete smooth and in the proper plane.
- e. If the seat geometry is incorrect or grinding cannot correct the seat profile, the Engineer must require the Contractor to remove and replace the concrete to provide a smooth surface along the correct plane to install the expansion device.
- f. Joint opening should be checked for accuracy of opening.
- g. Joint opening should be clear of forms and debris.

B. Placement and Control of Anchor Bolts

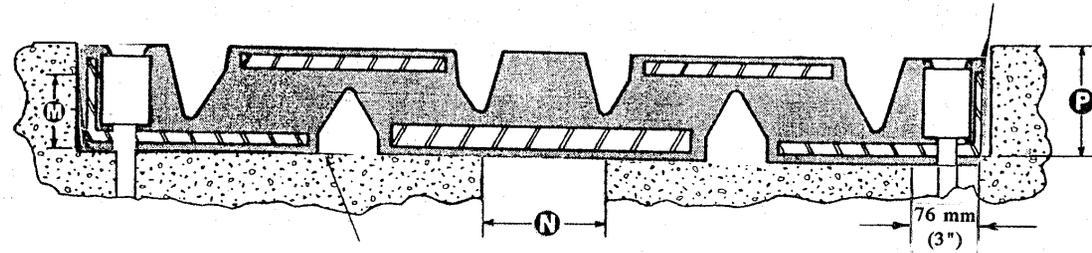
1. Cast-in-place anchors must be used in new concrete as shown on the plans. The bolts must be high strength and either stainless steel or galvanized.
 - a. Rigid templates should be used to assure accurate placement of anchor bolts when the blockout is formed and poured.
 - b. Never permit the use of concrete inserts, but use the cast-in-place anchor bolts as specified.
 - c. Inspect for placement accuracy during blockout inspection prior to pouring concrete.
 - d. Misaligned bolts can be cutoff or drilled out and replaced with epoxy grouted anchor bolts prior to installing the expansion device.
2. Automatic end welded studs shall be used when seal is to be set over existing steel angles.
 - a. No hand welding should be permitted.
 - b. Check for accurate placement prior to automatic end welding the studs.

C. Guidelines for proper installation of expansion devices.

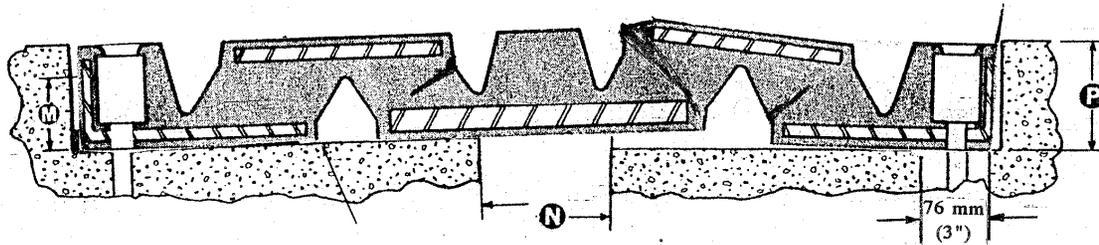
1. Only after the blockout, anchorage and joint opening have been checked and approved should the expansion devices be installed.
2. Allow installation of units in accordance with approved shop plans only.
 - a. Pad type units with full positive interconnects.
 - b. No cut sections should be permitted unless shown on approved shop plans.
 - c. Factory molded or vulcanized curb and parapet units are required as shown on the plans.
 - d. Seal element for strip seal types shall be in one continuous piece as shown on the plans.
 - e. Metal extrusion anchor blocks shall be in the longest practical single piece - joints between discontinuous extrusions must be seal welded.
 - f. All nuts must be galvanized, torqued to a minimum of 90 N m (65 ft. lb.).
 - g. 24 hours after initial installation, retorque the nuts to a minimum of 90 N m (65 ft. lb.)
 - .
3. Only approved adhesives and sealants will be permitted.
 - a. Sealant on seats must be spread uniformly with no skips or misses to avoid leakage under anchor blocks.
 - b. All neoprene surfaces shall be buffed or cleaned with acceptable solvent prior to applying adhesives for interconnects.
 - c. All bolt wells shall be filled with the approved flexible sealant and capped after anchor bolts have been torqued and rechecked after a minimum of 24 hours.
4. Do not permit sealing of bolt wells until you have rechecked the torque.
5. Final inspection of the installed joint seal should include:
 - a. Check for horizontal and vertical misalignments.
 - b. Misaligned units should be removed and correctly reset.
 - c. Check to ensure all bolt wells and joints are sealed.



PROPERLY FORMED BRIDGE SEAT READY FOR SETTING OF THE NEOPRENE EXPANSION JOINT



PROPERLY SET NEOPRENE EXPANSION JOINT NOTE PARALLELISM OF CONCRETE SEATS



IMPROPERLY SET NEOPRENE EXPANSION JOINT NOTE THE DIFFERENCE IN ELEVATION OF THE CONCRETE SEATS AND FAILURE OF JOINT

SECTION 542. PIPE CULVERTS

542.04 Method I Construction

Pipe culverts shall be installed by either Method I, Method II, or Method III. Unless otherwise specified, pipe culverts, except private entrances, will be installed by Method I. Familiarization with the Standard Specifications to understand the different methods of installation is essential. Proper supervision and inspection must be given each culvert location to ensure its proper placement.

In the Method I installation, the diameter of the pipe plus the specified width on each side of the pipe is necessary and strict enforcement of the width of trench should be required at all times. After the trench has been excavated to the proper width and depth, a cushion of not less than 100 mm (4 inches) of fine aggregate shall be placed in the bottom of the trench and compacted for the pipe bedding. Care should be taken that the fine aggregate cushion is shaped to provide uniform pipe support. When bell or hub pipe is used, a depression should be made to accommodate the bell or hub. The pipe shall be laid starting at the downstream end and worked toward the upstream end. After the pipe is installed, fine aggregate shall be placed uniformly on both sides of the pipe in uniform 200 mm (8 inch) layers and mechanically compacted except for the ends; 1 m (3 ft) of impervious material should be placed in this area to prevent erosion. Close inspection is necessary when starting backfill to be sure the haunches under the pipe are properly filled and compacted. Layers of fine aggregate shall be continued to the midpoint of the pipe. Above the midpoint, select material obtained from within the right of way shall be placed in additional uniform 200 mm (8 inch) layers to at least 300 mm (1 ft) above the culvert and compacted. Fine aggregate may be used above the midpoint at the Contractor's expense. If aggregate is used, 1 m (3 ft) of impervious material must be placed at each end of the culvert.

On Method I fill installation, placing a portion of the embankment before excavating the trench is sometimes required. Care should be taken to obtain at least the minimum embankment width and height for the pipe size and select material for the fill. The required density must be obtained in the embankment before the trench is excavated.

542.05 Method II Construction

Method II installations are used for extensions of existing culverts or inaccessible areas where a trench is impractical. When a pipe is to be installed by this method, it will be so noted on the plans.

542.06 Method III Construction

The Method III installation is for sideroad or field entrance culvert installation. You should require that the pipe lay firmly in the roadway ditch, the proper backfill placed around the pipe, and the pipe is not damaged.

CLEANING AND PAINTING EXISTING STEEL STRUCTURES

Most Resident Engineers understand the importance of paving and steel or concrete placement as it relates to maintaining our infrastructure, but have less understanding of the importance of coatings. While aesthetics may be the primary reason for applying coatings in the eyes of the public, the fundamental reason that our structures are painted is to prevent corrosion. Without a properly installed protective coating, the design life of the structures will not be realized, and there is risk of catastrophic failure due to corrosion.

Similar to the structure itself, the coatings have a design life. In order to achieve the required life and performance of the coating, the surfaces must be prepared to exacting standards and the coatings applied under controlled conditions and within specific tolerances. Unlike the lead based coating systems of the past, modern coating materials require much more care during installation in order to perform. The presence of lead in the existing coating adds further complications to the project when it is removed. There are a myriad of regulations that must be met for the protection of the public and the environment. Elaborate containment systems must be installed and maintained together with environmental monitoring and special controls over the handling and disposal of the waste. All aspects of painting have become a very complex process.

Fortunately, we have detailed Special Provisions that identify all of the necessary quality and environmental controls for removing existing coatings and installing new systems. Detailed Quality Control inspection forms are available that the contractors must complete together and Quality Assurance forms that are used by our Paint Technicians when overseeing the activities. By closely following the Special Provisions and assuring that the defined monitoring and inspection activities are performed, we have good assurance that the integrity of our structures will be preserved. A great deal of information can also be obtained by consulting with your Paint Technicians, who have had special training in surface preparation, painting, and environmental compliance. The Paint Technicians also have available a manual with additional information which may answer many questions.

The following forms are referred to in the Special Provision. Proper completion of the forms will allow the Department to best manage and analyze the performance of the paint systems we use.

FORM [BBS 2557](#), PRE PROJECT ENVIRONMENTAL SUBMITTAL REVIEW CHECKLIST

This form may be used by the Resident Engineer, normally in conjunction with the pre – construction conference, to assist in the compilation and evaluation of the Contractor's environmental submittals. It is an organizational aid to assist the RE with the multitude of submittals required to perform this work according to the specifications and although its use is not mandatory it is recommended.

FORM [BBS 2558](#), PRE PROJECT PAINTING SUBMITTAL REVIEW CHECKLIST

This form may be used by the Resident Engineer, normally in conjunction with the pre – construction conference, to assist in the compilation and evaluation of the Contractor's painting submittals. It is an organizational aid to assist the RE with the multitude of submittals required to perform this work according to the specifications and although its use is not mandatory it is recommended.

FORM [BBS 2559](#), CONTRACTOR ENVIRONMENTAL DAILY REPORT

This form must be completed by the Contractor for every scheduled workday of the project, whether or not work is being performed. This Form is a 2 page checklist with comments sections, and is used to provide a uniform means for the Contractor to document compliance with the containment, environmental protection, and waste handling requirements of the specification on a daily basis throughout the course of the project. ([Detailed instructions below.](#))

FORM [BBS 2560A](#), NON-CONFORMANCE REPORT

This form is used by the QA Inspector to document and track work activities that do not comply with the requirements of the project specification. It is used to identify a nonconforming condition, provide recommended corrective action, and to verify that the corrective action was implemented. Note that this report is issued to resolve specific non-conforming situations. The resolution does not automatically apply to the remainder of the project unless specifically stated so in other documents (e.g., change order or revision to the specification). ([Detailed instructions below](#))

FORM [BBS 2560B](#), NON-CONFORMANCE LOG

This form is used by the QA Inspector to track the nonconforming item(s) on the Nonconformance Report(s) (Form [BBS 2560A](#)) until the item has been resolved and closed.

A copy of this Nonconformance Log should be maintained on the job site for the duration of the project. ([Detailed instructions below.](#))

FORM [BBS 2561](#), CONSTRUCTION INSPECTOR PROJECT START UP CHECKLIST

This form is used by the Inspector at project start up to make certain that all required submittal items and equipment/materials are onsite. Note that while this report is completed only one time for each project, it may not be finalized in a single day (i.e., it may take a few days for all of the requirements to be met). ([Detailed instructions below.](#))

FORM [BBS 2562](#), CONSTRUCTION INSPECTOR DAILY(QA) REPORT

This form is prepared by the IDOT QA Inspector to provide a uniform means to document quality assurance inspections of Contractor's compliance with the surface preparation, painting, containment, environmental protection, and waste handling requirements of the specification on a daily or periodic basis throughout the course of the project. ([Detailed instructions below.](#))

FORM [BBS 2563](#), CONTRACTOR DAILY(QC) REPORT

This form must be completed by the Contractor for every scheduled workday of the project, whether or not work is being performed. This Form consists of 3 pages. The pages are divided into various sections for the documentation of inspections that are conducted by Contractor's QC personnel. Extra pages can be attached to provide additional documentation (e.g., specific dry film thickness readings) or for drawings. Drawings should be used when possible to show specific work locations and to track the progress of the major phases of work across the bridge. ([Detailed instructions below.](#))

FORM [BBS 2559](#), CONTRACTOR ENVIRONMENTAL DAILY REPORT**1. Purpose**

- 1.1 To provide a uniform means for the Contractor to document compliance with the containment, environmental protection, and waste handling requirements of the specification on a daily basis throughout the course of the project.

