Bridge, Culvert, and Retaining Wall Construction Manual

Georgia Department of Transportation

January 2024

Version

1. January 2024

Added Review of Contractor Wall Sketches and Data and Drilled Shaft Log

2. March 2025

Added Submittals information, Added Media Records

In Memoriam

This manual was dedicated to the memory of Mr. Bobby L. Moore; October 19, 1937 to June 21, 1996.

Bobby Moore began employment with the Georgia Department of Transportation (State Highway Department) in November 1960 as a Junior Highway Engineer and served as Assistant State Construction Engineer for Bridges from July 16, 1980 until his retirement on October 31, 1992. Bobby's interest and career revolved around bridges. He was admired by his peers as a designer, a constructor, and an educator and was well known and respected throughout the state. As the principal writer of the original Bridge Manual, Bobby's experience and knowledge is left as a legacy which will benefit many engineers for years to come.

The Bridge Builder

An old man going on a lone highway Came at the
evening cold and gray To a chasm vast and deep
and wide.
The old man crossed in the twilight dim; The sullen
stream had no fears for him. But he turned when safe
on the other side And built a bridge to span the tide.

"Old man" said a fellow pilgrim near, "You are
wasting your time with building here.
You never again will pass this way- Your
journey will end with this closing day. You have crossed
the chasm deep and wide, Why build you this bridge at
eventide?"

The builder lifted his old gray head. "Good friend,
in the way that I've come," he said,
"There followeth after me today
A youth whose feet must pass this way. This stream
which has been naught to me To the fair-haired youth
might a pitfall be.
He, too, must cross in the twilight dim.
Good friend, I'm building this bridge for him.

Will Allen Dromgoole

Preface

This manual is presented in English units of measure only.

This manual is intended as an aid to project engineers and inspectors in inspecting bridge, culvert, and retaining wall construction. It is not intended that this manual or any provisions thereof, supersede or in any way alter the terms of any contractual obligation. In the event of a conflict between the provisions of this manual and the provisions of the contract, the provisions of the contract shall always control.

In most instances, topics covered are arranged in the same order that they normally occur in actual construction. No attempt has been made to present new or novel methods of construction, but rather to show those that are well established. This should be of particular benefit to those who are inexperienced in this type of construction. Methods presented are by no means the only way to accomplish the work, and it is not intended that the contractor be limited to any specific method(s) mentioned.

Unless noted otherwise, all references to the Standard Specifications or Specification sections shall mean the Georgia DOT Standard Specifications for Construction of Transportation Systems, current edition.

The Department does not warrant the information in this manual and anyone making use of it assumes all liability for such use.

If errors are found, please notify the Office of Construction so that corrections may be made.

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CHAPTER 1
GUIDELINES FOR PROJECT ENGINEERS

I. Complete "Checklist for Plan Review"

One of the most common causes of redesign for bridge work is due to inaccurate or improper layout, either plan or field related. Some of these problems can be averted by proper checking of the plans prior to construction. This will also be of benefit to become familiar with the bridge plans. The Contractor should also make these checks before beginning work. A list of items that should be checked for typical bridges is included on the following pages and is labeled "Checklist for Plan Review".

II. Review Bridge Foundation Investigation (BFI)

For foundation information on the bridge site- contact the District Office if a copy is not with the project records.

III. Ensure Materials Are from Approved Suppliers

Concrete and steel must come from sources on the Qualified Products List (QPL). Invoices must be kept for Structural Steel and Bar reinforcement steel. Quality Assurance testing of all concrete must be done. See the Construction Manual and the Sampling, Testing and Inspection Manual for specific procedures and the associated QPL lists.

IV. Require Contractor to Furnish Bridge Layouts

As required in Section 149—Construction Layout.

The Contractor is responsible for construction layout including verifying plan dimensions, alignment and elevations, and making necessary adjustments to fit existing field conditions. Many field errors can be averted by requiring the Contractor to supply field layouts and perform redundant checks which are required by Section 149—Construction Layout, of the Specifications.

Acceptable layout sketches and typical layout procedures are covered in Appendix A. **The Contractor shall furnish an approved layout sketch prior to beginning the work.** Verifying actual field measurements is especially important for bridge widening to insure a proper tie-in.

The Project Engineer should check the Contractors submittals for completeness and compatibility with the plans.

In particular:

- Compare Contractor's layout to plans and actual field conditions.
- Original ground data must be taken in order to properly calculate excavation pay items.
- Review grade control for deck construction.

V. Ensure Shop Drawings for Beams and Stay-In-Place Deck Forms Are Approved Prior to Use:

Any changes to Shop Drawings shall be resubmitted for approval. See Next page for submittals and how they should be handled.

You will need submittals for the following items, this is not a comprehensive list and there may be other items that need submitting. For Bridge Office submittals, send to the appropriate design group leader through Projectwise Deliverables Management. For Geotechnical submittals send to Geotechnical_submittals@dot.ga.gov. Please include the PI # and description in the subject line of the email or Projectwise Transmittal.

Submittal	Submit to	Notes
Shop Drawings (Beams, Deck Pans, Bearing Assemblies, Deck Drain System, etc.)	Bridge Group Leader - *Submit each Shop Drawing individually. Don't send multiple shop drawing pdfs in one submittal.*	Use Initials in the Design Group section at the bottom right of your bridge plans. KMS (ACB) – Kevin Schwartz – kschwartz@dot.ga.gov DDF (DLC) – Doug Franks – dfranks@dot.ga.gov TKH (YSK) – Teresa Hartle – thartle@dot.ga.gov JBK (EJC) – Joe King – joking@dot.ga.gov DLW (LAIII) - Dexter Whaley – dwhaley@dot.ga.gov EJF (DPD) - Eric Fleckenstein – efleckenstein@dot.ga.gov JAC (---) - Jeff Crouch – jcrouch@dot.ga.gov JRT (SKG) - Jennifer Tait – jtait@dot.ga.gov
Special Design Walls (MSE Wall, Tie Back Wall, Soldier Pile, Soil Nail, etc.)		
Noise/Sound Walls		
Joints- certain types need submittals (Modular, Steel Armored, Finger, Etc)		
Bridge As-Built Plans		
Detour Bridges		
Utility that is attached to a new or existing bridge	BridgeOffice@dot.ga.gov	Only Utilities attached to new or existing bridge need to be sent to the Bridge Office
Temporary Shoring adjacent to RR Tracks		These are the only footing shoring drawings that need to be sent to the Bridge Office for approval.
Utilities not attached to a bridge such as water mains, sanitary sewer structures, and micro tunneling	UtilitySubmittals@dot.ga.gov	Requirements for utility appurtenances and installation methods can be found in the Utility Accommodation Policy and Standards Manual (UAM)
Light poles over 50 ft. and structural supports for overhead signs, Signal mast arms, and Strain pole shop drawings	SLTS@dot.ga.gov	Copy dwhaley@dot.ga.gov (Dexter Whaley), the SLTS@dot.ga.gov email shouldn't be set to acknowledge or respond.
Light poles under 50 ft.		District Traffic Operations to review lettering and spacing requirements; structural components handled by GDOT STDs 9041 & 9042
Pedestrian Bridge	sgaston@dot.ga.gov	Steve Gaston
Sound and Visual Barriers	efleckenstein@dot.ga.gov	Eric Fleckenstein
Bridge Maintenance Projects	BMUSubmittals@dot.ga.gov	Also, copy State Bridge Maintenance Engineer and Assistant State Bridge Maintenance Engineer.
New Bridge Completion	BMUSubmittals@dot.ga.gov	Also, copy State Bridge Maintenance Engineer
ITS Components	State ITS Engineer and State Signal Maintenance Engineer	The Office of Traffic Operations reviews the shop drawings for the following specifications: 631, 693, 925, 926, 935, 936, 937, and 939. These submittals are to be sent to the current State ITS Engineer and State Signal Maintenance Engineer, Emails are current as of 2/24 (asteede@dot.ga.gov; edyer@dot.ga.gov)
Temp Walls, Temp Shoring	jedaniel@dot.ga.gov	Construction Office reviews shop drawings such as temporary walls, temporary shoring, etc. Submittals shall be sent to Assistant State Construction Engineer
Dynamic Pile Testing (PDA)	Geotechnical_Submittals@dot.ga.gov	Notify the Geotech Office two weeks prior to driving PDA test piles. Submit all files required by Special Provision 523 for review and approval. The person performing the PDA does not work for the Department and the numbers they produce may not be the final driving criteria. If the contractor decides to use the PDA numbers to drive additional pile inform them that they assume full responsibility for any changes that may be made after the WEAP has been analized. This could include additional bearing, additionl pile, pile configuration, footing type, etc. Contractor is not supposed to drive production piles until they recieve approval of the PDA from Geotech. This can be up to 7 days from submitting the Report. Review can take up to 7 calendar days.
WEAP Analysis (report generated from PDA test)		Provide results of the WEAP, Wave Equation Analysis, to the Geotech Office for review and approval two weeks prior to driving the PDA test piles. *Contractor is not supposed to drive pile until they receive the approval of the WEAP from Geotech. This can be up to 14 days from submitting the report.* Review can take up to 10 working days.
Data Pile		Submit data pile forms to the Geotech Bureau for review and retention.
Drill Plan For Drilled Shafts		Submit the drilling plan 30 days prior to construction of the drilled shafts. Provide all information requested in the Special Provision 524. Review can take up to 30 calendar days.
Load Test Report for Pile,Drilled Shaft or Micropile		Submit the load test reports for piles, drilled shafts or micropiles with all information required by the respective Standard Spec for piles or the special provisions for drilled shafts/micropiles. Load test review period is 14 working days.
Micropile Installation Plan and Micropile Shop Drawings		Submit the installation plan and shop drawings for micropile 90 working days prior to construction of the foundations. Plans and shop drawings must include all information in the SP 999 to be considered complete for review. Department review period is 30 working days after reciept of complete shop drawings and installation plan. Re-submittals still have a 30 working day review period.

Submittal	Submit to	Notes
Non-Standard Precast Drainage Structures and Non-Standard Precast Box Culverts	shopdrawings@dot.ga.gov	Reviewed by Design Policy - Standards and Details/Roadside Safety Group
Lighting components	lighting@dot.ga.gov	Reviewed by Design Policy - Lighting Group
Bridge Layout	Place in Projectwise	Project Manager Approves
Warranty for Overlay (10yr) and Joints (5yr)		Project Manager
DFO Markups		Project Manager for Review, If negative markups are reported contact Bridge Liaison.
Work Bridge		Project Manager Approves; The Bridge Office does not need to approve Work Bridges unless there is going to be live traffic on the bridge.

VI. Maintain As-Built Documentation

- Complete the as-built foundation information sheet in the plans and transmit to the Bridge Office.
- Maintain records and plans of as-built elevations, dimensions, vertical clearances, and any changes to the as-let plans.

VII. Media Records

In addition to the Media Records requirements stated in Chapter 2 of the Construction Manual, the Construction Manager shall also maintain adequate photograph and/or video documentation of all Cast-in-place (C.I.P) reinforced concrete structures prior to concrete placement, and after form removal. Photographs and/or videos shall be uploaded in ProjectWise in the Project's Photo/Video Documentation Folder and labeled appropriately. Photographs or videos should show reinforcing steel placement and form arrangement. The following items are listed as examples and may be supplemented as needed depending on project scope.

- Bridge Substructure – Footings, Columns, and Caps.
- Bridge Superstructure – Endwalls, Edgebeams, Diaphragms, Deck, and Barrier/Endpost.
- Culverts – Floor Slabs, Vertical Walls, Top Slabs, Wingwalls/Headwalls, and Barrier.
- C.I.P. Retaining Walls – Footings, Stems, Barrier.

VIII. Checklist for Plan Review

It is the duty of the Engineers assigned to the construction of a bridge to make a thorough check of the bridge plans. This check can be sub-divided into the following:

A. Roadway Plans Vs. Bridge Plans

The ends of bridge stations on the bridge plans should be checked against those shown on the roadway plans. The direction and magnitude of skew angles, horizontal curve data, vertical curve data, points of superelevation, and all other general alignment and grade data should be checked to make certain that the roadway plans data is the same as the bridge plans data. If the centerline of the bridge is not the same as the roadway or construction or survey centerlines, check to see that the two are tied together. As a minimum check the following:

- ——— Stations (begin and end) Same?
- ——— Widths compatible? Transitions shown (if required)?
- ———Grades consistent? (horizontal and vertical)
- ———Crown/cross slope? Superelevation?
- ———Bridge length sufficient to span roadway, railroad or waterways, including toe of slopes?

- ———Railroad bridge on curve-spiral layout shown? (Railroad bridges use spiral curves instead of circular curves for horizontal alignment.)

B. Bridge Plans

- ———Stations and span lengths consistent?
- ———Are profile grade, survey, construction and bridge centerlines same or different?
- ———Vertical dimensions should be checked against elevations.
- ———Minimum vertical clearances should be checked, and field verified.
- ———The skew angles of the bents should be checked against the deck skew angle.

1. Beams

- Details and span lengths consistent?

Beam spacings should be checked against superstructure plans and against the beam chord layouts in the case of curved bridges.

- Dead Load Deflection Shown?

For simple beams the dead load deflections will consist of one value that is true at the midpoint of the span. For continuous span beams the dead-end load deflection information is given either as a plotted curve or a table of deflections at the one-tenth points between the bearings.

2. Fixed and Expansion Ends

Is Bearing Type Consistent?

The plan and elevation sheet should show the type of bearings at the end of each bent.

3. Bearing Pads

Anchor bolt hole/dowel bar layout should be checked against the structural steel or prestressed beam details.

4. Deck Slab

- Is thickness shown? check all spans and overhangs.
- Is thickness shown for slab + coping over beams?
- Clearances and dimensions add up to thicknesses?
- Bar lengths and lap dimensions check?

5. Cap, Columns and Footings

- Cap- Any conflict with anchor bolt hole/dowel bar locations?
- Compare bearing assembly dimensions with cap dimensions.
- Clearances and dimensions check?
- Bar lengths and lap dimensions check?
- Cap and column dimensions fit together?
- Plan dimensions and elevations correspond to each other?

6. Pile Foundations

- Compare beam spacing to pile spacing on pile bents.
- Footing elevations (or ground) - Minimum tip = minimum pile embedment (should be 10 feet or greater into natural ground)

7. Wing Wall Elevations

The top of the wall is to be poured on grade, not level.

8. Dimensional Checks

- Compare elevations and dimensions at end of each beam: Finished deck elevation @ beam - cap elevation = total thickness of bearing system+ beam height at bent+ total depth of concrete above the beam (slab + coping)
- Check to see that the bottom of cap elevation – Top of footing elevation = column length shown on plans
- Bottom of cap elevations should be checked to assure minimum cap depth.
- Compare recommendations on bridge foundations investigation (BFI) to plan driving objective (PDO) shown on the plans- obvious errors such as pile lengths being less than 10 feet or spread footings being above ground should be reported to the bridge office.

CHAPTER 2 BRIDGES

SECTION 1 FOUNDATIONS

A. Excavation (Section 201—Clearing and Grubbing and Section 211—Bridge Excavation and Backfill)

See Section 201—Clearing and Grubbing of the Specifications for Clearing and grubbing recommendations. Original ground data must be taken in order to calculate pay quantities for excavation. Section 211—Bridge Excavation and Backfill discusses measurement and payment for bridge excavation. For most footings a shot at each corner is sufficient unless the ground is irregular, then additional sections should be taken. Ground elevations for piles driven in water should also be gathered and included in the as-built information as a record of the embedment length of the piling.

B. Bridge Foundation Investigation (BFI)

The BFI report contains the recommendations on which the foundations are designed. The report may include minimum and estimated tips for piling, elevations and expected material for spread footings, any special notes, and boring logs with a sketch of the bridge site denoting the locations of the borings. "*The BFI is not a part of the Contract and as such any and all recommendations stated in it are not binding on the Contractor unless also shown on the Plans or in the Contract.*" Nonetheless, it is imperative that a copy of the BFI is on site before any foundation work is begun. The BFI should be used to compare actual subsurface conditions to those used in the foundation design. If the District does not have a copy contact the Geotechnical Bureau of the Office of Materials and Testing.

C. Piling (Section 520 Piling)

Piling types commonly used in Georgia include Prestressed Concrete (PSC), Steel H, Metal Shell and less frequently, timber. Before the driving of piling can commence the Engineer must inspect the piling gathering certain data in the process, get clearance from the Office of Materials and Tests for certain types of piling, and inspect and approve the driving equipment. In detail this is as follows:

1. Storage and Handling of Piles

Piles are structural members. They must be handled and stored on the job site in such fashion that their structural capacity is not damaged. Damaged piles shall not be driven.

2. Inspection of Piling

All types of piling must be inspected before driving. Piling should be inspected as soon as it is unloaded on the project. Different types of data and different requirements for driving are set up for each type of piling.

If the Engineer notices before or during the driving operation any condition that indicated that a pile has been damaged in storage, handling or in transit, or is otherwise not in accordance with the Specifications, the Engineer should not allow that pile to be driven. If this condition is questionable, the State Construction Office or Office of Materials and Testing (OMAT) should be asked to decide whether to discard the pile.

a. Prestressed Concrete Piles

Piling must come from an approved casting yard. On each pile the Engineer should find a pile number, the date cast, length and size. Each pile with the same casting date will have a different number but the pile numbers will repeat for different casting dates. Note that there is a difference in handling for unloading and in handling for placement in the leads for driving. The pick-up points for loading or unloading are embedded in the piles, usually in the form of cable loops, in the manufacturing process. The pick-up point or points to place the pile in the leads will be marked on the pile at the casting yard.

PSC piling are best stored supported by blocks adjacent to the pick-up points, but they may be laid on the ground if the ground will give uniform bearing for the full length of the pile. The piles shall be supported horizontally i.e. do not lay on an incline.

Prestressed concrete piles may be shipped to the project when they have reached a minimum compressive strength of 5000 psi. No prestressed concrete pile can be driven regardless of strength until it is five days old.

b. Steel Piling

H-piles and metal shell piles should have a heat number shown on each piece. A pile without a heat number cannot be driven. The pile heat number must be identified with an acceptable mill test report before the pile is driven. If the Engineer has in his files an acceptable mill test report that covers the heat number of the pile, the pile may be driven. An acceptable mill test report is one that has been reviewed and approved by the OMAT. The Engineer may receive verbal clearance from the OMAT to drive the pile of he has no mill report.

c. Treated Timber Piles

On each pile the Engineer should find a branded inspection mark. This mark will indicate the name of the inspection agency and the inspector's number.

d. Untreated Timber Piles

Untreated timber piles are not inspected by the OMAT or any inspecting agency. The Engineer will inspect the piles to see if they meet the requirements of the Specifications.

Untreated timber piles are not used as part of the permanent construction.

3. Inspection of Driving Equipment

The Engineer should inspect the Contractor's pile driving equipment to determine if it meets the requirements of the Specifications before pile driving is started. See Appendix B, Pile Driving for additional information.

4. Driving of Piles

Piles are to be driven to the Plan Driving Objective (PDO) shown on the plans, with the equipment called out in the WEAP, according to SP 520. In some cases, it may be necessary to jet, spud, or predrill to accomplish this. The Specifications give the Engineer authority to require the jetting of piles if it is necessary. Jetting must be carefully done in accordance with the Specifications. In many cases the Contractor may predrill, at his own expense, to expedite driving piles which are too long to fit into his driving leads; or to drive piles in places having restricted vertical clearance, such as under power lines.

a. Location

The location of each individual pile, whether in a pile bent or in a footing, is usually controlled by a template. In most instances, predrilling will also require a template. If the Contractor's leads are firmly attached to the crane (fixed leads) templates may be eliminated provided the location of the piles is adequately controlled by this equipment. Once the piles are in the template the straightness or batter is checked with a carpenter's level and is corrected by swinging the leads. Piling should not be driven without a template; templates are especially important for driving in water. During driving the pile must be watched and checked to make certain its rate of batter or its straightness has not changed.

b. Plan Driving Objective (PDO)

It is the Engineer's responsibility to have the Contractor drive the piles to the condition called for by the Plan Driving Objective shown in the Plans. The PDO is usually a driving resistance with a minimum tip elevation. The penetration needed to meet the minimum tip elevation can be marked on the pile and the driving resistance checked after minimum tip is achieved.

c. Driving Resistance

Bearing capacity is typically determined by evaluation of driving resistance but may be determined by load tests or by a combination of these means. Driving resistance is determined by the appropriate formula in the Specifications. All the formulas used are based upon two factors: the penetration of the pile in inches per blow and the energy in foot-pounds delivered to the pile by the hammer. The penetration in inches per blow is determined by marking the pile, counting some 5 to 20 blows, re-marking the pile, and measuring the distance between the marks and dividing by the number of blows. The energy delivered to the pile is determined by the height of fall and weight of the ram for open-end hammers. For closed-end diesel hammers the bounce chamber pressure must be recorded and changed into equivalent "WH" values by means of the chart furnished with each hammer.

For projects that have a Special Provision 520 driving resistance will be verified using dynamic pile testing (PDA), load testing, or the FHWA Modified Gates equation as specified on the Plans. Typically, only PDA testing is required on a project.

The Special Provision 520 requires a GRLWEAP report be generated and submitted to the Geotechnical Bureau **a minimum** of 10 working days prior to the Contractor scheduling the PDA test. This report should be submitted by the Contractor and forwarded to the Geotechnical Bureau at Geotechnical_submittals@dot.ga.gov. The review period for the GRLWEAP report is 10 working days from the date it is received in the electronic mailbox. Approval will be issued in writing to the District from the Geotechnical Bureau. Once approval has been provided, the Contractor may proceed with PDA testing.

The PDA testing will be performed by a 3rd Party Consultant hired by the Contractor. Any questions or concerns that arise during the PDA testing should be called into the Geotechnical Bureau. Contact the person listed on the GRLWEAP Acceptance letter issued by the Department. Once the PDA testing is complete, a report will be generated for review and approval of the driving criteria for this project. This report must be submitted by the Contractor and forwarded to the Geotechnical Bureau at Geotechnical_submittals@dot.ga.gov. The review period for the PDA report is 7 calendar days from the date it is received in the electronic mailbox. Approval will be issued in writing to the District from the Geotechnical Bureau. Once approval has been provided, the Contractor may proceed with pile driving using the approved driving criteria to install the piles on this project.

d. Load Test

Load test are typically set up in the plans as "If required". Contact the Geotechnical Section of the OMAT if a load test is required or needed on the project. A discussion on dynamic testing, load test procedures and requirements are included in Appendix B.

e. Test Piles

Test piles are used to evaluate driving conditions and to set the order lengths for piling. Except in unusual cases, the plans will call for test piles only when piles are of prestressed concrete or timber.

The plans usually call for prestressed concrete test piles to be driven at certain bents in the position of a permanent pile and become a part of the permanent structure. If the Contractor requests a change in the location of a test pile the Construction Office along with the Geotechnical Branch of the

Materials Office should be consulted.

A test pile should be driven until it will not go any further or until the pile is driven to cut- off elevation. All the test pile length should be utilized, if possible. If the driving resistance has not been achieved by cut-off elevation the Geotechnical Bureau should be contacted for additional recommendations.

Complete driving data must be kept on the test pile from the first blow until the last. Data should also include any predrilling, jetting or spudding requirements to complete the test pile. Test piles should be marked at one-foot intervals along the entire length of the pile, and once driving is begun, the number of blows required to drive the pile the one-foot distances counted and marked on the test pile form.

Driving Resistance determinations and elevations must be taken in increasingly close intervals as the driving resistance increases. This data is to be reported to the OMAT Geotechnical Branch on form DOT 500 A and 500B. See Appendix B. It is from this data that the pile order lengths are established.

When a bent does not contain a test pile, the order length will be given, and the permanent piling may be driven only after the test piles on either side of the bent have been driven and indicate that the plan driving objective can be achieved within the test pile length.

f. Driving-Data Piles

Driving-data piles are always required when steel or metal shell piles are used in a bridge and are sometimes called for on bridges which also have test piles. The purpose of a data pile is to obtain complete driving records of individual piles within a bridge. The specific bent locations will be shown on the plans.

A data pile is simply a “regular” pile on which a complete driving record of blows per foot is kept and submitted to the Bridge and Materials Offices. The form for Data Pile reporting is the same for Test Pile Reports. See Appendix B.

g. Driving Piles in Water

With regards to driving piling in water, special attention should be given to Subsection 520.3.02.F. The intent of this Specification is that the top of the piling is not to be driven below the surface of the water. If the top of the pile elevation is to be below the surface of the water additional pile length must be used and the pile cutoff to the plan elevation.

5. Problems in Driving Piles

If any of the following problems occur in pile driving, you should stop driving and contact the Construction Office or the Geotechnical Bureau of OMAT:

a. Piles not reaching minimum tip

b. Piles not achieving bearing and are 5-10 ft below estimated tip

c. Piles being damaged during driving

d. Location of piles cannot be controlled

6. Splicing of Piles

It is necessary at times to splice piles. These splices are to be made in accordance with the details shown on the Plans and Specifications, the Department does NOT allow premade splices to be used. Splices for steel piles must be made by a certified welder. The Engineer must check the welder’s certification card and should record the welder’s name, card number, and the expiration date of the card in the diary. Only those welders holding a certification card issued by the Department will be allowed to make splices. The Engineer must inspect the finished welding.

7. Protective Coatings for Piles

When required by the plans, steel piles shall be painted with a 2-P coating (2 coat bituminous coating). Locations and thicknesses are described in the Specifications under Section 520—Piling and under Section 535—Painting Structures.

Piles for pile bents to be permanently located in water must be partially painted and the thickness of the paint measured and approved before the piles are driven. This painting must be done only to the extent necessary to ensure that the Specification length of pile below the low water surface is protected by the full thickness of paint. Painting beyond these limits may reduce the load capacity of the pile by reducing the available pile to soil skin friction.

Coating for end bent piling is to be 2 ft below bottom of cap. This can be with a type 2-P paint or as an alternate a concrete collar may be poured 2 foot deep with 3 inch cover around the pile.

The thickness of the coats shall be measured with a dry film gauge.

D. Spread Footings

Spread footings are to be excavated and placed to the elevations shown on the Plans unless the field conditions are different from that indicated in the BFI report. Differing conditions, if they exist, should be discussed with the Area Manager and the Geotechnical Bureau before changes are made**.** **Do not**, by raising a footing, place it on material inferior to that which exist at plan datum. Never raise a footing just because the excavation is difficult. Normally, footings can be raised or lowered up to 3.0 ft. without redesign (check the general notes on the Plans). If the footing is to be raised or lowered more than 3.0 ft. the Bridge Office must be contacted so that the bent can be re-designed if necessary. It is also important that the footings not be over- excavated if a spread type of footing is to be used. If a spread footing is over-excavated, the footing must be lowered.

The foundation should be drilled in accordance with Section 211—Bridge Excavation and Backfill. The Standard Specifications require that rock for footings be drilled to a depth of 6.0 ft. and that soil for footings be drilled to a depth of 10.0 ft. by the Contractor. If the rock is hard and solid within the 6.0 ft. drill length and compares to the BFI borings, use the rock at plan elevation. If the rock is soft or is disintegrated and the BFI shows hard rock and the drilling shows that it gets harder with additional depth, then remove it down to the hard rock. If your spread footing is on soil and compares to the BFI borings, contact the Geotechnical Bureau to determine what inspection method (10 ft. test bore, A and P work, etc.) would be needed for your project.

Inspections of spread footings are conducted by the Geotechnical Bureau. Inspection requests need to be requested a minimum of 48 hrs. prior to the inspection. Request inspections through the Geotechnical Bureau at Geotechnical_submittals@dot.ga.gov.

Keys should be cut, and for sloping rock, any necessary benches also be cut in the rocks. When the rock is sloping it is not necessary to completely level up the rock but only secure the footing against slippage with keys or benches. Extra concrete necessary to fill keys, benches, and irregularities in the rock will be in accordance with the Plans or Specifications for filler concrete. (See Subsection 500.4.01.B.1 and Subsection 500.5.01.E).

Often the foundation is designed to bear on weathered rock instead of hard rock. Compare the material at, above, and below the foundation elevation with the material encountered in the BFI borings. If there is any question of the suitability of the material at plan elevation do not hesitate to call in the Geotechnical Bureau of the andOMAT, (24hour notice is required to set up field visit).

If spread footings are founded below the water table on weathered rock, even more care must be taken. Pumping should be done from a sump outside of the footing area and the last 12 inches of the excavation should not be done until immediately before the forms are to be set. After the forms are set, any material churned up by the workers should be removed, the reinforcement steel placed without further disturbing the soil and the footing poured. This can be done by tying the reinforcement steel together (both the mat and the dowel bars) outside of the footing and swinging it into place just before the placement of the concrete. This will allow all churned up or softened or loosened material to be removed just before the placement of the concrete.

Water shall be directed around the forms, not through the footing area, by suitable trenches. Concrete may be placed in the forms while the pumping is being done but the pumps shall be shut off as soon as the footing pour is completed.

Excavation for spread footings under water is discussed in Subsection G," Seals" below.

It is permissible, if the Contractor so elects, to eliminate footing forms and pour against the firm sides of excavation in either soil or rock provided the footing dimensions remain reasonably close to plan dimensions. Extra concrete required to do this would not be paid for nor can the footing size be reduced.

E. Drilled Shafts (Section 524 Special Provision)

1. General

Drilled shafts (also called drilled piers, or caissons) are constructed by excavating a hole, usually cylindrical in shape, placing reinforcing steel, and filling the hole with concrete.

Drilled shafts have one advantage over conventional driven piling in that they can be Installed in larger diameters and thereby making the quality of construction in each shaft critical. The construction of each shaft must be monitored closely for two very important reasons:

a. Most of the shaft is inaccessible for evaluation of integrity once it is cast.

b. The replacement of a defective shaft or repair of a foundation with the defective shaft can be extremely time consuming and very costly.

2. Required Submittals and Meetings

A minimum of 30 working days before the planned start of drilled shaft construction, submit the Drilling Plan from the Drilled Shaft Contractor or Prime Contractor to the Geotechnical Bureau for review and approval. This Drilling Plan should contain the information listed in 524.03.01 Personnel along with any documentation if load tests or CSL testing is required. Submit the Drilling Plan to the Geotechnical Bureau at Geotechnical_submittals@dot.ga.gov. The review period is 30 working days from when it is received in the electronic mailbox. Acceptance will be issued in writing to the District from the Geotechnical Bureau.

Special Provision 524 is project specific and requirements for pre-construction meetings, demonstration shafts, load tests, or non-destructive testing change between projects. Read the Special Provision 524 closely to ensure what is required for the project.

3. Construction

The method that is used to construct a drilled shaft will depend on the following conditions or requirements:

a. The material through which the shaft is to be constructed.

b. Whether the shaft is designed to develop load carrying capacity through end bearing or skin friction.

4. Casing

Casing is generally required through materials which might cave. Casing may be installed by drilling, pushing or driving. After the shaft is concreted, the casing shall be removed unless the plans call for the casing to be left in place. Casing may be pulled with some tapping allowed. Vibratory hammers may be used to place or pull casing but their use and the conditions for their use must be defined by the Engineer.

Temporary casing should be removed as soon as possible after the completion of the concrete pour. Any work to remove the casing will cause vibrations or other disturbances should be completed within three hours of the start of the concrete pour.

5. Excavation

Various methods of excavation are used for drilled shaft construction. These methods depend on the materials to be removed and whether or not the excavation is being made wet (under water or in a slurry) or dry. The excavation time required for friction shafts in a wet condition is critical because the sides of the excavation soften over time. If the shaft is not concreted in the required period noted in the plans, the shaft must be reamed to remove the softened material. Intentionally under sizing a drilled shaft in anticipation of reaming the sides is not permitted, reaming is meant for unanticipated delays in drilling that can cause you to miss the required open shaft window such as weather, equipment breakdowns, etc.

The bottom of the shaft must always be cleaned of all soft materials prior to concreting. For slurry construction, a sample of the slurry at the bottom of the shaft must be taken prior to concreting to assure that concrete will displace the slurry.

In general, the excavation for the shaft is to be made to the depth shown in the plans. For shafts that develop most of their capacity from end bearings, the materials below the tip of the shaft must be evaluated by drilling a test hole approximately six feet deep or coring rock below the tip elevation. The Special Provision 524 will indicate whether airtrack drilling or test coring is required for the project. Airtrack drilling will be provided by the Contractor in the presence of the Geotechnical Engineering Bureau, a 48 hour notice sent to Geotechnical.submittals@dot.ga.gov is required to request the inspection. Test cores will have to be made by the Contractor to a minimum depth of 10 feet below the tip and meet the quality requirements provided in the Special Provision. The Geotechnical Engineering Bureau will aid in this evaluation.

6. Concreting

The method by which concrete can be placed in the shaft will depend on whether the bottom of the shaft is dry (less than three inches of water just prior to concreting) or wet (over three inches of water or constructed with slurry). Shafts with a relatively high influx of water should be treated as wet. Concrete placed in the dry shall be placed in accordance with the Standard Specifications. Concrete placed in the wet condition may be either pumped or place with a tremie. In either method, a plug, valve or bottom plate will be required to prevent water entering the line or to purge the line of water before the concrete is placed in the shaft. The tremie or pipe should remain embedded in the concrete at least ten feet for the duration of the pour. The concrete should be placed full depth before the casing is pulled. An additional height of concrete may be required to allow for loss after the casing is pulled.

When a concrete pour is made underwater, a measuring tape with a weight must be used to monitor the top of the concrete. If the pour is made underwater and to be stopped below ground (i.e. cut off is below ground) an additional amount of concrete should be poured to adjust for possible contamination of the top of the concrete.

7. Inspection (See Drilled Shaft Inspection Report Form: Appendix B; Section 6)

After Geotech has inspected the shaft the inspector is responsible for keeping records on the following items:

a. The time at the beginning and end for excavation of the shaft.

b. The time at the beginning and end of concrete placement.

c. The diameter, length and method of installing casing.

d. The methods of excavation.

e. Any problems or obstructions encountered during excavation.

f. Depth of water in the shaft prior to concreting.

g. The tip elevation of the shaft.

h. Any information on the condition and type of foundation material at the bottom of the shaft.

i. The volume of concrete placed in the shaft.

j. The slump of concrete used.

k. The method of concrete placement.

l. The diameter and accepted top elevation of the shaft.

m. Displacement of rebar cage.

The inspector will also be required to examine or observe the measurement of the following items for compliance with Specifications:

a. Location, depth, diameter and alignment of the shaft.

b. Bottom condition of the shaft immediately prior to concreting.

c. The consistency of the slurry (natural or manufactured) at the bottom of the shaft.

d. Presence of appropriate spacers and clearance between rebar and the sides of the shaft.

e. The slump of the concrete prior to pouring.

f. The embedment of the tremie or concreting pipe during concreting.

F. Cofferdams (Section 525 Cofferdams)

A cofferdam is a temporary structure that encloses an area where permanent construction or bridge demolition is to be located. A cofferdam must be able to resist both the external forces of the material outside and the forces created by the work going on inside. It is the responsibility of the Contractor to provide a cofferdam that will fulfill these purposes. The Engineer shall record in the diary, whether a cofferdam is used at a specific bent. Earth dams and sand bag or dams constructed of excavated earth are not considered cofferdams for payment purposes. Cofferdams are only paid for if they are setup in the contract prior to bidding. If the contractor decides to use a Cofferdam and it was not setup then there is no additional cost to the Department.

Earth dams can either be a simple earth dike around the construction area or a dam constructed from earth filled bags. The dike type is usually used where footings are in the edge of a shallow stream and constructed in a half-moon shape around the excavation. Earth dams constructed from earth filled bags are very suitable for shallow water where there is no overburden on top of the rock.

Cofferdams are typically constructed from steel sheet pile sections along with a ringer or waler for lateral support. The ringer/waler are steel beam sections welded together to form a rectangular or square shape used to “ring” the inside of the sheets. Sheet pile driven without the ringer/walers are **NOT** considered Cofferdams without prior approval of the Engineer. A common process of constructing a cofferdam is as follows: walers are set on the ground or on support piling that are inside of the walers, the sheet piling is set and driven outside the walers, the walers are tied off to the sheeting, some excavation is performed, the walers are lowered, more excavation is performed, etc. This procedure will continue until the sheeting is completely driven and the excavation completed. In many cases more than one waler is used in a cofferdam. These are usually constructed in tiers, but they can be added as the bottom waler is lowered.

In order to properly evaluate the ability of the cofferdam to fulfill its purpose of preventing the inflow of water, the Engineer must know the elevation of the tips of the sheet piling. This is usually facilitated by either recording the length of each sheet near the top (usually with paint), or by marking the length in intervals of five or ten feet along the pile. This latter method is better, as the tip at any time during driving can be readily determined.

Driving of the sheet piling should be observed to anticipate potential problems in construction of the permanent foundation.

The sheets should normally be driven below the footing elevation before an attempt is made to dewater. If the sheets are adequately driven and properly placed and the Contractor provides adequate pumping capacity and is still unable to dewater the cofferdam, the placing of a seal may be necessary. See "G. Seals" below

If the foundation is to be placed on hard rock with little or no soil overlying the rock, it may be necessary to place a double-walled cofferdam, remove the material between the walls and replace with clay or some other impervious material in order to dewater the cofferdam.

G. Seals

A seal is used to "seal" off a cofferdam to allow construction of the foundation footing in a dry condition. Seal concrete is concrete placed underwater. This concrete is produced the same as Class "A" Concrete except that 10% additional cement and enough additional water to yield a 6 to 8-inch slump is added to the mix. This high slump is necessary so that the concrete will flow into the corners of the cofferdam and will level itself without any outside agitation.

If a seal is shown on the plans it was anticipated that the sheeting could not be driven deep enough to prevent intrusion of water into the foundation area or because of a concern for flow through seams in rock or through pervious layers up through the material in which the cofferdam is founded. A seal is authorized and paid for only to stop the upward flow of water from the area inside the cofferdam. A seal may be deleted if the Contractor can construct a cofferdam to control the water. If a seal for a spread footing is proposed to be eliminated, the Office of Bridge Design should be consulted regarding a possible re-design.

If a seal is not shown on the plans and it is determined a seal may be needed, the Construction Office should be notified. See Specification Section 525.

Seals can be used for spread footings or pile footings. Seals are especially important on spread footings as they transfer the total load of the structure to the foundation.

The thickness of the seal depends upon the depth of the water measured from the bottom of the seal to the height of the water outside of the cofferdam at the time of construction and whether the footing is spread or on piles. The thickness of the seal will be 0.4H for spread footings and 0.25H for pile footings. In both cases "H" represents the depth of water as defined above.

Excavation for footings in water is, of necessity, done blindly. Care must be taken to remove all material lodged in the corrugations of the sheeting and under the walers. This can usually be removed by blowing it out into the open area of the cofferdam with jets of air or water.

If the excavation is to go to rock, the overburden can usually be excavated with a clam bucket. If the materials get to hard for a clam bucket, it can usually be broken up with a spud, then removed with a clam bucket or an air lift. The material removed from the excavation should be compared to what was anticipated in the BFI. Regardless of the methods used, it is critical that the rock is cleaned of all overburden before the seal is poured. Forced air should be used around the bottom and sides just prior to seal concrete placement to insure any remaining fine overburden material is held in suspension and does not settle between the rock and the seal.

The seal concrete is placed with either a watertight tremie, a bottom dump bucket, or, when approved, by pumping. The Engineer should always keep a constant check on the elevation of the surface of the concrete during the pour. This is necessary to keep the pour level and to make sure the tremie pipe is continuously embedded in the concrete.

After the seal has been in place for 24 hours the cofferdam may be dewatered. A shallow layer of scum or laitance present on top of the seal. This shall be removed before the footing is placed. The amount of laitance present on top of the seal is an indication of how well the Contractor was able to minimize turbulence of the water while placing the seal. Turbulence will cause the cement to be “washed” from the mix. This laitance is made up of cement thus removed from the concrete. The amount of this laitance will vary according to the depth of the seal. Should laitance buildup be more than ¼ inch per foot of seal depth on seals under spread footings the seal shall be cored to determine if it is an acceptable foundation. All seals under spread footings shall be drilled the entire depth of seal as in done on foundations on rock, and the rate of penetration of the drill observed to determine if voids or soft layers exist.

When a footing is to be founded on a satisfactory placed seal, it is necessary only to clean the laitance, etc. from the top of the seal. If the seal is somewhat irregular, this will serve as a key and is not bad at all. If the seal is humped in the center the center should be cut down to prevent conflict with the footing dimensions.

If a footing is to be founded on foundation piles, it is necessary to clean any clinging soil from the length of piling to be embedded within the footing. It is also necessary to cut the foundation material down or build it up, as the case maybe, so that the proper length of piling will be embedded within the footing.

A record of the elevations of both the bottom and the top of the seal as poured and as used shall be kept. The elevation the seal is poured to will be used in calculating the pay quantity of the seal concrete, if payment is to be made. Other records that are normally kept for concrete should be kept for seal concrete.

SECTION 2 SUBSTRUCTURE

A. General

Section 500—Concrete Structures of the Specifications covers required pour rates, allowable time for removal of forms and falsework, allowances for application of external loads to concrete, proper placement and curing methods and concrete surface finishes. In addition, refer to the Sampling, Testing and Inspection Manual for quality assurance testing requirements.

All concrete shall be given a Type I finish as called for in the Specifications immediately after the formwork is removed. If contractor fails to provide a satisfactory Type I after forms are removed, then a Type 3 may be required.

B. Footings

Depending on location, footings can be poured with buckets, chutes, pumps or tremies. Concrete placed through a tremie can push the mat upwards as well as downwards, it may be necessary to tie the steel mat down. The mat should also be separated from the footing sides with concrete block spacers. If the Plans show footing reinforcement lying directly on top of piling without any spacers, it is satisfactory to place it in this manner. Dowel bars for columns or walls shall be held securely in place with suitable templates. They shall be placed and aligned before any concrete is placed.

Sometimes there will be some water in a footing and it is necessary to use the concrete to push the water out. This can be done but it must be done carefully. The concrete shall be placed slowly in one place letting the normal flow of the concrete displace the water. The concrete is not vibrated until all of the water has been pushed out. An ample supply of concrete to cover the entire bottom of the footing to a depth greater than any water outside of the forms must be on hand before this is attempted. All pumping of water during a pour must be from outside of the formed area. If the footing is below the water table, the water shall not be allowed to cover the footing during the pour.

Some footings can be cured by simply letting the water rise over them. Other footings must be covered with either moist soil or wet burlap or curing compound. No curing compound shall be placed in the column area.

Careful finishing of the footing concrete, so that even bearing all around the column form perimeter is secured, will solve a lot of the problems that arise in column alignment.

Footings not supported by piling should be backfilled to the top of the footing immediately after the forms have been removed and the concrete finish (type I) is accomplished. This is to prevent surface and ground water from collecting in the footing excavation and weakening the foundation strata. Backfill for intermediate bents and piers should be completed to the approximate density of the surrounding soil.

C. Columns

Except in some rare cases a line extending through the centroid of a column should be a plumb line. In order to achieve this, both the base and top of a column must be located in proper alignment. The base must be secured so that lateral movement during the succeeding operations is impossible.

1. Reinforcing of Column

All bars from the footing dowel bars on up through the main column bars and the hoop bars must be carefully placed.

2. Forming of Column

Column forms must be able to resist without distortion the pressures exerted by the concrete they confine, and the forces applied by lifting and aligning the forms. The forms can be built in place or built and then set in place. Clamps are normally used to hold the column form square. These clamps should be spaced closer together in the lower part of the column than in the upper part. The column can be checked for plumbness by simply looking down the column or by using a plumb bob at the corners. Check the squareness of the forms by measuring the diagonals, they should be the same if the column is square.

Round column forms will usually be made of either metal or cardboard. Distorted or out of round forms should be rejected. Cardboard forms cannot be spliced. Round metal column forms can be bolted together.

When columns are battered consideration must be given to the fact that the forms will tend to rise due to the lateral pressure of the plastic concrete. Effective counter measures must be taken.

3. Alignment

The base of the column must be checked for full and uniform bearing on the footing concrete. If necessary, wedges must be used to achieve this. This is necessary or the weight of the concrete pushing down through friction on the form side will cause the form to sway or twist.

4. Grading

The elevation to which the concrete is to be poured has to be established in the form. The elevation to which the concrete is to be poured should be slightly higher than the elevation of the bottom of the cap, up to a tolerance of one inch, to allow for shrinkage of the concrete.

5. Pouring

Columns are poured with a tremie. The tremie sections are removed as the height of the concrete rises. The concrete must be poured in the 18-inch lifts called for in the Specifications. A way to control this is to control the amount of concrete dumped at one time. A yard bucket will pour 36 inches of a 3.0’ x 3.0’ column. If a yard bucket is used to pour a 3 x 3 column, the Engineer must insist that only half a bucket at a time be dumped into the tremie. The concrete must also be carefully vibrated to ensure that no pockets of honeycomb will be left.

6. Realignment of Column

Immediately after pouring it may be necessary to realign the column. Therefore, the column alignment must be checked immediately after completion of the pour and prior to concrete set. The Contractor shall be required to make this check and adjust the column as necessary.

7. Finishing and Curing of Concrete

Immediately after the forms are removed, the column shall receive a Type I Finish. If the finishing is delayed, the column shall be kept wet until the finishing can proceed. If a Type III Finish is called for it shall be applied after not during, the Type I Finish. Curing compound may be used for curing only after the Type I Finish and, if required, the first rub part of the Type III Finish has been completed. Where curing compound is used to cure the column, the top of the column will have to be cured by other means.

When a special surface coating is used in lieu of a Type III Rubbed Finish, surfaces shall not be cured with a membrane curing compound nor shall bond-breaking agents or excess oil be used in connection with form removal. Only after a satisfactory Type I Finish is accomplished may the coating system be applied. Coating materials should be applied in accordance with the manufacturer's recommendations.

8. Construction Joints

If there are good and sufficient reasons involved, construction joints in columns may be either allowed or eliminated. All such requests should be referred to the Construction Office.

9. Web Walls

Web walls are constructed along with a set of columns. There will always be a construction joint in the columns at the bottom of the web wall. If the top of the web wall is different from the bottom of the cap, another joint in the columns will be allowed at the top of the web wall. Below and above the web wall, column construction will be as described above. Transverse to the bent the alignment of the web wall will be done the same as for columns alone.
Longitudinally with the bent the forms must be constructed on line in place. Column clamps cannot be effectively used where web walls are involved. Ties through and outside of the columns are therefore used. Also, long ties running the full length of the pier are necessary to keep the forms from spreading in that direction. These are necessary and must be insisted upon before allowing a pour to be made. Snap ties may be used in the wall itself.

All other aspects of web wall reinforcing, pouring, curing, etc. are much the same as simple column construction.

D. Cap Construction

Cap construction can generally be broken down into end bent caps and intermediate bent caps. Generally speaking, one is formed and poured on the ground while the other is formed and poured on falsework.

1. Anchor Bolt Holes

Anchor bolt holes must be formed into the cap pour. Polystyrene is typically used to form the holes. Drilling of anchor bolt holes is not permissible. It is also necessary to protect the anchor bolt holes from freezing water in cold weather. Ice forming in anchor bolt holes will crack the caps. Positive means of keeping the anchor bolt holes free from water during cold weather months must be provided.

2. End Bent Caps

In most cases end bent caps are poured on soil but they are supported by piling. Sometimes end bent caps are poured on soil or rock without being supported on piles. In this case the foundation material is prepared the same as for spread footings.

For end bents supported on steel piling the piles must be coated with 2-P coating below the cap or a concrete collar poured around the piles as required in Specification Section 520—Piling. This protection is required to prevent corrosion of the steel if the end bent fill settles under the cap and exposes the piles to the elements.

The cap and wings should be poured together. Start the pour by pouring the cap and the wings up to top of cap height first. End the pour by completing the wings. If the pouring of wings causes concrete to flow under the wing form into the cap causing the cap concrete to rise, a short delay between the pouring of the cap and the pouring of the wings may be allowed.

Care must be taken in vibrating this concrete. The vibrator head must not be allowed to extend below the concrete into the soil. The vibrator must be used carefully around the anchor bolt hole template so as not to disturb the template location. This same care must be exercised in the case of concrete deck girder bridges so as not to disturb the cap to girder dowel bar. The entire cap and the wings must be thoroughly vibrated.

The top of the wings and the top of the cap will receive a float finish. This finishing must be done carefully particularly at the beam seat areas around the anchor bolt holes or dowel bars. This is necessary to obtain a smooth level bearing area for the superstructure beams or girders.

3. Intermediate Bent Caps

Intermediate bent caps will usually be formed and poured on falsework. The caps are supported by falsework during pouring and curing.

a. <u>Caps on Columns</u>

The falsework in this case can take the form of two steel beams, one on each side of the bent, held up by either a cantilever shoe device bolted into the column or by false piles which rest on the footing and stand up alongside of the column.

If the bolted cantilever shoe device is used, one procedure is to bolt it to the column with a screw tie type of unit. At least three of these units with one-inch bolts should be provided for each shoe. A ½ to 1-inch deep depression should be formed around this unit so that it may be cut back and grouted over after the shoe is removed. Another method is to form holes through the column for bolts, or to use friction bands.

If false piles are used, they should be of moderate size (8” minimum) and they should be strapped to the column for lateral support.

Once the false beams are in place, the cap bottom is set. The bottom form is usually made of plyboard stiffened with timber joists. These joists will rest on the false beams. Wedges are driven between the beams and joists to raise the bottom to grade. This wedging is done with two wedges, one on top of the other to provide for flat even bearing on the joists.

b. <u>Caps on Columns with Web Walls</u>

The falsework in this case will usually be the same as is described in (a) above except that another member must be added. This extra member must be added because in this case the cap bottom must be constructed in two sections, one on each side of the web wall. The cap bottom joists cannot span across the web wall to rest on both false beams. Consequently, to keep the cap bottom from tilting, a timber is bolted or held by form ties against the web wall in between the columns. This timber will support one end of the cap bottom joists. Otherwise this work is done the same as for caps on columns alone.

c. Caps on Piles Bents

The falsework on pile bents can also be supported by friction bands around or draped over the piling, or by lugs welded to steel piles. After removal of the falsework, the lugs need to be removed and the piles ground smooth with no loss of section to the piling.

d. Forms

The grade of the cap bottom should be approximately even with the top of column or web wall grade or approximately 1.0 ft. below pile cut-off grade. Bottom of cap elevations should match those shown on the Plans. If there is much variance from these, all work must cease until the error is located and corrected. Allowances in grading should be made for falsework settlement and deflection.

The cap side forms are usually constructed of plyboard stiffened with timber studs and walers. A kicker should also be nailed tight against the studs along the cap form bottom.

e. Reinforcement of Cap

Reinforcement bars may be either tied in placed or tied as a cage on the ground and lifted into place as a unit. Minor changes in reinforcement steel locations may be made in order to facilitate the location of the anchor bolt holes.

f. Pouring of Cap

The cap should be carefully poured by starting in the middle and placing concrete towards each end. This is so as not to concentrate the load on a cantilever end and cause tilting of the false beams. The concrete should be handled and placed in layers as called for in the Specifications. After the forms are approximately three quarters full, the pouring should be slowed down and the grades of the top of the form rechecked.
This is done to adjust for form settlement and false beam deflection. If necessary, the top chamfer lines are raised. Some Contractors prefer on the first grading to simply mark the location of the chamfer lines and to place the chamfer strips after the final grading. Others prefer to place the chamfer strips on the first grading in hope that they will not have to be changed. Either method is satisfactory if the chamfer strips are finally located to agree with the final grading which is done only after the forms are at least three-quarters full.

After the pour is completed, the top of the cap is finished with a float. Particular care must be exercised to get the beam seat areas level and to a true grade.

E. Rip Rap (Section 603 Rip Rap)

There are normally two types of rip rap used for bridges. These two types are stone rip rap and sand cement rip rap. These are discussed as follows:

1. Stone Rip Rap

There are three types of stone rip rap. They are Stone Plain Rip Rap, Stone Dumped Rip Rap, and Stone Grouted Rip Rap. The same size and kind of stone is used for all three types.

Stone rip rap is to be placed to the over-all dimensions shown on the Plans and to the thickness called for in the Specifications. Filter fabric is typically called for in the Plans to be placed under rip rap. The method of placement is also covered in the Specifications.

The major problem in stone rip rap placement is in controlling the size of the stone. During the loading, hauling and dumping of the stone, pieces will break. The Specifications allow the Contractor to use as chinking stone pieces smaller than the minimum size specified.
Only those small pieces necessary for chinking stones and used as chinking stones will be allowed. In

other words, the entire area to be rip rapped must be covered to the proper thickness with stones of the proper size. Stones smaller than those specified may then be used to chink the crevices between the larger stone. After the chinking is completed the remaining small stones (if they are excessive in quantity) will have to be removed.

2. Sand Cement Rip Rap

There are normally three types of sand cement rip rap. They are Sand Cement Block Rip Rap, Sand Cement Bag Rip Rap, and Sand Cement Cast-in-Place Rip Rap. The same materials are used for each type. The water content is increased, however, for the cast-in- place and the precast block rip rap. The rip rap will be placed in accordance with the Specifications. Water must be added carefully to the mix. It is very easy to make the mix too wet. The mix is not proportioned on an absolute volume basis, so no weight

adjustments need to be made for water. Tests on a properly proportioned mixture of sand and cement shall be made to determine the optimum moisture content of the mixture before the production of the rip rap is begun. The amount of moisture in the sand at the time of production will be deducted from this optimum moisture content in order to arrive at the amount of water to be added to the mix.
Mixing may be done in any type of mixer that meets the requirements of the Specifications. The mixing shall continue until the mix is completely homogenous. The mix may appear to be dry, but it will have cohesion after it is tamped into placed.

If the subgrade is disturbed it must be prepared before the rip rap is laid on top of it. Under no conditions shall loose subgrade be allowed to mix with the rip rap.

Samples and records of kind and amounts of materials used must be recorded as part of the project's permanent records.

F. Concrete Slope Paving

When the road and bridge work is being done under separate contracts the roadway contractor shall construct the end fill or cut slopes to the lines and grades of the slope paving as established by the Engineer. The slopes must also be firmly compacted. The Specifications allow a tolerance of plus or minus 3 inches on slope paving subgrade construction by the roadway contractor. It is the responsibility of the bridge contractor to do the final preparation of the subgrade to the lines and grades as established by the Engineer.

Except for special cases such as slope paving under a bridge crossing a road that is sharply curved, the entire area of the slope paving should be one flat plane. It may be a tilted or out of level plane but a flat one. For the special case mentioned above, the slope paving should follow the curvature of the underneath roadway. This is usually necessary only where the area to be slope paved is long such as for parallel or extremely sharply skewed bridges.

The slope paving grades should be calculated so that the slope paving will spring from the true grade and line of the underneath roadway ditch or shoulder edge and will rise on the plan rate of slope to intersect the plane of the bottom of the cap forming the line of the edge of the berm. Note that the control is first the lower control line and grade (either ditch or shoulder of the underneath roadway) and second the plan rate of slope. The bridge length should be such that when the slope paving subgrade is graded to the grades dictated by these controls, the minimum berm width at the bottom of the cap will be 2.0 ft. This is the plan minimum berm. It may be greater and, as a matter of practical necessity, it can be somewhat smaller. If it is necessary to steepen the rate of slope somewhat to provide a minimum berm of 1.0' the Engineer has authority to do so unless the rate of slope is already a cut section and the cut has been made, the slope paving must conform to the rate of slope of the cut. Filling on a cut slope or cutting back into one is not acceptable. If this procedure changes the end of bridge location or cap depths, the Construction Office must be consulted.

Once the line and grade of the lower control line is established and the line and grade of the berm line is established and checked against the cap bottom elevation, preparation can begin.

1. Setting of Forms

The slope paving will be poured in either horizontal or vertical courses, one or the other, but not mixed. The forms for horizontal rows should be parallel to the grade of the lower control line (the line a person's eye follow as he travels on the underneath roadway). Lines made in this manner provide a much more pleasing appearance than truly horizontal construction joints. One or more trapezoidal sections at the berm line may be required. This is satisfactory because the line of sight of a person traveling on the underneath roadway will never get that high.

Slope paving poured vertically should not necessarily have vertical construction joints. Instead they should be normal to the end bent or end abutment. Trapezoidal courses at the sides of the slope will be permitted. All slope paving courses shall be limited to 40 feet in length. Weep holes shall have drain pipes or formed openings as shown on the Plans.

2. Pouring of Slope Paving

Care must be used during the pouring to keep loose dirt and other foreign material from collecting against the insides of the forms. Care should be used to ensure that the forms remain on true line and grade during concreting operations.

SECTION 3 SUPERSTRUCTURE

The superstructure of a bridge is that portion of the bridge above the caps. This includes the bearing devices, beams, decks, and railings.

A. Check of Substructure

The location, both vertically and horizontally, of the substructure controls the location of the superstructure. The location of the substructure must be checked before superstructure construction is commenced. The Contractor must verify the elevations for all bearing seats before setting beams. Also, the centerline of each beam or girder shall be laid out and the location of the anchor bolt holes or dowel bars checked.

B. Preparation of Bearing Areas

The areas of the cap where the bridge seats bear must be level and flat. These areas have been finished with a Type IV finish. A short (not over 6 inch) spirit level should be used to check these areas. If the areas are high in elevation or are not flat (either convex or concave) they must be ground down to a true surface. If the resulting area is low or started out low because of an error in elevation the lowness shall be compensated for by either shimming under the bearing plates or by adjusting the coping over the beams. If the error is greater than ½" it shall be corrected by shimming. This is for steel or prestressed concrete beams or girders.

C. Structural Steel Beams and Girders: (Section 501 Steel Structures)

1. Shear Connectors

Shear connectors extend out from the beams into the deck. Most of the time shear connectors will be welded to the beams in the shop. If the Engineer is in doubt about the acceptability of the shear connector welding or if the shear connectors are to be welded in the field contact the Inspection Services Branch of the OMAT for advice.

2. Erection of Beams

Beams shall be erected in accordance with the Specifications. All beams and girders must be pre-inspected at time of delivery as evidenced by GDT stamp on each member. No erection shall commence until approved erection drawings are on the job. Beams should be braced together as they are erected.

3. Bearings

If unbonded elastomeric pads are used on concrete, no preparation other than leveling of the bearing areas is required. A level but textured (floated) surface is best for these pads. If the pads are to be bonded to the cap concrete the bearing area must be ground smooth.

Self-lubricating plates, bushings or sliding plates fabricated from bronze material require special test reports. As the structural steel is shop inspected the Inspection Services Branch of the OMAT will inspect all these plates that pass through the fabricating shop. Inspected bronze plates will not be tagged or stamped accepted but will arrive on the project in shipments of GDT stamped primary steel members. If bronze plates do not arrive on the job in shipments which also include GDT stamped steel, they shall be considered as being uninspected. Notice by telephone should be given to the Inspection Service Branch of the OMAT when uninspected bronze plates are received on the project. All bronze plates must be physically inspected by the Engineer.

4. Inspection of Splices Connections

The Contractor is responsible for providing safe access to allow inspection of all splices and connections.

a. <u>Bolted</u>

All bolted splices and diaphragm connections shall be checked for torque. Calibration of torque wrenches must be done before bolted connections begin.

b. <u>Welded</u>

All welding on Georgia DOT projects must be performed by GDOT certified welders. Welding for butt splices must be performed by specially certified welders and must be ultrasonically inspected. The Project Engineer is responsible for visual inspection of all fillet welds and should have a weld fillet gauge (available through OMAT) to check the size of fillet welds. The Inspection Services Branch of the OMAT will ultrasonically test all welding of butt splices. The Inspection Services Branch of OMAT should be notified at least three days in advance when welding of butt splices is required in order to schedule ultrasonic testing of the welds. They should also be contacted if there is any question on the acceptability of other welded connections of for other guidance. Prior to scheduling non-destructive testing of field butt welds the Project Engineer shall inspect each welded splice to ensure that the Contractor has done the following:

1) Completed welding on all splices.
2) Removed all back-up strips and ground flush with parent material.
3) Removed all notch-effect in weld profile.
4) Removed all torch marks, slag, weld splatter, etc.
5) Dressed-up weld profile to acceptable workmanship and design.

The Inspection Services inspector will locate and mark all rejects and furnish a written report of the findings. The Engineer must be present when the rejects are located and marked. Record the results in the diary. After the rejected welds are repaired, they shall be inspected again.

5. Simple Spans

Simple rolled or plate girder beams shall be lifted into position and set on already placed bearings. After the beams are lifted and before they are set, the sole plates (fastened to the beams) must be carefully cleaned of any rust or foreign matter. Sole plates that are to bear on self-lubricating bronze plates shall be treated as required by the Specifications. Sole plates must be checked for cleanliness as they can easily become contaminated in storage or shipment.

6. Continuous Spans

Continuous beams of either rolled beam or plate girders shall be carefully lifted and set for either ground or air splicing. Welded splices must be made by welders qualified by the Georgia DOT.

a. Ground Splices

Ground splices (either riveted, bolted, or welded as detailed on the Plans) are made with the beams blocked up to relative grades before erection. The Engineer must see that the beam segments are set on relative grades in the proper relationship with each other, and the beam segments are set in line one with the other.

Sometimes the shop drawings will give a beam blocking diagram. Also, the bridge plans will give the slope of each one of the beam segments. These slopes or the blocking diagram can also be used to block the beams up to relative grades. The beam segments must be graded or check-graded the same day they are spliced. The blocking must be from firm ground.

If the beams are detailed to be broken longitudinally at the splice points, ground splices shall not be made.

The splices shall be made in accordance with the Plan and or Specification requirements for the type of splice detailed on the Plans. Bolted splices shall be checked on the ground and all corrections shall be made before erection of the beams. Radiographic or ultrasonic inspection of the welded ground splices may be delayed until the air splices are tested.

b. Setting of Beams

After the ground splices, if any, are made, the beams are ready to be set. They shall be set on already placed bearings. The sections of the continuous beams that will rest on the substructure (or falsework) are set first, then the suspended sections are set. The suspended sections may be held in place with clamping devices, erection bolts through the splice plates, or by tack welding, depending upon the type of splice being made.

The beams must all be positioned and shifted and repositioned if necessary, so that the air splices can be made. The beams must be in proper position for distance, line, and grade before the air splices are made.

c. Air Splices

Air splices shall be made in the same manner as ground splices. If bolted splices are made, they shall be made and checked as shown on the Plans and specified in the Specifications. Welded splices shall have radiographic or ultrasonic examination as noted under "Item #4—Inspection of Splices and Connections".

7. Final Setting of Beams

After all the beams within a simple span or within a continuous unit are set, spliced, tested, repaired, and re-tested, if necessary, the beams may be adjusted into their final position. The beams must be in the proper relation one with the other and with other portions of the bridge regarding the existing temperature conditions. Gaps between the ends of beams, gaps between the end of beams and backwalls, the angle of inclination of rocker type of bearings, the location of sliding bearings on bearing plates, the location of anchor bolts in expansion slots, must be set regarding the existing temperature. These should be set to their normal or median condition will occur at 60° F. In other words, they must be adjusted up or down, backwards or forwards, etc. from a base temperature of 60° F to the existing temperature. The temperature adjusted for should be the air temperature adjacent to the beam taken early in the morning before the beams have heated up from the sunshine. The adjustment can be made at any time during the day regardless of the position of the beams and rockers or the temperature at the time the adjustment is made.

The Contractor is responsible for performing these adjustments. For information, Appendix C includes a method to adjust for temperature effects.

8. Diaphragms

Diaphragms can be of either concrete or steel. Their purpose is to stiffen the beams, provide lateral support, and to help distribute loads. For stage construction the Engineer should review the plans and sequence to determine if the diaphragms between stages will influence beam deflections.

a. Steel

Steel diaphragms are erected prior to the pouring of the decks, and the plans will show whether they are welded before or after the deck pour.

b. Concrete

The tension rods shall be tightened as called for on the Plans or in the Specifications. It is important to hold the diaphragm side form where a skewed diaphragm makes an obtuse angle with the beam. The bottom form is also important to control. Sagging diaphragm bottoms are altogether too common. The bottom form must be securely attached to the side form or adequately supported by the beams. The tops shall be floated off and the curing commenced as soon as the concrete has achieved its initial set.

9. Straightening of Bent Members

The Specification tolerance on steel members is that specified under Subsection 501.3.04.A. If steel members are deformed outside of these tolerances, the Engineer should contact the Construction Office for determinations to accept or reject the members. If they are accepted, subject to straightening, the Office of Materials and Testing will supervise the actual straightening. This judgment must be made before the beams are erected.

If the members are within the tolerances but are not straight, the act of pulling them to make the diaphragm connections will make them sufficiently straight.

D. Prestressed Concrete Beams (Section 507 Prestressed Concrete Bridge Members)

All casting and tensioning of prestressed beams will be done at the concrete plant under the supervision of the OMAT.

1. Handling and Storage of Prestressed Concrete Beams

Beams of prestressed concrete will typically have embedded pick-up points. They should be stamped with a GDT number which indicates that the beam was acceptable when it left the plant. The beam should be inspected to determine if damage occurred in shipping and handling. If at any time the Engineer notices any condition that causes doubt on the acceptability of a beam do not allow that beam to be used until it has been re-inspected.

The Engineer should contact the Office of Materials and Testing for this further inspection.

The Engineer should find on each beam a DOT number, the date the beam was cast, and a beam mark number, if necessary, for erection purposes. These, together with the date received, should be recorded. Along with the beams will come anchor bolts, beveled plates (if required), elastomeric pads or other bearing devices, diaphragm rods, and perhaps other items of material. In most cases these miscellaneous items will have been sampled at the plant with test reports or certifications sent to the Area Manager. The test reports and certifications on these materials should have been approved by the OMAT. Contact the Office of Materials and Testing if you have questions about the reports.

2. Erection of Prestressed Concrete Beams

The beams are erected by simply setting the beams in place on bearing devices which have been previously set on the caps. They must be handled carefully, and only from the embedded pick-up points. They must not be allowed to rotate. They must bear on supports only at the bearings or under the pick-up points.

a. Bearings

The bearing device on which the beams rest should be placed on the caps prior to the setting of the beams. The bearing device detailed on the Plans shall be set in accordance with the Specifications for that type. If steel plates are to be field welded to the embedded beam plates these plates must be clear of elastomeric pads while the welding is done. They must also be held clear until the metal cools.

b. Anchor Bolts/Dowel Bars

Anchor bolts and/or dowel bars are to be carefully grouted in accordance with the Specifications.

c. Diaphragms

Diaphragms for prestressed concrete beam spans will be of cast-in-place concrete as discussed in Item # C.8.b, "Concrete", above.

E. Post Tensioned Concrete Box Beam Spans

Post tensioned concrete box beam bridges are used where restrictive conditions and longer spans are needed. The individual design and the range in the selection of materials and methods of prestressing make each of these bridges unique. All tensioning of post-tensioned concrete box beam bridges are done at the bridge site under the supervision of the project engineer. Because of their uniqueness, however, each bridge will require individual understanding of its construction and stressing. See Appendix E for general discussion on post tensioned box beam bridges, and an example.

F. Deck Construction

Bridge decks can be either concrete slabs on steel or prestressed concrete beams, reinforced concrete deck girders, flat or variable section concrete slabs, or steel grid flooring of either open or poured types. There are two major cases to be considered, precast or steel beams and cast- in-place beams (reinforced concrete deck girders or RCDGs). Slab bridges will also be discussed as a variation of reinforced concrete deck girder bridges.

1. Layout of Lines

Points for the horizontal control of the superstructure must be established. Once these control points are established, points and lines can be established on the forms or beams. Points along the bridge centerline, along curb lines, or along any established control line can be located on the floor pallets or on the beams. The Contractor will measure from these points to establish the location of the slab side forms. If the bridge is on a curve and ordinates from a chord are to be used, the ends of the chord will be run in with a transit. The chord line will be chalked off and points located along the chord from which the ordinates are to be measured. Lastly these ordinates would be laid off. The measuring from control lines to locate forms should be done by the Contractor. The Engineer must check these measurements.

2. Grading of Decks, Precast or Steel Beams

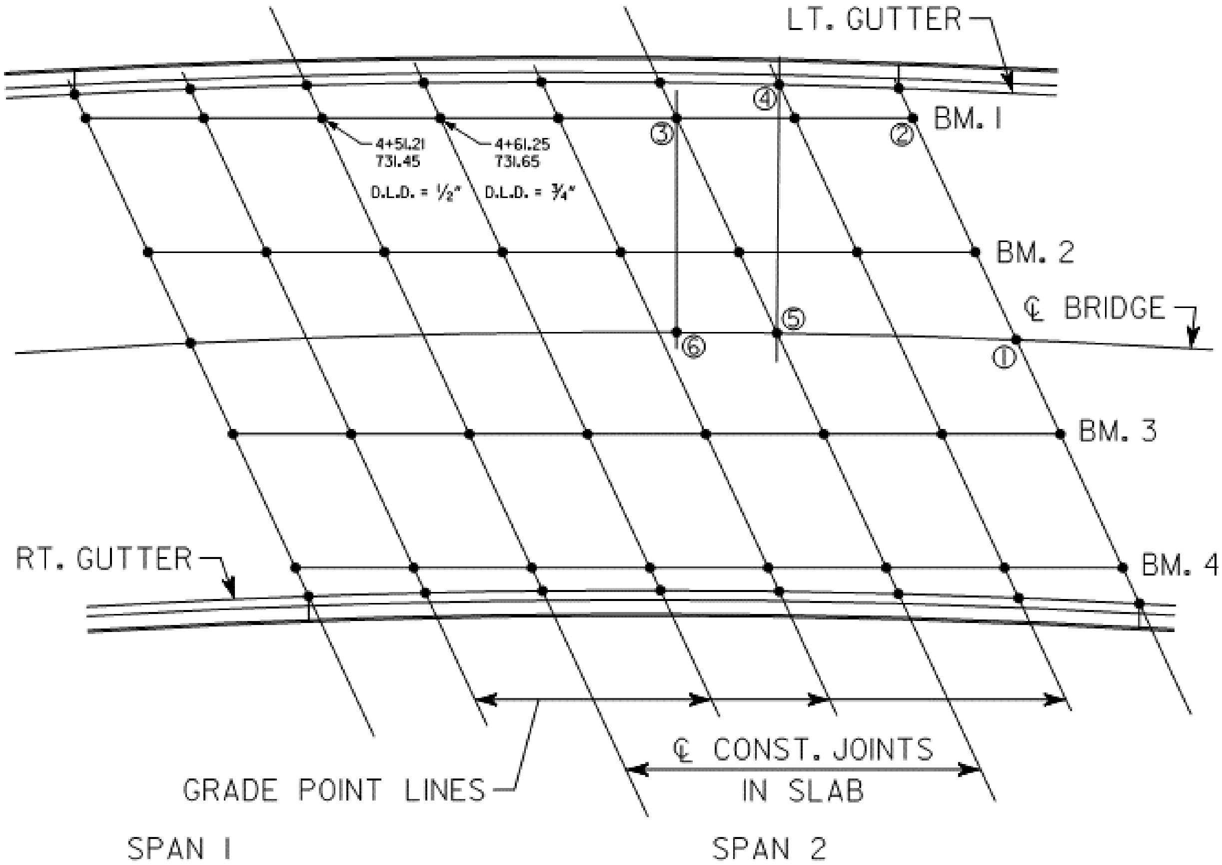
Decks are constructed from the beams. The location of deck grade points and the calculation of finished grades at these points is required to grade the deck. This procedure is straightforward for bridges on a tangent. The use of a coordinate system and right triangle relationship is needed to locate these points for bridges on a horizontal curve. See Appendix A, Section1 for an example problem showing a method to perform these calculations.

The grade points must be located and marked on the beams. Because of the irregular surface on the top of prestressed concrete beams, it may be necessary to clip or otherwise grind down the high spots to achieve a level surface at grade points. A good way to mark these points is to spot them with paint. Later numerical ordinates for each of these points can be painted at each point. These points should be carefully located along the beams (not more than 15 feet apart) to provide good grade control. A 40 feet span would have its beams marked every 10 feet, 50 feet span every 12.5 feet, etc. Examples of these points are shown on Figure 1. For single pour simple spans, each span is considered individually in locating these points. For simple spans with multiple pours and continuous or cantilever units, each pour is considered individually in locating these points. Once these points are located, painted, and the paint has dried, the actual elevation of the top of the beam (either top of beam flange or top of cover plate) at each one of these points is determined by leveling. This is called “profiling the beams”. These elevations must be carefully read and recorded so that it is clear which elevation is for which point on which beam.

a. <u>Deck Form Ordinates (DFOs)</u>

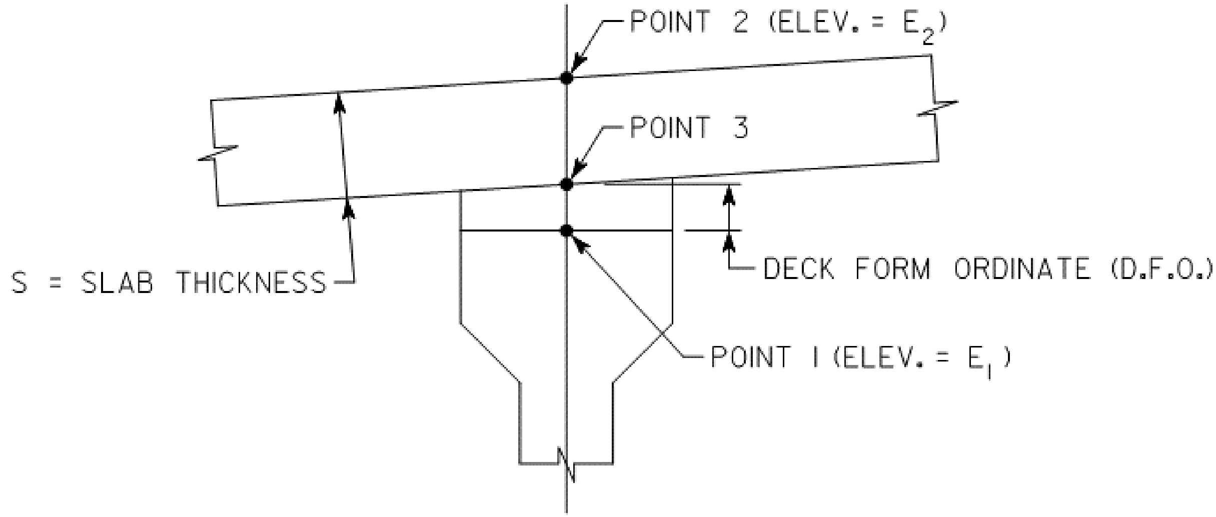
The term deck form ordinate (commonly referred to as “mark-up”) is defined as the distance from a specific point on the top of the beam to a specific point on line with the bottom of the slab and includes any necessary adjustment for dead load deflection.
Note that the term “specific point” is used. The specific point on the beam will be the point at which the elevation of the beam was determined (or ‘profiled’). This will usually be along the edges of the flanges. DFOs can be computed different ways as shown in Figure 2, Figure 3, and Figure 4. The method shown in Figure 3 includes the slab thickness and this is shown as the “D” dimension in most bridge plans. The Engineer should discuss with the Contractor what method is being used to determine DFOs. This discussion will be based upon the crown or superelevation of the deck, the forming methods, and the experience of the workmen.

Compensation must be made for crown or superelevation in the methods illustrated in Figure 2 and Figure 3. A common method used is to compute DFOs at each location on the beam as shown in Figure 4. Form grades for the bottom of the slab can then easily be determined. In this method two deck form ordinates are calculated (from point 1 to point 4 and point 1 to point 5) and are painted on their respective side of the beam flange



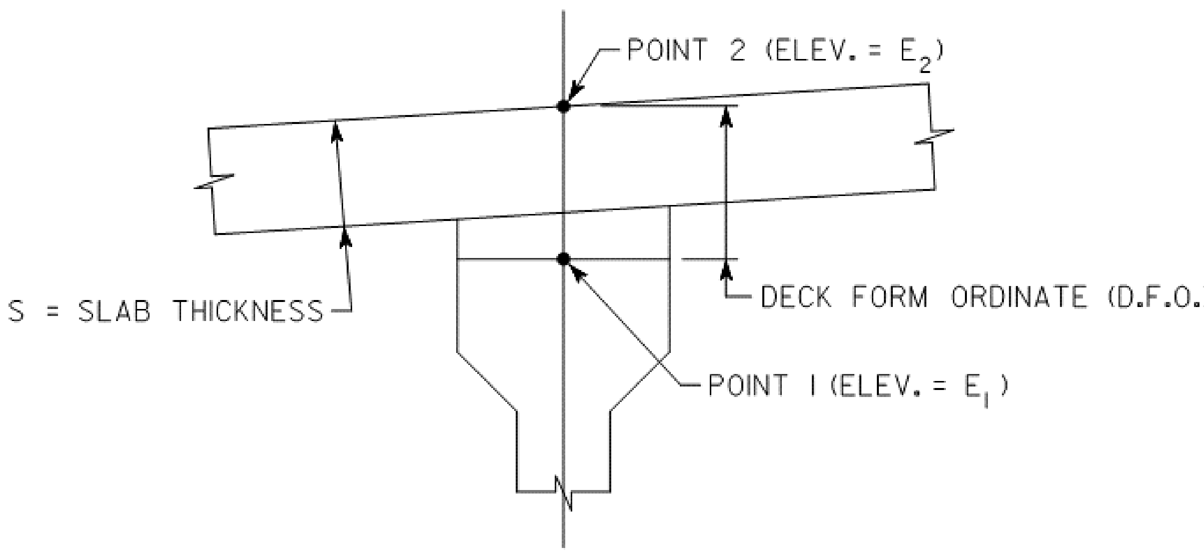
TYPICAL DECK GRADE POINT DRAWING FOR FIELD CONTROL

FIGURE 1



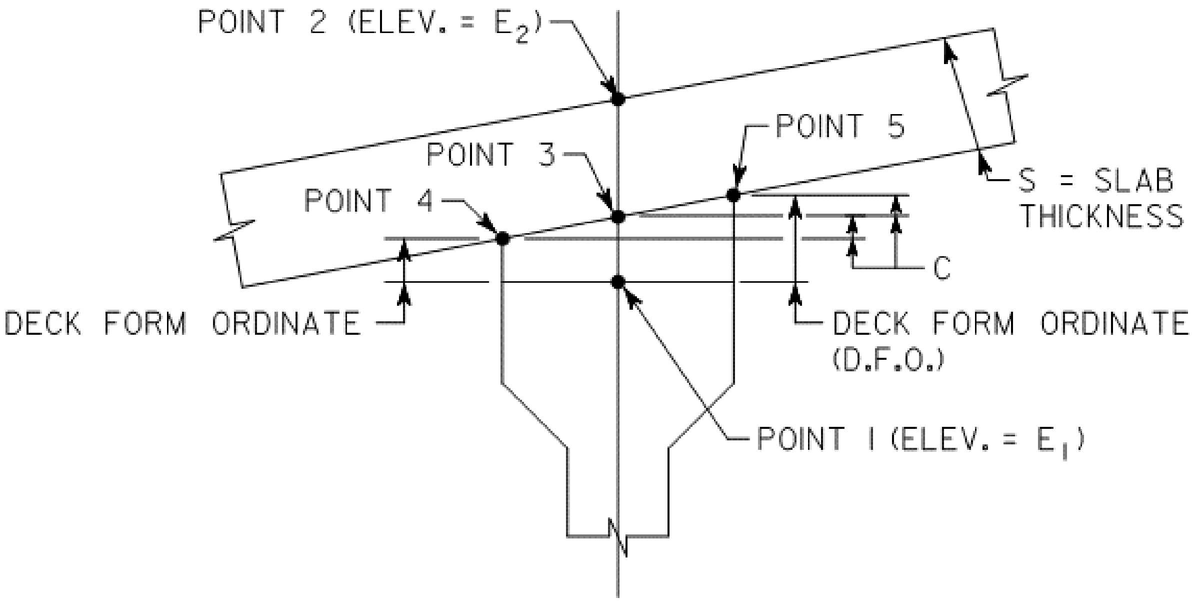
DECK FORM ORDINATE - BOTTOM OF SLAB

FIGURE 2



DECK FORM ORDINATE - TOP OF SLAB

FIGURE 3



DECK FORM ORDINATE - EDGES OF COPING

FIGURE 4

The deck form ordinate (DFO) for each of these cases illustrated in Figure 2, Figure 3, and Figure 4 should be calculated in accordance with the formulas given below. In each of these formulas the following terms are used:

DFO = Deck form ordinate in feet.

E_1 = Elevation of the point on the beam as established by the beam profile leveling. E_2

= Elevation of the point on the top of the slab as calculated by the Engineer.

S = Slab thickness as shown on the Plans in feet.

Δ = Dead load deflection for that point on the beam in feet.

The dead load deflection used should be the deflection caused by the superstructure items not constructed when the beams were profiled. Check the plans to see that the correct dead load deflections are used. Use the deflection from the slab and include deflection from any barrier or sidewalk; the dead load deflection of the beams themselves will never be used in DFO calculations since the beams are in a deflected condition when they are profiled.

For Figure 2: $DFO=(E_2 - E_1) -$

$S+\Delta$

For Figure 3: DFO=(E_2-E_1)+Δ

For Figure 4:

DFO= (E_2-E_1) -S+Δ+c (high side –Pt. 5) DFO=(E_2-E_1)

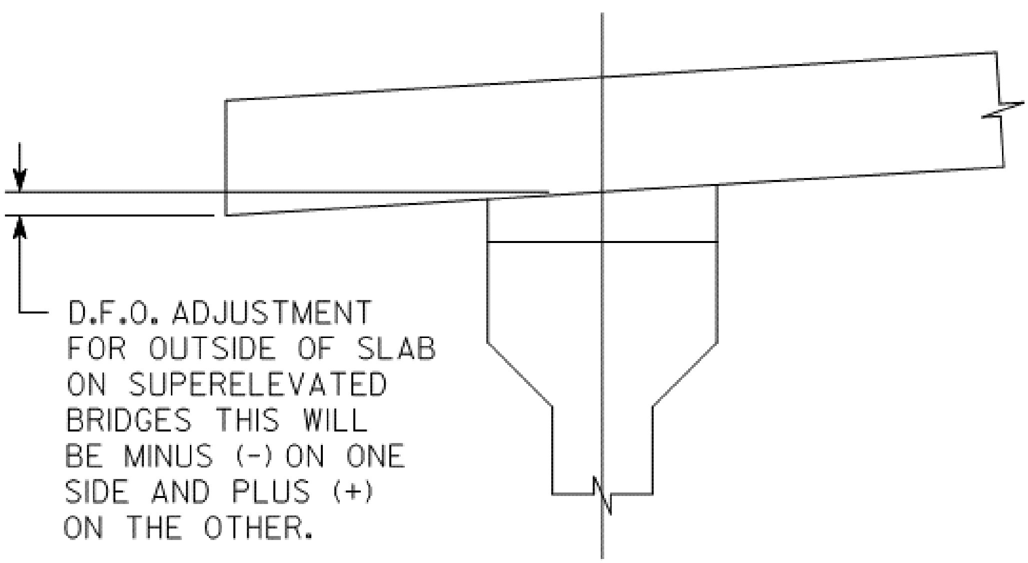
–S+Δ-c (low side- Pt. 4)

c = Compensation for crown or superelevation in feet.

The calculated DFO will be converted into inches and fractions of inches (to the nearest one-eighth only). It will then be painted on the beam adjacent to the point for which it was calculated. If the method in Figure 4 is used, a DFO for each side of the beam at a point will be painted on its respective side.

The DFO for the outside edge of slab forming on the outside of exterior beams will have to be further adjusted. This is because the bottom of the slab outside of the exterior beam will usually continue to follow the line of the bottom of the slab. This is shown in Figure 5 below.

The DFO for construction joint headers will be calculated by the method illustrated in Figure 3.



DECK FORM ORDINATE - EXTERIOR BEAM

FIGURE 5

b. Use of Deck Form Ordinates

Deck form ordinates (DFO) will be used to grade the deck from pallets and headers. Adjustments will be made for crown, superelevation, and outside of slab overhang. These adjustments will be dependent upon the methods used in calculating the DFO. The Engineer must be aware of how the DFO is to be used and adjusted. Pre- cambered girders are handled the same as un-cambered girders or beams. The advantage of pre-cambering is that the DFO's will be smaller than if no pre-cambering is done.

DFO's will be used to control the grades of construction joint headers for multiple pour simple spans and continuous units. The headers will be built up from the DFO's on the beams. Header elevations will be based upon the DFO's and will not be adjusted with a level. This is so that after all the pours have been made and all of the dead load deflection has been achieved the finished slab will be on grade.

Barriers or rails shall be poured to theoretical grades after the decks are poured. See Appendix A, Section2 for examples using DFOs.

3. Adjustment of Grades

At no point should structural steel extend more than ¼ inch into the slab. At no point should prestressed beams extend more than ½ inch into the slab. The copings on prestressed concrete beams are built up flush with the side of the prestressed concrete beam. If the actual position of the beams would reduce the slab thickness by more than this amount, the deck grades should be raised by the minimum amount necessary to keep the slab thickness within this limit. If such adjustments are necessary near the midpoint on short (3 to 4 span) bridges, this adjustment should be added to all elevations on the bridge, thereby keeping the adjusted grade parallel to the original (plan) grade. However, if adjustments are necessary on long bridges or near the end of short bridges, the adjustment can be transitioned back to original grade at the rate of 0.1 ft. in 15 ft. along centerline of roadway.

In the event that the length of bridge, or the Contractors procedure, or other factors dictate that deck forming and pouring begin before the entire bridge can be profiled, the Contractor should re-check the elevation of all beam seats on which structural steel has not been erected to ascertain whether a grade change might become necessary; and further, should be especially watchful when setting elevations and pouring all remaining caps.

4. Edge Beams

Forms for edge beams are usually built in place prior to flooring the main deck. Edge beams are part of the deck and can be poured with the deck. Edge beams may be supported from timber struts that rest on the bottom flanges of the permanent beams or on permanent structural sections detailed on the plans.

Expansion joint material between edge beams must be adequately braced to insure the joint matches up to any expansion or construction joint in the deck.

5. Deck Forms (Section 500 Concrete Structures)

The forms utilized on structural steel beams and prestressed beams may be conventional plywood forms or stay-in-place metal forms. Prestressed beams may also use stay-in-place concrete deck panels (forms) unless prohibited by the plans or specifications. All forms shall be mortar tight, not water tight.

a. Convention Plywood

Conventional temporary or removable forms are usually constructed of plyboard stiffened with 2 x 6 or 2 x 8 transverse or longitudinal members. Sometimes these will be constructed in place by building up on the support members and then laying the plyboard. Other times the plyboard will be stiffened up elsewhere and the assembled pallet laid onto the support members.

The settlement and deflection of deck forms can cause thick slabs if not properly supported. The Engineer needs to know the amount of this settlement and deflection. Tell-tales can be used to measure these values. The tell-tales should not extend from the form to the ground because of the deflection of the beams themselves. Instead a horizontal strut should be placed between the beams resting on the tops of the bottom flanges. Two tell-tales should extend down from the deck forms to this strut. One tell- tale should be attached to the forms adjacent to the beam flange. This one will measure form settlement. A second tell-tale should be attached to the forms in the center of the bay. This one will measure deflection. The tell-tales should be marked along the top of the strut both before and after pouring. The different in these marks is the settlement or deflection. Forms may be adjusted to compensate for these values on later pours once they are known.

b. <u>Prestressed Concrete Deck Panels (Section 500—Concrete Structures Special Provision)</u>

Prestressed concrete deck panels are prefabricated in a prestress casting yard. The inspector should insure that shop drawings are approved by the Bridge Design Office before placing panels. Panels received at the site should have the casting yard's QC stamp, the project number and the date cast. All panels must come from yards that are approved through the OMAT.

The tolerance on the concrete deck panels are critical since it affects the rebar cover. Tolerances are specified in a <u>Special Provision for Section 500—Concrete Structures</u> of the Specifications. The concrete panel thickness should not be measured at the edge of panel since they are marked and broken along the edge which creates a harmless lip.

When placing concrete deck panels, the bearing material, bearing area and overhang shall be in strict accordance with the specifications. The ½" bleed holes on three feet maximum centers in the bearing material are essential.

Since concrete deck panels are relatively weak in the longitudinal direction, compressible material, (a minimum of ½") shall be placed between the panel and the beam or between the panel and other non-compressible bearing material.

To insure the necessary full bond between the panels and the cast-in-place concrete, at the time of concrete placement this interface must be free of any foreign matter.
Immediately prior to placing the slab concrete, the panels shall be saturated with water.

Concrete shall be placed in accordance with the Contract Specifications. Emphasis shall be placed on proper vibration of the concrete to avoid honeycomb and voids, especially at construction joints, expansion joints, valleys, and ends of panels. Pouring sequences, procedures and mixes shall be in accordance with the Plans and Specifications. Calcium chloride or any other admixture containing chloride salts shall not be used in the concrete placed on the panels.

Required minimum concrete placement rates shall be based on the actual quantity of concrete placed in lieu of plan quantity when precast concrete deck panels are used. This procedure is necessary since the deck area to be finished will remain the same, but the volume of concrete placed is reduced substantially using concrete deck panels.

c. <u>Stay-in-Place Metal Forms</u>

The use of stay-in-place metal forms must be approved by Bridge Design. The Contractor must submit shop drawings detailing the placement and use of metal forms. All forms shall be installed and maintained in a mortar tight condition (not water tight) and in accordance with approved fabrication and erection plans.

Deck forms are generally supported by support hangers welded to or draped over the top of the beam flange. The hangers will be metal and will remain in the concrete. Form support angles shall be placed in direct contact with the flange of stringer or floor beam. All such attachments shall be made by permissible welds, bolts, clips, or other approved means. Welding this structural angle section or form support to non-weldable steels or to portions of flanges subject to tensile stresses is not permitted.

Outside of the exterior beams a system of needle beams that are hung from the permanent beam flanges may be used. These needle beams support a system of legs and beams on which the slab overhang is to be constructed so that grade adjustments may be made to the overhang after the overhang is poured. In lieu of needle beams, a system of braces held up by angle hangers over the top of the permanent beam flange may be used. These braces would function as the primary support for the slab and curb overhangs.

Support angles may be partially affixed to beam or girder flanges to achieve proper profile, however, the support angles must be completely affixed to beam or girder flanges prior to setting stay-in-place metal deck forms. Metal deck forms should be affixed to the support angles with self-drilling screw fasteners as they are placed but shall be completely affixed to the support angles in accordance with approved fabrication and erection plans prior to rebar placement in the deck.

6. Grading of Deck, Reinforced Concrete Deck Girder Bridges (RCDGs).

The Department no longer uses RCDG but the following was left in the manual because it is good information and a great exercise if you would like to work through it.

Because the beams are cast-in-place, grades must be set from the girder bottom itself. Grades for the girder bottoms and other locations should be calculated as described below.

a. Falsework

Falsework is a necessary part of RCDG construction. It is necessary to support the false beams from or adjacent to the permanent caps. It is also usually necessary to provide false supports for false beams in between the permanent caps. If false bents are not provided, the deflection of the false work should be limited to no more than ¾”.

False beams may be either of timber or steel. All materials must be completely sound and properly designed. The Engineer may require approved falsework plans if commonly accepted falsework construction is not used or when the falsework spans traffic.

Timber caps for false bents must be sound. These caps are often critical as far as stress is concerned. Where one false bent and steel beams are used, caps are subject to high shear and crushing stresses. Even a small amount of crushing here can lead to thick slabs.

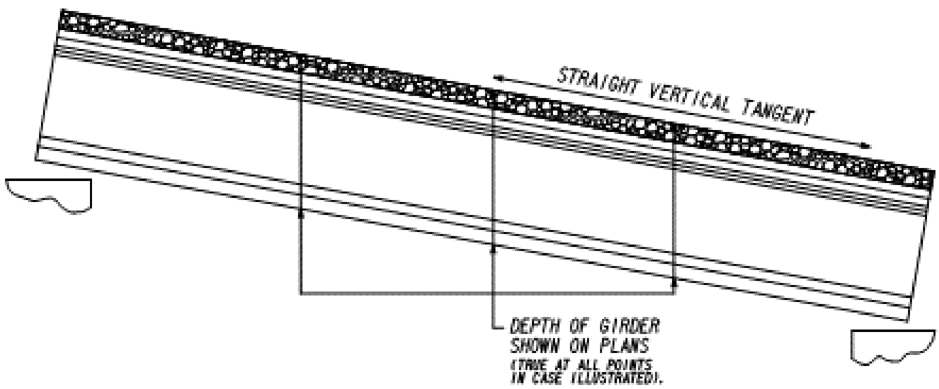
The construction of the falsework must be done carefully. Pile caps must fit with full bearing on the cut ends of the piling. Double wedging must be used in all cases to avoid edge bearings. Double wedging means one wedge on top of another making two horizontal surfaces. Wedges must be the size of the smaller of the members being wedged. Do not use two 4 x 4 wedges between an 8” round pile and a 12 x 12 cap.
Instead use two 8 x 8 wedges.

b. Girder Bottom Grades

For the ordinary RCDG bridge, girder bottom grades are calculated at five points. These five points are at the edge of the cap on each end of the span, at the ¼ points in the span, and at the ½ point in the span. Girder bottom grades are calculated so that the girder bottom will be on a straight line from the grade at the edge of one cap to the grade at the edge of the other cap. This will be adjusted as discussed below for falsework settlement, false beam deflection, and girder deflection. Adjustments will also be made as discussed below for variable section girders. In order to have the girder bottoms on a straight line, three different vertical control conditions must be considered. These are a bridge on a vertical tangent, a bridge on a rising vertical curve, and a bridge on a sagging vertical curve.