2. Scope

- 2.1 This procedure describes the completion of the Contractor Environmental Daily Report (Form [BBS 2559](#)).

3. General Report Requirements

- 3.1 The Contractor Environmental Daily Report (Form [BBS 2559](#)) is a 2 page checklist with comments sections.
- 3.2 This form must be completed for every scheduled workday of the project, whether or not work is being performed. For example, if work is cancelled due to inclement weather, complete the top section of the report and note in the comments section that no work was performed due to inclement weather.
- 3.3 Complete the form in permanent blue ink, in a neat, professional manner.
- 3.4 Submit the original report to the IDOT representative and maintain one copy in a jobsite file. Submit each day's report to IDOT prior to the start of work the following morning.
- 3.5 Complete all lines of the checklist each day. For each item, check "Yes" if it is satisfactory, "No" if unsatisfactory, or "NA" if it does not apply to the project or to the work performed that day. If an item is checked "No," identify the corrective action taken in the Comments section.

4. Instructions for Completing Contractor Environmental Daily Report (Form [BBS 2559](#))**4.1 General Information**

- 4.1.1 Contractor – Name of the company performing the surface preparation and coating application work.
- 4.1.2 Bridge ID – Bridge number and/or name.
- 4.1.3 Location – Route number and mile marker or other appropriate designation.
- 4.1.4 Contract No. – IDOT Contract Number for the specified work.
- 4.1.5 Report Number – A unique, sequential number assigned to each report. The Report Number is unique to the day in which the work takes place rather than the shift as explained in the two examples below:

Example 1 – Single shift work. When the work involves a single shift, the report number assigned to the first day at the start of the job (e.g., Monday) is #1, Tuesday is report #2, Wednesday is report #3, and the numbering continues sequentially through the end of the project.

Example 2 – Multiple shift work. When the work involves two shifts, with a different Inspector on each shift, each Inspector completes his/her own report. The report for the first day at the start of the job (e.g., Monday) completed by the day shift Inspector would be report #1 followed by a suffix (e.g., D for day shift). The report completed for the Monday night shift Inspector would also be report #1 since the work takes place on the same day, but it will be followed by a different suffix (e.g., N for night shift). Both Inspectors would complete report #2 for their work on Tuesday (with the D or N suffix), and so forth.

- 4.1.6 Date – The date of the work shift.
- 4.1.7 Contractor QC Start/Stop Time – Enter the time the Inspector starts and stops work for the day or shift.
- 4.1.8 Crew Start/Stop Time – Enter the time the crew starts and stops work for the day or shift.
- 4.2 #1 – Identify containment class specified. Report the class of containment specified for the work. Example: Class 1A.
- 4.3 #2 - Does the containment comply with specification & approved drawings? Verify that the containment is installed and maintained according to the specification requirements and approved drawings. If it does not comply (e.g., tarpaulins are worn, allowing debris to escape) check “No” and describe the problem and the corrective action taken.
- 4.4 #3 – Are the containment joints sealed as specified? Verify that the joints are sealed according to the specification requirements and approved drawings. If there was a problem with the seals during the shift, check “No” and describe the problem and the corrective action taken.
- 4.5 #4 – Is the ventilation system functioning properly? – If the containment requires the use of a dust collector, verify that the dust collector is functioning properly and that the make up air openings and ductwork are intact and functional. If there were problems with the ventilation system during the shift, check “No” and describe the problem and the corrective action taken.
- 4.6 #5 – Is the ground properly covered beneath the areas being cleaned? – Verify that the ground beneath the work areas is covered to collect inadvertent spills of debris. If there were problems with the ground covers during the shift, check “No” and describe the problem and the corrective action taken.
- 4.7 #6 – Is all surface preparation debris being captured for disposal? – Verify that the surface preparation media (e.g., abrasive), rust, mill scale, paint chips, and other debris that is generated are being captured and collected for proper disposal. If there was a problem with the collection of the debris as specified, check “No” and describe the problem and the corrective action taken.
- 4.8 #7 – Is all wash water being captured for disposal? – Verify that all bridge wash water and dislodged paint chips and debris are being captured and collected for proper disposal. If there was a problem with the collection of the water and debris, check “No” and describe the problem and the corrective action taken.
- 4.9 #8 – If spills occurred, were they cleaned-up per spec and approved plans? – If spills occurred, acknowledge it here. If they were cleaned up properly, check “Yes.” If

- there was a problem with the clean up (e.g., rain water carried some of the debris away before it could be collected), check "No." If spills did not occur, check "NA." If "Yes" or "No" are checked, describe the problem and the corrective action taken.
- 4.10 #9 – Are visible emissions controlled according to specification? – Verify that visible emissions from dust-producing operations are controlled according to the specification requirements. If emissions exceeded the specification limits during the shift, check "No" and describe the problem and corrective action taken.
- 4.11 #10 – Are regulated areas established at the AL and physically demarcated? – Verify that the regulated areas have been established at the OSHA Action Level (AL) and that visible barriers (e.g., ribbons and signs) are in place. If the regulated areas are not properly set up and designated, check "No" and describe the problem and corrective action taken.
- 4.12 #11 – Is ambient air monitoring performed per spec and approved plans? – Verify that all specified high volume ambient air monitoring is being performed according to the specification and approved plans. This includes monitor location and operation, calibration, documentation, and handling of filters. If the monitoring activities were not in compliance during the shift, check "No" and describe the problem and corrective action taken.
- 4.13 #12 – Are ambient filters sent to the laboratory at the specified frequency? – Verify that the filters from the high volume ambient air monitors are being sent to the laboratory at the specified frequency. If the filters were not sent according to schedule, check "No" and describe the problem and corrective action taken.
- 4.14 #13 – Are hand wash and shower facilities present and working properly? – Verify that all required hand wash and shower facilities are on site, properly equipped, and fully operational. If the hand wash and shower facilities are not in compliance during the shift, check "No" and describe the problem and corrective action taken.
- 4.15 #14 – Is the area outside of containment free of debris at the end of the day? – Verify that debris (with the exception of debris controlled within the containment) is removed from the work site by the end of the work day. If debris is not cleaned up at the end of the day, check "No" and describe the problem and corrective action taken.
- 4.16 #15 – Is clean-up conducted by hand or by HEPA vacuuming? Verify that clean up is accomplished by hand and/or HEPA vacuuming. If other methods are used, check "No" and describe the methods and corrective action taken.
- 4.17 #16 – Is waste handling and storage according to IEPA regulations? Verify that jobsite handling and storage comply with IEPA waste regulations. If the regulations are not being followed, check "No" and describe the variation.
- 4.18 #17 – Is all collected waste stored in approved containers? Verify that all waste is stored in containers approved by the Department. If the containers are not approved, check "No" and describe the corrective action.
- 4.19 #18 – Are waste containers kept closed except when adding waste? Verify that waste containers are closed at all times they are not in use. If the containers are open, check "No" and describe the corrective action.
- 4.20 #19 – Is the storage area secured (e.g. to prevent entry/tampering)? – Verify that the storage is properly protected to prevent vandalism, unauthorized access to the

waste, or tampering. If the site is not secure (e.g., waste stored in drums without protective measures such as fencing), check "No" and describe the storage conditions and the corrective action taken.

- 4.21 #20 – Are the containers examined weekly for breaks or deterioration? – Verify that the storage containers are examined weekly for breaks or deterioration (e.g., corrosion) and that a log of the inspections is maintained. If the inspections are not being performed or the results are not logged, check "No" and describe the corrective action.
- 4.22 #21 – Are all containers labeled as to their content, accumulation dates, etc.? – Verify that waste containers are properly labeled. If unlabeled containers of waste are on-site, check "No" and describe the problem and corrective action taken.
- 4.23 #22 – Is all wastewater filtered through a multi-stage filter? – Verify that the specified water filtration system is on-site, that it is functioning properly and is being used. If the water is not being filtered, or the equipment is not operational during the shift, check "No" and describe the problem and corrective action taken.
- 4.24 #23 – Is hazardous waste stored less than 90 days? – Verify that the hazardous waste is transported from the site in less than 90 days after the start of accumulation. If the waste is onsite for longer than 90 days, check "No" and describe the corrective action.
- 4.25 #24 – At the time of final blast cleaning, has waste transporter been given advance notification for final pick up? The purpose is to give the waste transporter ample notice before project completion that a pick up is due in order to assure that waste is removed from the site prior to demobilization. If notice is not provided, check "No" and provide an explanation.
- 4.26 #25 – Are hazardous waste shipments manifested? – Verify that all shipments of hazardous waste are accompanied by a signed manifest. If a manifest was not used, check "No" and describe the corrective action.
- 4.27 #26 – Is all other waste removed according to Federal, State, and local regulations? – Verify that all other waste is transported and disposed of according to applicable Federal, State, and local regulations. If the waste is improperly transported/disposed, check "No" and describe the corrective action.
- 4.28 #27 – Is a waste accumulation inventory table being maintained? – Verify that a waste accumulation inventory table is prepared showing the number and size of waste containers filled each day, the amount of waste shipped in a given day, and the dates of shipment. If the inventory table is not being maintained, check "No" and describe the corrective action.

5. General Comments

- 5.1 The General Comments can be used to identify other pertinent information or to provide greater detail on any of the checklist items.

6. Signature Section

- 6.1 Contractor QC Inspector and Resident Engineer/Paint Technician Signatures – no explanation necessary.

FORM [BBS 2560A](#), IDOT NON-CONFORMANCE REPORT
and
FORM [BBS 2560B](#), IDOT NON-CONFORMANCE LOG

1. Purpose

- 1.1 To describe a standardized form that is used by the QA Inspector to document and track work activities that do not comply with the requirements of the project specification.

2. Scope

- 2.1 This procedure defines a nonconformance and describes the completion of the Nonconformance Report (Form [BBS 2560A](#)) in order to identify a nonconforming condition, provide recommended corrective action, and to verify that the corrective action was implemented.
- 2.2 Note that the NCR is issued to resolve specific non-conforming situations. The resolution does not automatically apply to the remainder of the project unless specifically stated so in other documents (e.g., change order or revision to the specification).

3. Definitions

- 3.1 A Nonconformance is a condition that differs from the Contract Plans, Specifications, or approved Drawing requirements, and which cannot be brought into conformance with the requirements or accepted without an engineering disposition.
- 3.2 Example 1. The specification requires SSPC SP10 Near White Metal. The Contractor leaves paint and mill scale on the surface. When discovered, the Contractor conducts additional blast cleaning and the surface is improved to SP10 prior to painting. An NCR would not be generated under these conditions because the surface cleanliness complied with the specification at the time of painting.
- 3.3 Example 2. In Example 1 above, when the rust and paint are discovered, the Contractor refuses to conduct additional blast cleaning. He applies the prime coat. An NCR would be issued to address the insufficient quality of blast cleaning. Since the primer has been applied, it is no longer possible to achieve the specified degree of cleanliness. An engineering disposition is required that will either mandate that the surface be re-cleaned and repainted, that the surface preparation be accepted as is despite the presence of the paint and mill scale, or some other resolution (e.g., accept as is with extended warranty).