1) A RCDG bridge on a vertical tangent

The beam bottom is a constant distance below finished grade at all points along the beam. This is illustrated in Figure 6. The distance from finished grade to bottom of girder will be given on the Plans. This will be constant for all points along the beam in this case. The height the bottom of the girder is above the cap at the edge of the cap will also be shown on the Plans. To calculate girder bottom elevations at any point simply calculate finished grade at the point and subtract the plan depth of girder.



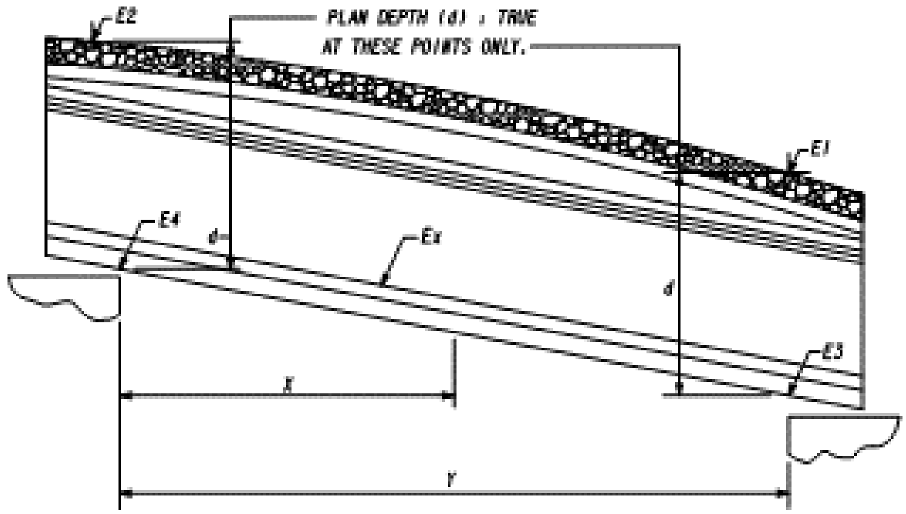
GIRDER BOTTOM-BRIDGE ON VERTICAL TANGENT

FIGURE 6

These elevations are the ones that will be adjusted for falsework settlement, etc. The adjusted elevations will then be used to grade the girder bottom.

2) A RCDG bridge on a rising vertical curve

The plan depth of sections is true at only two places in each span. These two places are the edge of the caps in each span. To establish elevations along the girder bottom first calculate finished grade above the edge of caps. Subtract from these elevations the plan depth of girder. This will yield two bottom of girder elevations, one at the edge of the cap on each of the girder. These elevations and the distance along the girder between the edge of the caps will be used to calculate the straight-line slope of the girder bottom. This straight-line slope will be used to calculate the elevation of any point along the bottom of the girder. This is illustrated in Figure 7.



E1 & E2 = FINISHED GRADE ELEVATION AT EDGE OF CAP

E3 & E4 = BOTTOM OF BEAM ELEVATION AT EDGE OF CAP

$E3 = E1 - d$

$E4 = E2 - d$

Ex = ELEVATION OF BOTTOM OF BEAM AT ANY POINT

$$Ex = E4 - \left(\frac{E4 - E3}{Y}\right)(X)$$

BOTTOM OF BEAM – BRIDGE ON RISING VIRTICAL CURVE

FIGURE 7

These elevations are the ones that will be adjusted for falsework settlement, etc. The adjusted elevations will then be used to grade the girder bottom.

If a true theoretical slab thickness is to be maintained, the girder side form height would have to be varied. Most Contractors will prefer to construct their girder side forms to plan dimensions. This is acceptable since the error involved will be small and will increase rather than decrease the slab thickness.

3) A RCDG bridge on a sagging vertical curve

The plan depth of section is true at only one point in the span. That point is mid- span. (Figure 8) In this case "extra coping" as illustrated in Figure 3, must be computed and added to the plan depth of section. This sum is then subtracted from the finished grade elevations above the edge of the cap at each end of the span.

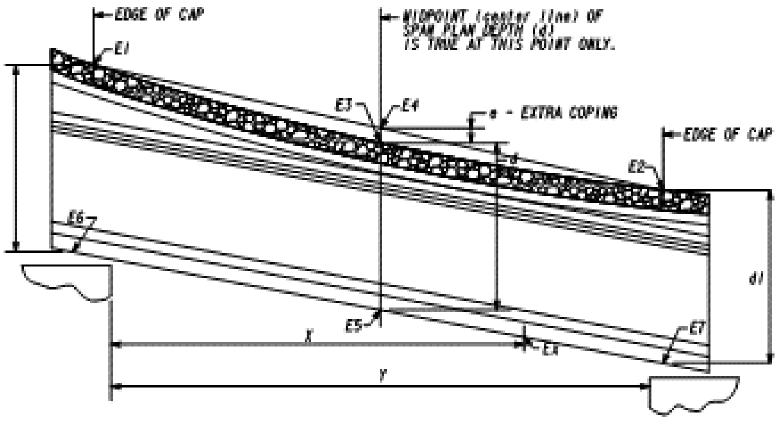
This will yield the bottom of girder elevations at the end of the cap at each end of the girder. These elevations and the distance along the girder between the edge of the caps will be used to calculate the straight-line slope of the girder bottom between the edge of the caps. This slope will then be used to calculate the elevation of any point along the bottom of the girder. This is illustrated in Figure 8. These elevations are the ones that will be adjusted for falsework settlement, etc. The adjusted elevations will then be used to grade the girder bottom. As we stated above if a true theoretical slab thickness is to be maintained, the girder side form height must be varied.

c. <u>Adjustments to Girder Bottom Grades</u>

Girder bottom elevations must be adjusted for falsework settlement, false beam deflection, for elastic deflection in the concrete which occurs immediately after the falsework is struck, and for plastic deflection in the concrete which will occur over an extended period. The amount of adjustment at any one point will be the sum of all of these. Each of these is discussed individually below.

1) Falsework settlement cannot be calculated. It can only be estimated. It can be checked with tell-tales and adjusted in spans yet to be formed. In many cases the Contractor will be more aware of the expected falsework settlement for his type of falsework than the Engineer. The allowance for falsework settlement should be arrived at jointly by the Contractor and the Engineer. In lieu of any better knowledge, an allowance for falsework settlement of 1/16" per joint in the falsework will be allowed. Joints in the forms themselves will not be considered. For example, if a form bottom is sitting on a shim, which is sitting on a beam, which is sitting on a timber cap, which is sitting on a false pile, how much will be allowed for settlement? There are four joints but only two will be considered. They are between the beam and the cap and between the cap and the pile. In this case the allowance would be 2 x 1/16" = 1/8".

   If additional shims or wedges are used, which is usually the case, a greater allowance would be made. This allowance would normally be constant throughout the span unless considerably more shimming, etc. were used at one support than others.



E1 & E2 = FINISHED GRADE ELEVATION AT EDGE OF CAP.

E3 = FINISHED GRADE ELEVATION AT MID-POINT OF SPAN.

E4 = ELEVATION AT MIDPOINT OF SPAN ON STRAIGHT VERTICAL TANGENT BETWEEN E1 & E2.

$$E4 = \frac{E1 + E2}{2}$$

E5 = BOTTOM OF BEAM ELEVATION AT MID-POINT OF SPAN.

$$E5 = (E3 - d) + (E3 - d1)$$

E6 & E7 = BOTTOM OF BEAM ELEVATION AT EDGE OF CAP.

$$E6 = E1 - d1 \qquad E7 = E2 - d1$$

Ex = ELEVATION OF BOTTOM OF BEAM AT ANY POINT.

$$Ex = E6 - \left(\frac{E6 - E7}{Y}\right)(X)$$

e = EXTRA COPING.

$$e = E4 - E3$$

d1 = PLAN DEPTH OF BEAM ADJUSTED FOR EXTRA COPING

$$d1 = (d + e)$$

BOTTOM OF BEAM - BRIDGE ON SAGGING VERTICAL TANGENT

FIGURE 8

This is illustrated in Figure 9. In Figure 9 there are 7 form and falsework joints adjacent to the concrete bent and 8 form and falsework joints

over the false bent. Of these 7 and 8 joints, however, only 3 and 4 (the falsework joints) respectively would be considered. Since this is an estimate anyway, use as a constant value the value for 4 joints. The value is 4/16” or ¼”.

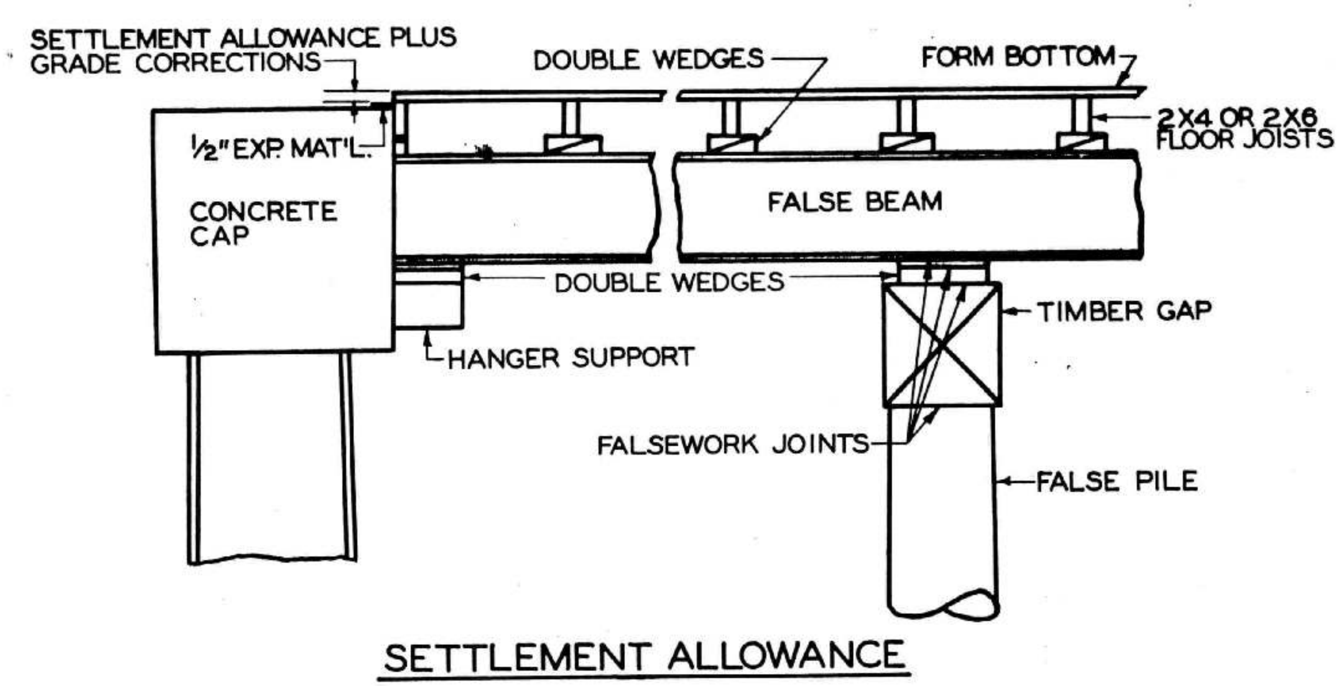


FIGURE 9

Note that this value will be added to the girder bottom elevations at every grade point along the girder bottom in this span. If the number of falsework joints differed by 2 or more, a different adjustment value would be used at these points. Also, for any immediate points in between these control points (such as the ¼ point) the adjustment difference should be pro-rated. For example, if there were 8 falsework joints adjacent to the permanent bent and 12 falsework joints over the false bent, then an adjustment value of ½" would be added to the elevation adjacent to the permanent bent and ¾" to the elevation over the false bent. The adjacent value half way between these two (at the ¼ point of the bridge span) would be 5/8".

2) The next adjustment value must be considered is that due to false beam deflection between supports. This value can be calculated for each specific case. It will vary with span between supports, the type (material) of beam used, the size of the beam, whether the beam is continuous, the number of beams used, and other factors. One very common practice is to use two continuous steel H pile beams under each girder with one false bent at mid-span. By continuous beam it is meant continuous over the false bent. This is very good and is recommended but no required. In this case a false beam deflection adjustment value of 1/8" can safely be

used at the ¼ points of the bridge spans (the ½ point of the false beam spans). This value would be added to the girder bottom elevations at these points only.

3) The third adjustment value that must be considered is the deflection of the RCDG span itself. This deflection can be divided into two parts as shown in Table 1.

These parts are the elastic deflection which will occur as soon as the falsework is struck and the plastic deflection which occurs over a period of several years due to plastic flow in the concrete. The appropriate sum of these deflections must be added to the elevations for specific points for anything else, such as curbs, that are poured before the falsework is struck. The appropriate plastic deflection only must be added to the elevations for specific points for anything that is poured after the falsework is struck. Table 1 gives values of plastic and elastic and total deflections at the ¼ and ½ points in the bridge spans. The deflection at the ends of the spans adjacent to the caps would, of course, be zero.

The total adjustment value for calculated girder bottom elevations for any one point would be the sum of the adjustments value discussed above.

The final elevations used to grade the girder bottoms would be the sum of the calculated elevation and the total adjustment value. These should be computed and listed individually in tabular form and then summed up in the same tabular form. An example of this is shown in Table 2 for a 40' RCDG span.

ELASTIC AND PLASTIC DEFLECTIONS - RCDG BRIDGE

SPAN LENGTH	ELASTIC DEFLECTION		PLASTIC DEFLECTION		TOTAL DEFLECTION	
	1/4 POINT	1/2 POINT	1/4 POINT	1/2 POINT	1/4 POINT	1/2 POINT
40	3/16"	1/4"	1/4"	3/8"	7/16"	5/8"
38	1/8"	3/16"	1/4"	5/16"	3/8"	1/2"
36	1/8"	3/16"	1/4"	5/16"	3/8"	1/2"
34	1/16"	1/8"	1/8"	1/8"	3/16"	1/4"
32	1/16"	1/8"	1/8"	1/8"	3/16"	1/4"
30	1/16"	1/8"	1/8"	1/8"	3/16"	1/4"
28	0"	0"	1/8"	1/8"	1/8"	1/8"
26	0"	0"	1/8"	1/8"	1/8"	1/8"

RCDG BRIDGE DEFLECTIONS

TABLE 1

GIRDER BOTTOM FORM ELEVATIONS RCDG BRIDGE						
POINT IN SPAN	GIRDER BOTTOM ELEV.	ADJUSTMENTS FOR				GIRDER BOTTOM FORM ELEVATION
		FALSE WORK SETTLEMENT	FALSE BEAM DEFLECT.	CONCRETE ELASTIC DEFLECT.	CONCRETE PLASTIC DEFLECT.	
EDGE CAP BT 1 FWD.	546.06	1/2"	0	0	0	546.10
SPAN 1 1/4 PT	546.30	1/2"	1/8"	3/16"	1/4"	546.39
SPAN 1 1/2 PT	546.60	1/2"	0	1/4"	3/8"	546.69
SPAN 1 3/4 PT	546.90	1/2"	1/8"	3/16"	1/4"	546.99
EDGE CAP BT 2 BACK	547.14	1/2"	0	0	0	547.18
EGDE CAP BT 2 FWD	547.26	1/2"	0	0	0	547.30
SPAN 2 1/4 PT	547.50	1/2"	1/8"	3/16"	1/4"	547.59

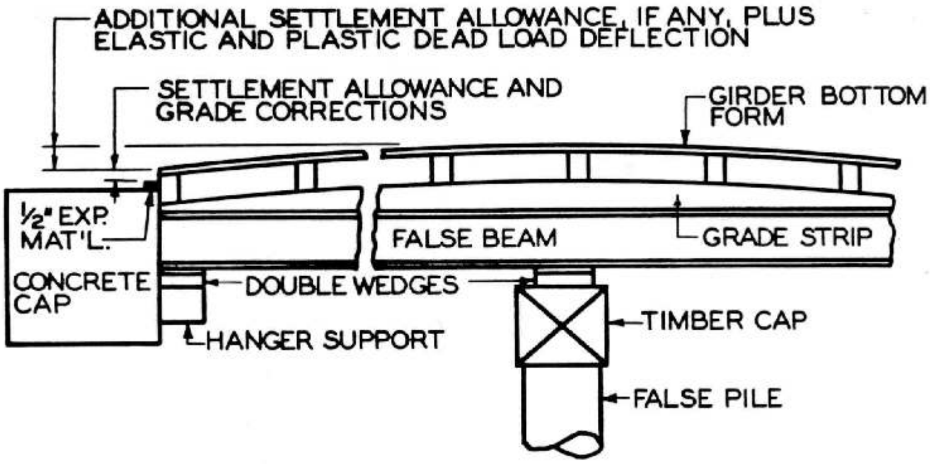
RCDG BRIDGE - GIRDER BOTTOM CALCULATIONS

TABLE 2

d. Girder and Slab Forms

Girder bottoms will usually be constructed of pallets of plyboard stiffened with 2 x 4 or 2 x 6 floor joists as illustrated in Figure 9.

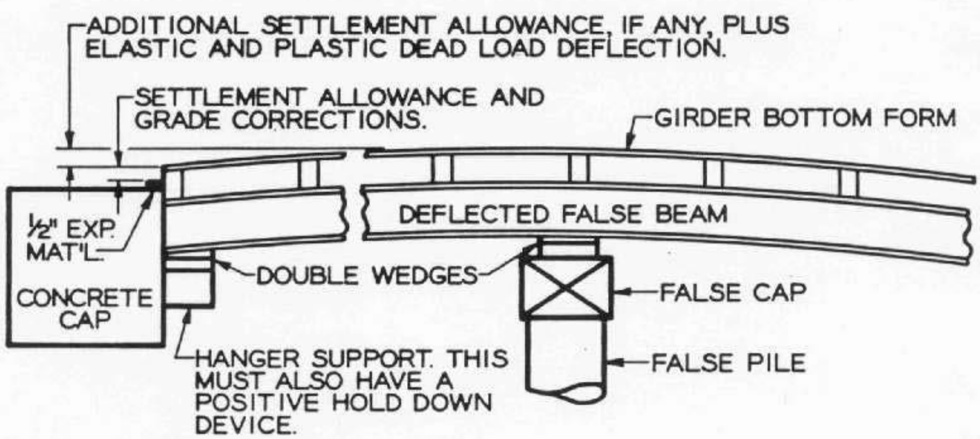
This same type of pallet or flat timber pallets or even just plyboard may be laid directly onto deflected false beams or on flat false beams with grade strips. These conditions are illustrated in Figure 10 and Figure 11.



NOTE: THE GIRDER BOTTOM FORM MAY BE OF ANY SUITABLE TYPE. PLAIN PLYBOARD IS NOT SUITABLE HERE BECAUSE OF DEFLECTION BETWEEN ADJACENT GRADE STRIPS.

GIRDER BOTTOM DETAILS

FIGURE 10



NOTE: THE GIRDER BOTTOM FORM MAY BE OF ANY SUITABLE TYPE.

GIRDER BOTTOM DETAILS

FIGURE 11

If plyboard or flat pallets are laid directly on the false beams, the beams must be free from splice plates, bends, etc. that will affect the smooth lines of the beam bottoms.

Girder side forms will usually be constructed of plyboard stiffened with 2 x 4 or 2 x 6 studs. Girder side forms will sit on the girder bottom forms. After they are into position, they must be securely held with a kicker strip nailed tight against the studs into the bottom form. This is the minimum. If deep girders are being formed, additional bracing at the bottom of the sides may be necessary. Also, if the girder bottom forms consist only of plywood laid directly on beams without being stiffened by floor joists, additional support at the bottom of the side forms will be needed.

The girder side forms will usually be adequately supported at the top by the bottom of slab form joists. For positive support the side form studs must be braced directly into the slab form joists. There are no slab form joists to hold the exterior side forms of the exterior girders. It will be necessary, therefore, to hold the top of this form with a line of form ties and walers against the side form studs. Some cross-bracing from top to bottom of adjacent girders is also advisable.

Slab bottom forms will usually be constructed from plyboard stiffened with 2 x 6 or 2 x 8 floor joists. They will sometimes be constructed in place or sometimes constructed off the bridge as pallets and then set into place. The floor joists can be supported on each end by a continuous timber strip nailed onto the girder side form studs. The joists will also be connected or braced in some manner to the top of the girder side form.

e. Side and Overhang Forms

The side forms and the overhang forms are generally constructed together. These forms are usually constructed of plyboard stiffened with floor joists and studs. These can be supported from a system of joists that are held by nailer strips on the side form studs on one end and a system of supports from the false beam on the other end. A means of adjusting the grade of the outside edge of the overhang must be provided. This can be in the form of wedges between the overhang floor joists and their supports.

f. Headers

Headers are the vertical forms constructed across the ends of each slab pour. Normally on RCDG spans the only headers will be over the bents. The header grades will be the actual theoretical grades calculated for points on the headers. It may be necessary to adjust these grades for form settlement. If a longitudinal screed is used, these headers and the crown of the screed control the grade of the deck surface. It is essential that these headers be constructed in an exact location and to an exact grade. It is also essential that the headers be rigidly constructed, if a longitudinal screed is used, as the headers must support, without deflection, the weight of the screed, and they must also be able to resist without movement the sawing action caused by screeding the concrete. Header supports must be substantial so that the need for header adjustments is rare, however, the headers must be constructed so that adjustments, if necessary, in both line and grade may be made. Headers must be checked and the adjustments, if necessary, made while the concrete is still very plastic.

On long span continuous RCDG spans, headers will be located in the spans. In this case the headers are to be set and held the plan distance above the girder bottom

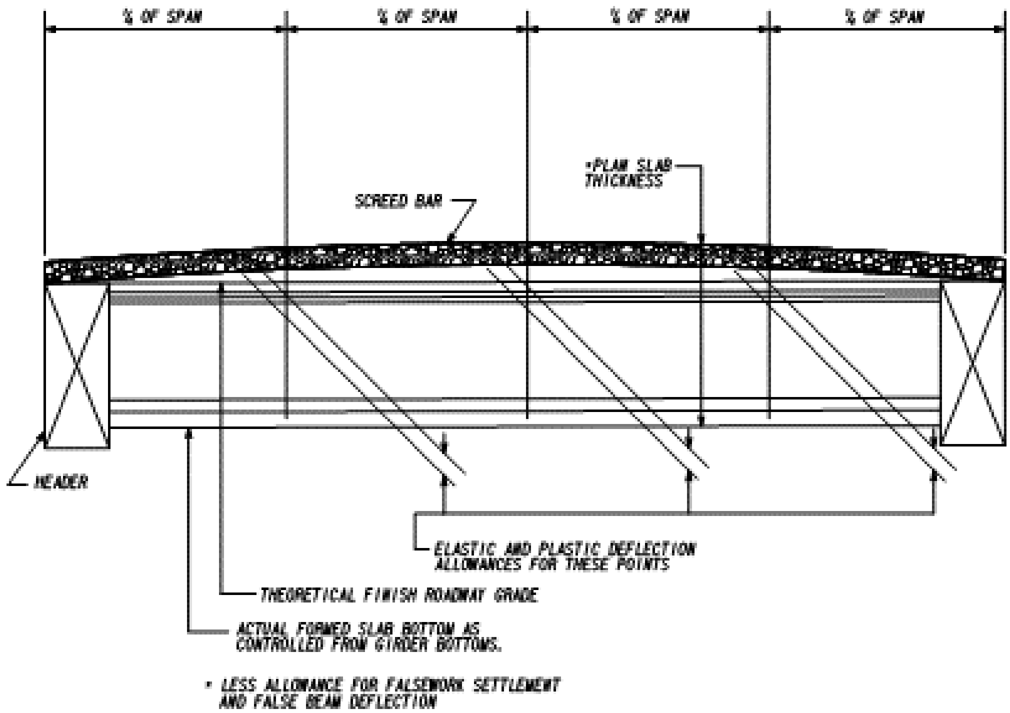
forms. All adjustments that apply to girder bottom forms at those points apply to the headers also.

Screeds used on RCDG spans should be set to follow the theoretical top of concrete grade plus the same adjustment for elastic and plastic concrete deflections as was added to the girder bottom grades. No adjustment in screed grades should be made for falsework settlement or false beam deflection. In other words, when the screed is sitting on the graded headers the strike off bar should conform to the finished roadway grade plus the allowance for elastic and plastic deflection. If the elastic and plastic adjustments are not put into the screed, the slab will be too thin. This is illustrated in Figure 12.

For transverse screeds, the rail grade is determined by the addition, or subtraction, of a constant dimension to the theoretical grades (theoretical grades are arrived at by the addition of dead load deflection ordinates to the finish grade elevations) Of a line on the bridge, usually the gutter line. This dimension will be given by the Contractor to accommodate his particular screed and screed-support method. The rail is graded by instrument, while the screed is at each location being graded. A rod is held at the pre- determined points and the rail is raised or lowered as necessary by the Contractor. Rail supports are a nut-and-bolt arrangement and raising or lowering can be accomplished by turning the nut. Usually the pre-determined grade points are spaced no more than ten feet apart, and closer if the grade is on a short vertical curve.

g. Tell Tales

Tell Tales must be used in RCDG construction. They should be placed at the ends, ¼ points, and ½ points in the spans. They must be checked so that the actual falsework settlement is known. These readings should form the basis of future falsework settlement allowances.



SCREED ADJUSTMENTS

FIGURE 12

h. Variable Section RCDG Bridges

In some locations continuous RCDG bridges of variable depth will be constructed. In these cases, the same type of adjustments must be made to the grades. The calculated elastic and plastic deflections will be shown on the Plans. Allowances will also be made for form settlement and false beam deflections. It may be necessary to provide control points closer than the ¼ points. In all cases control points must be located at the beginning of the variable depth sections.

i. Slab Bridges

Slab bridges will be supported and formed along the same lines as RCDG bridges. The false beams will be more evenly distributed throughout the width of the slab. The bottom of slab form will generally be constructed of plyboard stiffened with floor joists. These will be supported by false beams. The same type of allowances for settlement and deflections and grades as outlined for RCDG construction will be made for concrete slab spans.

7. Deck Reinforcement Steel

The Engineer must inspect the reinforcement steel to see that it is properly fabricated. Bars not fabricated within the tolerances allowed in the Specifications shall be rejected. The Engineer must also inspect the placement of reinforcement steel to see that variations from plan locations are no more than the allowable tolerances. The Engineer should inspect the steel while it is being placed, and then after all of the steel for a pour is completely in place, tied, and supported, a final thorough inspection must be made. During the course of this last inspection the Engineer should measure the clearance, spacing and type of each bar support. He must also check the size of the bars and the number of bars placed to see that the proper amount of reinforcement is placed.

a. Placement and Tying

The reinforcement steel will be placed beginning with the bottom steel and working on up to the top steel. When truss bars are used in slabs, partial placement of top distribution steel as shown in the plans before the truss bars are placed is necessary. In RCDG construction, the girder stirrups and then the main girder reinforcement is usually the first steel placed. Bundled girder bars shall be tied firmly together with no clearance between the bars.

Main slab bars for skewed bridges that frame into the edge beams are detailed on the Bridge Plans as an equivalent full-length bar. These are broken down by the steel detailer into bars with varying increments of length. These bars will also be detailed to frame into the edge beam, approach the header, and then when the proper clearance from the header is achieved turn parallel to the header for a short distance. This will be clearly shown on the Plans. If these bars are to fit, they must be placed in their proper location. One good method of placement is to place the full-length bars first and then start with the longest variable bar and work right on down to the shortest. If the slab pour length and skew are such that no full-length bars are used, place the longest bar or bars in the middle of the slab and work from these.

b. Supports (Section 511 and Section 514)

Clearances are determined largely by the bar supports. The Engineer must know where and how a support is going to be used before he can check the support. Basically, a support is going to be used before the lowest bar it is to support. For instance, bottom mat supports should fit underneath the main slab bars and top mat supports should fit under the top mat longitudinal bars. Heights of supports must be carefully checked so that when they are used the resulting clearance and spacing will be as called for on the Plans. After the steel has been placed on its supports and completely tied in place, the spacings and clearances must be checked. If they are wrong, the first things to look for are improper supports or improper use of the supports. Another source of error is a place where a support is tied in the curved portion of a bend under a longitudinal bar. Longitudinal bars used in conjunction with the supports must be tied onto the horizontal part of the transverse bars.

8. Pouring of Decks

The requirements for and the methods of pouring decks are covered in Section 500— Concrete Structures of the Specifications. When needed the sections on Cold Weather Concreting and Hot Weather Concreting in Section 500 shall be followed.

a. Pre-Pour Check

Before a pour, the Engineer must check and inspect the reinforcement steel, the forms, the pouring and finishing equipment, the time of day verses the amount of time required to make the pour. The prevailing and predicted weather conditions, and the screed must be checked to verify proper set-up.

The Engineer must also inspect the concrete production equipment and supplies to assure that they are adequate for the pour.

A work bridge must also be on the job prior to pouring and the Engineer should make sure that it meets Specification requirements.

See Appendix A, Section 2 for a discussion of required procedures for a deck pour and a copy of the "Pre-Pour Checklist".

b. Screeding and Screed Types

Methods of setting up a screed will depend upon the type of screed used. Longitudinal screeds typically are supported along the bents and span the entire length of the pour, longitudinally. Transverse screeds typically are supported off rails that run longitudinally along the beams and span the pour transversely. Vibratory Screeds like a Razorback that use vibration to provide a surface finish are not allowed to be used on bridge decks without consulting the State Construction Office.

1) Longitudinal Screeds (Shugart)

Longitudinal screeds can be used on spans up to 70 feet in length. If a longitudinal screed is used, lateral movement of the screed along the headers must be accompanied by a continual sawing movement of the screed in a longitudinal direction. The screed must rest flat upon the headers at all times. Tipping of the screed over sideways on its edge can cause corrugations in the deck surface. The full weight of the screed must rest on the headers at all times. Care must also be taken to ensure that the screed does not ride upon material deposited on the headers. The screed must be operated parallel to the longitudinal axis of the bridge, not skewed to it. Headers are usually constructed so that the top surface is a 2 x 4 or 2 x 6 laid flat. This helps resist the sawing action of the screed and provides a wide bearing area for the weight of the screed.

The screed is set by calculating camber ordinates (up or down) of the profile grade for the length of the screed and then setting this camber into the screed. For Reinforced Concrete Deck Girder bridges, these camber ordinates must include the amount of dead load deflection. Camber can be placed in a screed by placing it on blocks located at each end and stretching a string line from end to end and then adjusting the screed until the vertical distance from string to screed is equal to the calculated ordinate at that point. The location of points for computing camber ordinates should be selected to coincide with adjustment bolts on the screed. The frequency of points shall be dictated by the degree of vertical curvature. See Figure 13 for determining camber ordinates for screeds on curved bridges.

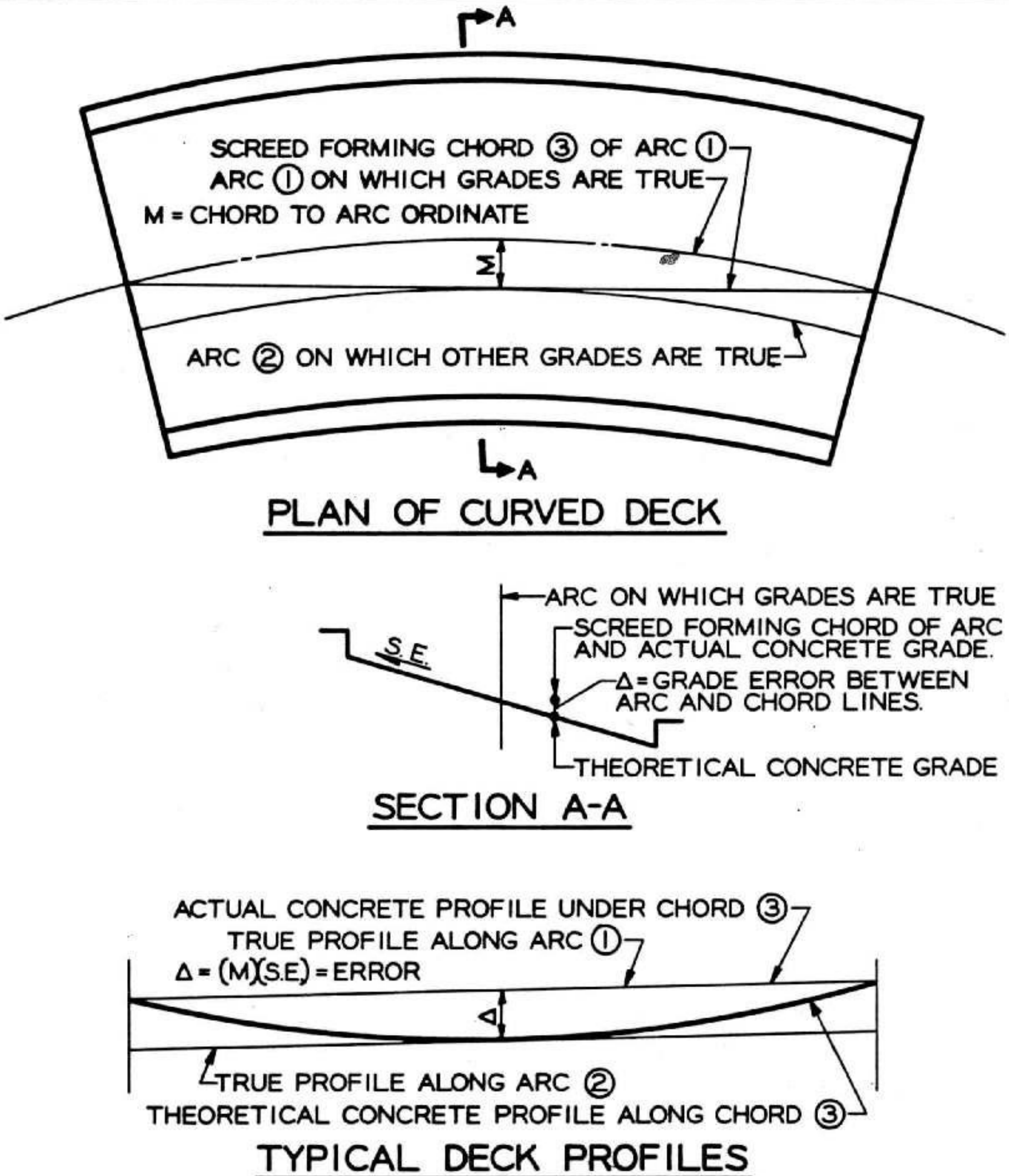
For a curved bridge true grades can be calculated along any arc for any point on the arc. A longitudinal screed is straight. When a longitudinal screed sits on headers it forms a chord of an arc that passes through the points formed by the intersection of the screed and the headers. Grades would be true along this arc but not true along the chord (which is what the screed is) of the arc. The amount that the grade at any point along the chord (the screed) would be in error, would be the product of the chord-to-arc ordinate and the superelevation rate. This is illustrated in Figure 13.

The error is a function of the span length, the degree of curvature, and the rate of superelevation. It is the responsibility of the Contractor to calculate the error for the particular spans involved and decide whether or not the screed will require corrective adjustments.

After the screed has been adjusted, it should be placed on the headers, and measurements taken from the strike-off to the top of the reinforcing steel and to the top of the deck formwork to check steel clearance and slab thickness.

Measurements thus taken at any point within the span must be adjusted by the amount of the dead load deflection at that point plus possibly a small allowance for form settlement in order to indicate resulting clearance and slab thickness. This applies to simple spans where the entire length of span is included in one pour.

On all spans where headers for longitudinal screeds are placed at points other than over caps, i.e. continuous units, the header grades must include the expected overall dead load deflection at the header location. The amount of deflection between the headers can be determined from the dead load deflection curve on continuous units, or through use of a formula for a parabola on simple spans. (See Figure 14) Adjustments must be made to reinforcing steel clearance and deck thickness to account for header deflection.



SCREEDING ERROR-CURVED SPANS

FIGURE 13

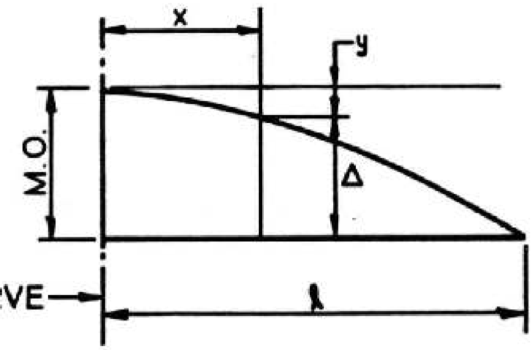
PARABOLIC CURVE DERIVATION

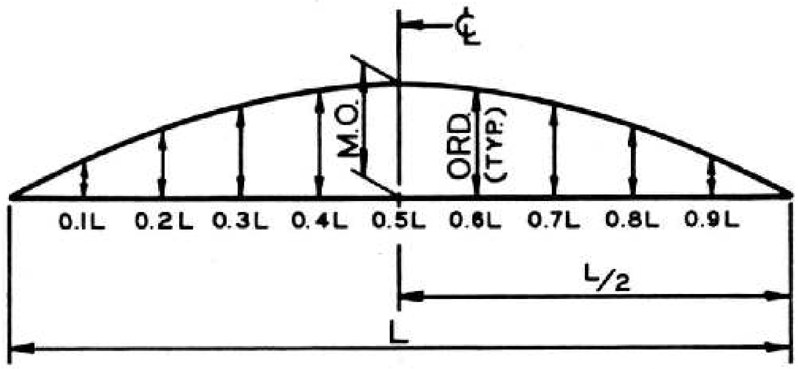
BY DEFINITION $y = Kx^2$

$$\frac{M.O.}{\ell^2} = \frac{y}{x^2}, \quad y = \frac{M.O. \cdot x^2}{\ell^2}$$

$$K = \frac{M.O.}{\ell^2} \quad \therefore \quad y = Kx^2$$

$$\Delta = M.O. - y$$





SINCE WE OFTEN USE PROPORTIONAL POINTS IN LIEU OF ACTUAL DISTANCES WE MAY ALSO USE PROPORTIONS IN LIEU OF DISTANCES IN COMPUTING THE ORDINATE Δ. THIS MERELY SIMPLIFIES OUR CALCULATIONS.

EXAMPLE: COMPUTE THE ORDINATE Δ AT 0.7L

CONSIDER $L/2 = 1$ AND $M.O. = 1$ IF $L/2 = 1$, $x_{0.7L} = 0.4$

$$y_{0.7L} = \frac{M.O.\ [0.4]^2}{1^2} = 0.16\ M.O., \quad \Delta = M.O. - y_{0.7L}$$

THEREFORE $\Delta_{0.7L} = 1 - 0.16$ OR 0.84 M.O.

OTHER CONVENIENT ORDINATES ARE AS FOLLOWS:

- ORD. AT 0.1L AND 0.9L = 0.36 M.O.
- ORD. AT 0.2L AND 0.8L = 0.64 M.O.
- ORD. AT 0.3L AND 0.7L = 0.84 M.O.
- ORD. AT 0.4L AND 0.6L = 0.96 M.O.
- ORD. AT ⅛ L AND ⅞ L = 0.4375 M.O.
- ORD. AT ¼ L AND ¾ L = 0.75 M.O.
- ORD. AT ⅜ L AND ⅝ L = 0.9375 M.O.

PARABOLIC CURVE ORDINATES

FIGURE 14

2) Transverse Screeds (Bidwell, Allen)

This type of screed must be set so that the transverse guides along which the strike- off float moves conform to the cross section of the bridge deck surface. Because the screed is supported by the beams the deflected in the beams must be accounted for in setting up the screed. The longitudinal rails along which the screed moves must be graded and must include these dead load deflection ordinates. Screeds of this type have features which permit the support rail to be at an elevation either even with, above, or below the deck surface. Usually, the rail is placed outside the gutter lines of the bridge, being supported directly by a beam if possible, and by the overhang formwork if the bridge does not have a beam outside the gutter line.

Another method, in the event no beam is outside the gutter line, is to place rail supports on the top of the exterior beams and finish only the portion of the deck inside the rails with the screed. The remaining portion of the deck (from the rail to the gutter lines) must be finished by hand as soon as the screeding has progressed the length of a section of the rail. The sections are usually from 10 to 16 feet long and can be removed to permit the hand finishing. If the screed rails are supported by the overhang forms rather than directly from the beams, the overhang form system must be especially rigid in order to prevent deflection of the rail relative to the beams or girders, and the rails themselves must be supported at intervals close enough to ensure that the rail will not deflect between supports. This last requirement can be checked before pouring operations begin by moving the screed along the rails and observing any deflection of the rail due to the weight of the screed.

After the screed rails have been graded the screed should be run the entire length of the span and measurements taken from the strike-off to the top of the reinforcing steel and to the top of the deck formwork in order to check the steel clearance and slab thickness. Measurements in this case should show plan thickness and clearance, with a possible allowance for form settlement which should be no more than 1/8” at form supports.

On bridges to be widened or stage constructed, the screed shall not be supported on the existing bridge in order to screed the new portion without consent of the Engineer.

c. Deck Pour

During the pour the Engineer must check each batch of concrete to see that it conforms to the requirements of the Specifications. Check the first truck to insure proper mix, air content and slump before placing any concrete! Concrete plants are set up to be consistent-if the first truck is bad the odds are high that the second truck may be, too. The forms and reinforcing steel should be wet down in advance of the concreting. If the ground is muddy, workmen must not be allowed to track mud onto the forms, reinforcement steel or concrete. Workmen walking outside of the pour along the overhang bottom forms must not be allowed to walk on the overhang reinforcement steel. This will cause slight movements of these bars which will destroy their bond. This steel can easily be bridged with a walkway.

The concrete placement operations must be observed, seeing that they conform to the requirements of the Specifications, paying particular attention that the rate of placement conditions are met. Concrete placement begins when concrete is first placed on the deck and ends once initial strike off is completed. Pour rate is calculated for each span or section, if pouring multiple sections. Many construction problems stem from a failure to meet the concrete placement rates required by the Specifications for bridge superstructure concrete. The failure to meet the required pour rates is primarily critical because it often prevents proper finishing of the concrete. This is especially true in the summer months. Bridges designed with structural steel beams having high dead load deflections present special problems, especially when a longitudinal screed is used. Rapid placement of the concrete is mandatory as several beams must be loaded before the full deflection takes place and final screeding of the concrete can be accomplished. Finishing of the concrete must take place when the concrete is still in a plastic state. Non-deflecting structures such as those supported by falsework are less critical; but none-the-less, placement rates should meet the specifications to allow time for finishing.

Section 105.01 and Section 105.03 of the Specifications outline the authority of the Engineer to accept work which is not in accordance with the Specifications. We will not accept at full pay, work which does not substantially conform to the Specifications.

Payment for deck pours where placement rates are lower than that required in the Specifications and where the quality of construction has been affected will be made as follows:

$$\text{Actual Payment} = \text{bid price} \times \frac{\text{Actual Placement Rate}}{\text{Required Placement Rate}}$$

It is not the desire of the Department to place a penalty on any Contractor. However, unsatisfactory performance makes it necessary to use reduction in pay as a tool to encourage better quality work. In some cases, it may even be necessary to remove the deck pour where the quality of construction is lower than can be tolerated. Contractors who ignore our specifications concerning placement rates should be advised that payment will be adjusted as described above.

A continual watch must be made over the reinforcement steel to see that it does not get displaced or if it does get displaced, it is relocated into its proper position. The forms must be inspected to see that they are holding, and the finishing operation must also be inspected.

The concrete supply must be regulated so that fresh concrete can be maintained along the leading edge of the pour at all times. This leading edge must also be placed uniformly along the full length or width of the pour.

As part of his “during the pour” inspection of the forms the Engineer should look for missing wedges, broken timbers, leaning struts, leaning joists, deflected pallets, leaks that would indicate the opening of joints in the forms, etc. If any of these conditions are evident or if the forms fail, the Contractor’s attention must be called, and investigations and/or repairs made immediately. Sometimes this repair will entail the removal of some of the fresh concrete.

The “Bridge Deck Construction Checklist” (refer to Appendix A, Section 2.C) requires probing the slab during deck placement operations to verify plan dimensions. Probing of the deck must be made to check proper clearance over the top mat of steel and correct thickness of the deck. This inspection will allow the deficiencies to be corrected in a timely manner. Probes should be recorded as described in Appendix A, Section 2.C and the record placed in the project files with the pre-pour checklist.

d. Finishing and Curing

After the final strike-off of the concrete and as close behind the final strike-off as practical, the surface shall be checked with a 10’ straightedge. It is preferable that the straightedge be affixed to a broom-type handle for control and ease in using.

The gutters are usually hand finished with floats. This should be done between the screeding and final finishing operations. This way the final finish will cover the float marks and give the deck a more uniform texture. The floating and working of the gutters is necessary because the screed usually will not work well close to the rail steel. Also the area behind the curb steel has to be struck off and any slush or weak grout pushed up by the screed must be removed. The final gutter lines and grades must be such that the gutters will not pond water and the deck drains can operate. The area which will be covered by the barrier should be patted down with a trowel to smooth the concrete. Any required keyways shall be constructed.

The final finishing shall be accomplished with a street-type broom, burlap drag or belting. If grooving is required, it shall be done with mechanical equipment for grooving hardened concrete. The finish will always be transverse and is begun as soon as the concrete has hardened sufficiently. The Specifications cover final finishing under Subsection 500.3.05.T.7.

Poor joint finishing causes the majority of the deck finish problems. Transverse joints include the expansion joints at the ends of a span, construction joints between pours, and crack control joints within pours. They are either edged with an edging tool with a ¼" radius while the concrete is plastic, or ground to approximately that radius after the concrete has set. If finished while the concrete is plastic, the joints should be worked after the screeding is done and before the final finish is applied. Finishers, in edging the joint and in working it, very often will edge the joint either high or low. The only way for a finisher not to do this is to use a straight edge on the joint. This straight edging must be done as part of the joint finishing operation.

Curing is critical for deck concrete because of the large exposed area and shallow thickness of the decks. Curing requirements are covered in the Specifications. On large deck pours the curing of some areas will have to start before the last of the concrete is poured or finished. Oftentimes it is necessary to fog the fresh deck surface prior to final finishing and curing to minimize early moisture loss. Early loss of surface moisture can lead to excessive plastic shrinkage cracking. Care must be exercised in fogging the concrete. It is possible to over fog a concrete surface. If the excess water from over-fogging is worked into the concrete surface through the finishing process, a thin but weak layer of cement grout can form on the top of the deck. Often a finishing crew is tempted to over fog because it aids them in finishing the concrete and many times creates a grout layer that will initially provide a good-looking deck and a good ride. However, these looks may be deceptive as the long-term durability of the bridge deck could be significantly reduced resulting in future spalling and deterioration of the riding surface. Fogging should not be applied unless the water sheen begins to disappear from the concrete surface.

After the bridge decks, approach slabs, and roadway pavement tie-ins are completed, they may be subjected to smoothness test in accordance with the Specifications. See Appendix "D".

e. Protective Surface Treatment

When its use is specified on the Plans, a protective surface treatment consisting of 75% boiled linseed oil and 25% mineral spirits by volume should be applied to the entire top surface of the bridge decks, curbs and sidewalks, and to inside vertical faces of curbs, parapets and end posts, as a preservative seal coat. The preparation of surfaces to be treated, application rate, method of application should be specified in the contract documents. Protective surface treatment should not be applied until all required grinding and grooving have been accomplished. Under no circumstances should curing compounds be used on concrete which is to receive this special protective treatment.

9. Other Bridge Structures

a. Steel Grid Flooring Decks

Steel grid flooring construction will be covered in each case by a Special Provision. This is a specialized operation. The Engineer must review the Special Provision very carefully before the work is commenced.

Prior to the start of the erection and welding of the steel grid flooring the Engineer will contact the Materials Office. The Materials Office will send a representative to the project. No welding should be commenced before the arrival of this representative.

b. Corrugated Steel Bridge Plank Decks

The construction of Corrugated Steel Bridge Plank Decks is covered by Section 505— Corrugated Steel Bridge Plank of the Specifications. Lap details, welding details, etc. are shown on the Plans. The Engineer must review these before such work is commenced.

10. Bridge Deck Joints

The type of joints to be considered are poured joints, joint seals with elastomeric concrete headers, steel armored or finger joints, and modular expansion joints. The poured joints will include expansion joints, construction joints, and crack control joints.

a. Poured Joints

The forming of joints and the placement of the preformed joint filler and sealant will be shown as details on the Plans and is covered by Section 461—Sealing Roadway and Bridge Joints and Cracks of the Specifications. Poured joints are formed by placing headers between deck sections and pouring against the header. Poured joints are sealed with a poured or troweled type of joint sealer. The poured material will run to the lower end of the joint when there is any great slope to the joint such as on super elevated bridges. One way to help this situation is to construct a series of dams across the joint out of troweling grade material. The joints are normally sealed after the entire bridge is completed.

Poured joints can be expansion joints, construction joints or crack control joints.

1) Expansion Joints

Preformed joint filler is placed between pours to the top of the deck. In normal construction the preformed joint filler will be placed, and the radii constructed as part of the deck construction. If the preformed material is high or low, it shall be cut back or built up so that the ratio of width to depth shown for the joint sealant in the plans will be maintained. See Figure 15.

2) Construction Joints or Crack Control Joints

Concrete is poured against concrete without the preformed joint filler. These joints are used in decks where the reinforcing steel is continuous to regulate the transverse crack that develops over the bents. These joints shall be sealed the same as expansion joints except that no bond breaking tape is required nor is too much depth a problem. When shown as “required construction joint” on the Plans the construction joint cannot be eliminated. See Figure 15.

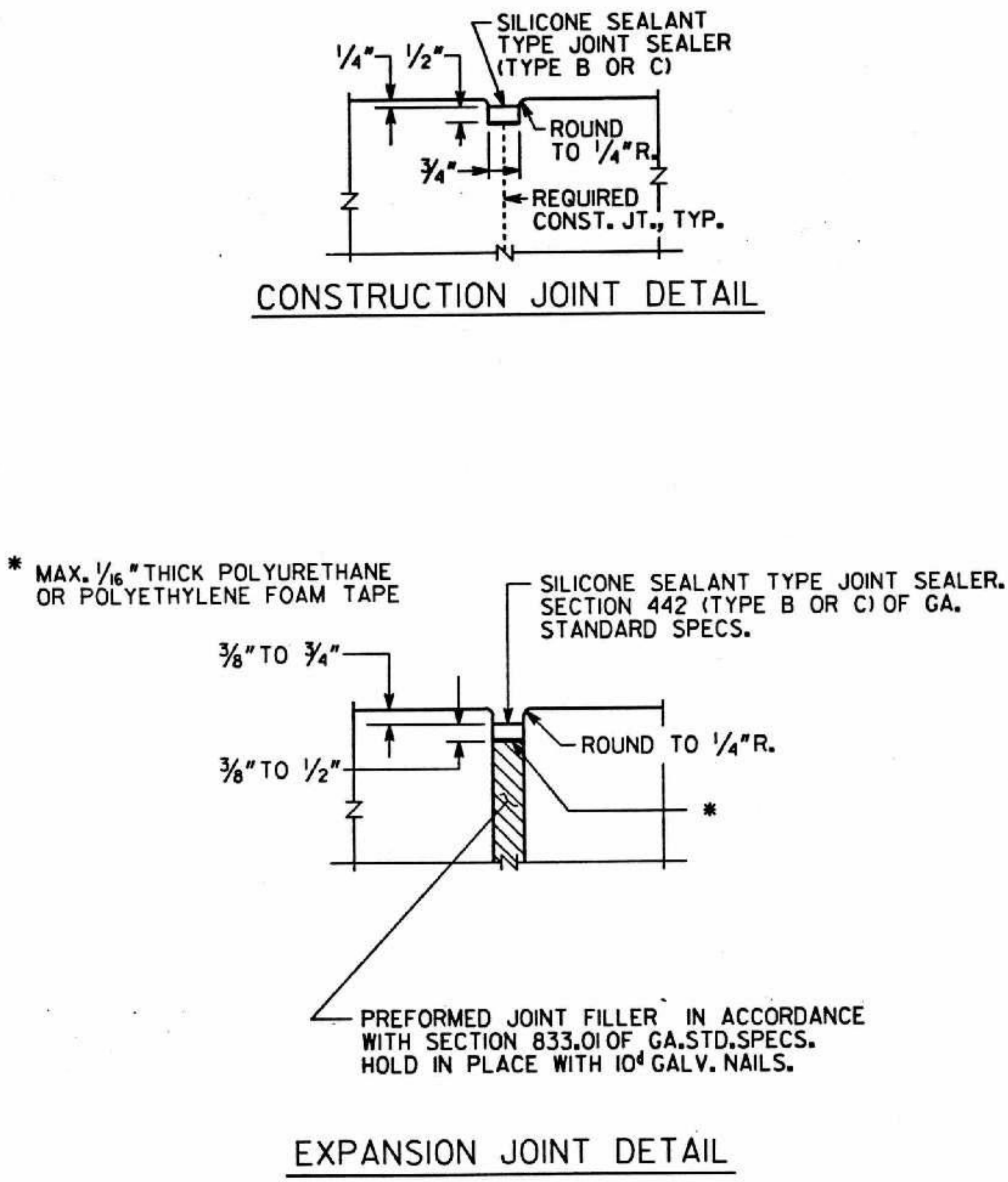


FIGURE 15

b. <u>Joint Seals with Elastomeric Concrete Headers</u>

This type joint is used where intermediate movement is expected, typically in the range of 1 ½ to 3 inches. Generic details for these types of joints will be shown in the bridge plans along with joint width, and installation criteria.

The Contractor shall submit working drawings of the proposed joints in accordance with Section 449—Bridge Deck Joint Seals. No materials should be ordered and no work begun on the joints or the joint blockouts (including edgebeams) until the shop drawings have been reviewed and accepted by the Bridge Office. All aspects of the joint installation shall be in accordance with the manufacturer's recommendations and are to be included with the working drawings.

These bridge deck joint seals typically consist of a neoprene seal (strip seal) attached to steel extrusions that are anchored in elastomeric concrete (see Figure 16). The elastomeric concrete is placed in preformed concrete blockouts in the deck slab above the edge beams. Proper surface preparation of the concrete blockouts is crucial if adequate bond is to be achieved. The joint assembly is held in the elastomeric concrete with straps, bars, or studs once the concrete has set. The manufacturer's recommendations for surface preparation, as well as mixing, placing, and curing the elastomeric concrete must be strictly adhered to or the joint will not perform as intended and may ultimately fail.

Blockouts in the deck slab for the joints will be detailed in the bridge plans but the dimensions of the openings shall be as per the joint manufacturer's recommendations. Since the width of the joint opening will vary with temperature, it is imperative that the joint openings be set based on the temperature during installation. Temperature adjustment criteria should be shown on the working drawings. Prior to placing the elastomeric concrete, the engineer should visually inspect the grade and alignment of the joint and verify that the joint width agrees with the working drawings.

For bridge widenings, measures should be taken to ensure that the width of the new joint, including the opening between edge beams, matches the width of the existing joint. Complications in joint performance can occur otherwise.

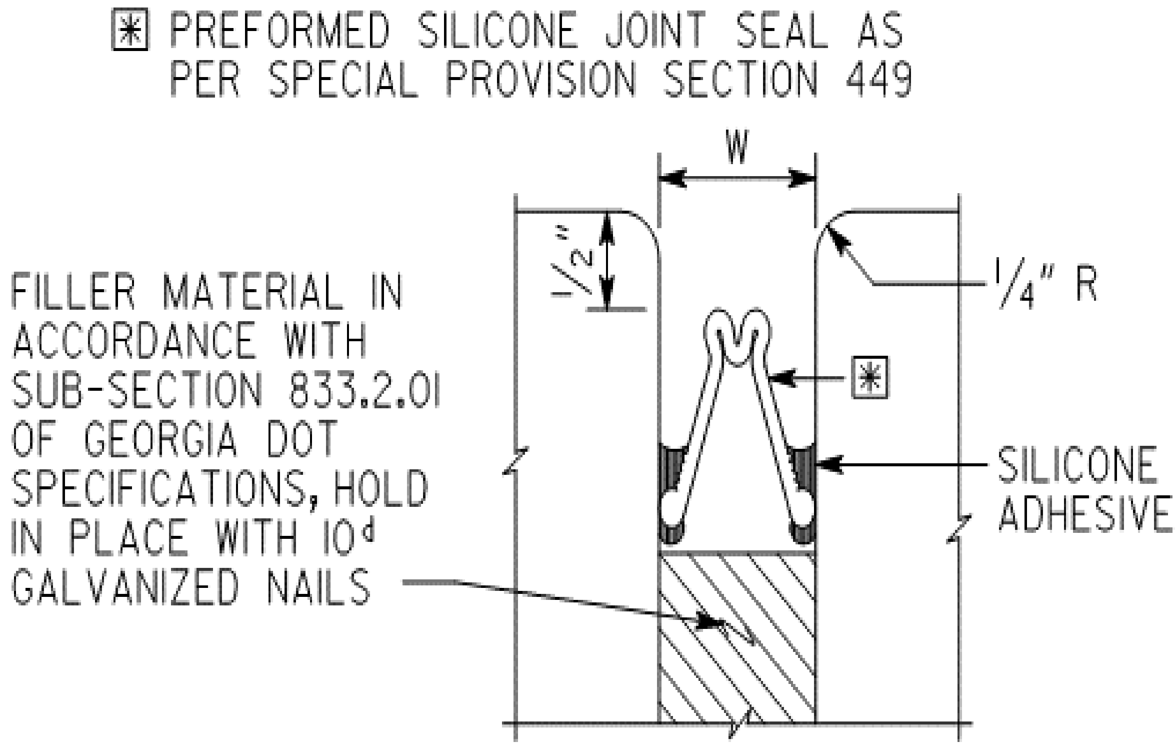
After the elastomeric concrete has cooled and solidified, the neoprene seal can be placed. The neoprene seal shall be seated as per the manufacturer's recommendations and attached with an approved adhesive. The seal shall be one continuous unit turned up at barriers, curbs, and parapets as per plan details.

c. Steel Armored Joints or Finger Joints

These type joints are used when large movement is expected, typically in excess of three inches. Steel joints will be detailed in the bridge plans. An opening dimension at an assumed installation temperature (usually 60 degrees) will also be shown along with an adjustment value for the actual installation temperature. It is imperative that both the edge beam opening and joint opening be properly set to account for the actual temperature encountered at the time of installation.

The contractor shall submit shop drawings of all steel joints in accordance with Subsection 501.1.03. No materials should be ordered and no work begun on the joints or the joint blockouts until the shop drawings are approved.

Steel joints are usually set in preformed concrete blockouts in the deck slab above the edge beam and concreted into place. The joint assembly is held in the concrete with straps or studs once the concrete has set. The joint assembly must be set so the top plate is on the grade of the deck. It must not be set level unless the grade is level.



EXPANSION JOINT DETAILS

NO SCALE

d. Modular Expansion Joints

This type of joint is used where large movement is expected, typically in excess of four inches. Modular expansion joints may be used as alternates to steel armored or finger joints. Only basic geometrical criteria is given in the plans. Special design, fabrication, and acceptance criteria will be stipulated in the Specifications (Special Provision Section 447—Modular Expansion Joints). The joint manufacturer is responsible for furnishing working drawings, installation criteria, test specimens and any other required submittals necessary for approval of the particular joint system

Modular expansion joints vary greatly in size and shape. The various manufacturers and geometric configuration are too numerous to be covered in this manual.

G. Pouring of Sidewalks, Parapets, and Barriers

Sidewalks, parapets, and barriers may be formed conventionally, or slip formed. In any case the bridge decks shall have the strength and age required by Specification prior to such placement. Generally, sidewalks and raised medians will be of the removable type. By providing a natural break surface for removal, the deck area below the sidewalks and/or raised medians can be retained without damage if future removal or widening becomes necessary. This is typically done by placing a bond breaker like plastic sheeting between the deck and the sidewalks and medians.

The contractor may saw cut joints in sidewalks, parapets, and barriers if slip forming is allowed. Contractor must submit in writing how they will form and tool the joints in barrier wall if they choose not to place expansion material as shown in the plans, this must be submitted and approved for construction on every project. Sawing shall commence as soon as the concrete has sufficiently hardened to permit sawing, usually about four hours after placement. Minor surface raveling may occur but must be corrected with edging tools or by grinding to provide a uniform and neat appearance. Waiting until the next day to saw cut is too long as uncontrolled cracking will usually begin before this time. Sawing crack control joints becomes useless after natural cracking occurs.

1. Barriers

Barriers should be constructed to the required dimensions within the allowable tolerances.

2. Hand Railing

Bridge hand railing will be of two basic types. These are Ferrous Metal Handrailing (Section 515—Handrail-Ferrous Metal and Pipe) and aluminum handrailing (Section 516—Aluminum Handrail). Handrailing is also designed to resist specific loadings. It must be carefully constructed so that its structural capacity is not reduced.

a. Ferrous Metal Handrailing

There is very little allowable tolerance in the location, plumbness, or height of the post anchor bolts. They must be set in exact location, in an exact pattern, and to an exact height. These bolts will be cast into either the curbs or the parapets. The Bridge Plans will give the location of the centerline of the posts. The Handrailing Plans will give the spacing of the bolts around the centerline of the post. The Handrailing Plans will also give the minimum required projection of the bolts above the finished concrete. This is the minimum projection for a flat grade. No allowance for shimming or for grade change is in this projection. The plan projection should be increased by ½” for grade adjustment shimming and also by another amount equal to the grade change in the width of the post base.

One good way to hold the location and spacing of the bolts is to set them with a template. A plyboard template with holes for each bolt properly spaced around the centerline of the post (which has been marked on the plyboard template) is adequate. The bolts should be rigidly bolted through these holes so that when the template is set the proper projection above the concrete will be realized. This template, with the bolts, should be securely fastened to the forms before the concrete is poured. As soon as the concrete into which these bolts are cast has been placed, the area around the bolts must be finished and the location, spacing, and height of the bolts checked. Adjustments, if necessary, must be made before the concrete has set.

The erection of the railing should be done in accordance with the Specifications. The posts shall be shimmed, where necessary, so that the railing will be on line and grade. This can be controlled with a transit or a string line but in all cases adjustments necessary to make the handrailing pleasing to the eye shall be made.

b. Aluminum Handrailing

As in Ferrous Metal Handrailing one of the most important jobs in the construction of Aluminum Handrailing is the setting of the post anchor bolts.

Aluminum Handrailing shall be erected in accordance with the Specifications. Special attention must be paid to the requirement for protecting the aluminum from contact with the concrete. The aluminum shims must also be protected from contact with the concrete. It is not sufficient to spread the caulking compound on the bottom of a post and then place a shim between the post and the concrete. The caulking compound must be placed on the concrete so that if a post is raised and a shim is placed the shim will be protected.

H. Painting

Painting shall be done in accordance with the Specifications, Section 535. The types and kind of paints to be used will usually be specified on the Plans by a system number. The paints for a specific system number are given in the Specifications.

For steel beams, there is one major area in cleaning where most of the trouble develops. This is the bottom of the top flange of beams or girders. The deck forms can settle slightly, and a film of concrete mortar will set and adhere to the bottom of the top flange. This must be removed before the paint is applied. This removal must be complete. All adhering mortar and dust must be completely removed, and the neat edge of the beam flange exposed. Adhered concrete, when removed, will leave some adhered dust which forms a stain. This should be removed to the extent it can be removed with scrapers, brushes, and wipers.

Another problem lies in keeping the beams and freshly applied paint on the beams of underpasses free from dust when hauling is going on under the bridge during the painting and cleaning operation. The Engineer must insist that under such conditions either the hauling be ceased, the ground under and for a distance on either side of the bridge be kept wet so that dust will not rise, or that the painting or the cleaning be ceased. The Engineer must insist that the painting be protected.

Beams, piles, etc. should be cleaned by the Contractor and inspected by the Engineer before the paint is applied. If possible, an inspector should be assigned full time to the cleaning and painting. If this is not possible, arrangements should be made with the painters so that they will clean a span and get it inspected and approved before the paint is applied. This would also apply to piling.

The paint must be applied in a neat and workmanlike manner. Paint may puddle on horizontal surfaces causing improper curing as well as adhesive failure. This heavy coating must be corrected prior to application of the next coat. If sags or runs develop they shall be removed, and the areas repainted. The final result should be a smooth, continuous, even coat of paint free from runs, sags, brush, roller or spray pass markings.

The parts of the structure that are not to be painted must be kept free from paint. Concrete slope paving must be covered while painting is being done above it. There is no objection to a fairly regular line of paint on the underside of the slab adjacent to the beams. There is no objection to a fairly regular line of paint on concrete diaphragms where they meet the beams. There is objection to streaks and splotches of paint on the underside of the slab, on the side of diaphragms, backwalls, or edge beams, or on the structure. Such paint shall be removed.

Steel surfaces that will be inaccessible after erection shall be painted with two coats of prime paint before erection. This includes the bottom surface of armored joint plates. After the paint has been applied and allowed to dry the thickness should be checked with a dry film gauge. Paint must be thoroughly cured before any readings are taken or next coat applied.

The painting of piling is discussed under Chapter 2, Section 1, paragraph C.7 of this manual. Miscellaneous steel items shall also be painted. Requirements for these items, armored plates, concrete beam bearings, etc. are given either on the Plans or in the Specifications.

Paint should be received on the job in sealed containers. Such paint may be used if the container is marked with a GDT number and the paint is of the proper type. The GDT number, the lot number, the kind and amount of the paint must be reported to the OMAT. Unmarked paint or paint over six months old, must be sampled and approved before it can be used.

If painting existing steel beams (i.e. for a widening) the Specifications must be adhered to for cleaning requirements and any required containment or special handling of the removed paint. Refer to the Contract Special Provisions for guidance.

I. Detour Bridges

The design, construction, maintenance, and removal of detour bridges is covered by Section 541—Detour Bridges of the Specifications. The Contractor must submit detour bridge plans to the Engineer for approval through the Departments electronic submittal system. This submittal shall be made six weeks in advance. This should be submitted by the Construction Manager to the Bridge Office. The Bridge Office will check the Plans and will either approve them or will advise the Construction Manager and Contractor as to what modifications to the Plans will be required.

Once the Detour Bridge Plans are approved, copies marked with an approved stamp will be furnished to the Construction Manager. The Construction Manager will then inspect the construction of the detour bridge, the same as he would permanent construction, requiring that the approved Detour Bridge Plans be followed, and that all construction be in accordance with the Specifications for that type of construction.

The Construction Manager must also see that the detour bridge is properly maintained and completely removed after traffic is on the new facility.

J. Widening of Bridges

Plans for widening of bridges will be prepared by the Bridge Office. As with completely new structures, the Area Manager must see that these Plans and the appropriate Specifications are followed. There are, however, some special considerations that must be given to a widening job. These are discussed as follows:

1. Grade Check

The Bridge Plans may show grades at the bents, but these are often based upon some adjustment to existing structure grades or assumed grades rather than upon a true grade line. The Contractor should profile the existing structure down the centerline and the gutter lines as per Section 149—Construction Layout of the Specifications. The elevations of the caps can now be checked. Plan beam or girder depths must be maintained. If necessary, cap grades can be adjusted.

2. Removal of Portions of Existing Bridges

The removal of portions of an existing bridge is covered by “Removal of Existing Bridges” in Section 540—Removal of Existing Bridge of the Specifications. The Plans will show the lines to which the existing structure will be removed. The Plans will also show what reinforcement steel, if any, is to be retained and extend into the new concrete.

Any special considerations in removal over and above those given in the Specifications that are deemed necessary will be covered on the Plans or in a special provision.

3. Special Construction Items

Sometimes the Plans for the widening of bridges will call for the new concrete to be bonded to the old with an epoxy bonding compound. Epoxy compounds have a short life after they are mixed. They must be carefully but rapidly applied.

CHAPTER 3
CULVERTS

SECTION 1 GENERAL

This chapter on culverts deals with reinforced concrete box culverts only. For information on pipe culverts, etc., see other Construction Manuals.

SECTION 2 LAYOUT

For the purposes of this manual the Contractor's layout of a culvert will include the following:

- Checking and, if necessary, adjusting the plan skew and alignment of the culvert.
- Checking and, if necessary, adjusting the plan flow line of the culvert.
- Checking and, if necessary, adjusting the plan length of the culvert.
- Gathering and recording original ground data for both the culvert and any necessary channel work.
- Staking the culvert and any necessary channel excavation for construction.
- Taking final cross-sections of the excavation.

Each of these will be discussed in the following paragraphs:

A. Skew and Alignment

The station of the intersection of the centerline of the culvert and the survey centerline will be shown on the Plans. The skew of this intersection will also be given. The station of this intersection should be established, and the skew angle turned. This establishes the plan alignment of the culvert.

The Engineer must now use his knowledge and good judgement. Is this the best alignment? Do the ends of the culvert, with channel extensions perhaps, line up with the natural flow of the stream? If not, is it possible to line the culvert up with the natural flow of the stream? Is there some condition not known by the designer that renders the plan alignment unsatisfactory?
Instead of having a culvert on a straight line throughout its length would it be better to break the alignment of the culvert in one or more places? While it is not desirable to break the alignment of a culvert it may in extreme circumstances be done. The approval of higher authority must always be secured.

All these questions must be considered and answered by the Engineer. If the situation is complex it may be necessary to traverse the stream, take cross-sections, plot the traverse and cross-sections, and select the culvert alignment from this data. In all cases, however, the culvert alignment most suitable for the site as it exists in the field should be used. This ideally would be the plan alignment, but sometimes actual field conditions will make a change necessary. If the actual skew does not fit the standard skews, use the actual skew for determining barrel length and the closest standard skew for wing wall lengths.

B. Flow Line

The establishment of the flow line of a culvert is very important. If the flow line is too low the culvert may silt up. If the flow line is too high, it may not carry enough flow. In most cases the plan flow line will be satisfactory. If, however, the plan alignment has been changed, the flow line may be changed. Also, in some cases where the plan alignment is held, there may be conditions not evident to the designer that would make a flow line change necessary.

The way to check or establish the flow line is to plot the original ground line profile along the centerline of the culvert and, using this visual data, set a flow line that best fits the stream conditions. Basically, the ends of the culvert or the channel extensions on each end should fit the natural flow line of the stream. There may be conditions up or downstream from the culvert ends that would make a lowering of the culvert and the channel advisable, but these should be approached with caution.

C. Original Ground Data

The centerline of the culvert should be stationed with the intersection of the culvert centerline and the upstream right of way line as Station 0+00. Cross-sections that extend beyond the limits of excavation should be taken along the culvert centerline at the break points in the terrain. These cross-sections should be taken normal to the centerline of the culvert. Any unusual conditions, rock, muck, etc. should be noted on the cross-sections and in the Culvert Foundation Report (CFI).

D. Culvert Length

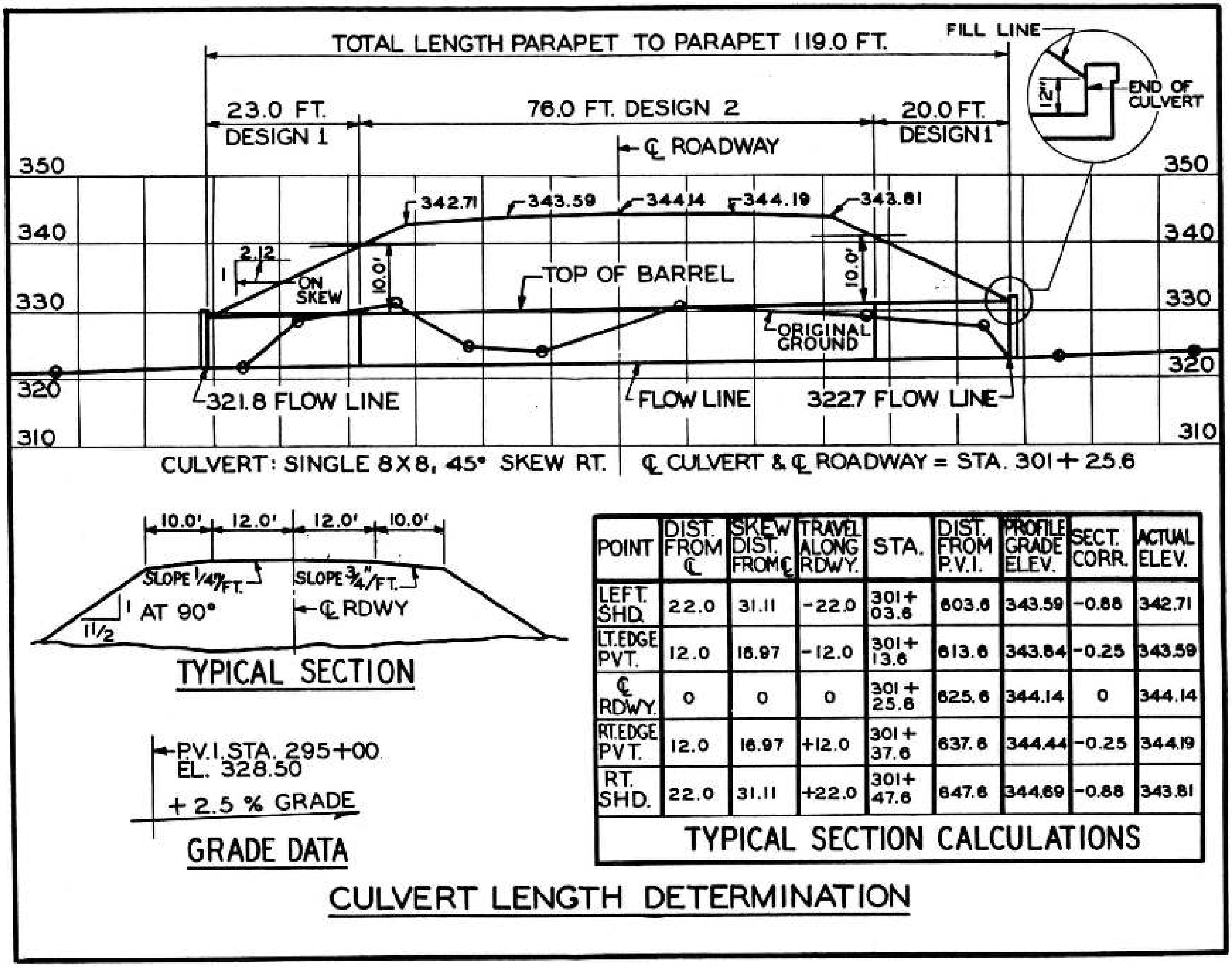
The length of the culvert is best determined from a cross-section plot along the culvert alignment. A typical "Culvert Length Determination" is shown in Figure 17. A cross-section of the original ground along the centerline of the culvert should first be plotted. Also, on this same plot a cross-section of the roadway taken along the culvert centerline should be plotted. On the roadway cross-section the normal roadway widths, shoulder widths, sloped, etc. must be modified for skew. A normal 2:1 slope when plotted on a skew will be flatter than a 2:1 slope.

After these two sections (original and roadway) are plotted, the proposed flow line will be plotted on the same section. If it is evident that changes must be made in the flow line, they should be made at this time. Once the flow line is finalized the final length determination can be made.

The length of the culvert is determined from a plot. On the above described cross-section, plot the line of the top of the barrel concrete. The length of the culvert between parapets is the distance between the points of intersection of the roadway side slopes and the inside face of the parapet along a line which is 12" above the top of the culvert barrel as determined for this plot.

This length should be rounded off to the nearest whole foot.

Once the over-all length of the culvert has been determined the length of each section of barrel design can be determined. This can be done by plotting the limiting fill heights as lines parallel to the top of the culvert barrel. These lines must be plotted the proper height above the culvert barrel. The end points of each design section will be determined by where the limiting fill height line intersects the roadway side slopes. The length of each section is determined by measuring between these points. These lengths should be rounded off to the nearest whole foot and their sum checked to see that it is equal to the total length of the culvert.



POINT	DIST. FROM ℄	SKEW DIST. FROM ℄	TRAVEL ALONG RDWY.	STA.	DIST. FROM P.V.I.	PROFILE GRADE ELEV.	SECT. CORR.	ACTUAL ELEV.
LEFT SHD.	22.0	31.11	-22.0	301+03.6	603.6	343.59	-0.88	342.71
LT. EDGE PVT.	12.0	16.97	-12.0	301+13.6	613.6	343.84	-0.25	343.59
℄ RDWY.	0	0	0	301+25.6	625.6	344.14	0	344.14
RT. EDGE PVT.	12.0	16.97	+12.0	301+37.6	637.6	344.44	-0.25	344.19
RT. SHD.	22.0	31.11	+22.0	301+47.6	647.6	344.69	-0.88	343.81

TYPICAL SECTION CALCULATIONS

FIGURE 17

E. Staking for Construction

Construction stakes can now be placed by the Contractor. The culvert should be staked for construction by establishing offset lines along each side of the culvert outside of the construction limits. These offset lines should be staked with hubs and tack points opposite one another except that the points for the parapets will be on the parapet line. The lines of the parapets will be parallel to the centerline of the roadway. If the roadway is on a curve, the parapet lines should be parallel to a tangent to the roadway curve at the station of the end of the culvert. All points on the offset lines should be referenced with respect to the centerline of the culvert and marked with cuts to the bottom of the excavation. Also points at each design change should be placed along the offset lines.

Once the parapet lines are established, the wing wall lines should be staked and cross- sectioned. In the absence of special design wing walls, standard wing walls of the skew nearest to the actual skew should be used.

F. Final Cross Section

After the foundation, including all undercutting for foundation stabilization, has been excavated and before the placement of the foundation backfill material as described in the CFI is commenced, final cross-sections of the foundation should be made. Final cross-sections should be taken at any breaks in the final excavation caused by changes in the depth of the undercut.

SECTION 3 CONSTRUCTION

Though culverts are frequently considered minor structures their proper construction is of major importance to the serviceability of the roadway. Foundations must be carefully prepared.
Decisions must be made as to the type and amount of foundation backfill material required. Forms must be set tightly and adequately braced. Reinforcement steel must be carefully placed and tied. Good quality concrete must be produced and poured and must be done in accordance with the Specifications and sound engineering judgement must be used if the culvert is to fulfill its function.

A. Foundations

Culvert foundation conditions, because of the location of culverts and flow line considerations, are rarely ideal. Fortunately, however, culverts, because of the large area over which their load is spread, do not require foundation material capable of supporting high concentrations of loading.

1. Culvert Foundation Investigation Report (CFI)

The soils section of the Office of Materials and Testing will make a foundation investigation of each culvert site. When the site is accessible to a truck rig, a combination of wash borings and post hole digger borings will be made. In either case, a one-page report showing the results of the foundation investigation and giving specific recommendations for the foundation design will be issued. On projects that are not solely culverts the culvert information will be included in the Soil Survey Report. This report will be stored on ProjectWise and notifications sent to Bridge Design and District Office. The Inspector at the culvert site shall have a copy on the job site while the culvert is being constructed and backfilled. The CFI report will normally cover the following topics:

a. Soil Profile

The culvert borings will be made at intervals along the culvert centerline. The results of these borings will be plotted, and a profile of soil types and sub-surface conditions will be drawn.

b. Foundation Types and Treatment

Specific recommendations will be made for the type and amount of foundation backfill and foundation design.

1) Foundation on Soil

When the culvert is to be founded on soil, which will be the case the majority of the time, the report will recommend the amount and type of backfill material to be used. A statement might be made saying "undercut this foundation______________________feet and backfill with type ____backfill". This statement might be varied to apply only to stated portions of the foundation area. In this case it would be expected that this amount of backfill would be provided if the flow line was raised or lowered. Of course, if actual soil conditions are not as shown on the profile, the amount and type of the backfill may be changed to reflect the actual field conditions.

2) Foundations on Rock

Any time isolated high points in rock are encountered, a Type II backfill material may be required for a cushion effect to avoid point loads. If the character of the rock is such that the bottom slab of the culvert may be omitted and the culvert walls founded on footings on rock, this will be plainly stated in the soils report. In the absence of a specific statement allowing the omission of the bottom slab, the bottom slab must be poured.

If rock appears in a culvert foundation that is not covered by a foundation investigation report, the Engineer should determine if the extent of the rock is such that the omission of the bottom slab would be practical. If this is the case, the Engineer should then request that the soils section of the Office of Materials and Testing investigate the character of the rock to determine if wall footings can be used in place of the bottom slab.

3) Foundations on Piles

In some cases, it will be necessary to found culverts on piles. In these cases, Special Design Plans and details will be provided. The construction of the pile foundations will be as covered in the Specifications and in Chapter 2 of this manual.

c. Backfill Around the Culvert

Backfill around culverts is placed as part of the embankment construction operations. There are, however, certain conditions at culverts that will require that the backfilling around the culverts be specially handled. These two conditions may occur individually or may occur in combination at any particular site. These conditions are (1) a fill height of no more than 1.5 times the culvert height and (2) compressible original ground soils adjacent to the culvert.

These conditions can cause the fill and the riding surface on either side of the culvert to settle leaving a hump in the riding surface. The soils section of the Office of Materials and Testing has developed two steps to be taken to counteract this settlement. These two steps may be used individually or in combination. They are: (1) Require 100% compaction to a distance of 50’ from each culvert wall. A Class II or better soil according to the Standard Specifications 810.02 should be used within this area. (2) Require the removal of compressible material adjacent to the culvert and backfill with select material requiring 100% compaction. Unless otherwise stated in the foundation report, the compressible material should be removed to a distance of 50’ from each culvert wall. Where the compressible soils are excavated and the backfill material will be below the ground water table, Class IA or IA materials according to Standard Specification 810.02 should be used.

If the Office of Materials and Testing feels that these steps are necessary, this will be so stated in the culvert foundation investigation report. The design office should also

show these requirements on the Plans. If such requirements are in the report and not on the Plans the matter should be referred to the District Construction Engineer.

2. Culvert Foundation Preparation

The foundation must be excavated to the depth of the footings or the undercut as called for on the Plans, in the foundation report, or decided upon from field observations. Care must be taken not to over excavate or to disturb the material below the plane of excavation. The less the activity within the area the better.

Diversions are required to allow construction of the culvert while at the same time preventing erosion. Water must be diverted and seepage into the footing area removed by pumping from sumps outside of the footing area or by diversions. When widening a two-barrel culvert (or larger) water may be dammed up in one of the barrels and diverted around the construction area by pumping. Diversions can also consist of plastic lined channels which capture the water upstream of the culvert and carry it around the construction area.

Sometimes a combination of these methods works best.

After the excavation is complete the proper backfill material will be placed and compacted in accordance with the Specifications.

B. Reinforcement

Reinforcement steel placement is thoroughly discussed in the Standard Specifications. The Engineer should review this section of the Specifications before this phase of the work is commenced. The Specifications call for specific types of supports for specific areas. All the reinforcement must be checked before the pour is commenced. Tying of reinforcement steel shall not be done while the concrete is being poured. All wall steel or dowels must be placed and securely held in position. This too must be done before the pour is commenced.

It must always be remembered that accurate placement of reinforcement steel is necessary if a reinforced concrete structure is to achieve its designed strength. Certain placement tolerances are given in the Specifications. These tolerances represent the maximum allowable deviation from Plan location. There shall be no tolerance allowed on the tolerance.

It must also be remembered that the proper quantity of reinforcement steel is essential to the strength of a reinforced concrete structure. Therefore, not only should the spacing of each bar be checked but also the size and type of each bar should be checked against the Plans. The location of the bends in truss bars is particularly important as this controls where the steel is in the working structure.

In checking the reinforcement attention must be paid to barrel steel at design changes. Spacings and sizes of bars can change at these points of design change.

C. Forming

The function of forms is to act as a structural unit in holding and supporting plastic concrete to the desired configuration until such time as the hardened concrete can support itself. The forms must be so designed, supported, and tied together so that they will not sag, bulge, sway or become misaligned. The forms must be set so that concrete of the proper configuration will be obtained.

The Engineer must also check the size of the formed footings, the depth of the forms, the alignment of the forms, the height of the wall forms and all of the details necessary to produce the finished structure as detailed on the Plans. Every dimension should be checked during the forming and again after the forms are complete before the pour is commenced.

Special attention must be paid to the forming of cut-off walls. Weep hole locations must also be carefully checked.

D. Joints in Barrel

Transverse Construction joints must be made in the barrel of the culvert at all locations indicated on the plans and at all design change locations. These must be full construction joints, constructed at an angle of 90° with the barrel. After the concrete has achieved its initial set in a floor or top slab pour, it is permissible to remove a header and pour the adjacent section. When this is done the concrete surface along the joint must be coated with curing compound to prevent bond of the two surfaces.

At all transverse construction joints outside the limits of the payment width, reinforcement steel must not extend through the joint. Construction joints inside the limits of the pavement width should be avoided. However, if conditions require that such a joint be made, all longitudinal reinforcement steel must be extended through the joint for a distance of at least one-foot, with no bond-breaking procedure as in the above paragraph.

E. Concreting

All placement equipment such as chutes, vibrators, tremies, etc. should be checked before placement commences. Stand-by equipment should also be checked.

F. Backfilling

In placing backfill material around the culvert care must be taken not to damage the culvert by loading one side more than the other. Backfilling should be done concurrently on both sides of the culvert. To avoid building uneven pressure on the sides of the culvert, fill should never vary more than 3 foot on either side of the culvert

CHAPTER 4
RETAINING WALLS

SECTION 1 GENERAL

Retaining walls are generally used whenever they are more economical to construct than acquiring additional right-of-way to extend a slope. Retaining walls are used in both cut and fill slopes, and this sometimes controls which wall type is used at a location. The basic wall types are cast-in-place walls, precast walls and tieback walls. There are advantages and disadvantages associated with each type, and situations where one wall type is preferred over another.

SECTION 2 REVIEW OF CONTRACTOR WALL SKETCHES AND DATA

Retaining wall envelopes are developed using survey data that is not as detailed as needed for final plans. With this lack of detail possible, subsections 149.1.03 and 149.3.03 of the Construction Layout Section in the Standard Specification requires the Contractor to act to verify the compatibility of actual field conditions and the proposed walls in the contract plans. Potential adjustments to plans and quantities as a result of this process should not be viewed as a win or loss for either party but part of the collaboration process that will result in the proper structure to fit the site.

A. Submittals

The Standard Specifications may not include all the specific information the Contractor must provide as this allows the Contractor freedom to address unique situations on a project-by-project basis. Coordination between the Engineer and the Contractor before and during this field investigation can save time and frustration. Some contractors will survey the existing groundline and prepare fresh wall envelopes indicating the elevations at which they feel the footings need to be placed to satisfy the requirements of the Construction Standards or Plans. Other contractors may choose to provide survey data overlaid on the contract drawings or in spreadsheets. One of the most helpful things that the Contractor can do is provide you with assumptions and conclusions to go along with the survey information and drawings they provide for review. Also, if sketches are being used to illustrate their findings, providing elevation data on the drawing, and not simply lines, is important so that the data is easily interpreted without confusion. This may include “callouts” which will accurately identify the wall sections and corresponding elevations. Additionally, the Contractor should state any proposed changes/ adjustments to the wall due to field measurements particularly if the proposed changes exceed the limitations set by the special provisions, standard specifications, or standard detail.

B. Review Responsibility

The initial and primary review of these submitted documents should be done by the Construction Manager (CM). The State Bridge Construction Liaison can assist with the initial review of the submitted wall profiles from the Contractor if necessary. Inclusion of other subject matter experts, specifically the Bridge Office is not required for the initial review of the submitted wall profile. Rather, the Bridge Office and design consultant engineers are resource for the CM once problems outside their capacity to resolve are identified.

C. Reviewing Submittals for Walls found in Section 31

Retaining walls and side barriers represented by an envelope presented in Section 31 of the typical GDOT plan set are often referred to as Standard Walls. The information the Contractor needs to construct theses walls should be presented in Sections 13, 31, and 41 (if applicable, otherwise refer to GDOT Standard Drawings and Details).

Section 13 should provide the Contractor with the “Plan” view of the wall and include stations, offsets, angles, radii, etc.

Section 31 sheets will sometimes provide a more detailed depiction of the “Plan” view when necessary but is primarily for the presentation of a walls “Elevation” view, also referred to as its envelope. The wall envelope should identify the locations along the wall where a given section, which often correlates to a specific pay item, should begin and end.

Locate the appropriate Standard Detail sheet which corresponds to the proposed wall in the plans (if your plan set does not contain Section 41, then refer to the published GDOT Standard Drawings and Details). This sheet, or sheets, will include sections through the wall and provide details about the necessary dimensions of the wall, reinforcement requirements, and other details needed for completion of the work. The Standards include tables that define the important variables for varied section heights, and the correlated pay items. These Standards are to be compared to the submitted profiles from the Contractor by the Construction Manager.

The two primary questions that should be considered through the Contractor’s survey and CM’s review of the associated submittals are:

1. Does the planned elevation of the wall footing in comparison to the existing or proposed groundline allow for proper embedment of the footing below grade in accordance with the standard? The wall standards all include minimums for the depth the footing should be below ground, and maximums for the slope grades at the top and bottom of the wall.
2. Does placing the wall footing at the planned elevation and constructing it to the necessary height agree with the design heights and type of wall pay item in the contract? (Or if changes are made to satisfy question #1, how will that affect the situation?)

Both questions, and this whole review process is really all about evaluating the wall height designed compared to the wall height needed.

Potential Outcomes

Scenario 1: The reviewed and agreed upon Contractor’s survey shows that everything about the situation in the field matches the plan and contract documents.

CM Action: No action required.

Scenario 2: The reviewed and agreed upon Contractor's survey indicates that a wall footing needs to be lowered (or potentially raised), but the new height of the wall does not violate any of the maximums on the Standard, and still falls into the pay item range designated on the plans.

CM Action:

1. Note the change in footing elevation on the As Built Plans.
2. For Gravity Walls (Std 9031L) adjust the base pay quantity per Section 500.5.01.D.

   For Side Barrier or Parapet Walls (Std 4949-series) no quantities need to be revised.

Scenario 3: The reviewed and agreed upon Contractor's survey indicates that a wall footing needs to be lowered (or potentially raised), but the new height of the wall does not violate any of the maximums on the Standard. However, the revised wall height would place the wall into a different pay item range according to the Standard than what was originally designated on the plans.

CM Action:

1. Note the change in footing elevation on the As Built Plans.
2. For Gravity Walls (Std 9031L) adjust the base pay quantity per Section 500.5.01.D.
3. Notify the Area Office of a supplemental agreement for the new wall type pay item if not already included in the Contract.

Scenario 4: The reviewed and agreed upon Contractor's survey indicates that a wall footing needs to be lowered (or potentially raised), but the new height of the wall DOES violate the maximum wall height for the Standard. This will constitute a "Special Design" wall which will require the support of the bridge office.

CM Action:

1. Notify the Bridge Construction Liaison and start coordination with Design and the Area Office for a Use on Construction Revision.

D. Reviewing Submittals for Walls found in Section 32 (Special Design Walls)

Retaining walls in Section 32 of the plans have either been designed specifically for the project by an engineer during the preconstruction design phase (Cast in place walls and Soldier Pile walls), or will be designed under the contract, by the Contractor (MSE walls, Tie-back walls, and Soil nail walls).

The review of the field survey information for these walls should still begin with the CM and the State Bridge Construction Liaison (if necessary). Depending on the type of wall, the evaluation of what is submitted will be different. It is important that the contractor acquires approval of the "Wall Envelope" prior to the submittal and approval of the "Wall Design". The "Wall Envelope" may be initially reviewed by the Construction Manager.

Cast in Place Walls – Special designed cast in place walls need to be evaluated in essentially the same way that the Standard walls discussed above are evaluated, BUT any indication that the wall does not fit the site should automatically prompt notification of the Bridge Construction Liaison for coordination with Design for a Use on Construction Revision.

Soldier Pile Walls – Soldier pile walls need to be evaluated similarly to the cast in place and standard walls discussed above, asking the core questions about embedment, design height, and slope of backfill. If there is any indication that the wall does not fit the site, the Bridge Construction Liaison should be contacted and coordinate with Design. It might be possible to address the changes without a Use on Construction Revision, but the designer will need to consider the specifics and provide guidance.

MSE Walls – MSE walls are to be designed by the Contractor and paid for based on the area of the wall bounded by the top of the wall and the maximum top of leveling pad elevations shown on the plans. Every potential MSE wall contractor will install a wall that has more actual area than is in the contract because they are given freedom in establishing step locations and panel dimensions suitable for their proprietary product. Therefore, a review of the Contractor's survey and submittals for an MSE wall should not be focused on the proposed placement of the leveling pad, but only on the validity of the maximum top of leveling pad elevation line shown in the contract plans. If the reviewed and agreed upon Contractor's survey indicates that this line does not fit the field conditions, the CM should notify the Bridge Construction Liaison for coordination with Design for a Use on Construction revision. CORRECTIONS TO THE ENVELOPE SHOULD NOT BE "WORKED OUT IN THE SHOP DRAWINGS". Contract revisions are necessary.