4. Reporting and Tracking Non conformances

- 4.1 Obtain concurrence from the Resident Engineer before initiating a nonconformance report.

- 4.2 When it is agreed that the situation is a nonconformance, document the item(s) in the comments section of the Construction Inspector Daily QA Oversight form (Form [BBS 2562](#)), and on the Nonconformance Report (Form [BBS 2560A](#)).
- 4.3 Track the nonconforming item(s) on the Nonconformance Report Log (Form [BBS 2560B](#)) until the item has been resolved and closed.
 - 4.3.1 Enter the appropriate information in each block depending on status of the nonconformance.
 - 4.3.2 Maintain one (1) Nonconformance Log (Form [BBS 2560B](#)) for the duration of the project.

5. Guideline for Completing the Nonconformance Report (Form [BBS 2560A](#))

- 5.1 Enter all the general information on the top portion of the report. Generate a unique NCR tracking number for each nonconformance.
- 5.2 Nonconformance Description
 - 5.2.1 Enter a detailed description of the nonconformance. Be certain to include the specific location of the nonconformance.
 - 5.2.2 Controlling document or drawing - Reference the specification page and paragraph title, drawing number (e.g., containment drawing), or the appropriate governing document.
 - 5.2.3 **Example** – The re-coat time for the intermediate prior to applying the finish coat in span 1 was exceeded by 30 days.
- 5.3 Cause of Nonconformance
 - 5.3.1 Identify the cause of the nonconformance. Provide factual information, rather than conjecture.
 - 5.3.2 **Example** – The project was shut down for 45 days due to emergency repairs to another bridge, causing all traffic to be diverted over this structure.
- 5.4 5.4 Recommended Steps to Resolve Nonconforming Situation
 - 5.4.1 Discuss the situation with the Resident Engineer and generate the steps that are recommended for resolving the problem. Note that the recommended steps at this stage involve the contacts that should be made and the data that should be collected in order to ultimately arrive at an engineering solution for the problem (i.e., the ultimate solution, such as pressure washing the coating, is not addressed at this stage).
 - 5.4.2 **Example** – The Contractor should contact the coating manufacturer for written recommendations on the suitability of the surface for re-coating, including recommended methods of surface preparation.

- 5.4.3 Provide the Contractor with a copy of the NCR as completed through this stage.
- 5.5 Recommended Disposition and Basis for Disposition.
- 5.5.1 Based on the information received in response to the "Recommended Steps," provide the recommended disposition for resolving the nonconformance and the rationale for that position. Check the appropriate block (rework, repair, use as is, or reject)
- 5.5.2 **Example** – Based on the attached (date) letter from the coating manufacturer and recommendations from Materials, the surface can be overcoated after it has been thoroughly cleaned of grease, oil, diesel smoke, chalk and other surface interference material using low pressure water according to SSPC-SP12 and solvent cleaning according to SSPC-SP1. Check the "rework" block.
- 5.5.3 Sign the block entitled "Signature of Dispositioner." Forward the form to the Resident Engineer who will sign the block entitled "Approval of Disposition by."
- 5.5.4 Provide the Contractor with a copy of the NCR as completed through this stage.
- 5.6 Corrective Action Taken
- 5.6.1 Report the action taken by the Contractor.
- 5.6.2 **Example** – The surface was thoroughly cleaned of all surface interference material using potable water at 3,500 psi.
- 5.7 Action to Prevent Nonconformance Recurrences
- 5.7.1 Enter a descriptive comment regarding how the Contractor plans to prevent the nonconformance from occurring in the future.
- 5.7.2 **Example** – The emergency repairs responsible for the problem have been finished and the control of the schedule is back in the hands of the Contractor.
- 5.8 Corrective Action Verified by
- 5.8.1 Complete and sign this section to indicate that the corrective action was successfully performed.
- 5.8.2 Circle "yes" indicating that the nonconformance is closed.
- 5.8.3 Obtain the signature of the Resident Engineer as well.
- 5.9 Close out
- 5.9.1 Close out the item in the Nonconformance Log (Form [BBS 2560B](#)) by filling in "date closed."
- 5.9.2 Maintain copies of the NCR on file and provide a copy of the final NCR to the Contractor, and the Resident Engineer.

**FORM [BBS 2561](#), CONSTRUCTION INSPECTOR PROJECT START UP
and
FORM [BBS 2562](#), CHECKLIST AND DAILY QA OVERSIGHT**

1 Purpose

- 1.1 To provide a uniform means for IDOT personnel to document quality assurance inspections of Contractor’s compliance with the surface preparation, painting, containment, environmental protection, and waste handling requirements of the specification on a daily or periodic basis throughout the course of the project.

2 Scope

- 2.1 This procedure describes the completion of IDOT Construction Inspection QA forms:
 - 2.1.1 Form [BBS 2561](#) – Construction Inspector Project Start Up Checklist
 - 2.1.2 Form [BBS 2562](#) – Construction Inspector Daily QA Oversight

3 General Report Requirements

- 3.1 Form [BBS 2561](#) is completed during the early phases of the painting project.
- 3.2 Form [BBS 2562](#) is completed each day to document the daily painting and environmental oversight observations made by the QA Inspector.
- 3.3 Complete the forms in permanent blue or black ink in a neat, professional manner, or by typing.
- 3.4 Complete all lines of the applicable checklist.

4 Instructions for Completing – Construction Inspector Project Start Up Checklist (Form [BBS 2561](#))

- 4.1 Complete this form at project start up to make certain that all required submittal items and equipment/materials are onsite. For each item, check “Yes” if the item is onsite and is satisfactory, “No” if it is not onsite or unsatisfactory, or “NA” if it does not apply to the project. Note that while this report is completed only one time for each project, it may not be finalized in a single day (i.e., it may take a few days for all of the requirements to be met).
- 4.2 General Information
 - 4.2.1 Contractor – Name of the company performing the surface preparation and coating application work.
 - 4.2.2 Bridge ID – Bridge number and/or name.

- 4.2.3 Location – Route number and mile marker or other appropriate designation.
- 4.2.4 Contract No. – IDOT Contract Number for the specified work.
- 4.2.5 QA Inspector Name – no explanation necessary.
- 4.2.6 Signature – no explanation necessary.
- 4.3 #1. Special Provisions Reviewed? – Verify that the special provisions for the project have been reviewed by the Paint Technician. Also verify that the Contractor has a copy of the approved Special Provisions at the jobsite.
- 4.4 #2. Contractor Qualifications submitted? – Verify that the Contractor has submitted the following qualifications as applicable.
 - 4.4.1 a. QP1/QP2 certifications. Note that when the Painting Contractor is the General Contractor, these certifications will have been in place prior to the time of bid. If the Painting Contractor is a subcontractor, the certifications must be provided prior to the beginning of work.
 - 4.4.2 b. QC Manager qualifications – Verify that the qualification and experience requirements have been met.
 - 4.4.3 c. QC Technician qualifications – Verify that the training requirements have been met.
- 4.5 #3. Submittals onsite and reviewed? – Verify that the following items are present at the jobsite as applicable to the contract requirements:
 - 4.5.1 a. – Contractor's Quality Control (QC) Program – Verify that the QC Program that has been submitted and accepted for use by IDOT. The QC Program must identify the following: the instrumentation that will be used, a schedule of required measurements and observations, procedures for correcting unacceptable work, and procedures for improving surface preparation and painting quality as a result of quality control findings. The IDOT Paint Technician should retain a copy for future reference to verify that it is being implemented. It is often beneficial to review the document and use it as the basis for discussions with the Contractor QC Inspector during the performance of his/her inspection duties.
 - 4.5.2 b. – Contractor's Inspection Access Plan. – Verify that the Contractor's Inspection Access Plan is available in the field. Determine if the inspection access plan for use by Contractor QC personnel and by the Paint Technicians during Quality Assurance (QA) observations is adequate with regard to the actual jobsite conditions.
 - 4.5.3 c. – Contractor's Surface Preparation/Painting Plan. – Verify that the Contractor's Surface Preparation/Painting Plan is available to field personnel and it is applicable to the scope of painting work specified (i.e. not generic). The surface preparation/painting plan should include the methods of surface preparation and type of equipment to be utilized for washing, hand/power tool cleaning, removal of rust, mill scale, paint or foreign matter, abrasive blast or water jetting, and remediation of chloride. If detergents, additives, or inhibitors

are incorporated into the water, the Contractor must include the names of the materials and Material Safety Data Sheets (MSDS). Verify that the Contractor has identified the solvents to be used for solvent cleaning together with MSDS.

- 4.5.4 d. – Abrasive information. – Verify the Contractor has the product composition and MSDS's for the abrasive being used. Verify that it complies with specification requirements. For expendable abrasives, verify that the Contractor has provided certification from the abrasive supplier that the abrasive meets the requirements of SSPC-AB1. For steel grit abrasives, the certification must indicate that the abrasive meets the requirements of SSPC-AB3. Verify that the abrasives to be used for blast cleaning have a gradation such that the abrasive will produce a uniform surface profile of 38 to 90 microns (1.5 to 3.5 mils). Obtain a small sample for future reference.
- 4.5.5 e. – Contractor's Protective Covering Plan. - Verify that the Contractor's Protective Covering Plan is available to field personnel. Determine if the plan adequately addresses the specific site conditions where the work will be performed. Verify that tarpaulins or protective coverings being used are fire retardant.
- 4.5.6 f. – Progress Schedule - Verify that the Contractor has a project schedule for the specified work. Determine if it is current, and if not, request that it be updated to accurately identify the sequence and duration of work anticipated. Verify that the progress schedule identifies all major work items (e.g., installation of rigging/containment, surface preparation, and coating application).
- 4.5.7 g. – Contingency Plan - Verify that the Contingency Plan has been accepted and is present at the jobsite. Verify that the contingency plan for emergencies including fire, accident, failure of power, failure of dust collection system, failure of supplied air system or any other event that may require modification of standard operating procedures during lead removal is understood by responsible Contractor personnel. Determine if the plan is accurate in regard to emergency contact information, and adequately addresses potential emergency situations that might be encountered based on the site conditions (water, railroad tracks, public interactions, etc.).
- 4.5.8 h. – Containment Plan (Lead Projects Only). - Verify that the Containment Plan has been accepted by IDOT and is present at the jobsite.
- 4.5.9 i. – Environmental Monitoring Plan (Lead Projects Only). - Verify that the Environmental Monitoring Plan has been accepted by IDOT and is present at the jobsite. Verify that the Contractor QC Inspector understands the requirements for high volume ambient air monitoring (if applicable), visual inspections and clean up of the soil and water. Verify that daily visible emissions observations will be performed and that the corrective action that will be implemented in the event emissions or releases occur.
- 4.5.10 j. – Waste Management Plan (Lead Projects Only). - Verify that the Waste Management Plan has been accepted by IDOT and is present at the jobsite. Verify that responsible Contractor personnel understand all aspects of waste handling, storage, testing, hauling and disposal. It must include the names, addresses, and a contact person for the proposed licensed waste haulers and