Tie-Back and Soil Nail Walls – Tie-back and Soil nail walls are both to be designed by the Contractor and are paid for as lump sum pay item per wall. While no wall areas are specifically quantified in the contract, a theoretical wall area is presented in the contract plans by way of the wall envelope. If the reviewed and agreed upon Contractor's survey indicates that the situation at the site is significantly different than what is presented in the contract plans, the CM should notify the Bridge Construction Liaison for coordination with Design for a Use on Construction Revision.

SECTION 3 BASIC WALL TYPES

Each wall type has characteristics and components particular to that system, and an understanding of each component is necessary to construct and inspect each wall.

A. Cast in Place Walls

Cast-in-place walls include both gravity and cantilever walls, and as the name implies, these walls are constructed by pouring concrete into forms which are built on site. Gravity walls withstand the forces from the earth backfill by the weight of the structure itself. Cantilever walls consist of a reinforced base and stem which resist earth pressures by use of reinforcing steel. These walls are generally less complicated to construct and inspect than other wall types.

The foundation for most gravity and cast-in-place walls consists of a spread footing poured directly on the underlying soil or rock. A bearing pressure on a specified material is recommended in the wall foundation report, and this material should be verified before the footing is constructed. Occasionally piles are required to support the foundation, and these are driven to the elevations and with the loads specified on the plans. Footings are normally poured on undisturbed material, except when undercuts are required due to soft or saturated soil conditions found at grade. In these instances, the footing would be poured directly on foundation backfill material, which consists of clean, open graded stone.

After the footing is poured and cured, the wall is then constructed. Drainage weep holes should be installed through the wall according to the plans to prevent the buildup of water pressure in the backfill material behind the wall. A layer of backfill is normally placed on the front side of the wall to help resist sliding forces; this layer is a minimum of two feet thick for cantilever walls and one foot thick for gravity walls. Care should be used during backfill operations to avoid pushing material against the structure. Backfill material should be placed next to the wall and compacted in the lifts specified.

A summary of the important inspection criteria for cast-in-place walls is as follows:

1. The horizontal and vertical layout of the wall should be checked after staking is completed.
2. The leveling and granular backfill area should be excavated at the same time.
3. For walls supported by spread footings, the foundation material specified on the plans or foundation report (dense soil, weathered rock, hard rock, etc.) should be verified prior to pouring the footing.
4. Rainfall and surface water should be kept off the foundation soils at grade as much as possible to prevent them from becoming saturated and weakened.
5. All exposed concrete should be cured accordingly to the specifications.

B. Precast Walls

Precast retaining walls include mechanically stabilized earth walls (Section 626), Doublewalls (Section 602), and other modular type walls. Mechanically stabilized earth walls use reinforcing straps, mesh or geogrid, attached to a precast panel to resist sliding and shearing forces from the backfill. Doublewalls and other precast concrete wall systems use concrete modules filled with stone to construct a wall which resists movement by its own weight, similar to a gravity wall.

The most common types of precast walls used in Georgia are the mechanically stabilized earth wall systems. These wall types are most economical in fill situations and are cost competitive with most other wall types. The main advantages of this system are the relative speed and ease of construction, and the ability of the wall to accept some differential settlement while still maintaining its structural integrity.

Mechanically stabilized earth retaining walls include Reinforced Earth Walls, Georgia Stabilized Embankment (GASE) walls and VSL walls. Although the panel shapes and individual components are somewhat different, the basic design and construction concepts are very similar. Each system consists of three main components: precast concrete panels, steel reinforcing straps or mesh (polymer geogrid material has also been used though less frequently), and special stone backfill. The concrete facial panels are attached to the reinforcing straps (or mesh), which are placed in compacted stone backfill to create a reinforced mass which resists sliding and shearing forces. For a more extensive list of the major components of mechanically stabilized earth walls, their functions and potential malfunctions, see Appendix F.

The first step in the construction of a mechanically stabilized earth wall is to layout, grade, and compact the foundation area. Next, an unreinforced concrete leveling pad is poured. This pad helps to maintain the panels in line both vertically and horizontally. After the concrete pad has cured, the first row of panels is set and braced off, after which the stone backfill material is spread and compacted behind the wall up to the first level of the reinforcement connections.

Backfill material adjacent to the wall panels is only lightly compacted so as not to displace the panels from line. The embankment reinforcement (straps, mesh or geogrid) is then attached to the panels, and backfill material then placed up to the level of the next connection. Before the next row of panels is set, neoprene bearing pads are placed on top of the lower, previously set panels. These pads distribute stresses between the rows of panels to assure even bearing and prevent localized cracks and spalls. Steel alignment bars are then placed in preformed holes in the panels to keep each row of panels aligned with the next row.

Temporary clamps are also used to brace panels before the reinforcing straps and backfill are placed. After the next row of panels is set, polyether foam and filter cloth are placed over all the panel joints to prevent backfill fines from being washed out.

The panels are placed with a slight batter (1/2" in four feet) into the reinforced volume to compensate for small movements during placement and compaction of backfill material. All steel reinforcing straps or mesh, alignment bars and connection devices are galvanized to resist corrosion. It is important to keep as much soil as possible out of the backfill material to reduce potential for corrosion of the reinforcement. Soil will retain water and salts better than open graded fill, and these salts will accelerate the loss of galvanization and metal. Soil will also reduce the drainage characteristics of the backfill, which is designed to be a freely draining

material. Backfill material should be placed one foot beyond the end of the straps to ensure that the ends are not in contact with soil.

A summary of important inspection criteria for a mechanically stabilized earth wall is as follows:

1. Check the wall envelope to verify that the coping makes smooth and logical transitions along the top of wall for an aesthetic appearance. Improvements can usually be accommodated relatively easily if panels have not been cast.
2. Check that the contractor has verified his well envelope for agreement with actual field conditions and that he is working from approved drawings.
3. Check that the contractor has accounted for the proper width, depth, and grade of the excavation in his layout. The excavation should include the panel thickness, plus the reinforcement strip or mesh length, plus one foot beyond the end of the strip or mesh and include enough room to pour the leveling pad and set the wall.
4. The horizontal and vertical layout of the leveling pad should be checked before the pad is poured.
5. The foundation material under the leveling pad and backfill should be compacted according to the Specifications.
6. Before the panels are placed, they should be checked for cracks, damaged corners, out of tolerance sizes and other defects.
7. Any damaged galvanization on the reinforcing straps or mesh, connection devices and alignment bars should be repaired before they are used in the wall. Check that the bolts and nuts are used on all connections.
8. The filter cloth and joint filter should be installed at all panel joints.
9. Each layer of special backfill material should be placed to the thickness specified and compacted according to specifications. The backfill material should extend to one foot beyond the end of the straps. As much natural soil as possible should be kept out of the special backfill material.
10. The front face of wall should be backfilled as soon as practical to prevent erosion and undermining of the leveling pad or softening of the foundation.

The other main types of precast walls are Doublewals and other modular block walls which are essentially gravity walls. The Doublewal System is made up of precast concrete modules which are erected on site and filled with special backfill material. These walls are generally more economical in cuts and can be constructed fairly easy. The foundation area is first graded and compacted as with other wall types. The construction of the footing for this wall is more critical than for mechanically stabilized earth walls, because Doublewals will not accept as much settlement before cracks and spalls occur. After each row of modules is set, the backfill material is placed and compacted. Bearing pads are used between each row of modules, and filter fabric is also used to cover joints on the inside of the front and back faces.

A summary of important inspection criteria for modular walls is as follows:

1. The layout and grade of the wall should be checked after staking is completed.
2. Surface water should be kept off the foundation soils at grade to prevent them from becoming saturated and weakened.
3. The foundation material specified in the plans or foundation report (dense soil, weathered rock, hard rock, etc.) should be verified and the foundation area should be compacted uniformly as per the specifications and approved before erection is started.
4. The footing should check level longitudinally with the required batter as shown in the approved wall drawings.
5. Modules should be checked for casting defects prior to acceptance on jobsite (wrong key size and/or location, ends not vertical, poor concrete finish, exposed rebar or improper cover, etc.). Check that the back wall is not cast too long for wall sections in curves.
6. Modules should be checked for handling, shipping and/or storage damage prior to acceptance on the jobsite and during erection (cracked, broken or spalled modules).
7. Check for proper size and placement of bearing pads and for proper gap between modules.
8. Check for proper joint treatment (non-woven or woven filter fabric, preformed cork, etc.) and coverage as per the plans and specifications.
9. Check for proper placement, lift thickness, and compaction of the modular backfill material and embankment as per specification requirements.
10. Check that the additional requirements specified for modular backfill material at bridge structures has been met. Backfill with sufficient fines to fill aggregate voids is required at bridge structures and should be prevented from leaching out into open graded areas if transitional zones occur. Filter cloth should be used between the different backfill materials in these cases.
11. Check that parapet is properly aligned and battered. Check for proper steel cover before casting.

C. Tieback Walls

Tieback walls utilize anchors of concrete with steel tendons which are installed into natural ground and attached to soldier piles. A cast-in-place face is then constructed over the piles. This wall type resists earth forces by means of the friction developed between the anchors and the soil.

The tieback wall utilizes design concepts very different from those of the other wall types. Tieback walls are built only in cuts, and are essentially constructed from the top down, so that no temporary bracing or shoring is needed. Tieback walls are generally more expensive than other wall types and require closer inspection, but they can be used in places where no other wall type can be built, such as directly underneath an existing bridge where there is no room to excavate for a footing. The components of this wall are the soldier piles, the tieback anchors, and a cast-in-place wall face. The wall face is designed as a structural component used to transfer earth forces to the soldier piles. The soldier piles in turn transfer the forces to the tieback anchors. The tieback anchors provide enough pullout resistance through friction from the concrete to soil (or rock) contact to resist overturning forces from the backfill. The wall face also provides weathering and corrosion protection to the system, as well as providing an aesthetically acceptable appearance.

The first step in constructing this wall is to install the soldier piles, which are either driven H-piles or cast-in-place caissons. These piles extend below the proposed ground at the front face of the wall to resist kickout pressures at the wall base. The front face of the wall is then excavated to just below the first proposed row of anchors and lagging or other means of retaining the soil between the piles is installed. The wall face will eventually resist the soil pressure transferred from the timber lagging as it deteriorates. The anchors are installed by drilling a horizontal or sloped hole through a sleeve in the piles back into undisturbed soil or rock. Steel tendons, which are enclosed in a plastic cover for corrosion protection, are then inserted into the drill hole, and high strength concrete grout is pumped into the hole under high pressure. Spacers are used over the steel tendons to help provide adequate grout coverage.

Plastic sheaths used as bond breakers are placed around the tendons in the unbonded zone, which is from the back face of the wall to a pan specified distance, usually fifteen feet, into the soil. Because this area is within the theoretical failure wedge of the wall, it is not desired to have the anchor bonded in this zone. Beyond the unbonded zone no sheaths are used, and the tendons are surrounded by grout. The grout forms a bulb around the tendons which provides additional corrosion protection, and the means of anchoring the tieback into the soil to resist pullout forces.

After the concrete has cured, each tieback is tested by applying a series of loads with a jack and measuring the movements that occur with each load. This is called a proof test. The movements should not exceed certain limits which are specified in the job specifications. The anchor must be regrouted or redrilled if the limits are exceeded. Those anchors which are considered acceptable are locked off at the design load with steel wedges. Additional tests called lift-off tests are performed on some of these anchors to ensure that they still maintain their loads after a period of time. Special performance tests are also made on a selected number of anchors, in which the loads are cycled up and down on an anchor while movements are measured, and the maximum load is kept on the anchor for a longer period. It is essential that an inspector be present to monitor, and record results of each test made on every anchor.
This is due to the critical nature of each anchor in the wall system.

After all the anchors in the first row are tensioned, tested and locked off, the anchor plates and the ends of the tendons are covered with grout to provide corrosion protection to this area.
Additional material is then excavated from the front face of the wall to the next proposed row of anchors, and the process of installing, testing, and locking off anchors is repeated. After all anchors are accepted and grouted over, a drainage layer is installed against the lagging, and a concrete wall face is constructed over the area.

Some of the important inspection criteria for tieback walls are as follows:

1. The horizontal line for the installation of the soldier piles should be checked before piles are installed.
2. The drilling operations should be monitored to note the presence of rock, boulders, voids or other conditions which may affect the installation and performance of the anchors.
3. Before the anchors are installed, they should be inspected to ensure that the correct number and length of strands are being used, that the plastic sheath and grease encapsulate the tendons in the unbonded zone, and that no defects exist with the tendons or the protective plastic covers.
4. All the grouting operations, including proportioning and mixing of grout, pumping pressures, and quantities of grout used for each anchor should be monitored.
5. Each test made on every anchor should be reviewed by the project inspector to verify the test results. This includes proof tests, lift-off tests, and performance tests.
6. All anchor head locations should be covered with grout after extra tendon lengths are cut off to ensure that all steel components are protected from corrosion. The drainage layers must be installed before the wall face is constructed.
7. Tying and placement of rebar should be inspected and checked to insure conformance with the plans and specifications prior to placing concrete for the wall face.

APPENDIX A

APPENDIX A

SECTION 1 OVERALL LAYOUT

A. Typical Procedure for Layout of Bridge

The station of the intersection of the center (or control) line of the bridge and the centerline (BFPR in case of end bents) of each bent is computed and established on the ground. Bent angles are turned and reference points, two on each side of centerline, are set a specific distance away from the centerline. This cannot be done of course for bents located in a stream. Figure A-1 shows a bridge with a constant skew to a tangent. Figure A-2 shows a bridge where the bents do not have a constant skew. By using right triangle formulas and geometry the following is true:

$b = E \div \sin\Delta_3$

$a = (C \div \sin\Delta_3) - b$ d, e, f, - - -

are similar

$G = B + D \cot\Delta_2 + D \cot\Delta_3$ $I = B - C \cot\Delta_2 - C \cot\Delta_3$ $H = A + D \cot\Delta_1 - D \cot\Delta_2$ $J = A - C \cot\Delta_1 + C \cot\Delta_{32}$

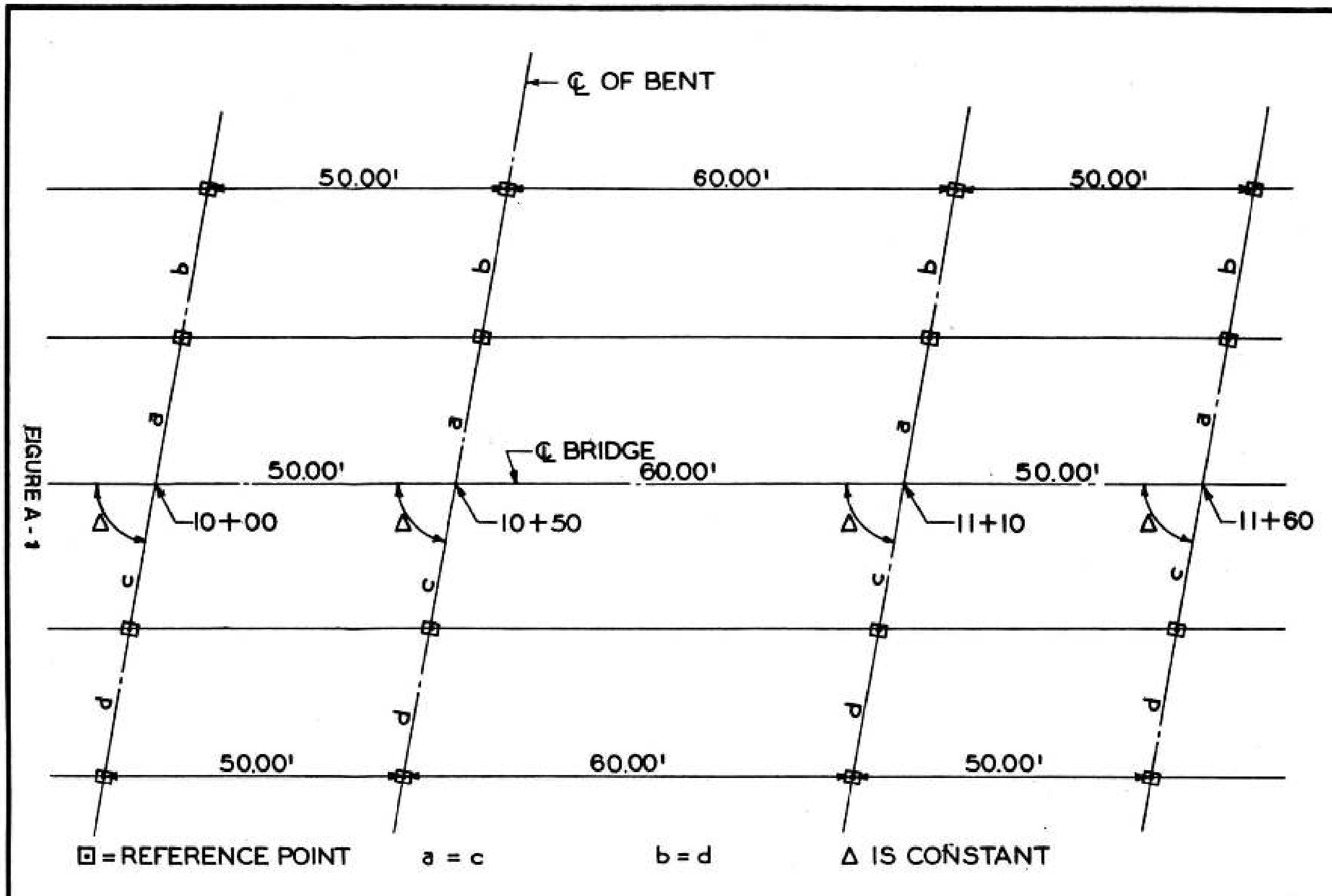
These dimensions are calculated as shown above and checked by field measurement. They must check.

B. Alignment for Horizontal Curved Bridges

Figure A-3 shows a bridge on a curve. In this case two other points are laid out on the centerline of the bents along with the reference points. These two points are the exterior beam chord end points. To lay these points off, dimensions a, b, c, d, etc. are taken from either the bent details or the beam chord layout on the plans. After the layout is completed, dimensions A, B, C, D, etc. are measured and checked against the dimensions shown on the beam chord layout. They must be the same. The skew angles Δ_1, Δ_2, andand Δ_3, etc., are given on the plans.

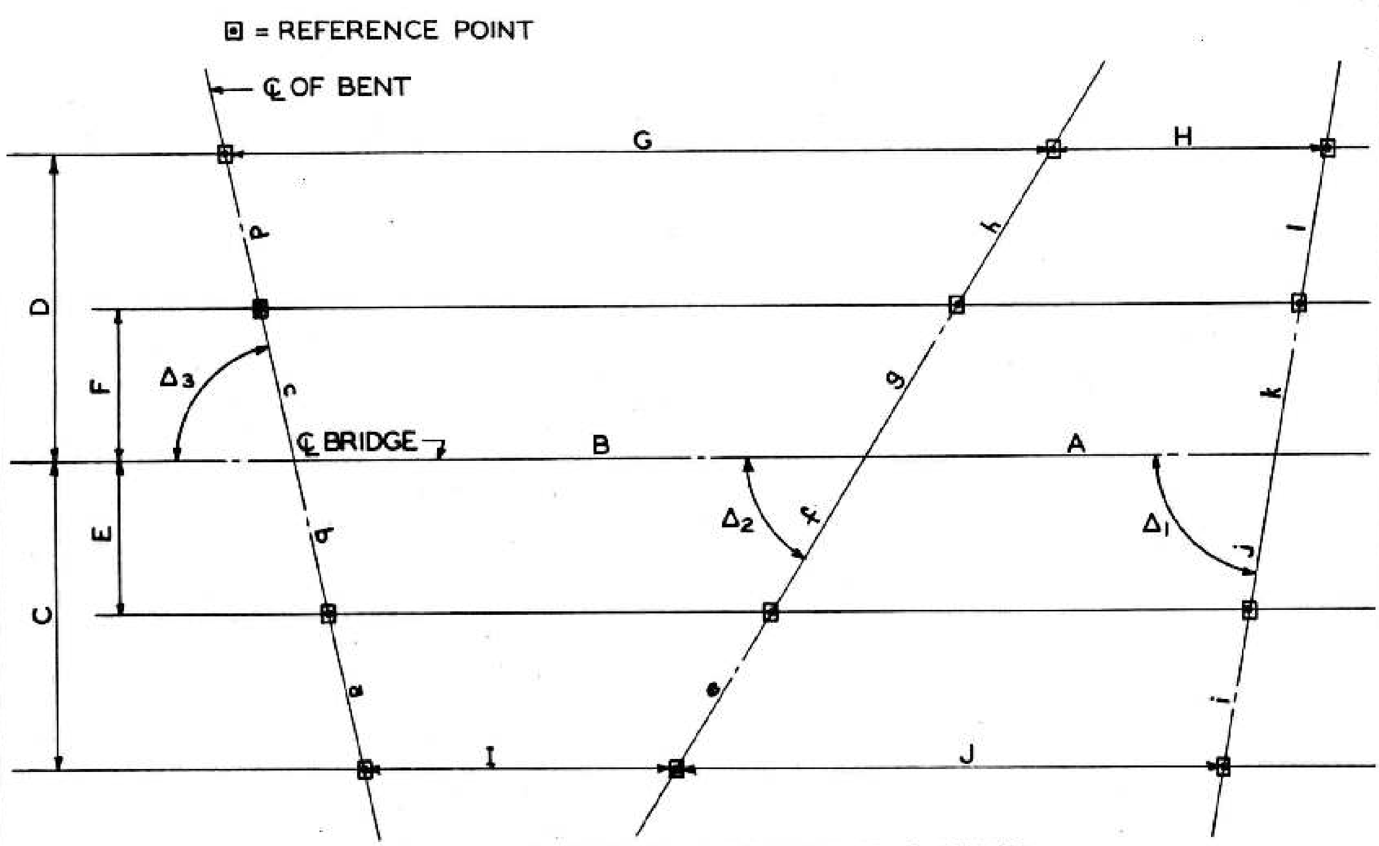
There are other methods that may be used to perform the over-all structure layout and control the alignment of curved bridges:

1. If the bents are parallel and the plans give the square dimensions between the bents the bent lines can be established, and the centerline of bridge intersected with the bent lines. The beam chord end points for the exterior beams can be established and the beam chord distances checked. This information would be found on the plan and elevation sheet and the beam chord layout sheet in the plans.



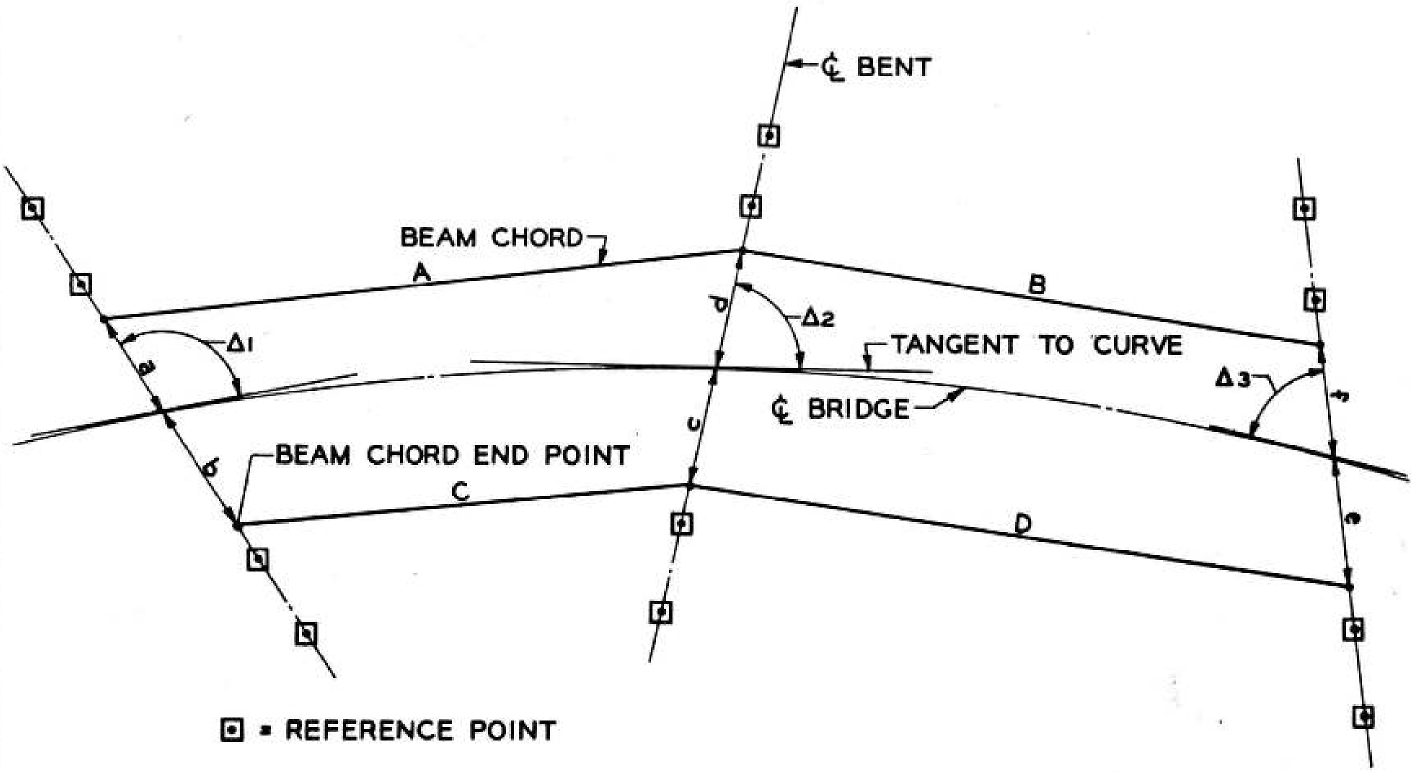
OVERALL LAYOUT – CONSTANT SKEW

FIGURE A-1



OVERALL LAYOUT-VARIABLE SKEWS

FIGURE A-2

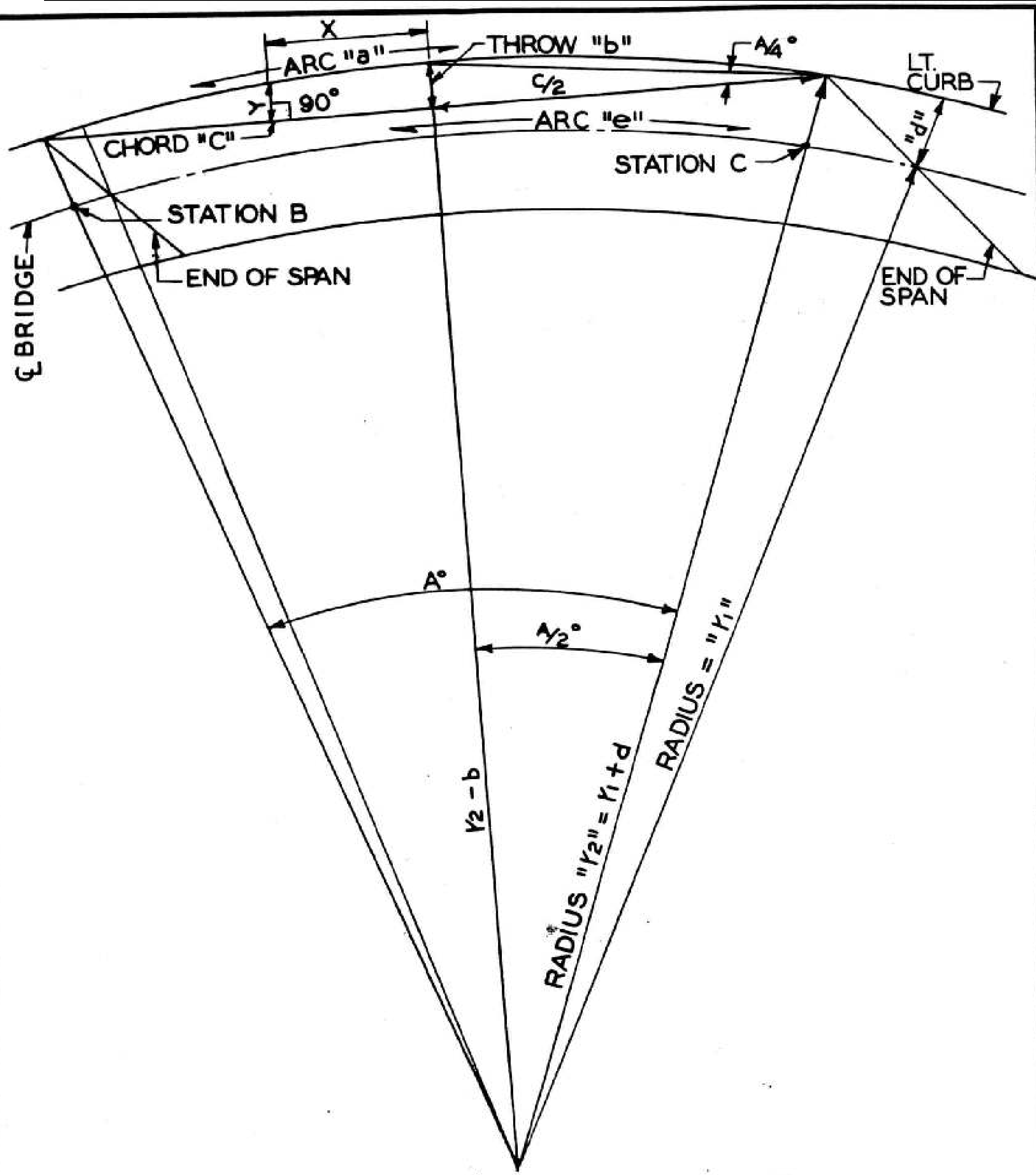


OVERALL LAYOUT - CURVED BRIDGE - EXTERIOR BEAM CHORDS

FIGURE A - 3

2. Stations and deflection angles for the points where the control lines (centerline, gutter line, barrier line) cross the ends of the spans can be calculated and then chord offsets set for intermediate points. This method is for where the degree of curvature of the bridge is relatively small. The stations of where the control lines cross the ends of the span can be taken from the computer information. The chord that the ordinates are calculated from would pass through the end points of the arc, but the ordinates can then be adjusted to any parallel line.

   The calculation of ordinates from a chord is shown in Figure A-4 and the calculations that follow. It is assumed that the Engineer has Station "B" and Station "C" either from a computer run or his own calculation.



ORDINATES-CHORD TO CURVE
FIGURE A-4

To calculate ordinate "Y" for any distance "X" along the Chord "C" proceed as follows:

Arc "e" = Sta. C – Sta. B

ARC "a" = $\frac{e(r_2)}{r_1}$

Angle A° = $\frac{a(180°)}{\Pi r_2}$

Chord "c" = $2r_2$ (Sin A/2°)

Throw "b" = c/2 (tan A/4°) = $r_2 - r_2$ (cos A/2°)

$$= r_2 - \sqrt{(r_2)^2 - (c/2)_2}$$

Ordinate "y" (at any distance "x") = $b - r_2 + \sqrt{r^2 - x^2{}_2}$

These ordinates may then be used from any line parallel to chord "C" by simply increasing the ordinates by the distance between the parallel lines.

These ordinates can be used to control the alignment of the edge of the slabs, the gutter lines, and the overhang.

Other Engineers prefer to calculate deflection angles for points closely spaced (10.0 ft. maximum) along the bridge centerline. These points can be run in on the form pallets for form control, and on the poured slab for curb and railing control. Also these angles can be used to run in concentric curves for the curb and rail lines if the Engineer prefers. In either case stations and deflection angles should be calculated and recorded prior to the start of construction.

3. Another method that is in use is to use a long chord from centerline of bridge at one end bent to the centerline of bridge at the other end bent as a base line for establishing the horizontal control. One advantage of this method is that the long chord can be used as a control line for both the substructure and the superstructure. The end points of the long chord can be referenced on the fill. Once the beams are up this can be put on the deck forms as they are constructed. Measurements to control the decking would be made from this line.

C. Method to Coordinate Alignment to Stationing

To develop this method, a coordinate system with the (0,0) point at the radius point of the centerline of survey curve would be assumed. (Depending on the curve and the skew angle it may be necessary to set the center of the bent at (0,X), with X some number greater than the radius, and back-figure the coordinate of the center of the horizontal curve). As is shown in Figure A-5, the bridge would be placed on this curve so that at least one bent (all bents if they are parallel) would be parallel to one of the axes.

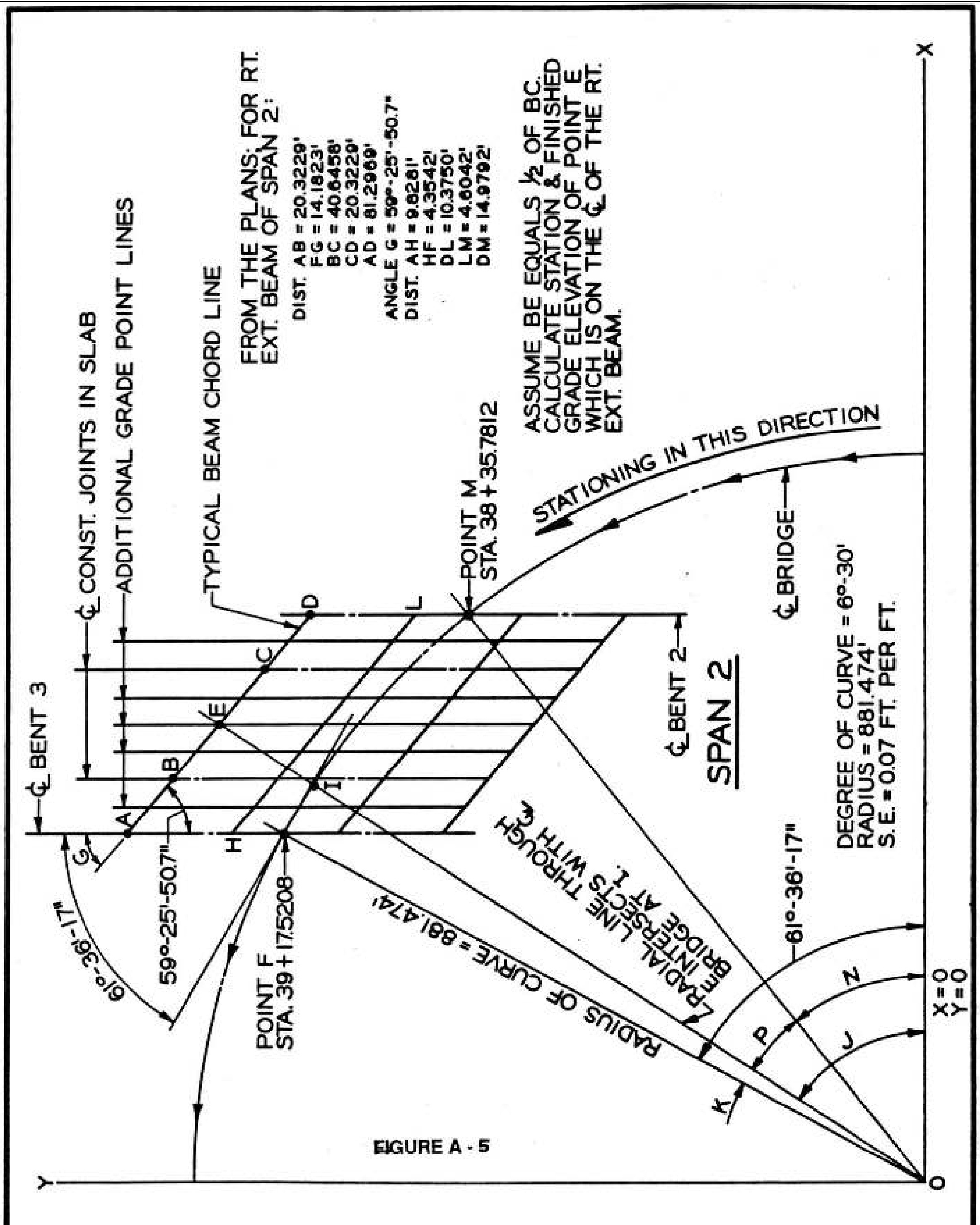


Figure A-5

The coordinates of the end points of the long chord would then be found using trigonometry. Once these coordinates are known, distances and angles to the centerline of each bent from the long chord can be computed. At the same time distances along the long chord from its end points to the bent lines can be computed. With this data in hand the bents can be laid out. The calculations described above would be similar in detail and complexity to those shown in Example Problem No. 1 along with Figure A-5.

EXAMPLE PROBLEM NO. 1:

Example Problem No. 1 consists of a calculation of the finished concrete grade above a beam on a curved skewed bridge at a specific point. To do this the station of the point on the centerline of the bridge will also be calculated. A portion of a set of bridge plans has been reproduced here to provide the data for this problem. These portions are the beam chord layout for the entire bridge (Figure A-6) and a plan of Span No. 2 (Figure A-7).

The problem is set up in Figure A-5 using data reproduced on Figures A-6 and A-7. The station of the intersection of the centerline of Bent 3 and the centerline of the bridge was taken from the plan and elevation sheet of the plans which was not reproduced. The same is true of the horizontal curve and vertical curve data.

The problem is set up on an “X” and “Y” coordinate axis with the centerline of Bent 3 set parallel to the “Y” axis. This is done by setting the angle a radial line through Station 39+17.5208 makes with the “X” axis equal to the skew angle between the centerline of Bent 3 and the centerline of the bridge.

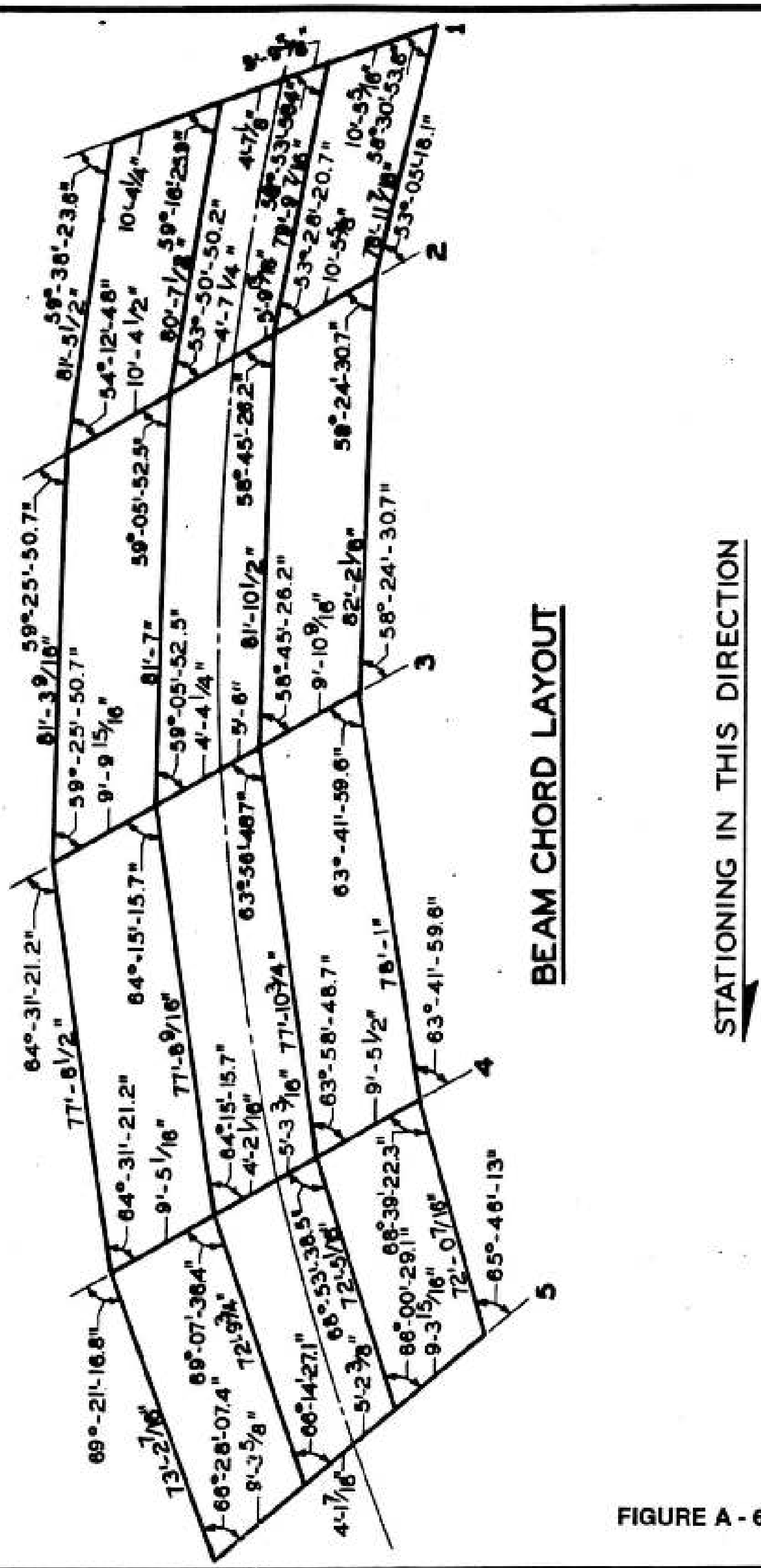
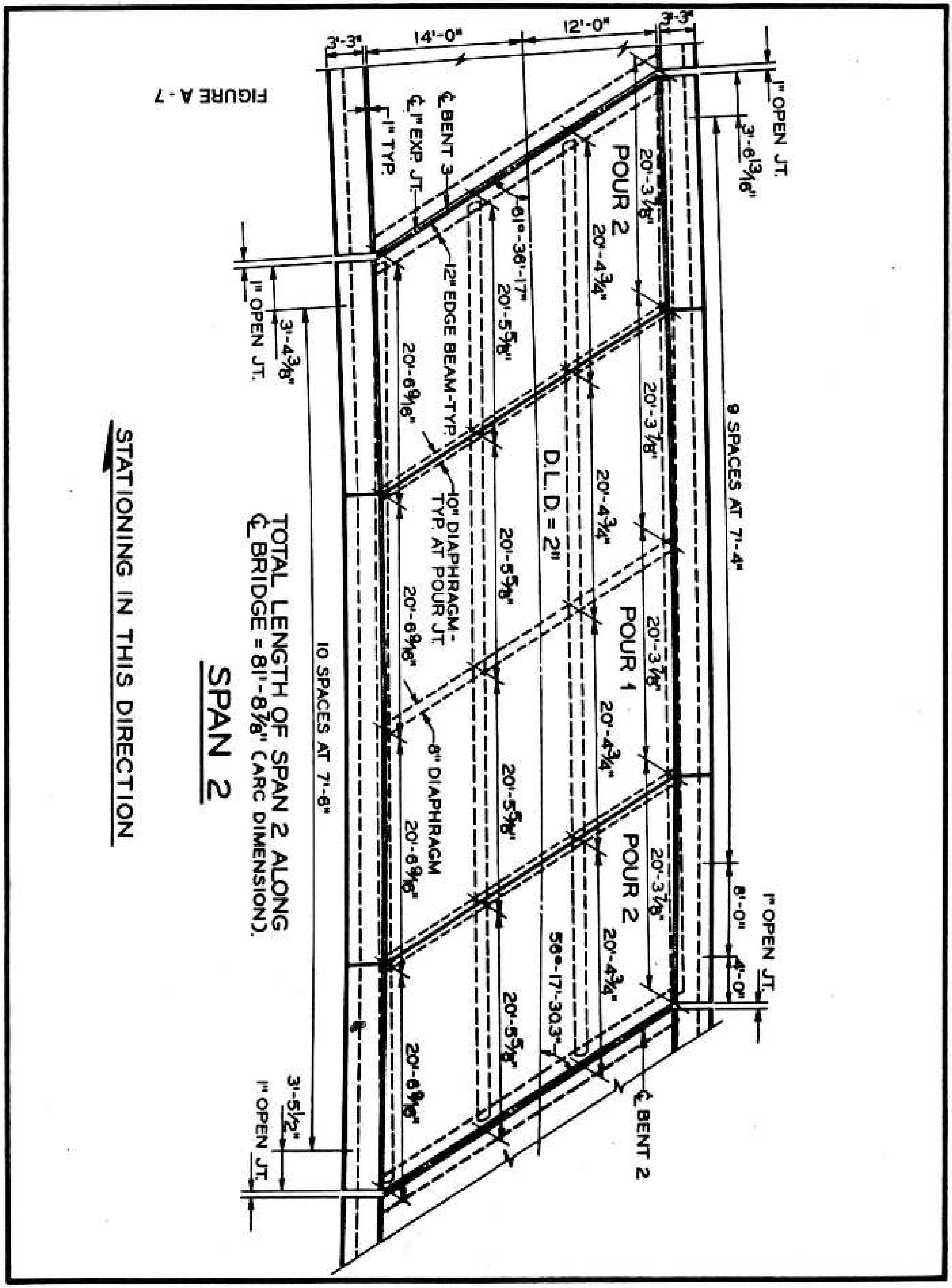

BEAM CHORD LAYOUT
STATIONING IN THIS DIRECTION
1
2
3
4
5
59°-25'-50.7"
81'-3 9/16"
59°-25'-50.7"
9'-9 15/16"
64°-31'-21.2"
77'-8 1/2"
64°-31'-21.2"
9'-5 1/16"
69°-21'-16.8"
73'-2 7/16"
58°-24'-30.7"
82'-2 1/8"
58°-24'-30.7"
63°-41'-59.6"
78'-1"
63°-41'-59.6"
9'-5 1/2"
65°-48'-13"
59°-05'-52.5"
81'-7"
59°-05'-52.5"
4'-4 1/4"
64°-15'-15.7"
77'-8 9/16"
64°-15'-15.7"
4'-2 1/16"
58°-45'-26.2"
81'-10 1/2"
58°-45'-26.2"
9'-10 9/16"
5'-6"
63°-58'-48.7"
77'-10 3/4"
63°-58'-48.7"
5'-3 3/16"

FIGURE A - 6



3'-3"
14'-0"
12'-0"
3'-3"
1" OPEN JT.
3'-6 13/16"
℄ BENT 3
℄ 1" EXP. JT.
1" TYP.
POUR 2
20'-3 7/8"
20'-4 3/4"
61°-36'-17"
12" EDGE BEAM-TYP.
20'-5 5/8"
20'-6 9/16"
1" OPEN JT.
3'-4 3/8"
9 SPACES AT 7'-4"
D.L.D. = 2"
10" DIAPHRAGM-TYP. AT POUR JT.
POUR 1
8" DIAPHRAGM
10 SPACES AT 7'-6"
TOTAL LENGTH OF SPAN 2 ALONG
℄ BRIDGE = 81'-8 7/8" (ARC DIMENSION)
SPAN 2
STATIONING IN THIS DIRECTION
8'-0"
4'-0"
1" OPEN JT.
56°-17'-30.3"
℄ BENT 2
3'-5 1/2"
1" OPEN JT.