- disposal facilities. The name and qualifications of the laboratory proposed for Toxicity Characteristic Leaching Procedure (TCLP) analysis must also be identified.
- 4.6 #4. Contractor inspection equipment onsite? - Verify that the Contractor QC Inspector has the equipment required by specification:
- 4.6.1 Psychrometer or comparable equipment for the measurement of dew point and relative humidity, together with all necessary weather bureau tables or psychrometric charts.
 - 4.6.2 Surface temperature thermometer.
 - 4.6.3 Hypodermic Needle Pressure Gage for determining blasting pressure at the nozzle.
 - 4.6.4 SSPC Visual Standards VIS 1 for abrasive blast cleaning, VIS 3 for hand/power tool cleaning, VIS 4 for water jetting, and/or VIS 5 for wet abrasive blast cleaning, as applicable.
 - 4.6.5 Commercially available putty knife of a minimum thickness of 1mm (40 mils) and a width between 25mm and 75mm (1 and 3 in.). Note that the putty knife is only required for projects in which the existing coating is being feathered and must be tested with a dull putty knife.
 - 4.6.6 Testex Press-O-Film Replica Tape and Spring Micrometer.
 - 4.6.7 Bresle Cell Kits or CHLOR*TEST kits for chloride determinations, or equivalent.
 - 4.6.8 Wet Film Thickness Gage.
 - 4.6.9 Blotter paper and plate glass for compressed air cleanliness checks.
 - 4.6.10 Type 2 Magnetic Dry Film Thickness Gage per SSPC - PA2.
 - 4.6.11 Calibration standards for dry film thickness gage.
 - 4.6.12 Light meter.
 - 4.6.13 All applicable ASTM and SSPC Standards used for the work
- 4.7 #5. Specified coating materials onsite? – Verify that the materials comply with the specification and special provisions provided for the work. Determine if the color of the finish coat is correct, that the materials are not leaking, damaged, and have tight lids. Verify that coating manufacturer product data, application instructions, and MSD sheets are available for all coating materials and solvents and that the solvents are approved for use with the coating materials.
- 4.8 #6. Test sections prepared and accepted? - Verify that the Contractor has prepared a test section(s) on each structure to be painted in a location(s) which the Resident Engineer considers to be representative of the existing surface condition and steel type for the structure as a whole. Verify that the test section(s) are prepared using the same equipment, materials and procedures as the production operations. Verify

that the Contractor has prepared the test section(s) to the specified level of cleaning according to the appropriate SSPC visual standards, modified as necessary to comply with the requirements of the specification.

5 Instructions for Completing – Construction Inspector daily QA Oversight (Form [BBS 2562](#))

- 5.1 Complete this form daily to record the QA observations that are made. For each item, check “Sat” if it is satisfactory or “Unsat” if unsatisfactory. Enter “N/A” in the NA/NW column if the item does not apply or “NW,” not witnessed, if the item is applicable, but not witnessed or verified by the Paint Technician. If an item is checked “Unsat,” in the Comments section identify the problem and the corrective action taken.
- 5.2 General Information
- 5.2.1 Contractor – Name of the company performing the surface preparation and coating application work.
- 5.2.2 Bridge ID – Bridge number and/or name.
- 5.2.3 Location – Route number and mile marker or other appropriate designation.
- 5.2.4 Contract No. – IDOT Contract Number for the specified work.
- 5.2.5 Report Number – A unique, sequential number assigned to each report. The Report Number is unique to the day in which the work takes place rather than the shift as explained in the two examples below:
- Example 1 – Single shift work. When the work involves a single shift, the report number assigned to the first day at the start of the job (e.g., Monday) is #1, Tuesday is report #2, Wednesday is report #3, and the numbering continues sequentially through the end of the project.
- Example 2 – Multiple shift work. When the work involves two shifts, with a different Paint Technician on each shift, each Technician completes his/her own report. The report for the first day at the start of the job (e.g., Monday) completed by the day shift Paint Technician would be report #1 followed by a suffix (e.g., D for day shift). The report completed for the Monday night shift Paint Technician would also be report #1 since the work takes place on the same day, but it will be followed by a different suffix (e.g., N for night shift). Both Paint Technicians would complete report #2 for their work on Tuesday (with the D or N suffix), and so forth.
- 5.2.6 Date – The date of the work shift.
- 5.2.7 QA Inspector Name – No explanation necessary.
- 5.2.8 Signature – No explanation necessary.
- 5.3 #1. Access to jobsite – Verify that the access to the work site is suitable for the Contractor QC inspection and IDOT QA observations as required, including allowing ample time to view the work. Verify that the Contractor will furnish, erect and move

scaffolding or other mechanical equipment to permit close observation of all surfaces to be cleaned and painted. Note: When the surface to be inspected is more than 1.8 m (6 ft) above the ground or water surface, the Contractor must provide IDOT personnel with a safety harness and a lifeline according to OSHA regulations.

- 5.4 #2. Contractor equipment? – Verify that all cleaning and painting equipment includes gauges capable of accurately measuring fluid and air pressures and have valves capable of regulating the flow of air, water or paint as recommended by the equipment manufacturer. Verify that the equipment is being maintained in proper working order. Verify that diesel or gasoline powered equipment are positioned or vented in a manner to prevent deposition of combustion contaminants on any part of the structure. Verify that hand tools, power tools, pressure washing, water jetting, abrasive blast cleaning equipment, brushes, rollers, and spray equipment are of suitable size and capacity to perform the work required by this specification. Verify that all power tools are equipped with vacuums and High Efficiency Particulate Air (HEPA) filtration. Verify that appropriate filters, traps and dryers are provided for the compressed air used for abrasive blast cleaning and conventional spray application. Verify that paint pots are equipped with air operated continuous mixing devices unless prohibited by the coating manufacturer.
- 5.5 #3. Protective coverings in place? – Verify that all portions of the structure that could be damaged by the surface preparation and painting operations (e.g., utilities), including any sound paint that is allowed to remain according to the contract documents, are protected by covering or shielding. Verify that tarpaulins drop cloths, or other materials or methods are employed to prevent paint drips, spills, and overspray from damaging items not specified to be painted.
- 5.6 #4. Lighting? – Verify that the Contractor is providing artificial lighting in areas where natural light is inadequate or insufficient to allow proper cleaning, inspection, and painting. Verify that illumination for inspection is at least 325 LUX (30 foot candles). Verify that illumination for cleaning and painting, including the working platforms, access and entryways is at least 215 LUX (20 foot candles).
- 5.7 #5. Weather conditions? – Verify that surfaces to be painted after cleaning remain free of moisture and other contaminants. Verify that the surface temperature is at least 3°C (5°F) above the dew point during final surface preparation operations. Verify that the Contractor QC Inspector is monitoring the temperature, dew point, and relative humidity every 4 hours during surface preparation and coating application in the specific areas where the work is being performed.
- 5.8 #6. Compressed air cleanliness? – Verify that prior to using compressed air for abrasive blast cleaning, blowing down the surfaces, and painting with conventional spray, the Contractor QC Inspector has verified that the compressed air is free of moisture and oil contamination according to the requirements of ASTM D 4285. Verify that the tests are being conducted at least one time each shift for each compressor system in operation.
- 5.9 #7. Washing for overcoating? (Hold Point) – Verify that washing prior to lead based paint overcoating involves the use of potable water at a minimum of 7 MPa (1000 psi) and less than 34 MPa (5000 psi) according to “Low Pressure Water Cleaning” of SSPC-SP12. Verify that water washing has removed dust, dirt, chalk, insect and animal nests, bird droppings and other foreign matter prior to any solvent cleaning and that the specified chalk tests have been performed. Verify that after washing has

been completed, all traces of asphaltic cement, oil, grease, diesel fuel deposits, and other soluble contaminants have been removed by SSPC-SP1, supplemented with scraping (e.g., to remove large deposits of asphaltic cement) as required. Verify that the water, debris, and any loose paint removed by water cleaning is collected for proper disposal, and that the washing was completed no more than 2 weeks prior to subsequent surface preparation.

- 5.10 #8. Preparation for total coating removal? – Verify that if the Contractor uses water cleaning, all water and debris are collected for proper disposal. Verify that the tops of the pier caps and abutments are cleaned free of dirt, paint chips, insect and animal nests, bird droppings and other foreign matter and the debris and wash water collected for proper disposal.
- 5.11 #9. Removal of laminar/stratified rust? – Verify that all laminar and stratified rust that has formed on the existing steel surfaces are being removed. Verify that any rust remaining after cleaning the mating surfaces is tight and intact when examined using a dull putty knife.
- 5.12 #10. Abrasive type? – Verify that expendable abrasives meet the requirements of SSPC-AB1 and that recyclable steel grit abrasives meet AB3. Verify that the abrasives used for blast cleaning have a gradation such that the abrasive will produce a uniform surface profile of 38 to 90 microns (1.5 to 3.5 mils).
- 5.13 #11. Abrasive cleanliness (recycled)? – Verify that if recyclable abrasives are being used that the Contractor QC Inspector verifies that cleanliness according to AB3.
- 5.14 #12. Surface preparation? (Hold Point) – Verify that the surface preparation has been accomplished according to the requirements of the specification and special provisions. Verify that areas identified as deficient have been suitably reworked and are verified as acceptable prior to coating application.
- 5.15 #13. Surface profile? (Hold point) – Verify that the surfaces prepared by abrasive blast cleaning have a uniform surface profile of 38 to 90 microns (1.5 to 3.5 mils) unless the profile requirements of the coating manufacturer are more restrictive and have been approved by the Resident Engineer. If the surface has been power tool cleaned – commercial grade, verify that the surface profile is within the range specified by the coating manufacturer, but not less than 50 microns (2.0 mils).

- 5.16 #14. Soluble salt remediation? (Hold Point) – Verify that representative surfaces that were previously rusted (e.g., pitted steel) have remaining chloride levels no greater than 7µg/sq cm as read directly from the surface without any multiplier applied to the results. Verify that the frequency of chloride tests is according to the specification requirements.
- 5.17 #15. Surface condition prior to painting? (Hold Point) – Verify that the prepared surfaces, including shop primed steel, meet the requirements of the respective degrees of cleaning immediately prior to painting, are free of surface dust, debris, grease, oil, and diesel smoke, and are being painted before rusting appears on the surface.
- 5.18 #16. Materials, storage, and mixing? – Verify that paint is being stored according to manufacturer's instructions. Verify that all coatings are supplied in sealed containers bearing the manufacturers' name, product designation, batch number and mixing/thinning instructions, and that that thinning is performed only to the extent allowed by the manufacturer's written instructions and with the manufacturer's approved thinner.

Verify, that the batches of material have a Test ID Number or Approval Number indicating that Materials has approved the products.

The Test ID Number can be confirmed by looking up the batch number on the weekly MISTIC printout or by logging onto MISTIC itself. Make certain that the particular batches have been approved (i.e., even material that has failed will have a number representing it in the MISTIC system).

To access the report in the MISTIC system, open Report2Web which is located at <http://cocent1report1/r2w25/default.asp>. **Report2Web is only accessible to IDOT employees.** Note that you may need to select the button at the bottom of the page for "EnterReport2Web" and log in. If this occurs, use the same log in name and password that would be used to log onto the LAN system. Click on the "ReportList" and select "materials" from the top. The list of materials reports will be displayed. Select the "approved materials batch and lot" for the paint print out.

If you are unsuccessful, contact the Central Bureau of Materials and Physical Research Analytical laboratory Supervisor at 217/782-7218 for additional assistance.

- 5.19 #17. Coating application? – Verify that coatings are being applied in accordance with the coating manufacturers written instructions, including the application of stripe coats where specified.
- 5.20 #18. Overspray controlled, including containment, if applicable? – Verify that the contractor is controlling overspray, drips, and spills during application. Controls may include special containment materials or alternative methods of application such as brush and roller. Note that in some cases, the contract requires the use of the same surface preparation containment for the application of all coats.
- 5.21 #19. Wet film thickness for overcoating? – Verify that when the new coating is applied over an existing system, routine Contractor QC Inspections of the wet film thickness are being performed in addition to the painter's checks in order to establish that a proper film build is being applied.

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- 5-215.22 #1920. Re-coating/continuity/DFT. (Hold Point) – Verify that each coat of paint has been applied as a continuous film of uniform thickness free of defects including, but not limited to, runs, sags, overspray, dryspray, pinholes, voids, skips, misses, and shadow-through. Verify that coatings are dry for re-coating according to the time/temperature/humidity criteria provided in the manufacturer's instructions.
- 5-225.23 #291. Repair of damage – Verify that the Contractor has repaired all damage to the newly installed coating system and areas concealed by the containment/protective covering attachment points. Verify that the surrounding coating at each repair location is being feathered for a minimum distance of 40 mm (1 1/2 in.) to achieve a smooth transition between the prepared areas and the existing coating.
- 5-235.24 #242. Stencils – Verify that the painting date and the paint code on the bridge have been applied to the bridge in the specified location. Verify that the letters are capitals, not less than 50 mm (2 in.) and not more than 75 mm (3 in.) in height. Verify that the stencil contains the following wording "PAINTED BY (INSERT THE NAME OF THE CONTRACTOR)" and shows the month and year in which the painting was completed, followed by the appropriate code for the coating material applied.
- 5-245.25 #223. Contractor QC documentation – Verify that the Contractor QC documentation is completed and is turned into the Resident Engineer before work resumes the following day. Verify that the documentation is complete and accurately represents the results of all quality control tests and observations performed.
- 5-255.26 #234. Emergency stop work per plans – Identify any conditions that occurred where the Contractor had to stop work due to emergency conditions as described under their Contingency Plan, or the "Site Emergencies" portion of the specification. If emergency stop work did not occur, check "NA." If a stop work occurred, but was controlled according to plan, check "Sat." If a stop work occurred, but was not handled according to plan, check "Unsat." If "Sat" or "Unsat" are checked, describe the problem and the corrective action taken.
- 5-265.27 #245. Containment – Verify that the containment is installed and maintained according to the specification requirements and approved drawings (e.g., type of materials, entryway, cable sizes, dust collector and ventilation duct work sizes, etc.). Verify that the containment joints are sealed according to the specification requirements and approved drawings. If the containment is not according to the approved drawings, check "Unsat" and describe the problem and corrective action taken.
- 5-275.28 #256. Spills/releases controlled – Verify that if spills occurred, were they cleaned-up per specification and approved plans. If spills did not occur, check "NA." If "Sat" or "Unsat" are checked, describe the problem and the corrective action taken.
- 5-285.29 #267. Visible emissions – Verify that visible emissions from dust-producing operations are controlled according to the specification requirements. If emissions exceeded the specification limits during the shift, check "Unsat" and describe the problem and corrective action taken.
- 5-295.30 #278. High volume air monitoring (Lead Projects) – Verify that all specified high

volume ambient air monitoring is being performed according to the specification and approved plans. This includes monitor location and operation, calibration, documentation, and handling of filters. If the monitoring activities were not in compliance during the shift, check "Unsat" and describe the problem and corrective action taken.

| 5.305.31 #289. Regulated areas (Lead Projects) – Verify that the regulated areas have been established at the OSHA Action Level and that visible barriers (e.g., ribbons and signs) are in place. If the regulated areas are not properly set up and designated, check "Unsat" and describe the problem and corrective action taken.

| 5.345.32 #2930. Hygiene facilities (Lead Projects) – Verify that all required hand wash and shower facilities are on site, properly equipped, and fully operational. If the hand wash and shower facilities are not in compliance during the shift, check "Unsat" and describe the problem and corrective action taken.

| 5.325.33 #301. Waste handling – Verify that waste and debris are being collected, handled, and stored in sealed containers according to the specification requirements and approved plans. If waste handling and storage during the shift is not in compliance, check "Unsat" and describe the problem and corrective action taken.

| 5.335.34 #342. Project completion cleanliness – Verify that all Contractor equipment and materials have been removed, that a thorough inspection of the construction site and all surrounding property and surfaces located within the likely dispersion zone of dust and debris has been conducted. Verify that all lead dust has been removed from the surface of the completed structure as well as from the surrounding area.

FORM [BBS 2563](#), CONTRACTOR DAILY QUALITY CONTROL REPORT**1. Purpose**

- 1.1. To provide a uniform means for the Contractor to document compliance with the surface preparation and coating application requirements of the specification on a daily basis throughout the course of the project.

2. Scope

- 2.1. This procedure describes the completion of the Contractor Daily Quality Control Report (Form [BBS 2563](#)).

3. General Report Requirements

- 3.1. This Form consists of 3 pages. The pages are divided into various sections for the documentation of inspections that are conducted by Contractor's QC personnel. Extra pages can be attached to provide additional documentation (e.g., specific dry film thickness readings) or for drawings. Drawings should be used when possible to show specific work locations and to track the progress of the major phases of work (e.g., surface preparation, 1st coat application, 2nd coat application, etc.) across the bridge.
- 3.2. This form must be completed for every scheduled workday of the project, whether or not work is being performed. For example, if work is cancelled due to inclement weather, complete the top section of the report and note in the comments section that no work was performed due to inclement weather.
- 3.3. Complete the form in permanent blue ink, in a neat, professional manner.
- 3.4. Submit the original report to the IDOT representative and maintain one copy in a jobsite file. Submit each day's report to IDOT prior to the start of work the following morning.
- 3.5. Complete all lines and sections. If an item is not applicable, designate as "N/A."

4. Nonconforming Work

- 4.1. Specifically identify non-conforming work in one of the "Comments" sections of the report.

5. Instructions for Completing Page 1

- 5.1. Page 1 provides sections for reporting general project information, and sections entitled: Ambient Conditions, Surface Preparation, Surface Preparation Checklist, and comments.
- 5.2. General Information
 - 5.2.1. Contractor – Name of the company performing the surface preparation and painting work.
 - 5.2.2. Bridge ID – Bridge number and/or name.
 - 5.2.3. Location – Route number and mile marker or other appropriate designation.

- 5.2.4. Contract No. – IDOT Contract Number for the specified work.
- 5.2.5. Date – The date of the work shift.
- 5.2.6. Contractor QC Start/Stop Time – Enter the time the Inspector starts and stops work for the day or shift.
- 5.2.7. Crew Start/Stop Time – Enter the time the crew starts and stops work for the day or shift.
- 5.2.8. Number of Workers – Enter the number of workers on the project during the day or shift.
- 5.2.9. IR No. – A unique sequential report number assigned to each report. The IR No. is unique to the day in which the work takes place rather than the shift as explained in the two examples below:
- 5.2.10. Example 1 – Single shift work. When the work involves a single shift, the report number assigned to the first day at the start of the job (e.g., Monday) is #1, Tuesday is report #2, Wednesday is report #3, and the numbering continues sequentially through the end of the project.
- 5.2.11. Example 2 – Multiple shift work. When the work involves two shifts, with a different Inspector on each shift, each Inspector completes his/her own report. The report for the first day at the start of the job (Monday) completed by the day shift Inspector would be report #1 followed by a suffix (e.g., D for day shift). The report completed for the Monday night shift Inspector would also be report #1 since the work takes place on the same day, but it will be followed by a different suffix (e.g., N for night shift). Both Inspectors would complete report #2 for their work on Tuesday (with the D or N suffix), and so forth.
- 5.3 Ambient Conditions – This section is used to document weather conditions throughout the work day or shift.
- 5.3.1 Location – Briefly describe the location where the ambient conditions were measured (e.g., Span #1, Inside Containment at Abutment). Use a separate line each time ambient conditions are recorded, (generally every four hours or more frequently if weather conditions are changing rapidly).
- 5.3.2 Time – Record the time that the ambient conditions were measured.
- 5.3.3 Weather and Wind – Record the general weather conditions, such as sunny, partly cloudy, raining, etc. Indicate the wind direction and speed (e.g., southwest 10 miles per hour would be reported as SW-10).
- 5.3.4 DB/WB/RH/ST/DP/ +/- – In appropriate block record the dry bulb temperature (DB), wet bulb temperature (WB), relative humidity (RH), surface temperature (ST), and dew point temperature (DP). Calculate and enter the number of degrees the surface temperature differs from the dew point (+/- column). Enter “+” if the surface temperature is greater than the dew point or “-” if it is less (example: +15° or -3°).
- 5.3.5 Comments – Identify the general operations permitted based on the ambient conditions (e.g. all, rigging only, none, etc.)

- 5.4 Surface Preparation – Complete this section when surface preparation is being performed or inspected. Complete a separate line for each type or method of surface preparation performed that shift (e.g., record washing on a separate line from blast cleaning). This section is divided into three general categories of information – location, surface preparation and surface profile:
- 5.4.1 Location – Identify the location where the surface preparation was performed during the shift.
- 5.4.2 Surface Preparation
- Spec – Record the degree of surface preparation cleanliness specified (e.g., SP3, SP10, etc.).
 - Act – Record the actual surface preparation cleanliness achieved.
- 5.4.3 Surface Profile
- Spec – Record the surface profile specified.
 - Act – Record the actual profile achieved, measured in mils. Attach the Testex Tape to the inspection report.
- 5.4.4 Item/Shop Primed – Check the appropriate box “✓” for the type of shop prime used, OZ (Organic Zinc) IZ (Inorganic Zinc). If shop primed steel has been water cleaned in preparation for primer repair or the application of the intermediate coat. Indicate the numbers (1 through 4) from the preceding lines on the form that correlate with the locations where the shop-primed steel was washed.
- 5.4.5 Comments – Record specific comments or observations relating to surface preparation (e.g., containment leak lead to localized rusting on fascia – area spot cleaned per SP11).
- 5.5 Surface Preparation Checklist - for each inspection item listed, enter a check (✓) in one of the three columns: Yes (for being acceptable and complying with the specification), No (for being unacceptable and not meeting the specification), or N/A (for not applicable). For example, if the item is properly addressed (pack rust is present and has been removed), check Yes. If pack rust is present, but was not removed, check No. If there was no pack rust in the area or the item does not apply to the scope of work, check NA. If the item is checked as No, provide an explanation in the Comments section. For the three surface preparation checklist items that cannot be answered with a Yes/No, enter the requested information.
- 5.5.1 Laminar/Pack (stratified) rust removed? – Verify that pack rust has been removed according the specification requirements.
- 5.5.2 Is surface free of visible moisture? – Verify that no visible moisture was present on the surface prior to surface preparation in accordance with specification requirements.
- 5.5.3 Clean and dry abrasive being used (AB2 for recycled abrasive)? – For abrasive blast cleaning, examine the cleanliness of the abrasive as directed by the specification (e.g., visual test, and slurry test).

- 5.5.4 Compressed air check satisfactory? – Verify that the air supply is free of water and oil contamination.
- 5.5.5 Dust and abrasive removal satisfactory? – Verify that visible dust, abrasives, etc. have been removed from the surface prior to coating application (e.g., surface vacuumed or blown down with clean, dry air as specified prior to coating).
- 5.5.6 Record: Base metal reading (BMR) in mils – enter the average BMR obtained in mils.
- 5.5.7 Grease and oil removed? – Verify that the surface is free of grease and oil contamination as required by the specification.
- 5.5.8 Protective coverings suitable/in place? – Verify that all specified protective coverings are in place prior to the beginning of surface preparation in accordance with the specification requirements.
- 5.5.9 Abrasive meets SSPC-AB1/AB3? – Verify that the abrasive used complies with the specification with regard to the type, class and grade.
- 5.5.10 Soluble salts satisfactorily removed? – Indicate whether soluble salts have been removed as confirmed by the chloride tests. Conduct the tests at the locations and frequency established by the specification and attach the results.
- 5.5.11 Record: Type and size of abrasive – when abrasive blast cleaning is employed, enter abrasive type and size used (e.g., type "Black Beauty," size "20/40"). Also verify that the abrasive material is the correct type per specification.
- 5.5.12 Record: Chalk Rating – when the existing coating is being pressure washed for overcoating, record the results of the ASTM D4214 chalk tests.