FIGURE A - 7

Calculation of Station and finished grade elevation of Point "E":

Step 1: Calculate "X" and "Y" Coordinates of Point "F":

X_F = Radius x Cos 61° -36' – 17"

= 881.474 (0.47555171)

= 419.1865

Y_F = Radius x Sin 61° -36' –17"

= 881.474 (0.87968777)

= 775.4219

Step 2: Calculate "X" and "Y" Coordinates of Point "A":

Since L Bt. 3 is parallel to the "Y" axis the "X" Coordinate of "A" is the same as the "X" Coordinate of "F", and the "Y" Coordinate of "A" is equal to the "Y" Coordinate of "F" plus the distance along the L of Bt. 3 between the two points.

X_A = 419.1865

Y_A = 775.4219 + 14.1823

= 789.6042

Step 3: Calculate the coordinate of Point "E":

X_E = ("X" of A) + (Dist. AE) (Sin 59° – 25' – 50.7")

X_E = 419.1865 + 40.6458 (0.86101510)

X_E = 454.1831

Y_E = (Y of A) – (Dist. AE) (Cos 59° -25' – 50.7")

Y_E = 789.6042 - 40.6458 (0.50857939)

Y_E = 768.9326

Step 4: Calculate Angle J:

Tan ∠ J = Opposite Side ÷ Adjacent Side

Length of Opposite Side = "Y" Coordinate of "E"

Length of Adjacent Side = "X" Coordinate of "E"

Tan ∠ J = 768.9326 ÷ 454.1831

= 1.69300134

Angle J = 59° -25' –51.8"

Step 5: Calculate Angle K:

Angle K = 61° -36' –17" - Angle J

Angle K = (61° -36' –17") – (59° -25' –51.8")

Angle K = 2° -10' –25.2"

Step 6: Calculate Arc FI:

$$\text{Arc FI} = \frac{\Pi \text{ X R (Angle K)}}{180°}$$

$$= \frac{3.1416 \times 881.474 \times 2.1737°}{180°}$$

= 33.4416 ft.

$$\text{Also Arc FI} = \frac{100 \text{ (Angle K)}}{D}$$

$$= \frac{100(2.1737°)}{6.50°}$$

= 33.4415 ft.

Step 7: Calculate Station of "I":

Sta. of I = Sta. of F – (33.4416)

= (39 + 17.5208) – (0+33.4416)

= 38 + 84.0792

Step 8: Calculate Coordinates of "I":

X_I = radius x Cos 59° - 25'-51.8"

= 881.474 x 0.50857480

= 448.2955

Y_I = radius x Sin 59° - 25'-51.8"

= 881.474 x 0.86101782

= 758.9648

Step 9: Calculate Distance "IE":

$$IE = \sqrt{(X_E - X_I)^2 + (Y_E - Y_I)^2}$$

$$IE = \sqrt{(5.8877)^2 + (9.9678)^2}$$

$= \sqrt{(134.0209)}$

IE = 11.5767 ft.

Step 10: Calculate Station of Point "E":

Sta. of E = Station of I = 38 + 84.0792

Step 11: Check by Calculating Sta. of Point "M"

$X_D = X_E + ED$ (Sin 59° -25' – 50.7")

$X_D = 454.1831 + 40.6458\,(0.86101510)$

$X_D = 489.1797$

$Y_D = Y_E + ED$ (Cos 59° - 25' –50.7")

$Y_D = 768.9326 – 40.6458\,(0.50857939)$

$Y_D = 748.2610$

$X_M = X_D = 489.1797$

$Y_M = Y_D – DM$

$= 748.2610 – 14.9792$

$Y_M = 733.2818$

$X_M = 489.1797$

Tan Angle N = $Y_M \div X_M$

$= 733.2818 \div 489.1797$

$= 1.49900292$

Angle N = 56° -17' –32.6"

Angle P = Angle J – Angle N

= (59° -25' –51.8") - (56° -17' –32.6")

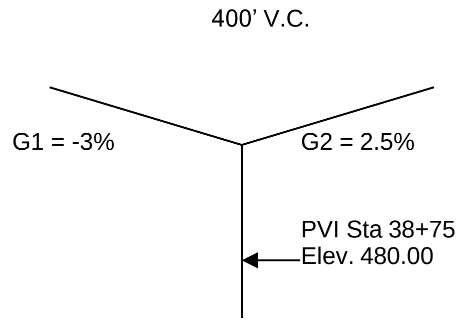
= 3° -08' – 19.2"

Arc IM $= \dfrac{3.1416 \times 881.474 \times 3.1387°}{180°}$

= 48.2878 ft.

Sta. of M = Sta. of I – 48.2878 = 38 + 35.79 ≈ 38 + 35.78 as shown on bridge plans. Therefore, o.k. considering round off.

Step 12: Calculate Finished Grade Elevation of Point "I": From Vertical Curve Data given in plans,



VERTICAL CURVE DATA

$$\text{PVC Sta.} = \text{PVI Sta.} - \frac{400'}{2}$$

$$= 36 + 75$$

$$\text{PVC Elev.} = 480.00 + 0.03\,(200')$$

$$= 486.00$$

Since Point "I" is on the_____Bridge and the______Bridge = Profile Grade Line, Finished Grade Elev. of Point "I" =

$$\text{Elev. “I”} = \text{PVC Elev.} + g_1\,(x) = k(x)^2$$

$$x = (\text{Sta. of I} - \text{PVC Sta.}) \div 100$$

$$= \frac{(38 + 84.0792) - (36 + 75.000)}{100}$$

$$= 2.090792 \text{ stations}$$

$$k = \frac{g_2 - g_1}{2L} = \frac{2.5 - (3.0)}{2(4.00)}$$

$$= 0.6875$$

L = Length of V.C. in 100' Stations = 4.00

Elev. "I" = 486.00 + (-3.0) (2.09072) + (0.6875) (2.090792)2 = 482.7330

Step 13: Calculate Finished Grade Elevation of Point “E”:

Finish Gr. Elev. Point “E” = Elev. “E”

= Elev. “I” + (S.E.) (IE)

= 482.7330 + (0.07) (11.5767’)

= 483.5433

This calculation can be made for any point on the bridge. This calculation, while not difficult, is tedious and may produce slight round off errors. It is, therefore, better to have computer generated data.

When this is done the over-all-structure layout is complete and it is time to layout the individual elements of the structure.

D. Typical Substructure Layout Procedure

The location of the bents must be laid out around the centerline. A typical layout procedure that the Contractor may use is discussed in the following paragraphs.

1. End Bent Layout

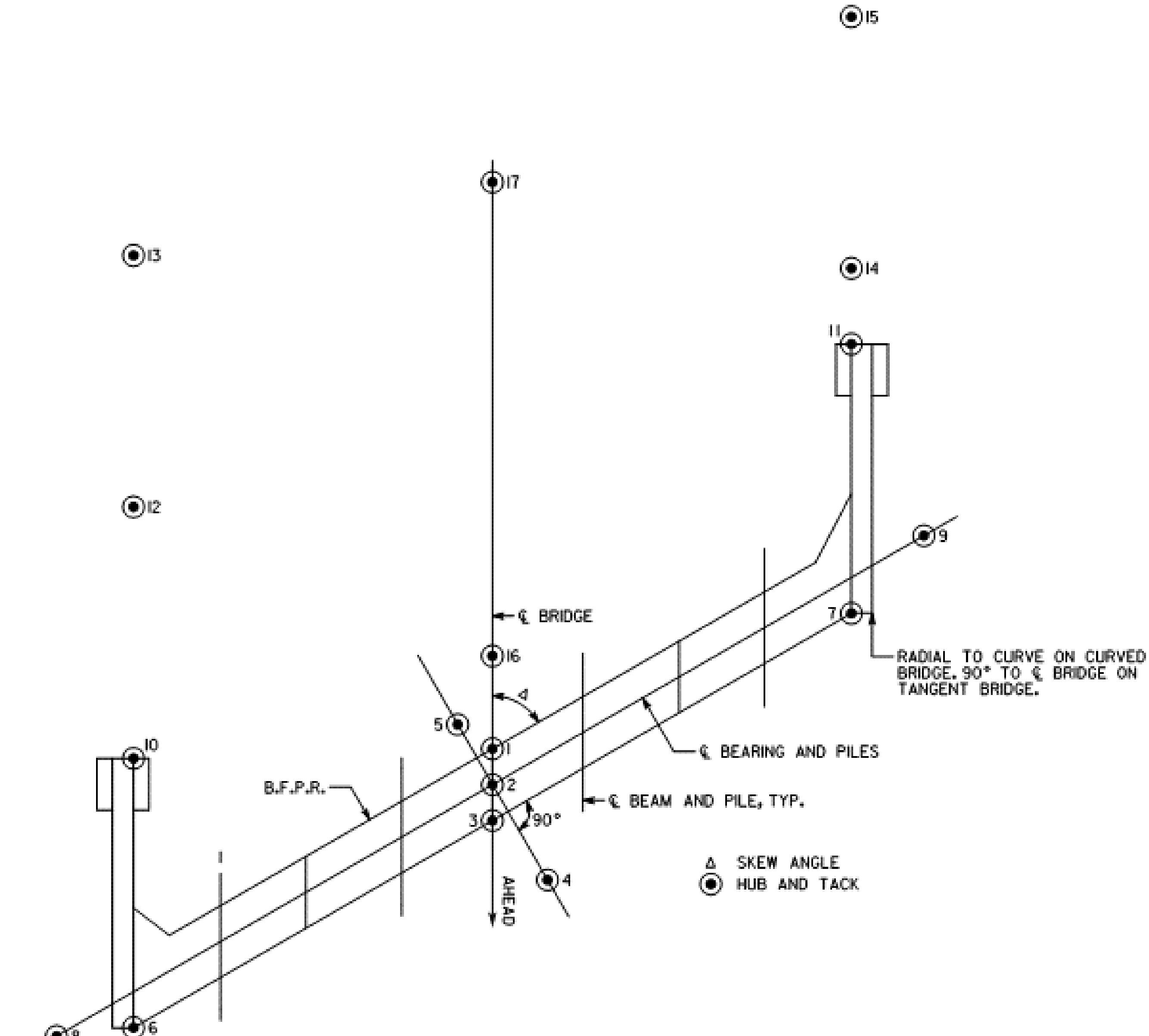
Figure A-8 shows typical end bent details that appear on bridge plans. Also, on Figure A-8 is shown typical hub and tack points used in the construction of the end bent. With the exception of points 12, 13, 14, 15, 16, and 17 all of these points will have to be put in after the end bent is graded out. Before the grading is done offset points (not shown) with cuts or fills will be established for the use of the Contractor in grading the end bent subgrade.

After the grading is done, the end bent can be staked in the following manner:

a. From points 16 and 17 (points of known station and alignment) points 1, 2, and 3 are established with surveying instruments.

b. An appropriate survey instrument is then set on point 1 and angle Δ is turned. The line of sight of the instrument should now hit the reference points already established in the over-all structure layout described above in “a”. If not, the necessary correction in point 1 must be made so that this does happen.

c. Next set the instrument at point 2, turn angle Δ and lay out points 8 and 9 just outside the limits of construction. Also, from line 8, 2, 9 turn 90 degrees and lay out points 4 and 5 just outside the limits of construction. These points, points 2, 4, 5, 8 and 9, will be used to locate and keep located a template by which the location of the piling will be controlled.



END BENT LAYOUT

FIGURE A-8

d. Next set the instrument at point 3, turn the angle Δ and locate points 6 and 7 the exact plan distance from point 3. Drive hubs 6 and 7 to the grade of the cap bottom and place a tack on line and distance in the hubs. Forms will be set on these tack points and plumbed with a carpenter's level for proper alignment of cap and wing wall forms.

e. Next set the instrument at points 6 and 7 and verify location of points 12, 13, 14, and 15. If the alignment checks on these points, set points 10 and 11. Points 10 and 11 should be driven to grade with a tack point. Points 12 and 13, 14 and 15 will be set outside of the construction. Forms will be set on points 10 and 11 and plumbed with a carpenter's level. This will control the wing wall alignment. The wing wall alignment will be checked by setting a transit on point 13 or 15 and sighting on points 12 or 14 respectively.

The bent is now laid out and can be constructed. If this bridge were on a curve, the layout would be very much the same except that angles would vary and the stations of points on the wing wall lines would be necessary. These stations would be necessary so that deflection angles to the wing wall points could be calculated and turned. The stations of points 3, 6 and 7 if not shown on the bridge plans can be computed. Also the angle between the front face of the cap and the tangent to the curve at point 3 can be computed.

2. Intermediate Bent Layout

The layout of intermediate bents can be broken down into four sections—accessible concrete bents, non-accessible concrete bents, accessible pile bents, and non-accessible pile bents.

a. Accessible Concrete Bent

A typical layout of an accessible concrete intermediate bent is shown in Figure A-9. In Figure A-9 points 1, 2, 3, and 4 are points of known station on the centerline of the bridge. Points 5, 16, 17, 18, and 19 were established in the over-all structure layout described in "b" above. The layout would proceed as follows:

1) Set an appropriate survey instrument on point 5, turn angle Δ and check on points 16, 17, 18 and 19. They must check.

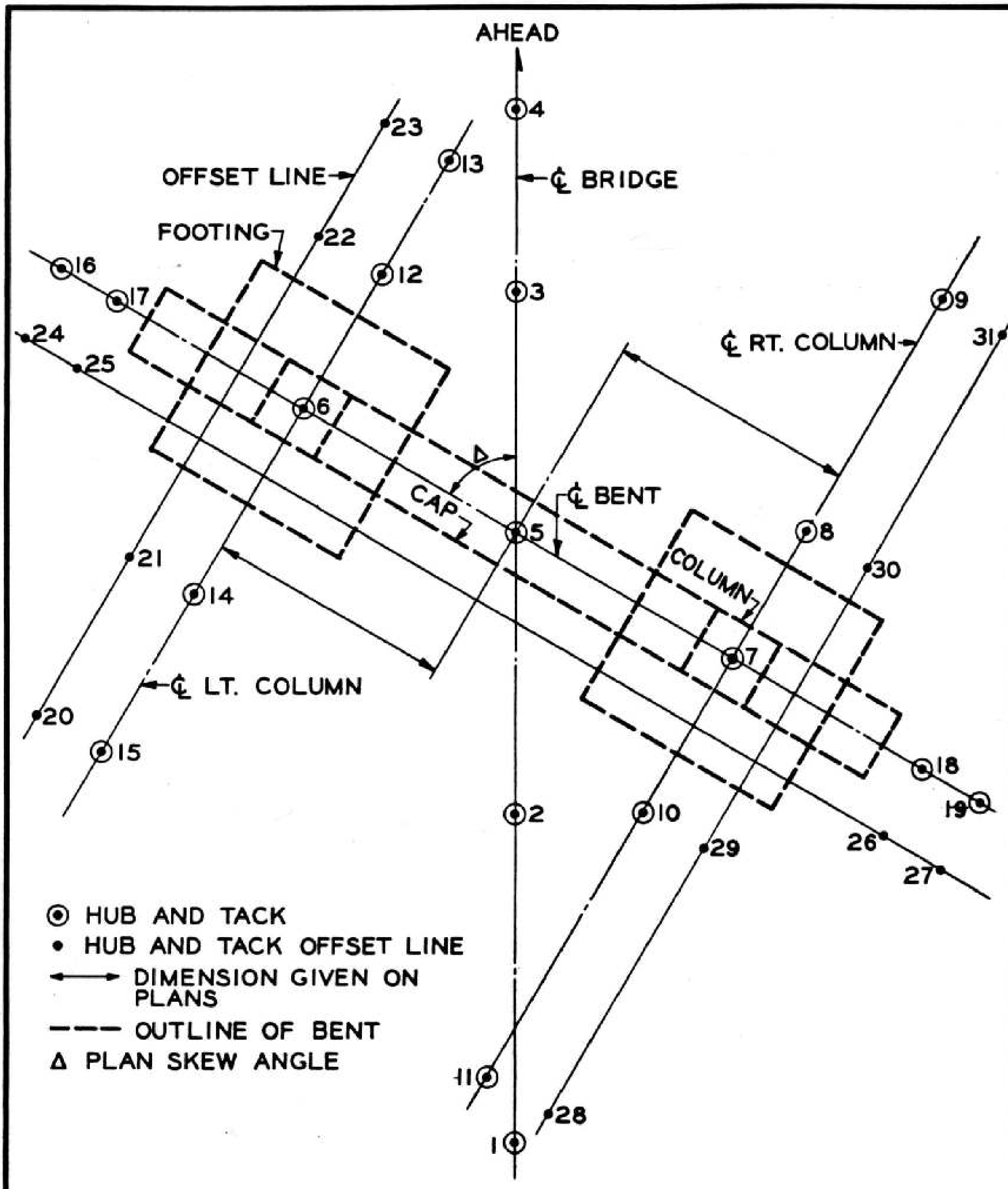
2) With instrument on point 5 layout points 6 and 7.

3) With instrument on points 6 and 7 layout points 12, 13, 14, and 15 and points 8, 9, 10, and 11 respectively. These points along with points 16, 17, 18 and 19 will be used to locate the footing and align the columns.

4) If the construction blocks the line of sight, the offset lines will be laid out and the columns and the cap aligned from the offset lines. This can be accomplished by sighting on a rule.

5) Cuts are placed on stakes adjacent to the footings to control the footing excavation. This would be done in exactly the same manner if the bridge were on a curve.

Construction of the bent can now begin.



INTERMEDIATE BENT LAYOUT

FIGURE A - 9

b. Non-Accessible Concrete Bent

In the vast majority of cases non-accessible bents will become accessible during the construction process. The Contractor will build either a work bridge or a work ramp from which he gains access to the bent. The Engineer can use this same work bridge or ramp to layout the bent. This will involve, in most cases, measuring along an offset line and then turning an angle with another measurement to the bent in question. This is not a difficult operation, but care must be taken to re-measure distances and re-turn angles each time a location is made because of possible movement of points caused by the construction equipment.

c. Accessible Pile Bent

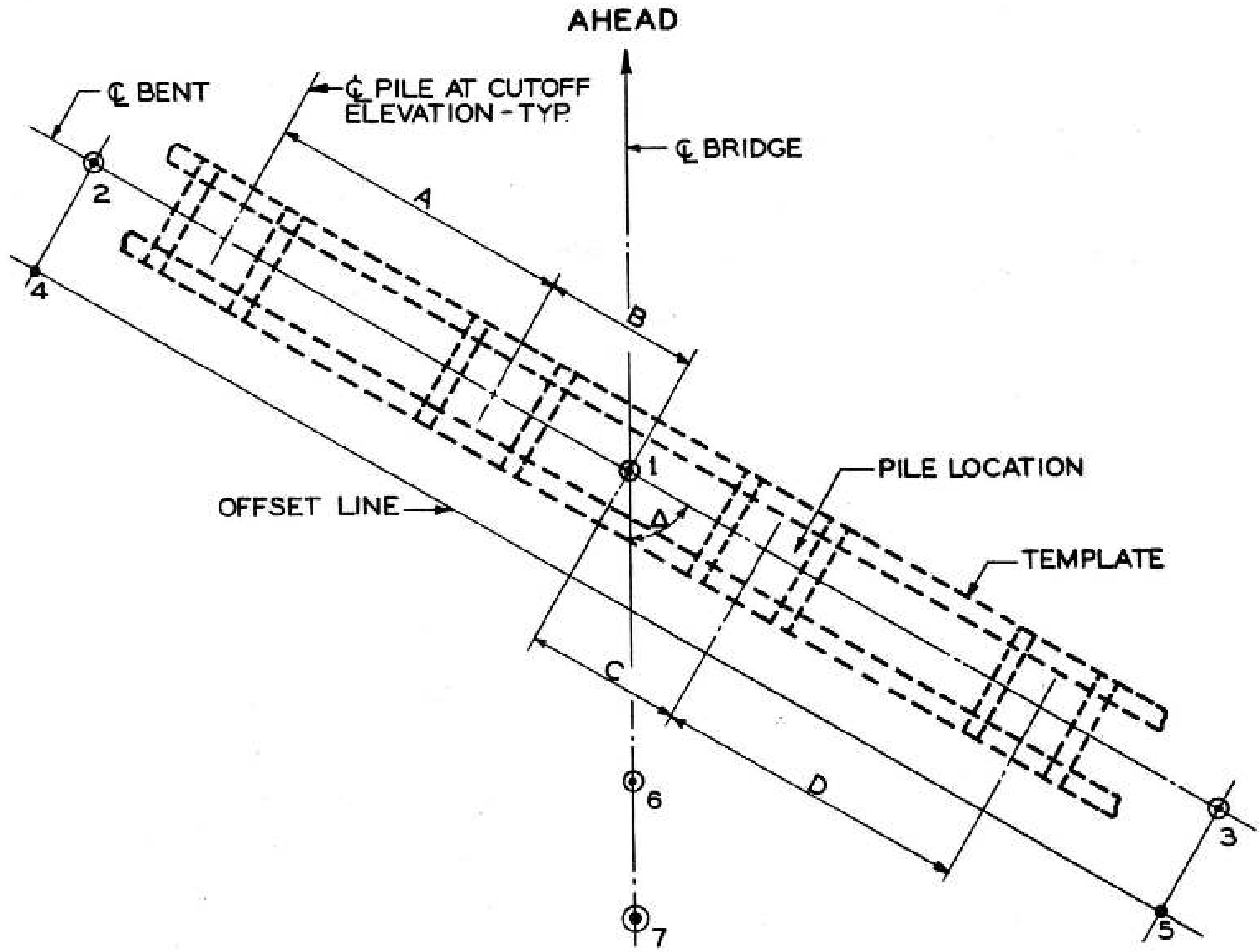
A layout of a typical pile bent is shown in Figure A-10. The problem is to provide sufficient lines so that the template (dotted lines) may be constructed by the Contractor in its proper location. The location of the individual piles will be controlled by the template. Dimensions A, B, C and D will be given on the Plans and are true only at pile cut-off elevation if the piles are battered. If piles are battered these dimensions will be adjusted by the rate of batter times the difference in elevation of the template and pile cut-off elevation. If the piles are plumb no adjustment needs to be made to these dimensions.

The layout would proceed as follows:

1) From points 6 and 7 (points of known station on the bridge centerline) re-check point 1 which was originally established as part of the over-all structure layout.
2) With an appropriate survey instrument at point 1 turn the skew angle Δ and re-check the reference points already established in the over-all structure layout. They must check.
3) With the instrument at point 1 layout points 2 and 3 just outside of the limits of the bent construction. The Contractor will use these points as string line points from which he will locate the pile template.
4) Locate points 4 and 5 on an offset line so that the template may be checked for movement during the driving operation.
5) Establish the elevation of the ground so that adjustments of Dimensions A, B, C or D can be made for the batter piles.
6) After the piles are driven, the same points will be used for cap construction.

d. Non-Accessible Pile Bents

Non-accessible pile bents are handled about the same as the non-accessible concrete bents. The problem is only to locate the ends of the template and in most cases, this can be done with an angle and distance from an offset line on the Contractor's work bridge or ramp.



TEMPLATE LAYOUT

FIGURE A-10

3. Column Layout

Some of the ways to align the top of column forms are as follows:

a. With Two Instruments

This is the best method. With instruments set up on both centerlines or offset lines, the column form is pulled with the guys until the top is in perfect alignment. If the instruments are on the centerlines, nails driven into the forms can be used as sighting points by which the alignment of the forms is checked. A plumb bob with a short string can be used for this but never plumb up high for a sighting point. If this is necessary, use an offset line.

If offset lines are used, the sighting point should be a rule held horizontally against the column form. The form is pulled by the guys until the proper reading on the rule is observed.

b. With Instrument Line and Tape

If an adjacent column or cap has already been constructed the column may be lined in one direction with an instrument line and in the other direction with a measurement from the existing construction.

c. With Plumb Bobs

A column can be lined with plumb bobs. If the base is in correct location, a plumb bob can be hung from the center of the column form. The column form is then moved until the plumb bob is directly above a center point in the column base. This cannot be used as a check after pouring, because the column will then be full of concrete. On a still day plumb bobs can be hung outside of the column form. The top of the form is then moved until the plumb bobs can be hung outside of the column form. The top of the form is then moved until the plumb line is equi-distant from the column form along its entire length. This can be difficult on a windy day.

4. Cap Layout

It is necessary to construct the cap and the wing walls to an exact alignment. Once the forms are built in place it will be difficult to shift them. The forms should be set on tack points as described in End Bent Layout and shown in Figure A-8 as points 6, 7, 10 and 11 or attached to the columns as shown in Figure A-9 as points 6 and 7.

a. Alignment and Grading of Cap

The cap forms are now ready for final alignment. The centerline of the bridge should be shot in on both of the cap side forms. The wing wall forms should also be checked with a survey instrument. The ends of the cap should be checked from the centerline of bridge points that have been placed on the form sides.

The cap can now be graded. Each break in grade can be located by measuring from the bridge centerline. The high grade and the low grade at each of these points can be shot in. The wing walls are also graded at this time. The grade lines are marked with a chalk line and the chamfers are tacked down. For the end bents, the accuracy of the grading should be checked by measuring with a rule the vertical distance from the chamfer to points 6 and 7 as shown in Figure A-8. These points were, of necessity, placed on the grade of the bottom of the cap. If this measured distance is not the same as the thickness of the cap, corrections must be made. Similar checks should be made at the intermediate bents.

b. Anchor Bolt Holes

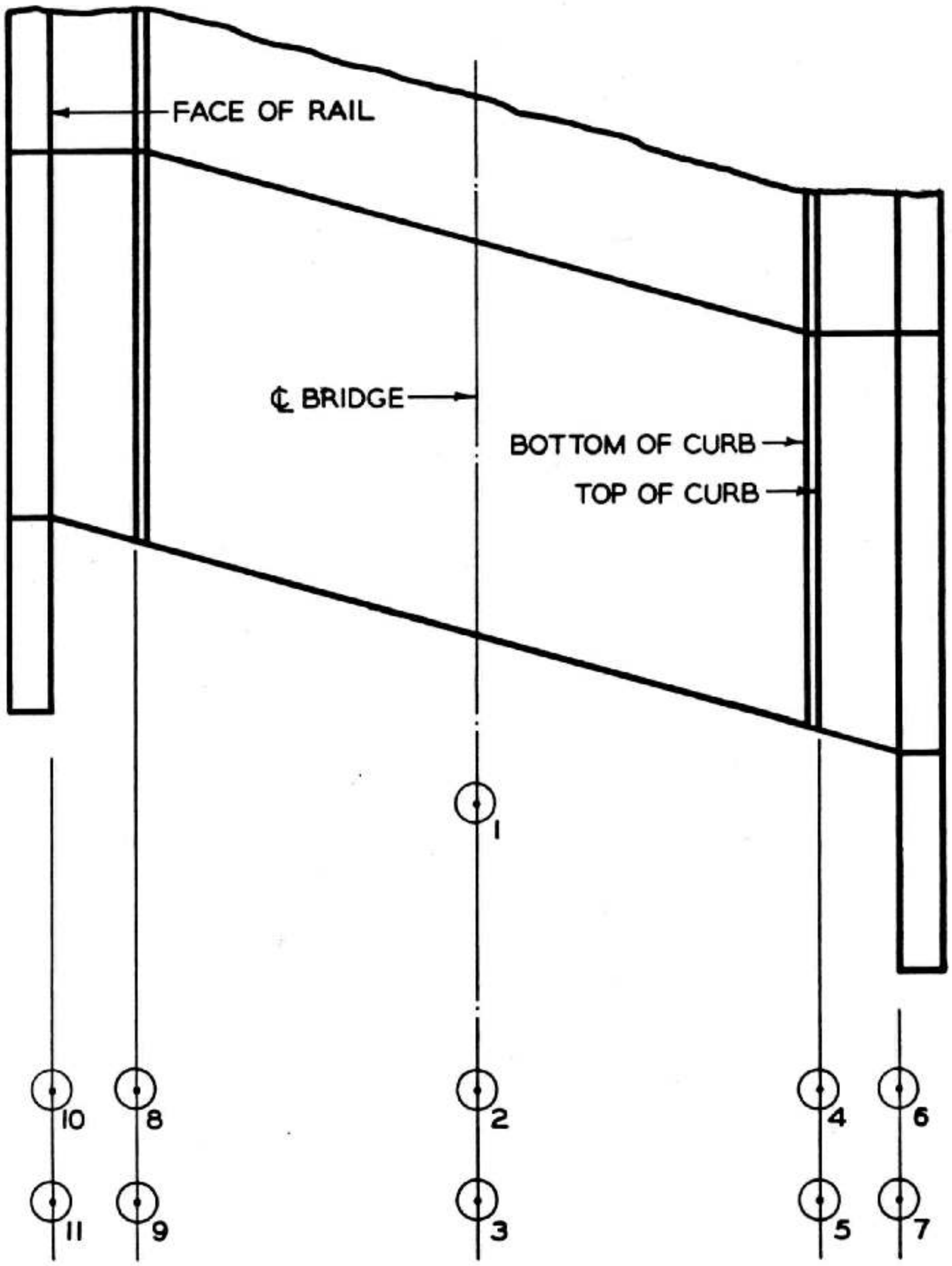
The location of the anchor bolt holes is now established by measuring from the bridge centerline.

E. Typical Superstructure Layout Procedure

The layout of the superstructure consists primarily of establishing the bridge centerline from which the edge of the slab, etc. is controlled, and furnishing line for the barrier or rail construction.

1. Bridge on a Tangent

A typical layout for a bridge on a tangent is shown in Figure A-11.



SUPERSTRUCTURE LAYOUT

FIGURE A - 11

The points shown should be duplicated on the both ends of the bridge. To better control the alignment, a transit should be set on a point on one end of the bridge and foresighted on a companion point on the other end of the bridge. When this cannot be done, a transit would be set on a back point (such as point 9), foresighted on a forward point (such as 8), and the line then projected forward. This should be done only when the line of sight of the transit cannot extend from end of bridge to end of bridge.

Some Contractors may prefer to line the barrier or rail forms from an offset line or even from the centerline of the bridge. This is perfectly acceptable.

There are no particular problems in deck alignment for bridges on horizontal tangent. The Engineer needs only to be aware that centerlines, curb lines, and barrier or railing lines will have to be established.

If a bridge is simply skewed to a tangent (not a curve) the travel (forward or backward) of the ends of each beam in reference to the survey line stations can be computed. This is the square distance the centerline of the beam is from the survey centerline times the cotangent of the skew angle. This is then added (plus or minus) to the survey centerline station to get the station of the end of the beam. Once the station of the end of the beam is calculated, it is a matter of addition or subtraction to secure the station of any other point along the beam. The finished grade elevation is then calculated as before.

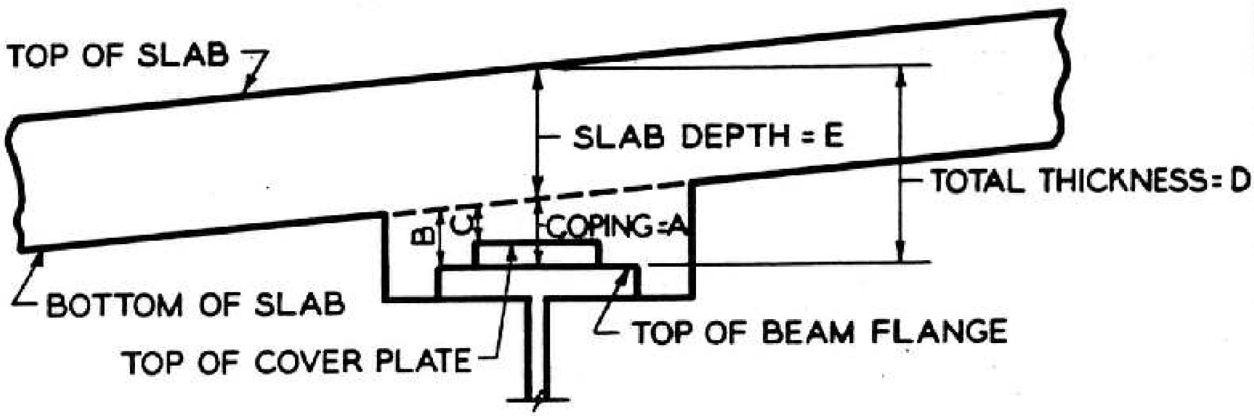
2. Bridge on a Curve

For bridges on curves: bear in mind that station distances are always arc distances and that highway bridge span and length distances are arc distances, while beams are on straight distances. The control points for the alignment of a bridge on a curve are laid out much the same as bridges on a tangent, except that the station of the points must be used and deflection angles and distances to specific points on the concentric curves of the centerline and edges must be computed and measured. Read B. Alignment for Horizontal Curved Bridge for further description and C. Method to Coordinate Alignment to Stationing for an example.

SECTION 2 DECK FORMING AND POURING

A. Deck Form Ordinates/Markups/Coping

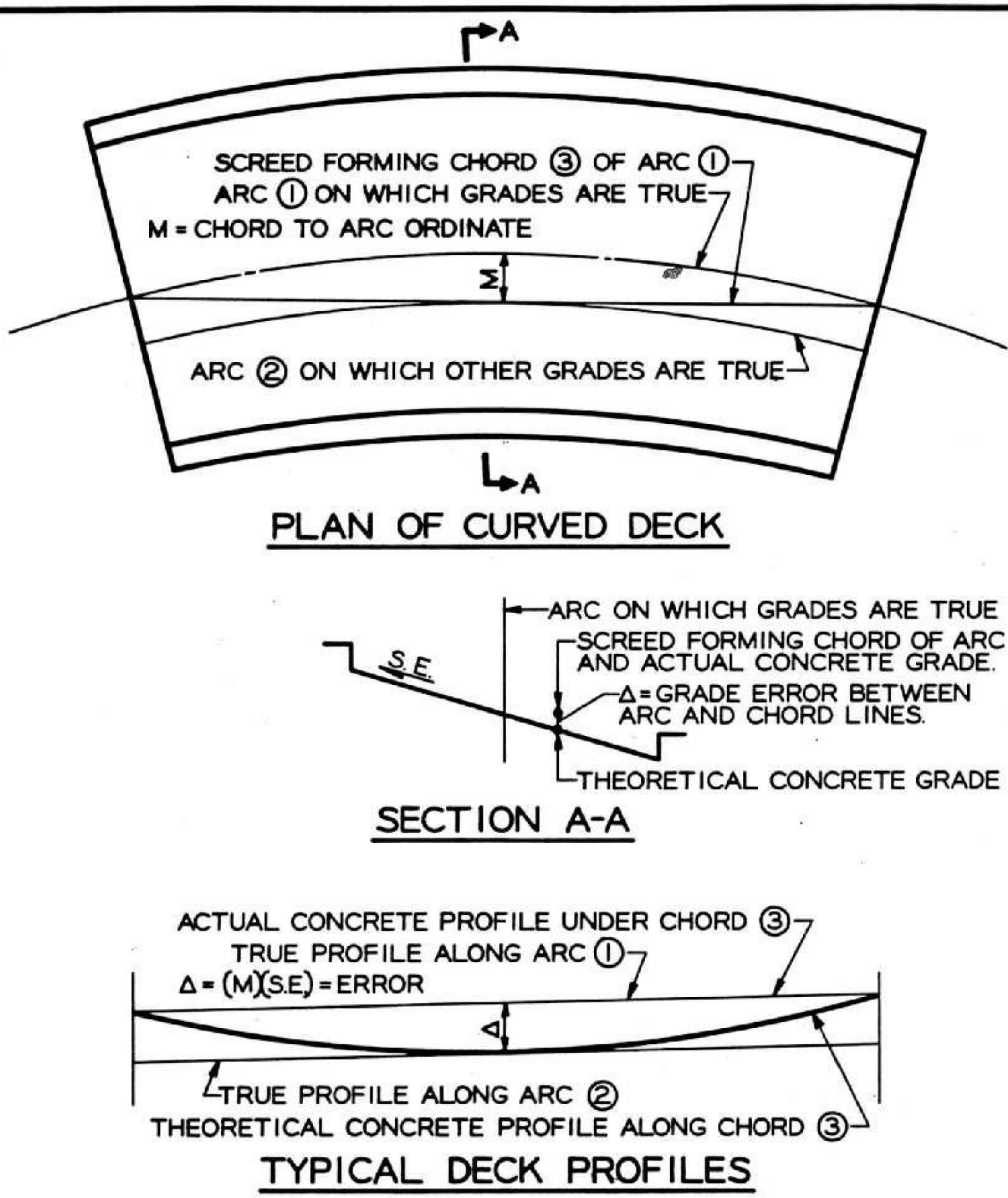
COPING is the additional concrete over beam necessary to ensure that no part of the beam or cover plate extends into the slab thickness. This is measured at the centerline of the beam.
The amount of coping shown on the plans (total thickness of concrete less the slab thickness) is controlled by several factors. These factors are crown on straight bridges, superelevation on curved bridges, vertical curve either rising or sagging, cover plate thickness and dead load deflection of the beam. Coping and the influence of these factors is illustrated in Figures A-12, A-13, A-14, A-15, A-16, and A-17. As the figures show, coping is not a constant dimension across the beams. Deck Form Ordinates (DFOs or markups) are used to set and adjust the coping thickness along the beams. After the beams are set, elevations along the top are taken and the DFOs determined based on these elevations and the final proposed deck elevations at the same points. Deck forms are graded based on these elevations.



"A" MUST BE SUCH THAT "B" OR "C" MUST NEVER BE LESS THAN ZERO. "D" AND "E" ARE SHOWN ON THE PLANS AT SOME SPECIFIC POINT. THE PLANS WILL ALSO STATE THAT THE COPING, "A", SHOULD BE VARIED TO COMPENSATE FOR THE EFFECT OF VERTICAL CURVE AND DEAD LOAD DEFLECTION. THE COPING, "A", WILL ALSO HAVE TO BE VARIED TO COMPENSATE FOR THE EFFECT OF COVER PLATES AND THE EFFECT OF THROW AND SUPER ELEVATION FOR BRIDGES ON HORIZONTAL CURVES.

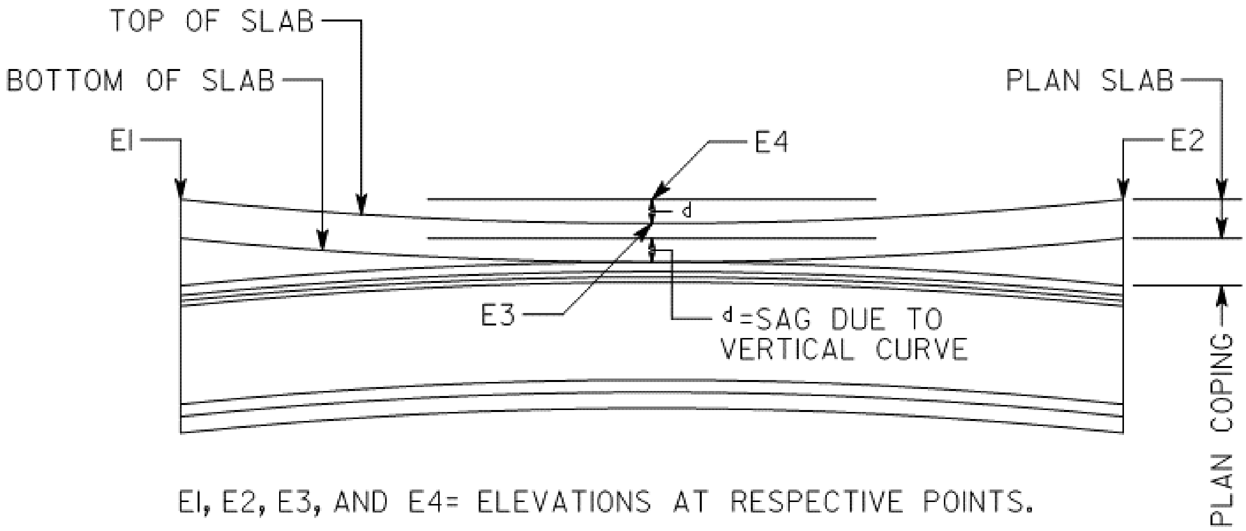
COPING

FIGURE A - 12



SCREEDING ERROR-CURVED SPANS

FIGURE 13



EI, E2, E3, AND E4= ELEVATIONS AT RESPECTIVE POINTS.

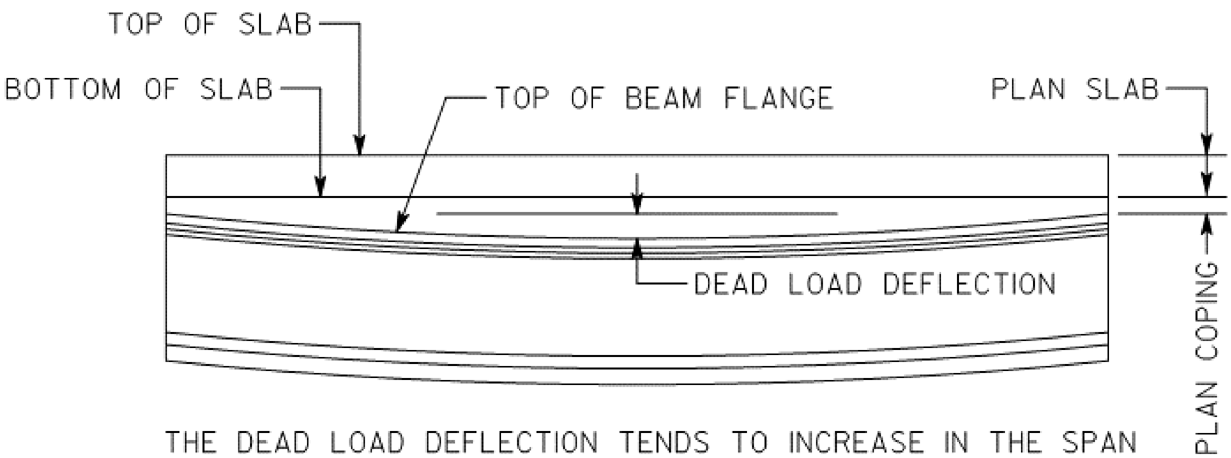
E4=(EI+E2)/2

d=E4-E3

A SAGGING VERTICAL CURVE TENDS TO INCREASE IN THE SPAN THE PLAN COPING SHOWN ON THE PLANS AT THE ENDS OF THE BEAM.

EFFECT OF SAGGING VERTICAL CURVE ON COPING

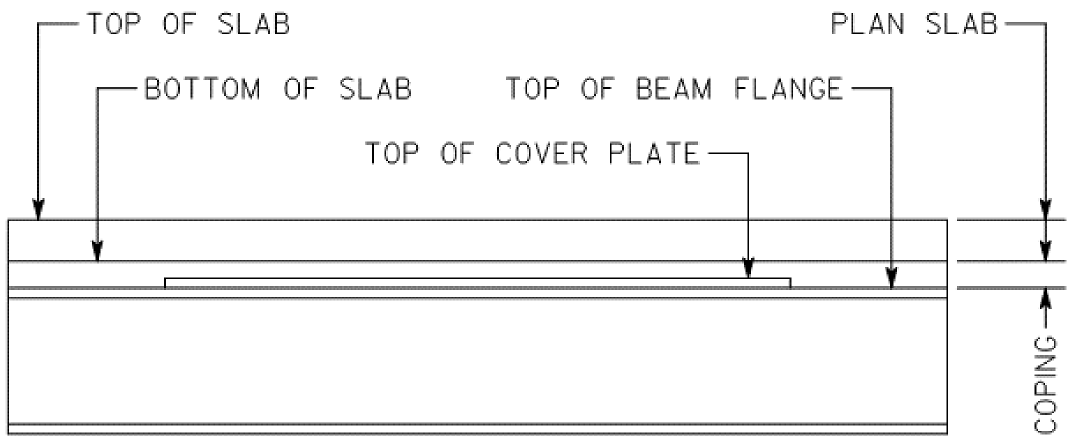
FIGURE A-I4



THE DEAD LOAD DEFLECTION TENDS TO INCREASE IN THE SPAN THE PLAN COPING SHOWN AT THE ENDS OF THE BEAMS.

EFFECT OF DEAD LOAD DEFLECTION ON COPING

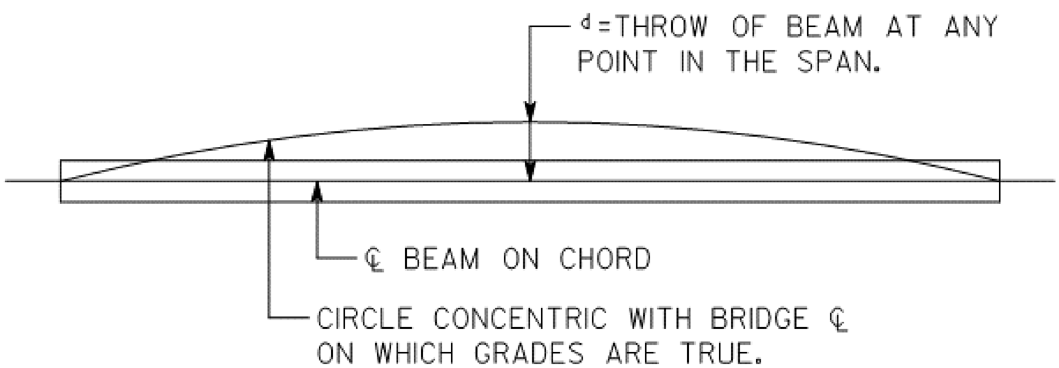
FIGURE A-I5



THE COVER PLATE THICKNESS WILL REDUCE THE PLAN COPING BY ITS THICKNESS FOR THE FULL LENGTH OF THE COVER PLATE.

EFFECT OF A COVER PLATE ON COPING

FIGURE A-16



THE PLAN COPING IS DECREASED BY d TIMES THE RATE OF SUPERELEVATION FOR ANY POINT IN THE SPAN.

PLAN VIEW OF BEAM FLANGE

EFFECT OF A HORIZONTAL CURVATURE ON COPING

FIGURE A-17

B. Deck Grades

The plans should be reviewed with the Contractor to identify the locations of deck grade points. This is best done by drawing line diagrams of each bridge or span showing beam centerlines, gutter lines, centerline of bridge, and the construction joint header lines. The best practice is to have grade points not more than 15 ft. apart along each beam. Corresponding points on different beams should form a straight line. These lines should be parallel to the headers or joints. It is also necessary to calculate grade points on the headers and joints.

If computer generated data is used all grade points will have to correspond with computer data. A typical drawing such as described above would be as shown in Figure 1 (see Chapter 2, Section 3). Figure 1 is drawn as one span of a curved bridge. It would be drawn the same whether it is curved or straight and whether one or several spans are shown on a drawing.