6. Instructions for Completing Page 2

- 6.1. Page 2 includes sections entitled – Coating Application, Mixing Report, Coating Application Checklist, Dry Film Thickness.
- 6.2. Coating Application – Complete this section when coating application is being performed or inspected. Complete a separate line for each area where a different coat is being applied during the shift (e.g., record information for the application of the intermediate coat on the outside fascia on one line and the application of the finish coat on interior steel on another). This section is divided into five general categories of information – location, coating type, mixing, application times, and wet film thickness:
 - 6.2.1. Location – Identify the location where the coating application was performed during the shift. Complete a separate line for each location involving the application of a different material.
 - 6.2.2. Coating Type – enter the brand name (e.g., CZ11, CM90, 133HB, etc.) of the coating applied to each specific location

- 6.2.3. Mix # - Insert the corresponding "mix number" from the Mixing Report section of the form. The purpose is to link the coating material information (e.g., batch numbers) from the Mixing Report to the specific locations where the batches are applied.
- 6.2.4. Application Begin/Stop Times - enter the time that the application for each specific location begins and ends.
- 6.2.5. Wet Film Thickness – enter the range of the applied wet film thickness readings in mils (e.g. 6-8).
- 6.2.6. Mist Coat – If application involved an intermediate coat applied over a shop primed inorganic zinc primer, indicate "✓" if a mist coat was first applied. In the first column, indicate the numbers (1 through 4) from the preceding lines on the form that correlate with the locations where the shop-primed steel was mist coated.
- 6.2.7. Comments – Record specific comments or observations relating to coating application (e.g., primer stripe coat applied).
- 6.3. Mixing Report – This report is used to record mixing information such as batch numbers, thinner type and amounts, and time of mix.
 - 6.3.1. Mix No. – Assign a unique sequential number to the batches of material mixed at a given time. For example, if 4 kits of primer were mixed at one time and all components are the same batch numbers, all 4 can be recorded on one line as mix no. 1. The mix number is transferred to the Coating Application section to identify the location(s) where the mix was applied.
 - 6.3.2. Location. – Enter the corresponding location(s) from the Coating Application section, showing where the mix was applied.
 - 6.3.3. Color – Enter the manufacturer's color identification and confirm that it is correct.
 - 6.3.4. Shelf Life – Verify that the shelf life of each component complies with the manufacturer's data sheet for shelf life. Record Sat or Unsat. If the batch number cannot be decoded to identify the manufacture date, contact the manufacture for the code information or the shelf life expiration date.
 - 6.3.5. Components – Enter the batch number for each component of each product that is mixed, even single component materials. Space is provided for up to 3 components.
 - 6.3.6. Thinner (Name and %) – Record the brand name (i.e., coating manufacturer's name and/or number) of the thinner used and the amount of thinner added, expressed as a percentage by volume (e.g., 5%, 10%, 15%, etc.).
 - 6.3.7. Mixed Coating Temperatures – Record the temperature of the mixed coating material.
 - 6.3.8. Time of Mix – Record the time that mixing is completed. When an induction time is required, record the time after mixing, but prior to the start of the induction time.

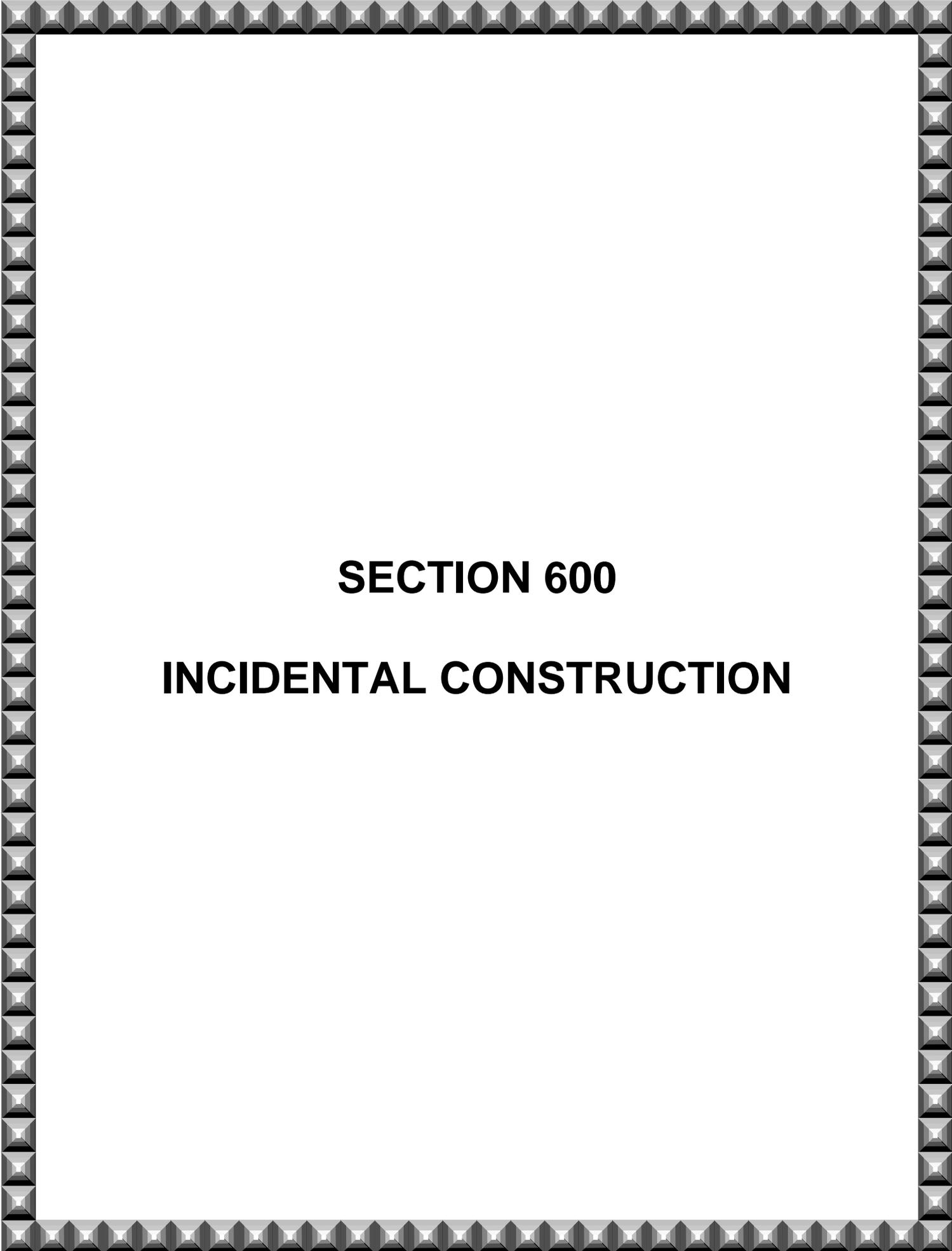
- 6.3.9. Induction Time - Enter the specified induction time that was actually observed (e.g., 30 minutes @ 77°F).
- 6.3.10. Pot Life – Record the manufacturer's specified pot life (e.g., 6 hours @ 75°F).
- 6.3.11. Quantity – Enter the number of gallons mixed.
- 6.3.12. Witnessed – Indicate whether the mix was witnessed by Contractor QC by checking “yes” or “no.”
- 6.4. Coating Application Checklist – Complete this checklist in the same manner as the Surface Preparation Checklist described in 5.5 above.
- 6.4.1. Compressed air check satisfactory? – Verify that the compressed air supply is clean as required by the specification.
- 6.4.2. Surrounding air cleanliness satisfactory? – Verify that airborne contamination is not visible in the vicinity of coating application.
- 6.4.3. Recoat times satisfactory? – Verify that the drying times between each coat are in compliance with the specification and the manufacturer's data sheet.
- 6.4.4. Application equipment – Record the type of equipment being used and verify that it is permitted by the specification (e.g., airless - AS, conventional - CS, brush - B, roller - R).
- 6.4.5. Stripe coat applied? – Note whether a stripe coat was included for the specific coat being applied that day.
- 6.4.6. Time-surface prep to coating? – Record the time lapse between the completion of surface preparation and the start of coating application.
- 6.4.7. Protective coverings in place? – Verify that coverings are in place in accordance with the specification requirements.
- 6.4.8. Intercoat cleanliness satisfactory? – Verify that the surface is free of visible contamination as required by the specification prior to the application of the next coat.
- 6.4.9. Material agitation satisfactory? – Verify that agitation is performed if specified or required by the coating manufacturer (e.g., for zinc-rich primers).
- 6.4.10. Adequate lighting? – Record the amount of light in the work area as measured by the Inspector and whether it complies with the specification requirements.
- 6.4.11. Free of application deficiencies? – Record whether the coating has been applied without defects such as runs, sags, misses, shadow-through, etc.
- 6.4.12.** Overspray Controls used. Effective? – Record the type of controls used to prevent overspray, drips, and spills from escaping the work area. Controls may include the containment used for surface preparation, specially installed painting containment materials and/or alternative methods of application such as brush and roller. Also note whether the selected controls are effective for the work that day.

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- 6.5. Dry Film Thickness – Complete this section to record a summary of the dry film thickness measurements of each coat before applying the next, and for the final inspection in an area after all coats have been applied. Complete a separate line for each area being measured (e.g., record the summary information for the dry film thickness of the prime coat on the outside fascia on one line and the thickness of the intermediate coat on interior steel on another). This section is divided into three general categories of information – location, dry film thickness and rework required:
- 6.5.1. Location - Identify the location where the dry film thickness readings were taken during the shift.
 - 6.5.2. Spec – Record the specified dry film thickness for the coat or coats being measured. The “spec” represents the cumulative thickness of all coats that are present at the time of measurement. For example, when measuring the thickness of the intermediate coat, the “spec” is the thickness of the prime and intermediate coats combined. If the specification for the primer is 3.5 to 5.0 mils, and the intermediate is 3.0 to 6.0 mils, enter 6.5 to 11.0 as the “spec” when measuring the intermediate.
 - 6.5.3. Act – Record the average dry film thickness measured in the area.
 - 6.5.4. Range – Record the range of the dry film thickness readings measured in the area.
 - 6.5.5. Rework Required – Check “Yes” or “No.” If “Yes” is indicated, explain why in the comments.
 - 6.5.6. Comments – Record specific comments or observations relating to dry film thickness readings.

7. Instructions for Completing Page 3

8. 7.1. Page 3 includes sections for Equipment on the Job, Instrument Record, Comments, and signature sections for the Contractor QC Inspector and the Resident Engineer/Paint Technician.
- 7.2. Equipment on Job – In the boxes, enter a list of the major equipment items the Contractor has on the job (e.g., 1250 CFM compressor, 6 ton blast pot, etc.).
 - 7.3. Instrument Record – Nine of the most common inspection instruments are identified with additional space for one other instrument. Record the name and serial number of all instruments used. For the Testex Tape, identify the tape used (Coarse [C], paint grade [PG], X-Coarse [XC], or X-Coarse Plus [XC+]). Check the boxes to confirm that the gages, as applicable, have been calibrated (e.g., the sling psychrometer is not calibrated and would be checked as NA).
 - 7.4. Comments - This section is used for supplementary comments on the daily activities, work progress, problems encountered deviations from the contract specification requirements and their resolution. Use additional sheets as necessary. The results of the soluble salts tests can also recorded in this section or on additional sheets.
 - 7.5. Contractor QC Inspector and Resident Engineer/Paint Technician Signatures – Sign and date the report. Note that the Resident Engineer/Paint Technician name and signature only confirms that the report was received, not that the information is valid or has been confirmed.