Stations, elevations, and distances between points are shown for each point of intersection. These stations, elevations, and distances are either computed in the field or taken from the computer data. These points are shown as dots on the drawing. The Dead Load Deflection of the beam at each point is also recorded. These points will be eventually marked on the beams, levels run on the points, and deck form ordinates calculated for each point. All of this will be placed on a drawing or in a chart form for the use of the inspector on the bridge. Table A-1 is a chart showing markups along a beam. The Contractor must submit this information before pouring any diaphragms or edge beams. Any negative mark-ups should be investigated closely. In some cases, positive mark-ups can be as high as five or six inches but around two inches is typical.

Table A-1

SR 317 SPAN 1 LT EDGE

STATION	TOP DECK	THICKNESS	CAMBER	BOTTOM DEC	BEAM PROFILE	MARK UP
CL BT #2	6.400			6.400	0.000	
CL BRG	6.416	0.000		6.416	6.403	0.013
11/12	6.533	0.000	0.000	6.533	6.528	0.005
10/12	6.645	0.000	0.000	6.645	6.594	0.051
9/12	6.750	0.000	0.000	6.750	6.084	0.066
8/12	6.849	0.000	0.000	6.849	6.705	0.004
7/12	6.941	0.000	0.000	6.941	6.875	0.066
6/12	7.027	0.000	0.000	7.027	6.985	0.042
5/12	7.107	0.000	0.000	7.107	7.063	0.044
4/12	7.180	0.000	0.000	7.180	7.145	0.035
3/12	7.246	0.000	0.000	7.246	7.208	0.038
2/12	7.307	0.000	0.000	7.307	7.283	0.024
1/12	7.361	0.000	0.000	7.361	7.345	0.018
CL BRG	7.408	0.000		7.408	7.410	-0.002
BRPR #1	7.426			7.426	0.000	

C. Bridge Deck Construction Checklist

The following “Bridge Deck Construction Check List” is currently required on all bridge deck pours (including the bottom slab of post-tensioned concrete box bridges) and requires depth checks or probing of the plastic concrete to determine slab thickness and cover over bar reinforcement steel.

The intent of the “Bridge Deck Construction Check List” is to assist in achieving quality bridge decks and, to a less degree, to assist as an investigative tool when problems occur.

Depth checks made in plastic concrete should be recorded on same sheet that the dry run was performed and attached to the checklist. Deck depth checks should be made near the center of the bays no more than 10 feet apart to reasonably be assured that plan bar reinforcement cover and slab thickness is obtained.

Copies Of the “Bridge Deck Construction Check List” and accompanying sketches shall be placed in the project files for future reference and comparison with pachometer and deck core measurements. Forms can be found on the State Construction Office Webpage to download.

Bridge Deck Construction Checklist

Project No. ________ Bridge No. ________ Span No. ________ Rev. 5/20

Page 1 of 3

Pre-Pour Inspection					
Item					Inspected (Initial)
1	Forms clean, mortar tight, and in place according to DFO/Markups.				
2	If SIP (stay in place) metal deck forms are used, insure that all support angles are affixed or welded to the beams or brackets in accordance with approved shop drawings prior to placement of metal deck forms. Insure that all metal deck forms are attached to the support angles with self drilling screw fasteners as they are placed.				
3	If concrete deck panels (forms) are used, insure all tolerances on panel thickness and strand locations are in accordance with speciafications. Also, insure that concrete panels are handled, stored and placed in accordance with specifications, shop drawings and the current MOG's				
4	Bar reinforcing steel placed and supported in accordance with plans and specifications. (511.3.05.G)				
5	Overhang slab special check - reinforcement steel placed in accordance with plans and specifications.				
6	Overhang brackets, needle beams, screed rails, and headers satisfactory in place as required.				
7	Inspect screed for the correct camber.				
8	Dry run with screed made to insure correct slab thickness and reinforcement clearance. See the attached dry run sheet. Contractor is not allowed to place concrete if either item is out of tolerance.				
9	Pre-Pour Conference held				
	Concrete Quantity	Required		Ordered	
	Concrete Trucks Available	Ordered		Actual	
	Contractor Personnel Available	Ordered		Actual	
	Number of Concrete Buckets Available (if applicable)				
	If concrete is to be pumped	How many Pumps		How many setups	
	Are the required curing materials available and in good condition.				

* Order sufficient concrete to complete pour within placement rate specification

Attach attendees

Bridge Deck Construction Checklist

Project No. ____________ Bridge No. ________ Span No. ______ Rev. 5/20

Page 2 of 3

Inspection During Pour		
Item		Inspected (Initial)
1	Inspectors on site	
2	Conctrete trucks in proper working order.	
3	Quality of concrete checked. (Low to High) Range: Air ____ Slump ____ Temp ____	
4	Field date recorded on concrete tickets	
5	Depth checks made in plastic concrete to determine if slab thickness is correct and within tolerance. See attached Dry/Wet Check sheet.	
6	Cover checks made in plastic concrete to determine if cover thickness is correct and within tolerance. See attached Dry/Wet Check sheet.	
7	Monitor the overhang profile and adjust as needed.	
8	Check deck surface with 10 straight edge. Does it meet 1/8 inch in 10 feet requirements both longitudinal, transverse and joints.	
9	Deck fogged as required to prevent shrinkage cracking due to drying out.	
10	Final finish meets specifications.	
11	Curing materials placed as per specification including overhang.	

Bridge Deck Construction Checklist

Project No. Bridge No. Span No. Rev. 5/20

Post-Pour Inspection						
Item						Inspected (Initial)
1	Placement Rate	Required		Actual		
2	Straight edge deck. Does it meet 1/8 inch in 10 feet requirements Check deck surface with 10 straight edge. Does it meet 1/8 inch in 10 feet requirements both longitudinal, transverse and joints.					
3	Check to determine if adequate moisture is available beneath curing material. Check daily for 5 days and require contractor to wet deck when necessary.					
	Day 1	Day 2	Day 3	Day 4	Day 5	
4	Reasons placement rate was not met or deck pour not considered satisfactory.					
5	Instructions given to the contractor to insure that the next pour meets specifications and the deficiences noted for this pour are corrected.					

Copy presented to ______________________ ,contractor representative.
(Name)

______________________ Signature DOT Inspector

______________________ Date

1. Furnish a copy of this report to the contractor.
2. Contractor will not be allowed to make next pour until corrective action has been taken that should allow the next pour to be placed in accordance with specifications.

Attachments

Dry Run

		OVERHANG COVER / DEPTH	BAY # 1 COVER / DEPTH	BAY # 2 COVER / DEPTH	BAY # 3 COVER / DEPTH	BAY # 4 COVER / DEPTH	OVERHANG COVER / DEPTH		
				BENT # 2	/ ENDWALL				
BT		2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	BT	
	DRY								DRY
	WET								WET
PT 7		2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	PT 7	
	DRY								DRY
	WET								WET
PT 6		2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	PT 6	
	DRY								DRY
	WET								WET
PT 5		2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	PT 5	
	DRY								DRY
	WET								WET
BT		2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	2 1/4" 7 1/4"	BT	
	DRY								DRY
	WET								WET
				BENT # 1	/ ENDWALL				

Use a chart that will allow you to put the dry and wet checks on the same sheet for comparison during the pour. No form will work on all bridges due to the number of beams and bays. Find or make one that works for your application.

APPENDIX B

SECTION 1

The Driving System- A brief summation of the functioning of pile hammers and related hardware.

SECTION 2

Internal Combustion Hammers – Single Acting (Open End Diesel Hammers)

SECTION 3

Internal Combustion Hammers- Double Acting (Closed End Diesel Hammers)

SECTION 4

Load Test Procedures/ PDA

SECTION 5

Test Pile or Driving Data Pile Forms 500A and 500B

SECTION 6

Drilled Shaft Inspection Report Form

APPENDIX B

SECTION 1 THE DRIVING SYSTEM

A. Introduction

For this manual, the driving system consists of the following components:

The lead, also called the set of leads, sometimes including a brace which allows for the adjustment of the lead angle without setting the leads on the ground.

The hammer cushion, which protects the hammer as well as the pile from excessive stress. Cushion material is relatively soft compared to steel. Usually, the cushion is protected by a striker plate.

The helmet, which aligns pile top and hammer. It is usually a steel casting.

The pile cushion, this is only needed on concrete piles and, usually consists of several layers of plywood.

All components of the driving system have some effect on the performance of a hammer and/or how the hammer transfers its energy into a pile.

B. Lead Systems

Depending on the relative positions of the crane and the pile, a specific type of lead system may need to be employed. There are three main categories of lead systems; the inspector should be aware of their working principles.

1. The Swinging Lead

A lightweight pile with a moderate batter (the angle formed between the axis of the pile and the vertical) may be driven with swinging leads. A swinging lead is supported at its top by a line from the crane. Its second point of support is the ground. Swinging leads have spikes mounted at their bottom, and these have to penetrate the ground surface.

2. The Fixed Lead

Fixed leads have a pivot point at the crane's boom top and are braced between crane and lead bottom. The brace is usually extendible (hydraulically or by hoist line) such that the pile batter can be easily achieved. Fixed leads offer good control; of course, they are more expensive that swinging leads and they are limited where the crane's working surface is substantially higher than pile grade (e.g., the crane is on original ground and the pile is driven in an excavation).

3. The Semi-Fixed Lead

The good control of the fixed lead and the flexibility of the swinging lead are combined in the semi-fixed lead. In this type of lead system, the lead slides axially along the pivoted boom point. The lead, pile, and hammer weight are supported by the lead line which is attached near the bottom of the lead. Semi-fixed leads are usually fitted with an extendible brace.

C. Maintaining Pile Position

Pile position is maintained by the leads. The pile is held at its top by the helmet. A second guiding point is the gate, which is usually located at the lead bottom. The gate should allow for only small lateral pile movements.

During driving, most crane-lead systems shift to some degree because of the constantly varying positions of hammer and pile load. Thus, corrections must be made, particularly in strong battered applications.

If the pile is forcibly moved out of position by some obstruction in the ground (pile walking), then it is not advisable to force the pile back or it may be destroyed. Swinging leads usually adjust themselves; braced leads may need operator attention.

D. The Helmet

The helmet is the heavy and rigid steel block between hammer and pile. It should be carefully fitted to a pile. First, it is important that the helmet's striking surface is smooth and contacts the pile top evenly. Second, it should not allow more than approximately two inches of lateral movement.

A poor helmet-pile seating will cause high localized stresses at the pile top. In addition, a poor seating may cause the exposed portion of a long pile to buckle elastically under each hammer blow (this is known as "pile whipping").

E. The Hammer Cushion

On top of the helmet there is usually a pot shaped recess which contains the hammer cushion. The hammer cushion should be protected by a striker plate, such that the material is compressed as uniformly as possible. The hammer cushion primarily protects the hammer.

Most hammer cushions have a limited life. They compress, and material may need to be added to maintain a certain thickness. Badly broken or burnt hammer cushions are inefficient.
Hammer cushions with poor properties or improper thickness lead to inefficient hammer operations and/or hammer failure.

F. The Pile Cushion

In the United States, plywood is the most common pile cushion material. Hardwood boards may also be used with the grain perpendicular to the pile axis. A pile cushion is only needed for the protection of concrete piles. If the pile is in danger of being broken in tension during driving, then pile cushions are often very thick (up to 18 inches). For the protection of the pile top against a compressive failure thinner cushions are usually sufficient.

The wood pile cushion should be dry and unburned. Once the wood cushion burns, it should be replaced.

SECTION 2 INTERNAL COMBUSTION HAMMERS- SINGLE ACTING (Open End Diesel Hammers)

A. General Description

An open-end diesel hammer consists of a long slender piston (the ram), which moves inside a cylinder. The cylinder is open at its upper end, thus allowing the ram to partially emerge from the cylinder. Since the ram falls only under gravity, the DED is also called single acting.

Each open-end diesel hammer consists of seven major parts:

- A piston or ram with piston rings.
- An impact block, also with rings, onto which the ram impacts.
- A cylinder in which ram and impact block move.
- One or more fuel pumps.
- Fuel injector(s).
- Ports.
- Recoil dampener.

B. Open End Diesel Hammer Operation

The hammer is started by lifting the ram a certain distance above the exhaust ports. This is accomplished by means of a tripping device and either a hoist or a hydraulic jack. When the ram has reached the starting height, the trip is released, and the ram starts to fall under gravity.

When the bottom of the ram passes the exhaust ports, it closes them, and a certain volume of air is trapped inside the chamber formed by the cylinder, ram, and impact block. As the ram descends further, it compresses the trapped air which therefore becomes hot.

After the ram has reached a certain position between the ports and the impact block, it pushes a lever and plunger system into the fuel pump, which in turn injects a certain quantity of fuel into the chamber.

Upon impact, the ram pushes the impact block, hammer cushion, helmet and pile top rapidly downward, allowing the cylinder to fall under gravity. The impact block separates from the ram within a very short time and the pressure of the combusting air-fuel mixture will cause further separation as the ram is forced upward.

Thus, practically all components of the hammer-pile-soil system have an effect on the diesel hammer's stroke. Under normal conditions, the ram stroke increases as pile driving becomes harder. In soils with high resistance but low stiffness, a "spongy" driving situation results, and the stroke will be relatively low. A similar situation exists with very long and flexible pile.

C. Checklist for Open End Diesel Hammers

1. Before Driving Starts

- Check and record hammer model and serial numbers. The hammer model and make must match that used in GRL WEAP report submitted prior to construction.
- Check the material, size, and the condition of the hammer cushion. When measuring the hammer cushion thickness, the thickness of the striker plate should also be measured and recorded.
- Check the calibration test date, it must be within the past 2 years.
- Check the pile cushion (if present).
- Check that the helmet and pile are well matched. If the type is such that no helmet is necessary, check that the hammer and pile are well matched.
- Check helmet weight; if in doubt, have it weighed.

- Check straightness of leads, and check lead connections for tightness.
- Make sure that the portion of the leads that guide hammer do not offer excessive friction.
- Check the alignment between leads and pile.

2. **During General Driving**
   - Using a stopwatch, calculate the stroke of the open-end diesel hammer and record these results together with the blow count.
   - Check that the ram, helmet, and pile stay in alignment during driving.
3. **During Driving As Resistance Builds Up**
   - Listen as ram impacts. There should be a clear metallic sound**.**

SECTION 3 INTERNAL COMBUSTION HAMMERS – DOUBLE ACTING (Closed End Diesel Hammers)

A. General Description

A closed end diesel hammer consists of a long slender piston (the ram), which move inside a cylinder. The cylinder is closed at its upper end, thus causing the ram to compress the air trapped between ram and cylinder top. When the ram falls, it is subject to both gravity and the pressure in the “bounce chamber”. For this reason, the CED is also called double acting.

A closed end diesel hammer consists of eight major parts:

- A piston or ram with piston rings.
- An impact blocks also with rings, onto which the ram impacts.
- A cylinder in which ram and impact block move.
- One or more fuel pumps.
- Fuel injector(s).
- Exhaust ports.
- Recoil dampeners.
- A bounce chamber including bounce chamber ports which allow for a regular venting of the bounce chamber.

The exhaust ports are merely openings in the cylinder wall. The impact block usually has enlarged top and bottom diameters. The cylinder bottom, through which the center of the impact block passes, is closed down to a diameter just large enough to allow free movement. Thus, the impact block can move up and down a few inches but is prevented from falling out of the cylinder when the entire hammers is raised. The recoil dampener is located in between the cylinder bottom and the impact block bottom. Its purpose is to cushion the cylinder against a strong upward impact block movement, due to pile rebound.

B. Closed End Diesel Hammer Operation

The hammer is started by lifting the ram a certain distance above the ports. This is accomplished by means of a tripping device and either a hoist or a hydraulic jack. As the ram rises, it closes the bounce chamber ports and air is compressed in the upper (bounce).

When the ram has reached the starting height, the trip is released, and the ram starts to fall under the action of both gravity and the pressure of the air in the bounce chamber.

When the bottom of the ram passes the exhaust ports, it closes them, and a certain volume of air is trapped inside the chamber formed by the cylinder, ram, and impact block. As the ram descends further, it compresses the trapped air which, therefore becomes hot.

After the ram has reached a certain position between the ports and the impact block, it pushes a lever and plunger system into the fuel pump, which in turn injects a certain quantity of fuel into the chamber.

Upon impact, the ram pushes the impact block, hammer cushion, helmet, and pile top rapidly downward, allowing the cylinder to fall under gravity. The impact block separates from the ram within a very short time and the pressure of the combusting air-fuel mixture will cause future separation.

The magnitude of the upward ram velocity depends on:

- The hammer combustion pressure.
- The pile mass and stiffness.
- The stiffness of the hammer and pile cushions.
- The soil stiffness and/or resistance.
- The rate at which the pressure in the bounce chamber increases.

Thus, practically all components of the hammer-pile soil system influence the diesel hammer's stroke. Under normal conditions, the ram stroke increases as pile driving becomes harder. In soils with high resistance but low stiffness, a "spongy" driving situation results, and the stroke will be relatively low. A similar situation exists with very long and flexible piles.

C. Checklist for Closed End Diesel Hammers

1. Before Driving Starts

- Check and record hammer model and serial numbers. The hammer model make must match that used in GRL WEAP report submitted prior to construction.
- Check the material, size, and the condition of the hammer cushion. When measuring the hammer cushion thickness, the thickness of the striker plate should also be measured and recorded.
- Check the calibration test date, it must be within the past 2 years.
- Check helmet weight; if in doubt, have it weighed.
- Check straightness of leads, and check lead connections for tightness.

- Make sure that the portions of the leads that guide the hammer do not offer excessive friction.
- Check the alignment between leads and pile.

2. **During General Driving**
    - Using the manufacturer's gauge and the correct connection hose, measure the bounce chamber and record it.
    - Using a stopwatch, measure blows per minute and record this, together with the blow counts.
    - Check that the ram, helmet, and pile stay in alignment during driving.
3. **During Driving as Resistance Builds Up**
    - Check and record whether cylinder rebounds excessively.
    - Listen as ram impacts. There should be a clear metallic sound.
    - Observe and record whether liftoff occurs, and when fuel pump adjustments are made.

SECTION 4 LOAD TESTS/PDA

A. General

A test load is used to determine the static bearing capacity of a pile. This information is compared with the bearing capacity obtained from the hammer formula or the wave equation bearing graph.

Test loading is performed in accordance with the Standard Specifications and Special Provisions thereto.

Piling to be test loaded are designated on the plans or by the Engineer and must be driven as "Test Piling" with a complete driving record made. The pile should only be driven to satisfy the P.D.O. shown on the plans. Do not overdrive pile. The loading of the pile is done by the "Quick Test Load Method".

For the "Quick Test Load Method", the load is applied by means of hydraulic jacks reacting against a suitable beam held down by anchor piling. The Bridge Office will aid in checking the test load details.

The Area Manager should arrange well in advance of test loading for certain equipment that is furnished by the Department.

This equipment consists of load cells and deflection gages with support accessories. All other equipment and labor are to be furnished by the Contractor.

The frictional resistance of a pile generally increases with time but in some cases it may become lower. Time should be allowed for the disturbed soil to reach equilibrium around the pile; therefore, the pile test load should be applied seven days after the pile has been driven.

The anchor piling which are used in the test load setup, should be fabricated long enough to allow for deeper penetration than the test load pile (as shown on plans) with enough projection above the ground to accommodate the reaction beam and jack. The number of anchor piling has been established in the planning stage by the Contractor and approved by DOT and is dependent on the anticipated load and the amount of skin friction developed along the embedded portion. The anchor piling should be located as specified in the pile test load details, but if no details are furnished, they should be located at least five times the diameter of the anchor piles but not less than seven feet from the test load pile to minimize disturbing the soil surrounding it. All anchor piling should be driven as test piling to check the driving technique and obtain the probably dynamic driving resistance of the test load pile.

The load setup is designed to carry the test load pile to plunging failure or to the capacity of the jacking equipment.

Provision must be made for measuring accurately the gross settlement of the test load pile at regular intervals as it is gradually loaded. Gross settlement measurements should be made to the nearest thousandth of an inch by means of deflection gages. These should be supported independent of the test load pile, on beams rigidly supported from the ground. A rigid projection attached to the test load pile should be in contact with the deflection gages to actuate the sensor. The ground around the test load pile is likely to settle during loading, therefore all supports for settlement measuring devices should be located far enough away to avoid being influenced by such settlement. Supports for the deflection gage supporting beams should be at least four feet away from the test load pile or as specified in the test load details.

B. Method of Loading

The loading is applied in increments of 5 or 10 tons (to be specified by the Engineer) at 2 ½ minute intervals. The following procedure is:

1. Take initial deflection gage readings with no load.
2. Apply the specified increment of load at 2 ½ minute intervals. Keep the load constant between each application.
3. Record deflection gage readings, total load and time immediately before and after the application of each load increment.
4. When the data indicates that the pile is being failed, i.e., the load on the pile can be held only by constant pumping and the pile is being pushed into the ground, stop adding load and immediately take deflection gage and total load readings. Allow the pile to reach equilibrium in load and gross settlement for five minutes taking load and deflection gage readings at 2 ½ minute intervals.
5. Release the load slowly back to zero load and immediately upon complete release of load, record the deflection gage reading.

C. Evaluation of Tests (Double Tangent Method)

From the test load data, a Load Settlement Curve is plotted, load vs. settlement. The values of gross settlement to be used need only be the values determined just prior to the addition of each load increment. Plot the curve on a scale of one-inch equals 20 tons of load horizontally and one inch equals two tenths of an inch of settlement

vertically, except that a different scale of the same ration may be used to fit the curve to a standard sheet of graph paper.

On the load-settlement curve, draw one line that originates at zero load and settlement, parallel to the recovery line. Another line is plotted tangent to the portion of the curve that indicates plunging failure, where the rate of settlement equals 0.05 inches/ton. For the recommended scale of scales of the same ratio, this line is plotted at an angle of 11.3 degrees measured off the vertical.

The ultimate bearing capacity is shown by the point of intersection of the two tangent lines plotted on the load settlement curve. This is the load which the pile would support without excessive settlement but does not have a factor of safety.

The maximum safe static load proven by the test load is 50% of the ultimate bearing capacity.

The net settlement is the total settlement after the test load pile has been allowed to recover for five minutes after the load has been removed.

The plunging failure load is the maximum load reached during the test that indicates the pile is being forced into the ground.

The maximum load on the pile is the maximum load applied to the test load pile whether plunging failure occurs or not. It is possible to load a pile to the limit of the equipment without plunging failure occurring.

The total gross settlement is the maximum settlement obtained during the test.

It is desirable to load the pile to plunging failure, but if the limit of the loading apparatus is reached without plunging, the double tangent method cannot be used for evaluation. In this case the maximum safe static load will be 50% of the maximum load applied resulting in a net settlement of 0.25 inches or less.

The load at which 0.25 inches net settlement occurs can be determined by plotting, on the load settlement graph, a line parallel to the recovery line beginning at zero load and 0.25 inch settlement. The maximum load resulting in a settlement of 0.25 inches occurs at the intersection of this line with the gross settlement curve.

D. Recording and Submitting Data

The field data sheet "Report of Pile Load Test" should be prepared for each pile tested, similar to that shown in Table B-1.

A load settlement graph is illustrated in Figure B-1.

A complete report for each completed pile test load, prepared for submission, should consist of the following:

District Engineer's letter of comment, explanation and recommendations. Load

Settlement Graph (Figure B-1).

Report of Pile Load Test (Table B-1).

Test Pile Data, Form 500 A and Form 500 B for anchor piling and test load piling. See Section 5.

The number of copies to be prepared are as follows:

- One copy for Area Manager's Office.
- One copy for Geotechnical Engineering Bureau of OMAT.
- One copy for Bridge Office.

Job Number	250892	Test Type	Compression
Job Name	GDOT CR 386 Bridge	Tested By	Shawn Cordell
Test Date	3/18/2020	Checked By	MDB
Pile Number	Bent 1 Test Pile		

Total Deflection

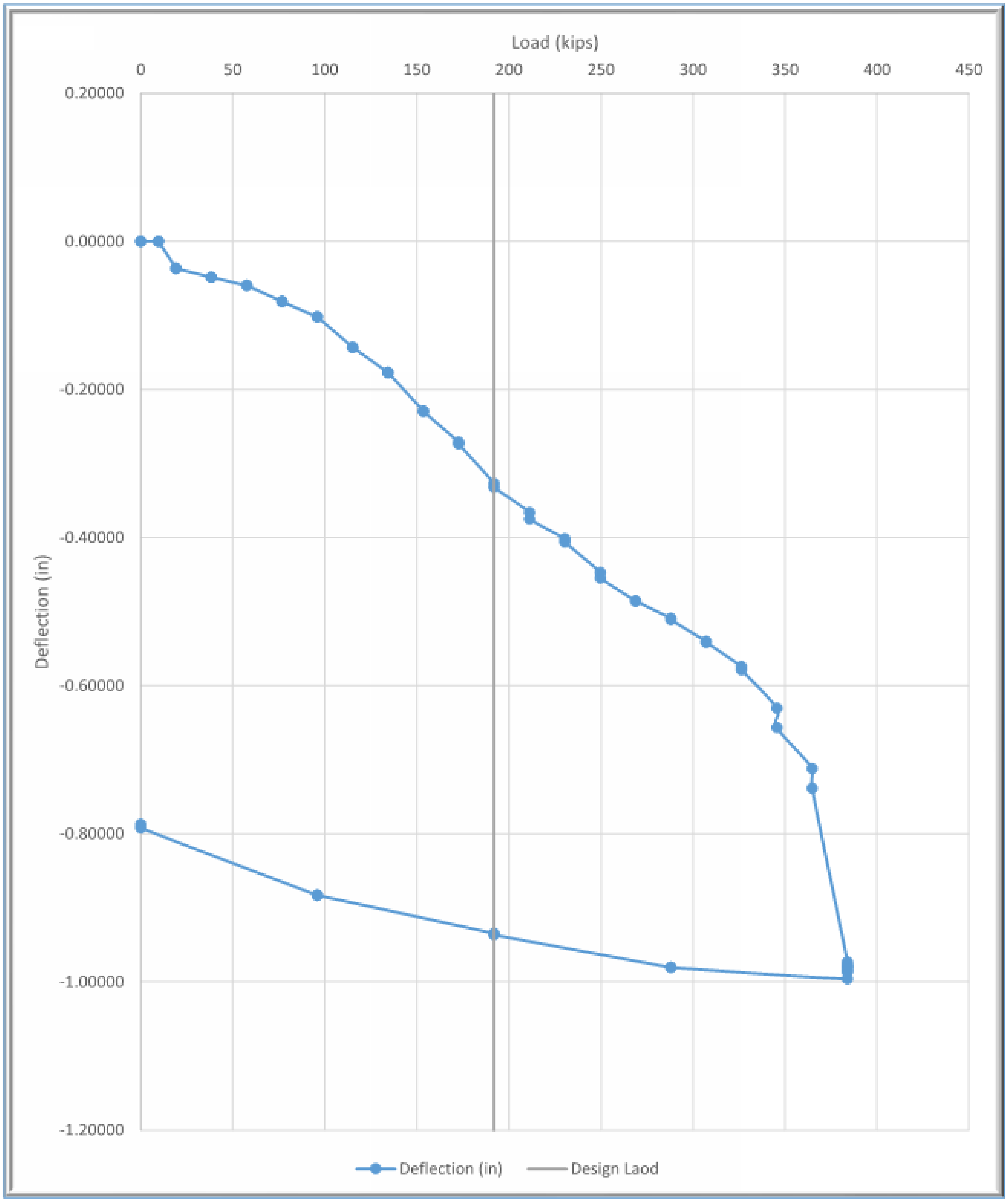


Figure B-1

E. Pile Driving Analyzer

1. A Pile Driving Analyzer is used to determine driving resistance and develop site specific driving criteria. It can also be used to troubleshoot driving issues on Construction such as:
   a. Piles unable to reach minimum tip elevations shown on the plans.
   b. When PSC piles are not showing bearing by the dynamic formula at the tip elevation given in the BFI reports.
   c. Unusually long erratic "H" piles. Many of these piles could be bending or leading off after striking ledge rock.
   d. Prestressed piles that are being damaged during driving.
2. Suggested Applications
   a. Pile Capacity

      The Pile Driving Analyzer was developed initially for the purpose of determining pile capacity. For projects designed in LRFD, using a Pile Driving Analyzer is the primary method for determining driving resistance and developing the driving criteria for piles on the project. This will be specified through the Special Provision 520 and Special Provision 523 in the Contract.

   b. Pile Selection

      Driving stresses and capacity for different pile types on a particular job site can be investigated. On large construction sites, great cost savings can be realized if the pile is chosen to minimize damage while maximizing capacity for a given pile penetration.

   c. Damage at the Pile Top

      Measurement of pile forces at the top will tell if damage to the pile top is likely. Use of the Analyzer can readily show the effect of changing throttle settings on stream and air pressures. The effect of changing the helmet and/or cushions of hammers on the stresses induced at the pile top is also readily recognized.

   d. Pile Damage at Other Locations Along the Pile Length
   e. Tension Stresses
   f. Hammer Performance

      The Analyzer computes the energy which is transmitted to the pile. This information can be used to compare with the rated or potential energy of the hammer to determine a transfer ratio (efficiency of the entire hammer assembly). Low transfer ratios can indicate problems in the driving system and maintenance can then be considered.

      Refusal blow counts can be caused by either high soil resistances or poor hammer performance.
3. Results
   a. Once the test is complete, the consultant must return to the office and process the data. They will then compile a report. The report must be submitted to the Geotechnical Bureau at Geotechnical_submittals @dot.ga.gov for approval.
   b. The Geotechnical Bureau has 7 working days to provide comments or approval. The count begins once the Geotechnical Bureau receives the report.

SECTION 5 TEST PILE/DRIVING DATA PILE FORMS 500A AND 500B

The attached sheets show examples of completed D.O.T. forms 500A and 500B below for a Test Pile and a Driving Data Pile respectively. Blank forms are also included and may be reproduced for use as necessary Forms can be found on the State Construction Office Webpage to download..

D.O.T. 500A
(10-20)

Test Pile ☑
or
Data Pile ☐

Date: 6/7/2020

Project Number. PI 122012 County HALL

Bridge Carrying SR 369 Over CHATTAHOOCHEE RIVER

PILING		LOCATION			SUMMARY	
UT X		DATA OR TEST PILE NO.	BRIDGE NO.	BENT NO.	ELEVATIONS IN WHOLE NO. ONLY	PILE LENGTH ESTIMATED IN BFI REPORT. THIS BENT
TT X		2	SOUTH SITE	PILE NO.	1 CUT OFF 12	FT
H BP X					GROUND 9	
MS IN, O.D. X					2 FINAL TIP -62	
PSC 14 IN. X	14				3 ACCEPT. TIP -62	
OTHER		HAMMER				REMARKS
PLAN DRIVING OBJECTIVE (P.D.O.)		GRAVITY	LB.		1 - 2 = 74	
☐ PRACTICAL REFUSAL		MKT DE			1 - 3 = 74	
☐ DRIVE RESIST	TONS	DELMAG D			NAME:	
☑ MIN. TIP ELEV.	-63	VULCAN NO.			TRAVIS BENNETT	
		LINKBELT MODEL				
		OTHER	ICE 1070			

DATA BEGAN WITH A PENT. OF 26 FEET BELOW CUT-OFF AND A TIP ELEVATION OF -14 (WHOLE NO'S ONLY)

HAMMER FALL (FEET)	NO. OF BLOWS	TOTAL PENT. (INCHES)	AVER. PENT. PER BLOW (INCHES)	ELEVATION OF TIP WHOLE FEET	DRIVING RESISTANCE IN WHOLE TONS	OCCASIONAL CORRECTED TIP ELEVATION, FINAL TIP ELEVATION, ORDER LENGTH. ETC.
15.75	5	12		-14	12	START 6/7/2020 @ 3:00 PM
15.75	6	12		-15	14	
15.75	7	12		-16	16	
20.12	6	12		-17	18	
20.12	6	12		-18	18	
20.12	6	12		-19	18	
19.17	4	12		-20	12	
20.12	5	12		-21	15	
20.93	7	12		-22	22	
20.93	8	12		-23	25	
20.93	7	12		-24	22	
21.74	5	12		-25	17	
21.74	7	12		-26	23	
22.52	10	12		-27	32	
22.52	7	12		-28	24	

* FOR GRAVITY AND POWER HAMMERS. / FOR DIFFERENTIAL OR DOUBLE ACTING STEAM OR AIR HAMMERS USE MANF.ENERGY RATING. / FOR ENCLOSED - RAM DISEL HAMMERS, CONVERT BOUNCE CHAMBER PRESSURE READING TO "E" VALUE USING CHART AND APPROPRIATE FORMULA

D.O.T. 500B
(10-20)
TEST / DATA PILE NUMBER 2 SOUTH CONTNIUED. PAGE NO. 2 OF 2

Project Number. PI 122012 County HALL

HAMMER FALL (FEET)	NO. OF BLOWS	TOTAL PENT. (INCHES)	AVER. PENT. PER BLOW (INCHES)	ELEVATION OF TIP WHOLE FEET	DRIVING RESISTANCE IN WHOLE TONS	OCCASIONAL CORRECTED TIP ELEVATION, FINAL TIP ELEVATION, ORDER LENGTH. ETC.
21.74	8	12		-29	26	
20.93	6	12		-30	19	
20.93	6	12		-31	19	
20.93	5	12		-32	16	
20.93	5	12		-33	16	
20.12	5	12		-34	15	
21.74	6	12		-35	20	
22.52	8	12		-36	26	
22.52	8	12		-37	26	
21.74	8	12		-38	25	
21.74	8	12		-39	25	
21.74	7	12		-40	23	
21.74	7	12		-41	23	
21.74	8	12		-42	25	
21.74	7	12		-43	23	
21.74	8	12		-44	25	
22.52	8	12		-45	26	
22.52	7	12		-46	24	
22.52	8	12		-47	26	
20.93	10	12		-48	30	STOP 3:10 PM
24.08	13	12		-49	43	START 3:12 PM
24.08	9	12		-50	31	
24.08	9	12		-51	31	
22.52	8	12		-52	26	
24.08	8	12		-53	28	
24.08	9	12		-54	31	
24.08	8	12		-55	28	
24.84	7	12		-56	26	
26.37	14	12		-57	50	
24.84	13	12		-58	44	
24.84	12	12		-59	41	
24.84	10	12		-60	35	STOP 3:14 PM
24.84	8	8		-61	41	START 3:26 PM
29.43	13	4		-61	116	STOP 3:27 PM
22.52	112	6		-61	178	START 3:46 PM
23.32	31	6		-62	118	
20.12	42	6		-62	117	STOP 3:50 PM

D.O.T. 500A
(10-20)

Test Pile ☐
or
Data Pile ☑

Date: 6/5/2020

Project Number. PI 122012 County HALL

Bridge Carrying SR 369 Over CHATTAHOOCHEE RIVER

PILING		LOCATION			SUMMARY	
UT X		DATA OR TEST PILE NO.	BRIDGE NO.	BENT NO.	ELEVATIONS IN WHOLE NO. ONLY	PILE LENGTH ESTIMATED IN BFI REPORT. THIS BENT
TT X					1 CUT OFF 19	
H BP X				PILE NO.	GROUND 9	
MS 14 IN, O.D. X	3/8" WALL	REACTION	SOUTH SIDE		2 FINAL TIP -131	FT
PSC IN. X		HAMMER			3 ACCEPT. TIP -131	REMARKS
OTHER	BOTTOM PLATE OPT 2 BEARING SHOE	GRAVITY		LB.	1 - 2 = 150	
PLAN DRIVING OBJECTIVE (P.D.O.)		MKT DE				
		DELMAG D			1 - 3 = 150	
☐ PRACTICAL REFUSAL		VULCAN NO.				
☐ DRIVE RESIST	TONS	LINKBELT MODEL			NAME:	
☑ MIN. TIP ELEV.	-140	OTHER	ICE 1070		TRAVIS BENNETT	

DATA BEGAN WITH A PENT. OF 31 FEET BELOW CUT-OFF AND A TIP ELEVATION OF -12 (WHOLE NO'S ONLY)

Energy	NO. OF BLOWS	TOTAL PENT. (INCHES)	AVER. PENT. PER BLOW (INCHES)	ELEVATION OF TIP WHOLE FEET	DRIVING RESISTANCE IN WHOLE TONS	OCCASIONAL CORRECTED TIP ELEVATION, FINAL TIP ELEVATION, ORDER LENGTH. ETC.
	2	12		-12		Start 2:20 PM June 5, 2020
	5	12		-22		Stop 2:34 PM
15.75	6	12		-32	14	Start June 6,2020 8:27 AM
17.55	5	12		-36	14	
17.55	6	12		-45	16	
16.74	6	12		-52	15	
20.12	8	12		-60	24	
20.12	9	12		-65	26	
20.93	9	12		-70	27	
21.74	11	12		-75	34	
21.74	11	12		-80	34	
21.74	11	12		-85	34	
23.31	12	12		-90	36	
24.08	13	12		-95	42	
25.16	19	12		-100	58	

* FOR GRAVITY AND POWER HAMMERS. / FOR DIFFERENTIAL OR DOUBLE ACTING STEAM OR AIR HAMMERS USE MANF.ENERGY RATING. / FOR ENCLOSED - RAM DISEL HAMMERS, CONVERT BOUNCE CHAMBER PRESSURE READING TO "E" VALUE USING CHART AND APPROPRIATE FORMULA

D.O.T. 500B
(10-20)

TEST / DATA PILE NUMBER 1 CONTNIUED. PAGE NO. 2 OF 2

Project Number. 122012 County Hall

Energy	NO. OF BLOWS	TOTAL PENT. (INCHES)	AVER. PENT. PER BLOW (INCHES)	ELEVATION OF TIP WHOLE FEET	DRIVING RESISTANCE IN WHOLE TONS	OCCASIONAL CORRECTED TIP ELEVATION, FINAL TIP ELEVATION, ORDER LENGTH. ETC.
24.08		12		-105	53	
25.61		12		-110	73	
26.37		12		-112	68	Stop 8:42 AM
27.14		12		-114	74	Start 8:45 AM
27.14		7		-118	69	Stop 8:47 AM
31.72	160	12		-120	231	Start 10:18 AM
31.72	120	12		-123	212	
31.72	120	12		-125	212	
31.72	110	12		-126	205	
31.72	116	12		-127	209	
31.72	115	12		-129	208	
31.72	122	12		-130	213	
31.72	200	8		-131	264	Stop 10:52 AM
						Plate still on bottom

D.O.T. 500A
(10-20)

Test Pile ☐
or
Data Pile ☐

Date

Project Number. ______ County ______

Bridge Carrying ______ Over ______

PILING

UT . . . . X ______
TT . . . . X ______
H ______ BP ______ X ______
MS ______ IN, O.D. X ______
PSC ______ IN. ______ X ______

OTHER

PLAN DRIVING OBJECTIVE (P.D.O.)

☐ PRACTICAL REFUSAL ______
☐ DRIVE RESIST ______ TONS
☐ MIN. TIP ELEV.

LOCATION

DATA OR TEST PILE NO. | BRIDGE NO. | BENT NO. ______ | PILE NO.

HAMMER

GRAVITY ______ LB.
MKT DE ______
DELMAG D ______
VULCAN NO. ______
LINKBELT MODEL ______
OTHER

SUMMARY

ELEVATIONS IN WHOLE NO. ONLY

1 CUT OFF ______
GROUND ______
2 FINAL TIP ______
3 ACCEPT. TIP

1 - 2 = ______

1 - 3 = ______

NAME:

PILE LENGTH ESTIMATED IN BFI REPORT. THIS BENT ______ FT

REMARKS

DATA BEGAN WITH A PENT. OF FEET BELOW CUT-OFF AND A TIP ELEVATION OF | WHOLE NO'S ONLY

HAMMER FALL (FEET)	NO. OF BLOWS	TOTAL PENT. (INCHES)	AVER. PENT. PER BLOW (INCHES)	ELEVATION OF TIP WHOLE FEET	DRIVING RESISTANCE IN WHOLE TONS	OCCASIONAL CORRECTED TIP ELEVATION, FINAL TIP ELEVATION, ORDER LENGTH. ETC.

* FOR GRAVITY AND POWER HAMMERS. / FOR DIFFERENTIAL OR DOUBLE ACTING STEAM OR AIR HAMMERS USE MANF.ENERGY RATING. / FOR ENCLOSED - RAM DISEL HAMMERS, CONVERT BOUNCE CHAMBER PRESSURE READING TO "E" VALUE USING CHART AND APPROPRIATE FORMULA

D.O.T. 500B
(10-20)

TEST / DATA PILE NUMBER __________ CONTNIUED. PAGE NO. _______ OF _______

Project Number. ______________________________ County ____________________

HAMMER FALL (FEET)	NO. OF BLOWS	TOTAL PENT. (INCHES)	AVER. PENT. PER BLOW (INCHES)	ELEVATION OF TIP WHOLE FEET	DRIVING RESISTANCE IN WHOLE TONS	OCCASIONAL CORRECTED TIP ELEVATION, FINAL TIP ELEVATION, ORDER LENGTH. ETC.

SECTION 6 DRILLED SHAFT INSPECTION REPORT FORM

The items listed under Chapter 2: Section 1. E. 7 can be recorded on the form depicted below. Please contact your District Construction Manager for an excel file of the form below.

GEORGIA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING BUREAU

DRILLED CAISSON INSPECTION FORM

A. GENERAL INFORMATION

Project No.: Bent No. & Location:
Bridge:

Drilling Contractor:
General Contractor:
Inspector:

	DESIGN MEASUREMENTS	FIELD MEASUREMENTS
Top El.		
Bottom Casing El.		
Casing I.D.		
Bottom El.		
Caisson Diam.		
Caisson Length	'	'

Design Load: Ground Elev.: Water Elev.:
Spacer Type: Side: Bottom:

B. CASING DATA

Casing No.	I.D.	Sidewall Thickness	Length	Top Elev.	Temporary or Permanent
					Permanent

C. REBAR / SPIRAL DETAILS

Vertical Bar Types

Type (1) Size: No. of bars: Bundled (Y or N):
Length: Clear Spacing between Bars:

Type (2) Size: No. of bars: Bundled (Y or N):
Length: Clear Spacing between Bars:

Spiral Bars

Size:
Pitch:
Double Wire – Double Tied (Y or N):

Rebar Cage Stiffeners

Size:
Spacing:

D. SLURRY

Type of Slurry or Additive	Brand	Mix Proportions

Treatment or Recycling Unit:

Property Tests

Date	Time	Density	Viscosity	pH	Sand Content	Sample Origin

E. DRILLING RECORD

Drilling Rig.:	(Make)	(Model)	(Engine)	(Torque)	(Crowd)

Date	Time	Depth	Soil Descrip.	Drilling Tool (Type / Size)	Observations (Setbacks, Cave-ins, Slurry loss, etc.)

STEEL PLACEMENT **Date:**

Start Time	Finish Time	Task Description

F. CONCRETE PLACEMENT **Date:**

Wet or Dry Pour: Wet Pour or Dry Pour

Placement Method: Bucket or Pump

Tremie

ID:
Length:
Hopper Capacity:
Type of Plug:

Truck No.	Conc. Vol.	Slump	Batch Time	Arrival Time	Start Time	Finish Time	Tremie Bottom Depth	Depth to Concrete (Theoretical)	Depth to Concrete (Measured)
1	8							#DIV/0!	
2	16							#DIV/0!	
3	24							#DIV/0!	
4	32							#DIV/0!	
5	40							#DIV/0!	
6	48							#DIV/0!	
7	56							#DIV/0!	
8	64							#DIV/0!	
9	72							#DIV/0!	
10	80							#DIV/0!	
11	88							#DIV/0!	
12	96							#DIV/0!	
13	104							#DIV/0!	
14	112							#DIV/0!	
15	120							#DIV/0!	
16	128							#DIV/0!	
17	136							#DIV/0!	

APPENDIX C

Steel Beams- Temperature Adjustments

The coefficient of thermal expansion of steel can be used as 0.0000065. The correction "C" to be applied to a beam or part of length "L" for an existing temperature of T° Fahrenheit is as follows:

C = 0.0000065 (T° - 60°) (L)

C = Total correction in feet for the particular point on the beam defined by distance "L".

60° = Assumed temperature at which beam would be set and from which plan dimensions are set.

L= The length in feet from the fixed point to the point for which the correction is being calculated.

"C" will be the distance in feet that an anchor bolt will be moved off of the center of an expansion slot, the distance the top of a rocker bearing will be set off of a plumb line through the center of the bottom of the rocker, or the distance that the centerline of a sliding bearing will be moved off of the centerline of the bearing plate.

"C" may be determined by either the formula given above or from the use of Table No. C-1 gives beam movements (either expansion or contraction depending upon whether the temperature difference is plus or minus) for temperature increments of 5° F and for each foot of beam length up through 10 feet. Thus the movement for any length of beam can be determined by multiplication and addition.

Example: Assume that a bridge consists of a three span continuous unit which is 81' – 101' – 81' in length. As shown in Figure C-1 (a typical beam) the beams are fixed at Bent 2 and will expand or contract from this point. The beams have been spliced, radiographed, and approved. It is time to do the final setting of the beams. A temperature determination is made and it is found that the temperature is 35° F. The required anchor bolts or "lubrite" plates in relation to the centerline of the expansion slots or the bearing plate is determined by formula and from Table No. C-1as follows:

By Fomula:

For Bent 1: C = 0.0000065 (T-60) (L)

C = 0.0000065 (35-60) (81)

C = 0.0000065 (-25) (81) C = 0.0132

feet = 3/16"

For Bent 3: C = 0.0000065 (-25) (101)

C = 0.0164 feet = -3/16”

For Bent 4: C = 0.0000065 (-25) (182)

C = 0.0296 feet = -3/8”

By Table No. C-1: To use the table break the lengths of beam up into multiples of 10 feet plus the remainder.