SECTION 600
INCIDENTAL CONSTRUCTION

SECTION 600. INCIDENTAL CONSTRUCTION**SECTION 606. CONCRETE GUTTER, CURB, MEDIAN AND PAVED DITCH****606.01 Description**

The construction of any concrete curb, concrete gutter, combination concrete curb and gutter, concrete median, or paved ditch, is governed by Section 606 of the Standard Specifications. These items are highly visible to the traveling public, therefore, smooth lines and appearances are important.

606.04 Forms

Article 1103.05 covers the size and type of forms required. Forms shall be made of 2 in (50 mm) surfaced plank or metal. All forms are to be checked prior to placing concrete. Joints should be carefully checked for tightness and any difference in elevation on the top of the forms. Variations in alignment on tangents and flat spots in horizontal curves and between control stakes can be detected by sighting down the form line. Sighting down the top of the back form line will locate variations in elevation between control points if observed from a distance.

SECTION 609. BRIDGE APPROACH PAVEMENT AND SHOULDER PAVEMENT DRAINS**609.03 Inlet Boxes**

The inlet box and pipe drain should be positioned between the proposed approach guardrail posts. It may be necessary to increase the length of the approach shoulder pavement or adjust the minimum distance from the end of the approach pavement to the center of the drain. Check the plans and the appropriate highway standard before positioning the inlet box.

SECTION 611. TREATMENT OF EXISTING FIELD TILE SYSTEMS**611.01 Description**

This work consists of maintaining the integrity of all existing field tile drainage systems within the limits of the right-of-way. Special care shall be taken in order to minimize possible future disputes with adjacent property owners.

611.02 Locating Existing Field Tile

It is important to locate all field tiles within the right-of-way. As a guideline, a continuous exploratory trench can be excavated along one side of the roadway close to the right-of-way. Intermittent trenching can be done along the opposite R.O.W. where it is anticipated to intersect with the file found in the initial trench. An accurate field book should be kept of locations and flowline elevations of all field tiles found during exploration trenching. This information can be plotted on as-built plan sheets for future reference during and after construction of the project.

611.03 Existing Field Tile Intercepted by Backslopes

Outletting field tile into the ditch is the economically preferred method of treatment. In some instances, however, this can cause continual wetness of the ditch which promotes unattractive weeds and can make maintenance mowing difficult. It can also drain along the ditch and then outlet onto adjacent private property, often the same property that the field tile is draining. This, in effect, takes subsurface water and makes it surface water again. This can cause disputes with the affected adjacent property owners. The Engineer should consider if there is a cost effective alternative to draining the field tiles into the ditch. Some options to consider are adjusting the ditch so as not to intercept the tile, reroute the tile along the R.O.W. to another tile which is not intercepted by the ditch grade, or reroute the tile to outlet into a stream which has a continual flow of water.

611.04 Field Tile Not Intercepted by Backslopes

If there is enough cover between the top of the field tile and the ditch grade, typically 600 mm (2 ft) or greater, then the concrete slab protection is not required.

611.05 Field Tile Junction Vaults

In addition to junction vaults, inspection wells (or risers) should be installed for future use to verify the operation of the field tile system. Inspection wells should be placed approximately 600 mm (2 ft) inside the R.O.W. lines at all locations where field tile enters or leaves the right-of-way. Risers would not be necessary at locations where the field tile is intercepted by the backslopes of ditches as water flow from the terminating headwalls would provide sufficient inspection.

Components used for inspection wells can typically be a T-section, a portion of pipe rising at least 300 mm (1 ft) above the ground line, and a suitable lid or cap. Materials can usually be the same as those used for the STORM SEWER (SPECIAL), except that the material rising above ground must be UV resistant.

SECTION 664. CHAIN LINK FENCE

664.03 General

The purpose of chain link fence is to control access onto State right-of-way in an aesthetically pleasing way. This result can only be accomplished by correct horizontal and vertical alignment.

The bottom of the fence should clear natural ground by a minimum of 25 mm (1 in) and maximum of 125 mm (5 in) with 75 mm (3 in) clearance being desirable. Any high points or other obstacles which interfere with the above clearances should be removed. At locations of small natural drainage ditches where it is not practical to conform the fence to the general contour of the ground surface, the resulting opening below the fence should be closed with barbed wire fastened to stakes of such length as required.

664.04 Installing Posts

To provide for true alignment and the centering of the post in the footing, a stringline or other suitable method of alignment should be used by the Contractor in excavating for the post footings. After the concrete is placed, alignment of posts should be checked by stringline or

"eyeball" while the Class SI footing concrete is still in a plastic state. All posts should be plumbed with a suitable carpenter's level and concrete footings trowel finished and sloped away from the post to protect the posts from later corrosion. When digging footing holes, care should be exercised not to disturb existing right-of-way posts. Although various soils behave differently, 300 mm (1 ft) clearance from the right-of-way post is generally sufficient. No fabric should be stretched or tied until the footing concrete is at least seven days old.

664.07 Braces

For each brace there must be a truss rod in the same span to transmit fabric from the brace post back to the terminal post. Braces and truss rods should be securely fastened to the posts prior to fabric erection.

664.08 Fabric

Fabric should be erected on the outside of the fence line with the top of the fence extending 25 mm (1 in) above the top tension wire. In no case should the erected fabric be in contact with the ground. No continuous run of fabric should be installed in excess of 200 m (660 ft) because of expansion considerations. Every run of fabric must terminate at a terminal (end, corner, gate or pull) post and be properly supported by brace and truss rod if called for on the plans. Protective electrical grounds should be installed as called for on the plans and Article 664.11.

SECTION 665. WOVEN WIRE FENCE

665.03 General

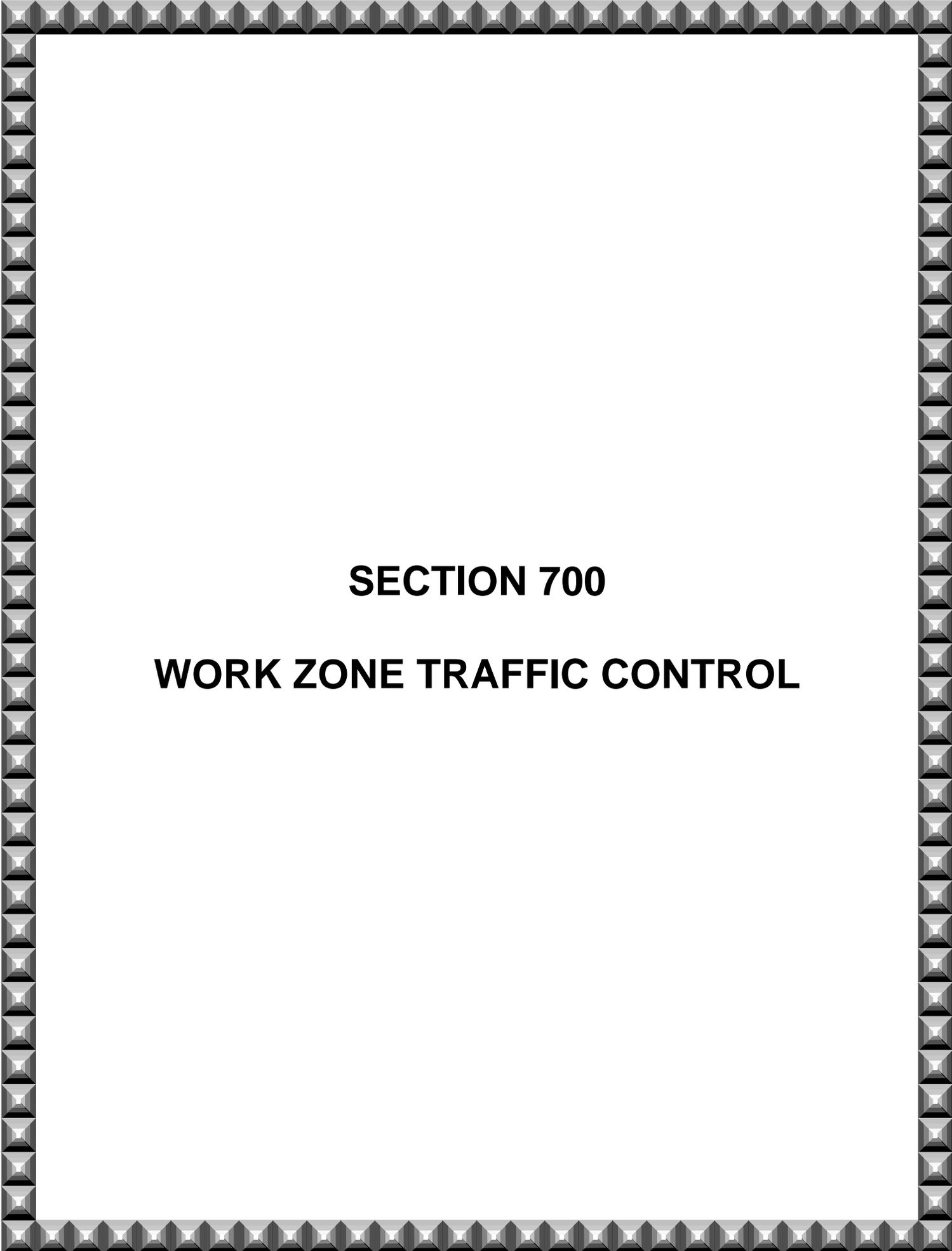
The purpose of Woven Wire Fence is to delineate the access control limits of property adjacent to the right-of-way.

It is desirable to have the fence built before other construction work is started. This is especially important in rolling terrain where areas may become inaccessible after cuts are made.

At locations where it may be impossible to build the fence on State right-of-way, an easement will be needed before any fence can be built on private property.

The bottom strand of the woven wire should clear the ground by 25 mm (1 in) with a maximum of 75 mm (3 in) allowable. Any high points or other obstacles which interfere with the above clearances should be removed. At locations of small natural drainage ditches where it is not practical to conform the fence to the general contour of the ground surface, the resulting opening below the fence should be closed with barbed wire fastened to stakes of such length as required. All concrete post encasements should be crowned and sloped to drain. No continuous run of fabric shall be installed in excess of 200 m (660 ft) because of expansion considerations. If wood posts are used, protective electrical grounds should be installed as called for on the plans and Article 665.03.

Review carefully the areas adjacent to culverts and pipes before setting pullposts to prevent washouts and maintenance.



SECTION 700

WORK ZONE TRAFFIC CONTROL

SECTION 700. WORK ZONE TRAFFIC CONTROL

The Contractor is responsible for providing, erecting, maintaining and removing traffic control signing and devices which are required to protect traffic in accordance with the contract traffic control plan. Required traffic control must be set up before the Contractor is allowed to begin construction.

Read the portions of the Standard Specifications, Supplemental Specifications and Recurring Special Provisions, Quality Standards for Work Zone Traffic Control Devices, contract proposal, engineering plans, [Manual on Uniform Traffic Control Devices](#) and SAFETY 3-07 (Bureau of Safety Engineering Work Zone Safety and Mobility Rule) concerning the requirements for traffic control. Discuss the responsibilities assigned to you in SAFETY 3-07 with your supervisor.

Any revisions in construction staging or operations that affect traffic shall include a revised traffic control plan approved by the District Operations Engineer, the Central Bureau of Construction, and the Program Development Engineer.

The importance of correctly placed and maintained traffic control devices in construction work zones cannot be overstressed. This importance does not diminish when the day's activities are completed and the workforce leaves the jobsite. To assure traffic control devices are in their proper position and functioning properly, the following actions are required:

1. When temporary traffic control devices are in place, the Resident Engineer, or appropriate designee, shall routinely drive through the jobsite, and document the drive through in writing. Every effort should be made to drive through the jobsite at the beginning and end of each workday; however, it is recognized this may not always be possible.

During periods longer than 21 days when no work is being performed, (winter shutdown, suspension of work, extraordinary third party delay, strikes, etc.) drive throughs shall be performed at least two times per week if temporary traffic control devices are in place.

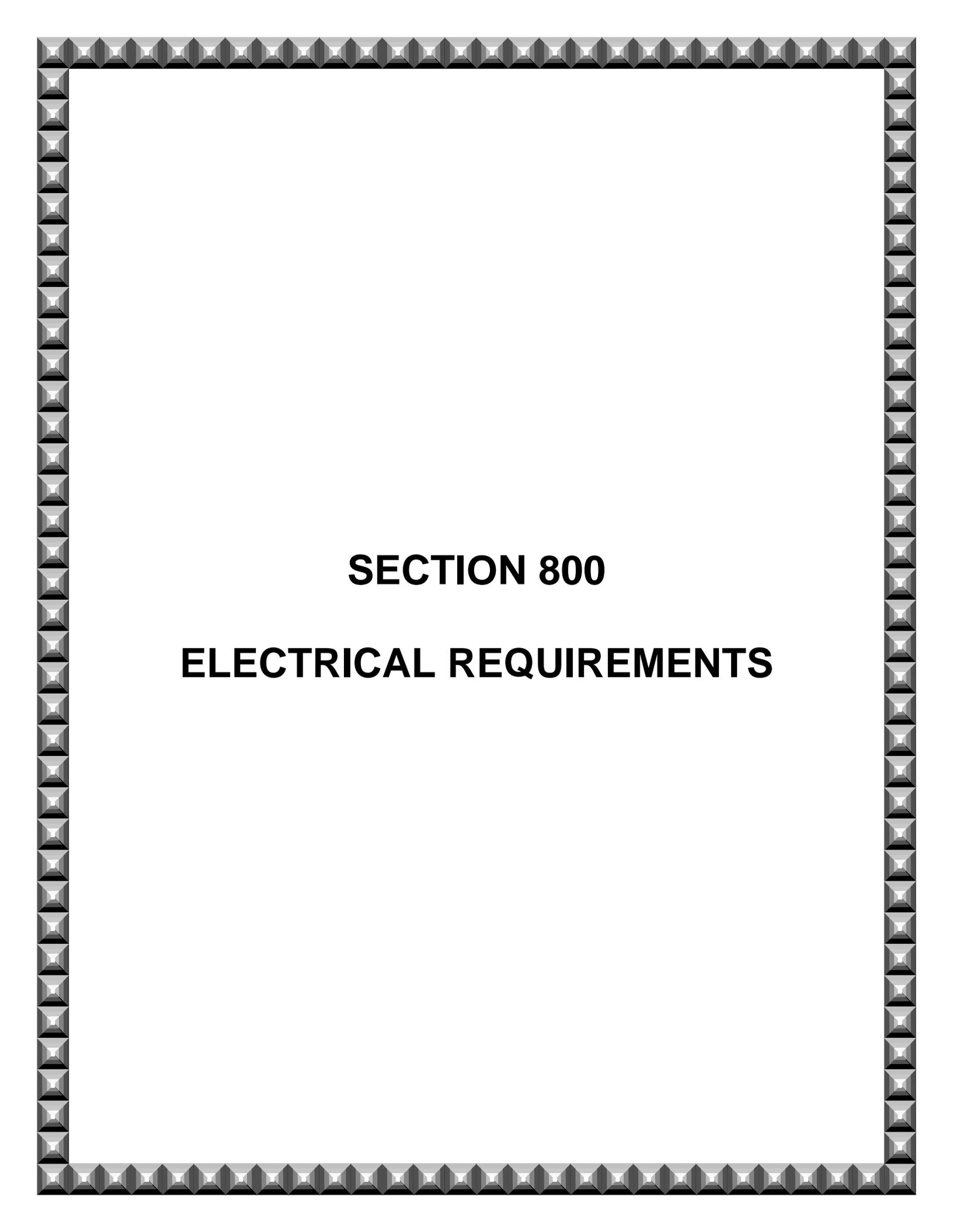
2. In addition, when temporary traffic control devices are in place, one detailed daytime inspection shall be done weekly for projects having hazards in the work zone, barricades on the pavement, or barricades on the shoulder. These inspections shall be recorded on Form [BC 726](#), Traffic Control Inspection Report.
3. When temporary traffic control devices are in place, routine nighttime inspections shall be performed at least two times per month to assure sign reflectivity, identify light outages and required maintenance of traffic control devices and to confirm clear direction to motorists through the work zones. These inspections shall be recorded on Form [BC 726](#), Traffic Control Inspection Report.
4. Should any deficiency be discovered during a drive through or inspection, the contractor shall be notified in writing. The contractor shall notify the Engineer when the deficiency has been corrected. The contractor shall be given evidence of the date and time the deficiency was corrected. If a deficiency is not corrected in accordance with the provisions provided for in the contract, the traffic control deficiency deduction will be applied.

This policy assumes typical daytime construction. When construction activities are performed outside normal working hours, adjustment will be made as to when the inspections will be performed. The adjustments will correspond to actual field conditions. The frequency of the

inspections will remain the same although they may be performed at times other than previously stated.

These reviews are especially critical before weekends and/or holiday periods. With routine inspection of traffic control, workzones will be safe for both the motoring public and individuals working within the workzone.

The Traffic Control Surveillance Report, Form [BC 2240](#), is to be used by the Contractor to document surveillance as required by Section 701.10 of the Standard Specifications.



SECTION 800
ELECTRICAL REQUIREMENTS

SECTION 800. ELECTRICAL REQUIREMENTS**SECTION 815. TRENCH AND BACKFILL FOR ELECTRICAL WORK****815.03 General**

In the case of cut trenches, backfilling should be done as soon as possible after the installation of the unit duct or conduit to avoid the loss or dispersal of the excavated material by rainfall. Particular attention should be paid to the compaction of the backfill material. Installation depth should be a minimum of 600 mm (2 ft) or 750 mm (2.5 ft) whenever possible. Extra depth may be desirable when crossing ditch bottoms, aggregate surfaces such as field entrances/driveways, railroads or where horizontal restrictions require the unit duct or conduit to be installed near the edge of the pavement. A detailed drawing should be made of the exact locations of the installed cables for future reference.

SECTION 821. ROADWAY LUMINAIRES**821.03 General Installation**

All factory wire connections and component installations should be checked for tightness and security.

SECTION 825. LIGHTING CONTROLLER**825.03 Installation**

The utility company should be advised of the beginning of work on the lighting system to allow the completion of their work in a timely manner. The control installation should be placed with consideration of possible flood water levels experienced in the past.

SECTION 836. POLE FOUNDATION**836.03 Installation**

Light Pole foundations should not be located in ditch bottoms.

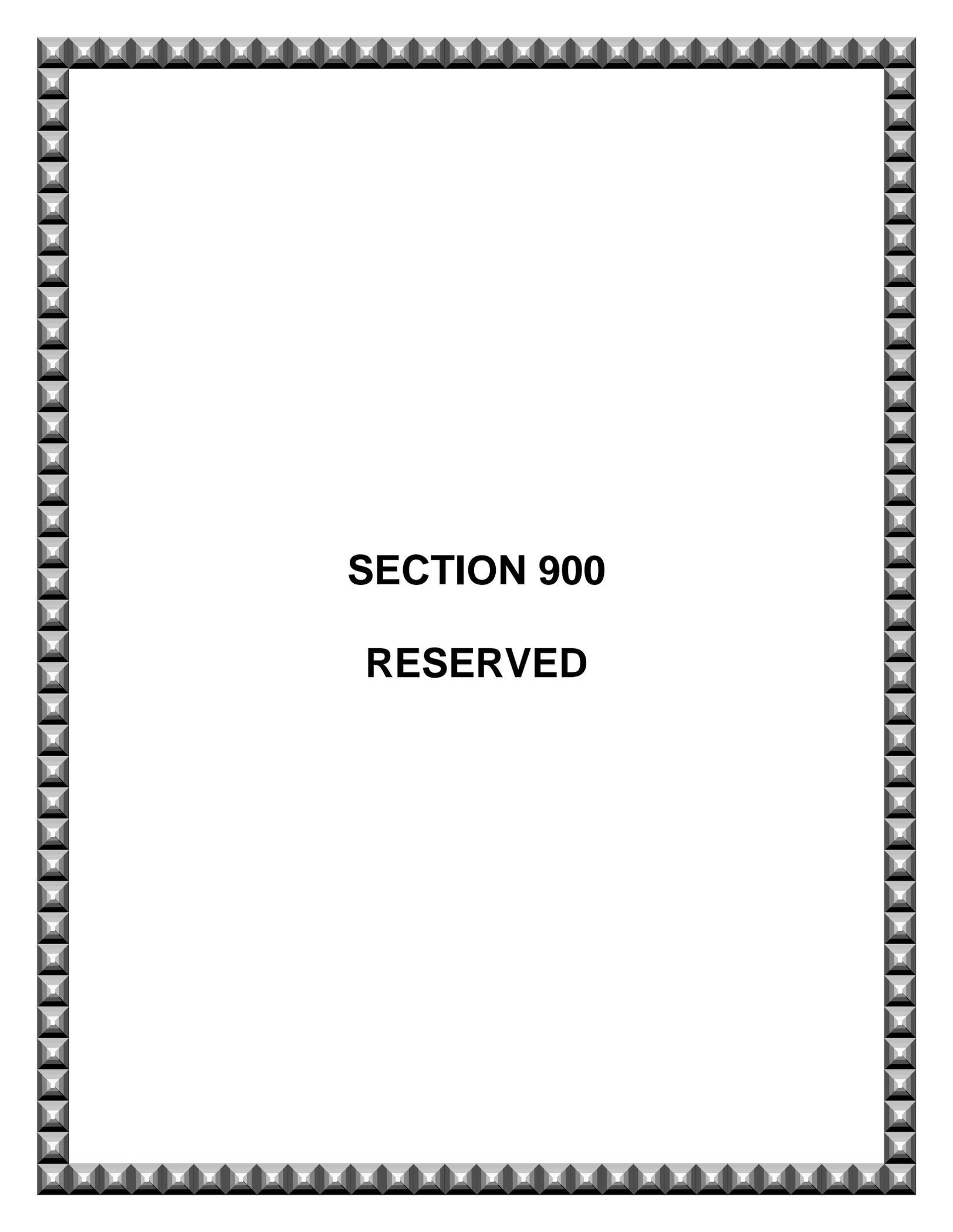
SECTION 838. BREAKAWAY DEVICES**838.03 Installation**

Torque nuts shall not be used to mount the pole to the breakaway device. The breakaway device shall be threaded completely onto the foundation anchor bolt.

SECTION 873. ELECTRIC CABLE**873.03 Installation**

Minimum installation depth should be as indicated in the plans. Extra depth may be desirable when crossing ditch bottoms, aggregate surfaces such as entrances/driveways or any other location where the conductor may be susceptible to accidental damage. A detailed drawing should be made of the exact locations of the installed cables for future reference.

Splices inside poles, towers and junction boxes should be made so that the power cables and components can be arranged with none of the conductors touching the interior metal surfaces.



SECTION 900

RESERVED