For Bent 1: Beam length = 8 (10) + 1

The contraction for 10 feet at 25° difference in temperature is taken from the table as 0.0016250. The contraction for 1 foot at 25° difference in temperature is taken from the table as 0.0001625. “C” therefore is determined as follows:

C = 8 (0.0016250) + 0.0001625 C = 0.0132

feet = -3/16”

For Bent 3: Beam Length = 10 (10) + 1

C = 0.0164 feet = -3/16”

For Bent 4: Beam Length = 18 (10) + 2

C = 18 (0.0016250) + 0.0003250 C = -

0.0296 feet = -3/8”

DIFFERENCE IN ACTUAL TEMPERATURE AND 60 F. (T-60)	BEARING DEVICE ADJUSTMENT IN FEET FOR EACH INCREMENT									
+/- 75	0.0004875	0.0009750	0.0014625	0.0019500	0.0024375	0.0029250	0.0034125	0.0039000	0.0043875	0.0048750
+/- 70	0.0004550	0.0009100	0.0013650	0.0018200	0.0022750	0.0027300	0.0031850	0.0036400	0.0040950	0.0045500
+/- 65	0.0004225	0.0008450	0.0012675	0.0016900	0.0021125	0.0025350	0.0029575	0.0033800	0.0038025	0.0042250
+/- 60	0.0003900	0.0007800	0.0011700	0.0015600	0.0019500	0.0023400	0.0027300	0.0031200	0.0035100	0.0039000
+/- 55	0.0003575	0.0007150	0.0010725	0.0014300	0.0017875	0.0021450	0.0025025	0.0028600	0.0032175	0.0035750
+/- 50	0.0003250	0.0006500	0.0009750	0.0013000	0.0016250	0.0019500	0.0022750	0.0026000	0.0029250	0.0032500
+/- 45	0.0002925	0.0005850	0.0008775	0.0011700	0.0014625	0.0017550	0.0020475	0.0023400	0.0026325	0.0029250
+/- 40	0.0002600	0.0005200	0.0007800	0.0010400	0.0013000	0.0015600	0.0018200	0.0020800	0.0023400	0.0026000
+/- 35	0.0002275	0.0004550	0.0006825	0.0009100	0.0011375	0.0013650	0.0015925	0.0018200	0.0020475	0.0022750
+/- 30	0.0001950	0.0003900	0.0005850	0.0007800	0.0009750	0.0011700	0.0013650	0.0015600	0.0017550	0.0019500
+/- 25	0.0001625	0.0003250	0.0004875	0.0006500	0.0008125	0.0009750	0.0011375	0.0013000	0.0014625	0.0016250
+/- 20	0.0001300	0.0002600	0.0003900	0.0005200	0.0006500	0.0007800	0.0009100	0.0010400	0.0011700	0.0013000
+/- 15	0.0000975	0.0001950	0.0002925	0.0003900	0.0004875	0.0005850	0.0006825	0.0007800	0.0008775	0.0009750
+/- 10	0.0000650	0.0001300	0.0001950	0.0002600	0.0003250	0.0003900	0.0004550	0.0005200	0.0005850	0.0006500
+/- 5	0.0000325	0.0000650	0.0000975	0.0001300	0.0001625	0.0001950	0.0002275	0.0002600	0.0002925	0.0003250
	1	2	3	4	5	6	7	8	9	10
	LENGTH OF BEAM INCREMENTS IN FEET									

STEEL BEAM THERMAL EXPANSION DATA

TABLE C-1

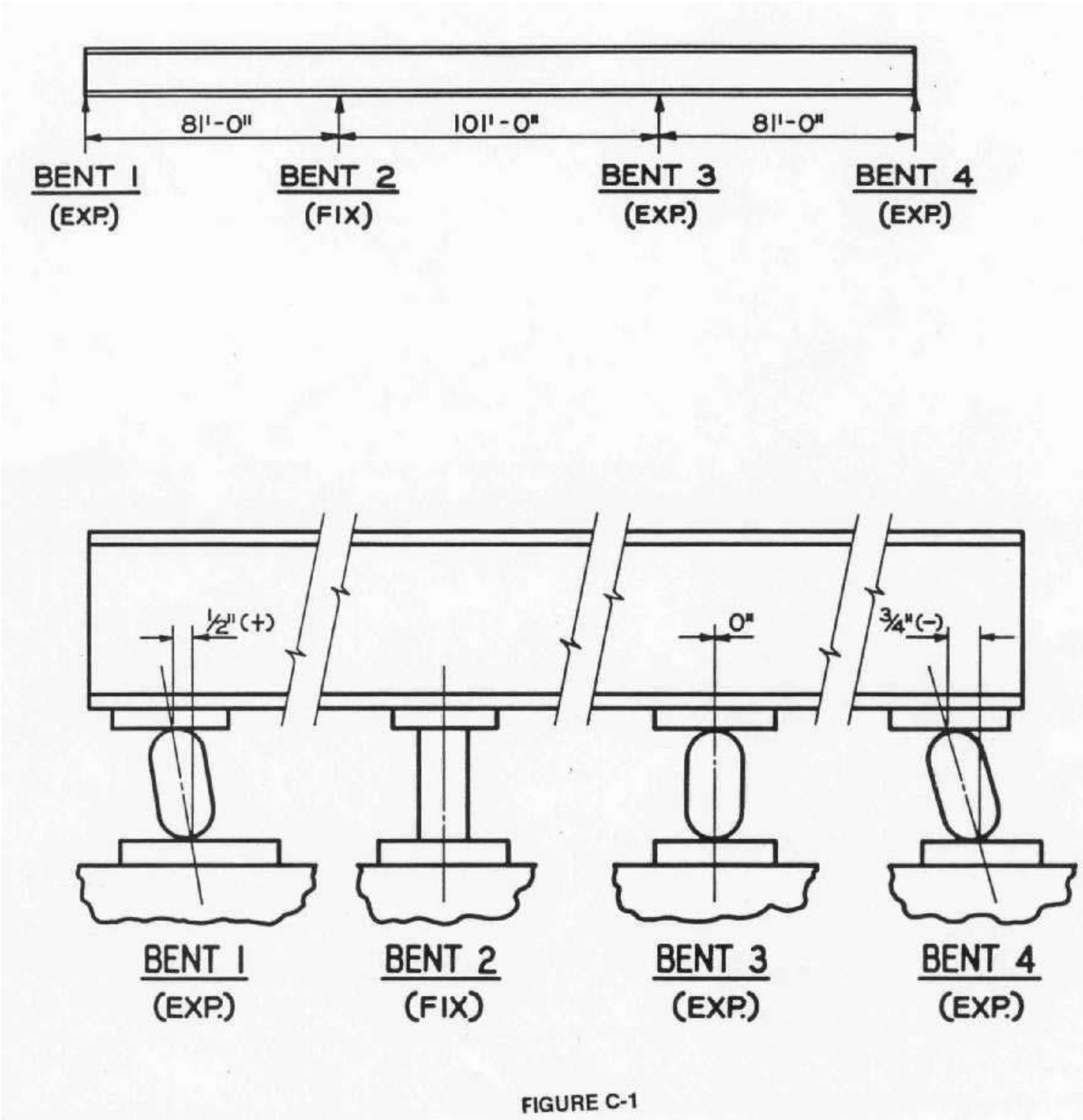

81'-0"
101'-0"
81'-0"
BENT 1
(EXP.)
BENT 2
(FIX)
BENT 3
(EXP.)
BENT 4
(EXP.)
1/2" (+)
0"
3/4" (-)
BENT 1
(EXP.)
BENT 2
(FIX)
BENT 3
(EXP.)
BENT 4
(EXP.)
FIGURE C-1

Figure C-1

In each case by either method the same calculated theoretical movement “C” is determined. This calculation is rounded off to the nearest sixteenth of an inch. The actual location of the rocker, anchor bolt, or “lubrite” plate is determined by actual measurement. This measurement must be made when the temperature is the same as that used in the temperature adjustment calculations, otherwise the calculations must be re-figured for the temperature when the actual measurements were taken. The difference between the calculated movement and the actual location represents the amount of adjustment that must be made. The magnitude and the direction of the adjustment should be recorded so that the adjustment may be properly made at any time. The actual locations of rockers at each of the bearings at the time the temperature was determined is assumed and is shown below.

The actual adjustment to be made will be determined as follows:

For Bent 1:

Actual position of Rocker =1/2” (expanded) Calculated position

of Rocker = 3/16” (contracted)

Actual Adjustment necessary = ½+3/16=11/16” towards Bent 2.

Actually, this is the amount the top of the rocker should be moved towards Bent 2. The same results can be achieved by moving the bottom of the rocker away from Bent 2 by the same amount or by a combination of the above to yield the total adjustment necessary.

For Bent 2:

Bent 2 is fixed. No adjustment is needed.

For Bent 3:

Actual position of Rocker = 0” (Plumb) Calculated position of

Rocker = -3/16” (contracted)

Actual Adjustment necessary = 0 + 3/16” towards Bent 2.

Actually, this is the amount the top of the rocker should be moved towards Bent 2. The same result can be achieved by moving the bottom of the rocker away from Bent 2 by the same amount or by a combination of the above to yield the total adjustment necessary.

For Bent 4:

Actual position of Rocker = 3/4” (contracted) Calculated position

of Rocker = 3/8” (contracted)

Actual Adjustment necessary = 3/4” –3/8” = away from Bent 2.

Actually, this is the amount the top of the rocker should be moved away from Bent 2. The same result can be achieved by moving the bottom of the rocker towards Bent 2 by the same amount or by a combination of the above to yield the total adjustment necessary.

Once these adjustments are made the anchor bolts may be grouted. This must be done carefully as detailed in the Specifications.

APPENDIX D
Method of Test for Determining Profile Index for Bridge Decks and Approach Slabs

A. Scope

This procedure utilizes surface profiles obtained from the Rainhart (Model 860) Profilograph. Profiles can be obtained and evaluated on the jobsite and made readily available to the Contractor to expedite corrective action if required.

Profiles will be obtained on all state roads where the current traffic count is 2000 VPD or higher, or as designated on plans.

Requests from the Contractor for testing should be made to the OMAT, Concrete Branch, at least five days prior to need. Insure all surfaces are clean and cleared of all obstructions prior to Profilograph arrival. Approach slabs should be in place and are tested in conjunction with bridge decks.

B. Equipment

The only special equipment needed to determine the Profile Index is a clear plastic scale, having an opaque band 0.1 inches wide near the center, with parallel lines scribed 0.1 inch apart on both sides of the opaque band, to measure both positive and negative deviations.

C. Procedures

Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. See Figure D-1. Scallops occurring above and below the blanking band are then totaled for the length of the scale to the nearest 0.05 inch (half of tenth). The scale is then moved forward repeating the above procedure until the entire trace has been totaled.

D. Calculations

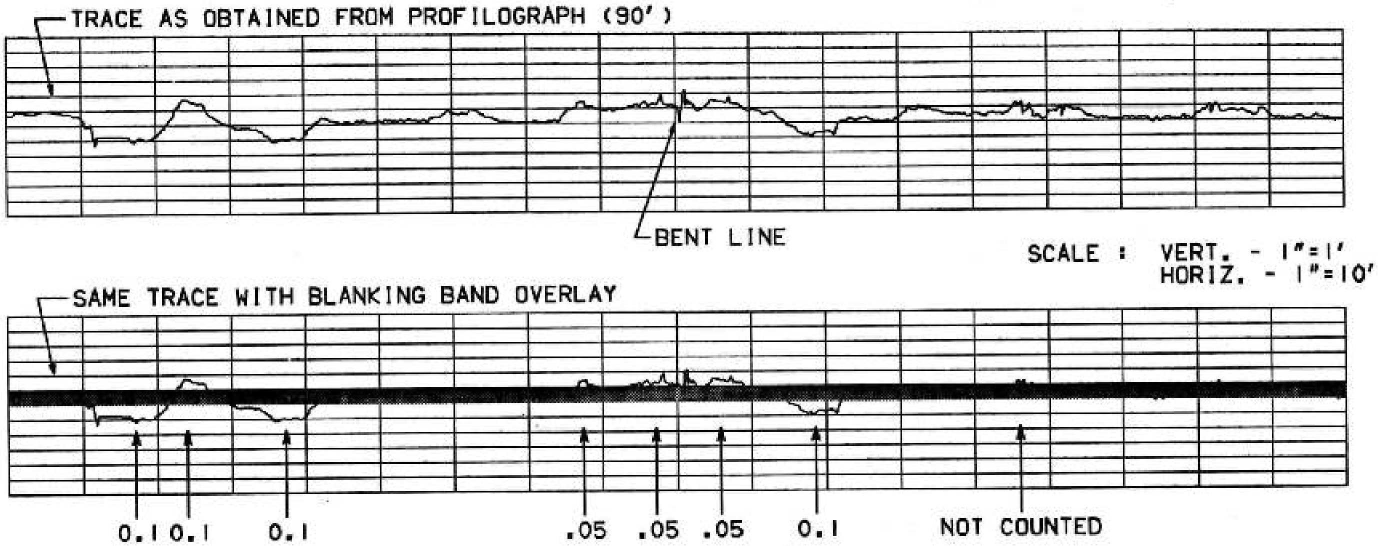
The Profile Index is determined as "inches per mile in excess of the 0.1 inch blanking band". The formula for calculating Profile Index is as follows:

$$\text{Profile Index} = \frac{5280'(1\text{ Mile})}{\text{Length of tested section (feet)}} \times \text{Total Count (inches)}$$

The Profile Index for each lane is then determined by averaging the two wheel paths of that lane.

E. Specification Limits

Profile index values shall not exceed the limits set forth in applicable Specifications or as designated on the Plans. (See Bridge Decks, Section 500 and Approach Slabs, Section 433, of the Specifications).



TOTAL COUNT FOR THIS SECTION = 5.5 TENTHS OF AN INCH. (0.55)

TOTAL LENGTH OF TRACE = 90'

PROFILE INDEX (P.I.) FOR THIS SECTION = $\frac{5820'}{90'}$ X 0.55

P.I. = 32.3 INCHES PER MILE

PROFILE INDEX CALCULATIONS

FIGURE D-1

APPENDIX E
Post-tensioned Concrete Box Beam Bridges

A. Shop Drawings

Shop drawings for post tensioned bridges are necessary to detail special, fabricator added reinforcement steel, reinforcement or coil ties under anchorage plates, duct types, size and location, anchorage systems, number of strands per tendon, jacking sequence, jack force, initial tendon elongation, anchor set, grout mix and grout ports and vents.

Stressing may be accomplished by tensioning wire, bar or strand. Strand is the most commonly used material for post tensioning. Tendons are made up of several strands together. Tendons are required to be stressable from both ends. Dead end anchorages embedded in concrete are not allowed due to experience with failures of these anchorages and the difficulty in replacing the embedded anchorage.

Details of duct installation should include support locations and duct spacing requirements as called for in the plans and/or specifications. Space between the ducts insures that the concrete can incase the ducts without voids occurring in the concrete and therefore prevent collapse of the ducts from lateral pressures when stressed. All duct joint connections are to be metallic and taped mortar tight. Connections should be staggered from adjacent duct connections as per plan and/or specification requirements.

B. Design Calculations

Some of the design calculations are needed in the field to carry out the post tensioning. Calculations needed are, jacking force of each tendon, tendon elongation calculations, friction and wobble losses, modulus of elasticity of the strands, seating losses, and length of tendon used in design. These design calculations values may need adjustment in the field for actual dimensions as built or altered, and for actual values of the materials and equipment used.

C. Testing and Approval of Prestressing Materials

Longitudinal duct is required to be rigid galvanized ferrous metal that is mortar tight and can be shaped without crimping or flattening. The use of plastic duct has been limited to short longitudinal and transverse tendons. All anchorage devices must hold a load of at least 95 percent of the guaranteed ultimate tensile strength of the tendon. Samples of the duct and a complete anchorage assembly must be submitted to the OMAT for approval. Two strand samples five feet in length must be taken from each bent or lot of strand. Tests must be completed, and all material approved prior to use in tendons.

D. Jack Calibration Curve

Stressing equipment, gauge and ram, must be calibrated and have certified charts for each gauge and ram combination. These calibration curves convert jacking force to hydraulic pressure in a gauge. The gauge readings are used to measure the force applied to the tendon.

E. Tendon Tests and Test Block

Before work is begun to construct the superstructure of the bridge tests must be performed. These tests are the Tendon Modulus of Elasticity Test, a Test Block, and the In-Place Friction Test.

1. Tendon Modulus of Elasticity Test

A test bench must be constructed of sufficient length to establish the actual tendon modulus of elasticity with the full-size tendon in a straight path without any contact friction of the tendon. The actual modulus of elasticity determined from this test is used to calculate elongation of the tendon when stressed and to determine the acceptability of the tensioned tendon.

2. Test Block

Prior to construction of the bridge a test block that simulates concrete dimensions and cross section at each point of anchorage is to be constructed. Forms, reinforcement, and concrete are placed in procedures proposed for actual bridge construction and stressed using the proposed post tensioning system. The test block verifies the design of the anchorage reinforcement size and location, and the configuration and strength of the anchorage. This test is considered successful provided there are no cracks more than a 1/100 inch in width developed within three days with the full load on the test block.

3. In-Place Friction Test

In-place friction tests are performed on the first draped tendon to establish actual friction and wobble values to be used for determining the applied stresses in order to accomplish the design stress value for the tendon. Results of the In-Place Friction test are to be submitted to the office of Bridge and Structural Design for review and approval before proceeding to permanent stressing and locking off of the tendon with wedges.

Adjustments in the jacking forces, elongation measurements, and number of strands may be necessary to obtain the desired stress in the structure. Tendons are not to be installed until stresses using the determined friction values are approved.

F. Installing Tendons

Before strands can be installed the Contractor should demonstrate that the ducts are unobstructed, free of water, and free of debris. Protection must be provided to the prestressing steel to protect it from physical damage, dirt, and rust. Rusting greater than a light film that can be wiped off with fingers is cause to reject the strand.

G. Inspection of Stressing

Tendon stressing must be observed, understood, and documented by the Engineer. The Contractor's recordings of gauge readings, elongation measurements, and anchor set must be observed and verified by the Engineer during stressing. Post tensioning must be applied so that the force and elongation can be measured at all times. Wire and strand breakage are to be documented and may not exceed the allowed two percent of total steel area.

Actual force and elongation measurements must compare to calculated values within plus or minus five percent. If the actual measurements do not compare to the calculated values within five percent, all stressing is to be stopped and the work is not to proceed until corrected or until an adjustment in the stressing to compensate for the differences are submitted to and approved by the Office of Bridge and Structural Design. After stressing is completed, the recorded gauge readings and the elongation, and anchor set measurements are submitted to the Office of Bridge and Structural Design. The tail ends of the stressed tendons are not to be cut and the tendons are not to be grouted until the post tensioning has been approved.

1. Maximum Stress of Strand

The maximum stress of the strand is not to exceed 80 percent of the guaranteed ultimate tensile strength of the strand at any time during the stressing unless a lower maximum stress is specified.

2. Anchor Stress of Strand

The stress of the strand when the strand is permanently anchored is not to exceed 70 percent of the guaranteed ultimate tensile strength of the strand. The anchor set value is used to obtain the permanently anchored stress. Increasing the anchor set may be used to correct overstress however the final corrected stress of the strand shall not exceed the allowed five percent variation from the design stress of the strand at any point along the strand.

H. Stressing Computation

The computations presented herein are for the generally used materials and methods of post tensioning. Each bridge, however, is unique and requires individual design and a particular stressing approach for the post tensioning to be applied.

1. Jacking Force

Tendons are tensioned by using a hydraulic ram equipped with an accurate gauge measuring the internal hydraulic pressure in the ram. The tensioning force applied is converted from the gauge reading. The force exerted by the ram or jack is the result of pump oil pressure against the ram area of the jack.

Load = P applied = (gauge psi) x (ram area in sq. in.)

Friction in the jack and accurate determination of the ram area are corrected by a jack calibration curve that converts the tensioning force applied to gauge pressure readings.

gauge reading = psi = pounds per square inch

psi = (number of strands) x (load per strand in kips) x psi ÷ kips from jack calibration curve)

2. Strand Properties

Strand is the predominate material used for post tensioning. The most efficient strand to reduce the total number of strands is 0.6” diameter, 270 ksi strand. The 0.6 inch is the nominal diameter of the seven wires that make up the strand. The total area of the seven wires is equal to 0.217 sq. inches. Two hundred seventy ksi is the guaranteed ultimate tensile strength of the strand in kips per square inch referred to as the GUTS of the strand.

270 ksi = GUTS = maximum strength

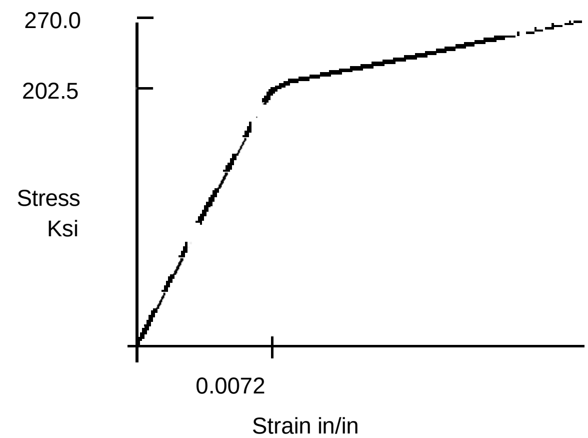
270,000 psi x 0.217 sq. in. = 58,590 lbs = 100% or max. load Initial

working load = 75% of GUTS

(.75)(58.59K) = 43.95K

Initial working stress = 75% of GUTS x steel area

43.95K ÷ 0.217 sq. in. = 202.5 ksi



Typical Stress-strain Curve 270 Ksi Strand

Modulus of Elasticity = E

$$E = \frac{\text{work load stress}}{\text{work load strain}}$$

E = 202.5 ÷ 0.0072

E = 28,130,000 for example strand

3. Elongation Formula

$$\text{Elongation} = \frac{PL}{AE}$$

P = Tensioning force, in pounds

L = Length of strand distance from dead end anchorage to live end reference point, in inches

A = Cross-sections area of strand, in sq. inches

E = Modulus of elasticity of strand, in pounds per square inch An example

for 100 feet of strand:

$$\text{Elongation} = \frac{43.95\text{K x (100 ft. x 12 in/ft)}}{0.217 \text{ sq. in. x } 28{,}130 \text{ ksi}}$$

Elongation = 8.64 inches

4. Elongation Corrections and Losses

A starting point tension defined as a preload is applied to each tendon. Elongation is not used to measure the amount of preload tension. The preload is determined by hydraulic jack gauge and is normally 20 percent of the total tensioning force. So that the elongation formula would be adjusted for a 20 percent preload as:

$$\text{Elongation} = \frac{0.8\,PL}{AE}$$

Correction for strand anchorage slip is added to the design elongation to compensate for the loss from the wedge bite into the strand determined from movement measured before and after tensioning.

Anchor set must be checked for agreement with the anticipated value used in the design stress calculations. Anchor set will reduce the high stress at the jacking end of the tendon and may be adjusted within a limited range to help keep initial strand stresses from exceeding 70 percent of the specified minimum ultimate tensile strength of the prestressing steel. Variation from the anticipated value of anchor set must be measured and elongation and stressing force corrected for by deducting excessive anchor-set from measured elongation.

When measuring tendon elongation, anchor set and tendon elongation within the jack must be subtracted. For example, if jacking to a stress of 202.5 ksi in the strand with a required anchor set of 5/8 inch and a jack with a length of 30 inches and E = 28,130 ksi:

$$\text{Elongation in jack} = \frac{\text{stress x length}}{E}$$

$$= \frac{202.5 \text{ x } 30}{28{,}130} = 0.22 \text{ inch}$$

Total elongation loss during anchor set = elongation in jack + 5/8 in. anchor set

= 0.22 + .625

= 0.845 inches

For computing the prestress losses due to friction the following formula is used:

$T = T_x e^{(\mu + kl)}$

T_x = prestressing force at point x

T = prestressing force at jacking end

e = base of Naperian logarithms

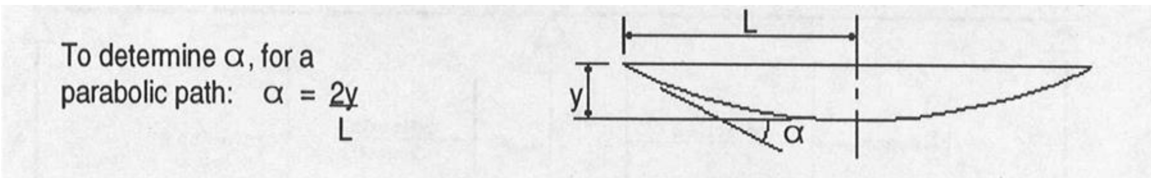
μ = coefficient of angular friction

α =total angular change in radians from jacking end to point x

k = wobble factor

l = length of cable from jacking end to point x in feet

For tendons installed in semi-rigid thin walled galvanized ducts, design values for μ are 0.25 and k are 0.0002. Practice has shown that friction losses can vary from case to case. The values above are suggested for calculating the friction losses, but the In-Place Friction Test are necessary to determine the friction factors to be considered in the actual post tensioning.



5. Stressing Calculation Example

Calculations will be provided by the Contractor and verified by the Office of Bridge and Structural Design for an actual bridge. This example is simply to illustrate the calculations for a better understanding of the stressing objective. Design considerations for the final stresses allowing for elastic shortening of the concrete or long-term losses are not included in this example. The tendon profile used is illustrated in Figure E-1 for a two-span cast-in-place box beam bridge.

Calculate friction losses using equation

$T_\alpha = T_x e^{(\mu\alpha kl)}$ = 202.5 ksi at 75% GUTS

Stressing sequentially at bents 1 and 3 (see Figure E-1):

$\tan \alpha_1 = \dfrac{2 \times 56}{80 \times 12} = 0.117$

$\alpha_1 = \dfrac{6.67\text{degrees} (\square\text{radians})}{180 \text{ degrees}} = 0.116$ radians

$\tan \alpha_2 = \dfrac{2 \times 56}{66.67 \times 12} = 0.140$

α_2 = 7.97 degrees = 7.97 degrees (∏ radians) = 0.139 radians
180 degrees Use

values of µ and k of 0.25 and 0.0002, respectively.

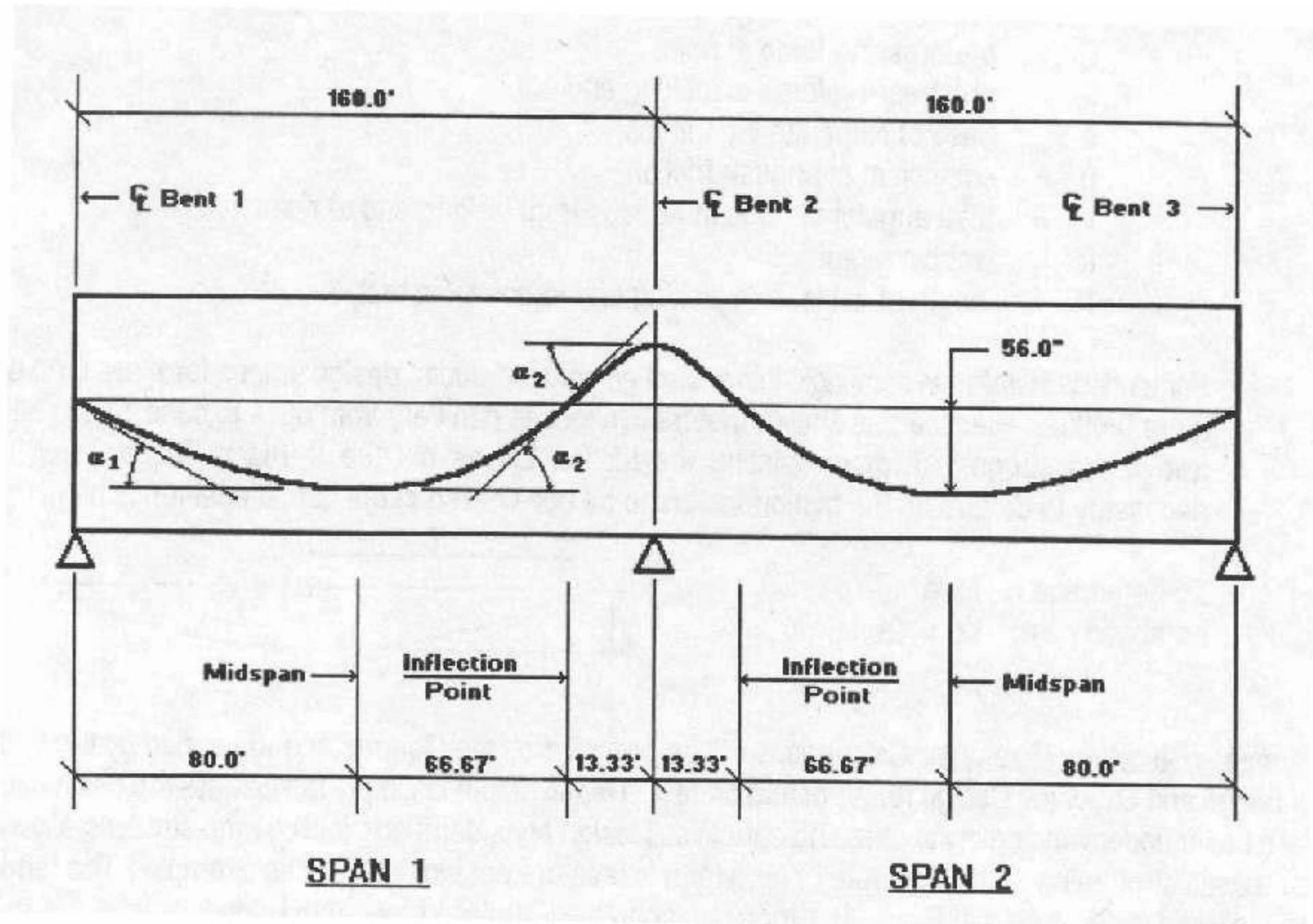


Figure E-1

Note: Spans are symmetrical about centerline of Bent 2 For

midspan at span 1:

µα	=	0.25 x 0.116	= 0.029
kl	=	0.0002 x 80	= 0.016
		µα+kl	= 0.045

$T_o = T_x e^{(\mu\alpha+kl)} = T_x e^{(0.045)} = 1.046T_x$

$T_x = T_o/1.046 = 202.5/1.046 = 193.6$ ksi

For point of inflection at span 1:

$\mu\alpha = 0.25\,(0.116+0.139) = 0.0637$

$kl = 0.0002 \times 146.67 = 0.0293$

$\mu\alpha+kl = 0.0930$

$T_o = T_x e^{(\mu\alpha+kl)} = T_x e^{(0.0930)} = 1.098T_x$

$T_x = T_o/1.098 = 202.5/1.098 = 184.5$ ksi

For interior support at bent 2:

$\mu\alpha = 0.25(0.116+2.0.139) = 0.0985$

$kl = 0.0002x160 = 0.0320$

$\mu\alpha+kl = 0.1305$

$T_o = T_x e^{(\mu\alpha+kl)} = T_x e^{(0.1305)} = 1.139T_x$

$T_x = T_o/1.139 = 202.5/1.139 = 177.7$ ksi

For point of inflection at span 2:

$\mu\alpha = 0.25(0.116+3x0.139) = 0.1333$

$kl = 0.0002x173.33 = 0.0347$

$\mu\alpha+kl = 0.1680$

$T_o = T_x e^{(\mu\alpha+kl)} = T_x e^{(0.1680)} = 1.180T_x$

$T_x = T_o/1.180 = 202.5/1.180 = 171.6$ ksi

For midspan at span 2:

$\mu\alpha = 0.25(0.116+2x0.139+2x0.139) = 0.1680$

$kl = 0.0002x240 = 0.0480$

$\mu\alpha+kl = 0.2160$

$T_o = T_x e^{(\mu\alpha+kl)} = T_x e^{(0.241)} = 1.241T_x$

$T_x = T_o/1.241 = 202.5/1.241 = 163.2$ ksi

For end support at bent 3:

$$\mu\alpha = 0.25(0.116+2x0.139+2x0.116) = 0.1970$$

$$kl = 0.0002x320 = 0.0640$$

$$\mu\alpha+kl = 0.2610$$

$$T_o = T_x e^{(\mu\alpha+kl)} = T_x e^{(0.2610)} = 1.298T_x$$

$$T_x = T_o/1.298 = 202.5/1.298 = 156.0 \text{ ksi}$$

Effect of anchor set using an anchor set of ¼ inch at each end:

The effect of anchor set on tendon stresses may be calculated with sufficient accuracy for this application with the formula presented below.

$$x = \sqrt{\frac{E\ (A.S.)\ L}{12\ d}}$$

x = length influenced by anchor set, ft.

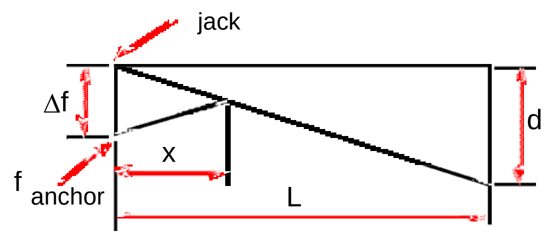
E = Modulus of elasticity, ksi

A.S. = Anchor set, in. (use ¼ in. for example)

d = Friction loss in length, L, ksi

L = Length to a point where loss is known, ft.

f = 202.5 ksi



f = 202.5 ksi	Tendon Stress in Length "L"

$$x = \sqrt{\frac{28.130(0.25)80}{12(202.5 - 193.6)}} = 72.6 \text{ ft.}$$

Δf = change in stress due to anchor set, ksi

$$\Delta f = \sqrt{\underline{E(A.S.)d}\ 3L}$$

$$\Delta f = \sqrt{\frac{28,130(0.25)202.5-193.6)}{3(80)}} = 6.1 \text{ ksi}$$

202.5 – 16.1 = 16.1 = 186.4 ksi is the stress after anchoring at ends of bridge for example calculation.

Stress at zero influence of anchor set:

$$202.5 - \frac{16.1}{2} = 194.5 \text{ ksi}$$

First end elongation calculation using average stress before anchoring:

Because the bridge is symmetrical the average stress for the first end stressing is the stress at the center of the bridge.

Average stress = 177.7 ksi

With a 20% preload, the first end elongation at bent 1 will be: Elongation

$$1 = \frac{0.8\,(\text{average stress})L + (202.5 \times \text{jack length})}{E}$$

$$\text{Elongation } 1 = \frac{0.8(177.7)\,(320 \times 12) + (202.5 \times 30)}{28{,}130}$$

Elongation 1 = 19.58 inches

Add the dead-end wedge bite (normally 1/8") to obtain the target measured elongation of 19.58+0.125= 19.70 inches at bent 1.

The second end elongation calculation before anchoring will be:

Because the bridge is symmetrical, the increased stress at the second end required to achieve the same jacking stress at bent 1 (202.5 ksi) can be figured from the weighted average friction and wobble losses over one half the bridge.

Working from bent 2:

$$\text{Increased stress at second end} = \Big[\ \frac{0+(184.5 - 171.6)}{2} \times (13.33 \times 12)$$

$$+\frac{(184.5 - 171.6 + (193.6 - 163.2)}{2} \times (66.67 \times 12)$$

$$+ \frac{(193.6 - 163.2) + (202.5 - 156.0)}{2} \times (80 \times 12)\ \Big] \div (160 \times 12)$$

= 28.78 ksi average increased stress at second end stressing at bent 3.

After preload the second end elongation at bent 3 will be:

$$\text{Elongation 2} = \frac{(\text{average increased stress})L + (202.5 \times \text{jack length})}{E} =$$

$$\frac{(28.78)(160 \times 12) + (202.5 \times 30)}{28{,}130}$$

Elongation 2 = 2.18 inches target value.

Total elongation for the tendon is the elongation at the first end added to the elongation at the second end corrected for wedge bite and elongation in the jack.

Total elongation in tendon before anchor set = (First end elongation) – (elongation in jack) – (Dead end wedge bite) + (second end elongation) – (elongation in jack) = 19.70 – 0.22 – 0.125) + (2.18 – 0.22) = 21.32 inches

6. Grouting of Tendon

Grouting of the tendon bonds the prestressing steel to the concrete structure and provides corrosion protection for the prestressing steel. The grout mix design and method of mixing and placing the grout should also be included with the Shop Drawings and Design Stressing Calculations.

a. Grout Materials

Grout for post tension tendons consists of Portland cement, water, and an expansive agent. The preferred type of Portland cement is Type II. Type II cement generates less heat and has a slower setting time to allow more latitude in the time needed to pump grout into the tendon. Samples of the grouting materials must be submitted to the OMAT for approval before grouting.

b. Grouting Equipment

The grouting equipment includes a mixer of high shear paddle blades or a collodial type mixer capable of continuous mechanical mixing which will produce a grout free of lumps. The grout pump should be capable of producing an outlet pressure of at least 150 psi and be of a positive displacement type. The grout must be screened over a 1/8” screen before it is placed into the grout pump hopper. The grout pump hopper must be kept at least partially full of grout at all times to prevent air from being pumped into the duct.

c. Mixing Grout

Water is added to the mixer first, followed by Portland cement and admixture. Mixing duration should produce a uniform, thoroughly blended grout and be continuously agitated until the grout is pumped. Proportions of materials should be based on tests made before grouting is begun. The water content should be the amount necessary for proper placement but should not exceed five gallons of water per bag of cement. A flow core efflux time for the grout may not be less than 11 seconds, but the flow time should be from 15 to 17 seconds.

d. Preparation of Ducts for Grouting

In preparing the ducts for grouting, flushing with water may be allowed to clean or test the duct before grouting. It is preferred, however, that the duct be grouted without the introduction of water if the duct is clean. Any water added must be expelled by the grout. Compressed air used to blow out ducts must be oil-free.

e. Injection of Grout

Grout is injected into the duct by a positive connection of the grout hose at the inlet with all other vents open. Ducts should be filled from the lowest point to the highest and the lowest duct filled before the ducts above it are filled to ensure that any leakage does not clog ungrouted ducts. One-way flow of the grout must be maintained so that air is not trapped in the duct. Grout must flow through the duct and out the outlet until all air and any residual flushing water is expelled. Grout should be expelled until the consistency is the same as the grout being injected. Pressures should be as low as necessary to fill the duct in a timely fashion and should not exceed 250 psi to prevent separation of the water and cement that will cause clogging. Both the inlet and outlet must have positive shutoff. Normally the grout pump is shutdown once the duct is completely filled with acceptable grout and the outlet closed.

Pumping pressure is then reapplied and the inlet closed and the pump shutdown again. This procedure is performed to ensure that the duct is completely filled and pressurized to fill all crevices and voids. Grout should remain undisturbed until set. Grout should be thoroughly set before removing plugs, valves, and caps. The grout should cure for 48 hours before falsework is released and before any construction load or live load is applied to the bridge.

7. Record Keeping

Complete records must be kept on stressing and grouting of post tension box beam bridges. These records should include for each tendon its location, number of strands, actual force and elongation measurements, and anchor sets, and any wire breakage, and the date grouted.

APPENDIX F
Mechanically Stabilized Earth Wall Components

The components of mechanically stabilized earth (MSE) walls are called by various names in accordance with the different companies with which they are associated. The following list is addressed in general to the major components of a Georgia Stabilized Embankment (GASE) wall and is comparable with other MSE walls. Each component has its own function and importance. If the wall components are not properly manufactured or placed in the wall, then the wall components cannot function properly.

Some of the common MSE components and their functions are summarized below. Also included are some of the malfunctions and potential effects resulting from defective components and/or poor workmanship during construction.

A. Precast Concrete Panels

Functions

1. Retain the special backfill material against facial sloughing.
2. Provide foundations for light fixtures, sign fixtures and traffic barriers.
3. Provide a cosmetic face for the wall.

Malfunctions

1. Panels with Broken Comers
   a. Can allow the special backfill material to leach out from behind the wall.
   b. Can change the cosmetic design of the wall’s front face.
2. Improperly Casted Panels
   a. Out of square -won’t set.
   b. Beveled bottoms – won’t set.
   c. Bows or dishes in face effect appearance andrebar cover.
   d. Pits in facial surface effect appearance and rebar cover.
   e. Soil reinforcement connection not proper length or location-attachment difficult and sometimes eliminated.
   f. Exposed rebar--rebar corrosion, panel cracking, and facial staining.
   g. Alignment holes wrong-pins cannot be set.
   h. Wrong angle or corner panel-bad fit at corner.
3. Improperly Stored or Handled Panels
   a. Stained facial surfaces.
   b. Broken or chipped panels.

B. Soil Reinforcing Devices (Reinforcing Strips, Mesh, etc.)

Functions

1. Stabilizes and provides tensile strength to the special backfill.
2. Holds the concrete panels in place.

3. Helps hold the Type “H” and Type “V” traffic barriers in place.
4. Helps stabilize certain bridge end caps and back walls.

Malfunctions

1. Steel soil reinforcement with broken places in the galvanization will not last the design life of the reinforcement.
2. Reinforcement with broken welds will not have the maximum design strength.
3. Soil reinforcement not correctly attached to panels will not perform as designed.
   a. Bolts too small.
   b. Nuts not on bolts or not tightened.
4. Soil reinforcement that is not placed in the design pattern may not perform as designed.
   a. End of reinforcement out of special backfill.
   b. End of reinforcement against face of cut.
5. Soil reinforcement that is not protected after placement is subject to damage.
   a. Reinforcement dug up or snagged by utility or construction crews.
   b. Reinforcement exposed by erosion.

C. Special Embankment Backfill

Functions

1. Holds the soil reinforcing devices in place.
2. Provides foundation for whatever is overlaid as a roadway, fill slope, etc.
3. Provides foundation support for walls in areas which have low soil bearing capacities.
4. Retains the natural backfill.

Malfunctions

1. If soils are allowed to get in the backfill material, the gradation, resistivity, pH, and permeability of the backfill material may be changed. (Can degrade or fail the backfill material).
2. Backfill that is not placed the proper width (1’) beyond the soil reinforcement will allow the reinforcement to extend into natural soil. This may increase the potential for corrosion of steel reinforcement devices and reduce their design life.
3. Backfill that is not properly placed.
   a. If the leveling pad is undercut without undercutting of the special backfill volume, uneven settlement may occur.
   b. Backfill not compacted will settle later and pull panels out of line.
   c. Backfill that is not sloped away from wall.
      1) Can cause water to be turned into the wall and cause settlement and/or panels to move out of line.
      2) Can cause the soil reinforcement to be laid uphill with insufficient cover and be damaged later by grading equipment.
   d. Backfill put down too dry can cause the wall to move out of alignment due to over rolling to

get compaction.

e. Backfill put down in layers too thick will make it hard to get the proper compaction.

f. Backfill lifts that are not first placed along the back face of panels and then worked to the ends of the reinforcing devices may cause slack in the reinforcement near the panels.

D. Joint Fillers

Functions

Prevents fines in the special backfill material from leaching out through the joints by percolation.

Malfunctions

1. Polyether foam that is stored in direct sunlight will deteriorate rapidly.
2. Foam left out of vertical joints may allow fines to wash out of the backfill.

E. Filter Cloth

Functions

Prevents fines in the special backfill material from leaking out through the vertical and horizontal joints.

1. Nonwoven Filter Cloth may be used 3’ above 100-year high water elevation and above.
2. Woven Filter Cloth may be used anywhere in wall system but is required from 3’ above the 100-year high water elevation and below.

Malfunctions

1. Improper placement of filter cloth can cause the fines to leach out of the backfill. This can be caused by:
   a. Filter cloth too narrow.
   b. Filter cloth not overlapped.
   c. Filter cloth not glued to both panels.
2. When enough fines go out through the joints the wall will move outward.
3. Using nonwoven filter cloth where woven filter should be used (below high-water mark) can cause the nonwoven filter cloth to deteriorate.

F. Bearing Pads

Functions

1. Provides a cushioning surface between the concrete panels when the panels are set on top of one another in the wall.
2. Produces a horizontal gap between panels to prevent concrete to concrete contact.

Malfunctions

Improper placement of pads (pads not under panels or not spaced properly) can cause overloading of the pads and/or panels and may result in cracking or spalling of the panels.

G. Concrete Leveling Pads

Functions

1. Are used to produce a level surface to begin the wall.
2. To provide temporary support for the wall panels.

Malfunctions

Leveling pads poured out of tolerance.

1. Poured too low will cause thick joints.
2. Poured too high will cause narrow joints.
3. Poured unlevel (front to back) will cause the panel to be out of batter and will have to be wedged back in place which will cause point bearing later.
4. Foundation not uniformly compacted to proper compaction.
5. Step-up not properly poured resulting in excessive gap between panel and step.
6. Leveling pad poured to far in advance of wall erection often causes erosion of foundation, cracks and breakage of pad.

H. Concrete Coping (A and B)

Functions

1. To provide support for a lighting system (Type “B”).
2. To provide support for a sound barrier wall (Type “B”).
3. To provide support for a surface drainage system such as a “V” ditch.
4. To provide a cosmetic design for the top of the wall.
5. To provide support for an enclosure fence.

Malfunctions

Improper line and/or grade on the coping changes the cosmetic design of the coping.

I. Traffic Barriers (“V” and “H”)

Functions

1. Provide a safety barrier for traffic.
2. Provide a support for sound barriers.
3. Provide a support for a surface drainage system.
4. Provide a cosmetic design for the top of the wall.

Malfunctions

Improper line and/or grade on the coping changes the cosmetic design of the traffic barriers.

J. Wooden Wedges

Functions

To hold the batter in the wall during the compaction stages.

Malfunctions

1. Wedges used on the back side of a panel to level it will cause point bearing.
2. Wedges left in joints will cause point bearing and cause the panel to crack or break.

K. Connecting Devices

Functions

To attach the soil reinforcing devices to the panel.

Malfunctions

Using wrong size bolts will cause the soil reinforcement not to develop full design strength.

L. Adhesives

Functions

To glue the filter cloth to the panels.

Malfunctions

Not gluing the filter cloth to the panels properly can cause the joint to come uncovered which will allow the fines to leach out through the joints.

M. Drainage System

Functions

1. To control the surface water runoff.
2. To provide a passage for the water to drain as designed on the plans.

Malfunctions

1. Broken bells on pipe can cause the pipe to leak and wash out the backfill material.
2. “V” ditches not long enough will cause the end of fill to wash out.
3. Broken pipe running through the wall can cause the leveling pad to be undermined.
4. “V” ditches that settle may cause water to be turned into the backfill.
5. Water turned on the face of the wall will undermine the leveling pad.

N. Erection Tolerances and Alignment

Functions

1. Batter
   a. To stress the backfill stabilizing mesh.
   b. To account for wall thrust during erection.
2. Horizontal and Vertical Joint Opening
   a. Allows for some wall settlement.
   b. Prevents point loading concrete to concrete.
   c. Allows for allowable casting tolerance.
3. Vertical Tolerance (Plumbness) and Horizontal Alignment Tolerance
   a. Allows for allowable casting tolerance

   b. Allows moderate placement of wall.
   c. Allows for some wall settlement.
4. Plumbness (Overall)—Controls the final position of the top of the wall.
5. Alignment (Overall)—No tolerance. (See Roadway Plans.)

Malfunctions

1. Batter
   a. Too much batter will cause the top of the wall to be out of plumb to the inside.
   b. Too little batter will cause the top of the wall to be out of plumb to the outside.
2. Horizontal and Vertical Joint Tolerances: Too little joint clearances can cause point bearing and cause the concrete to flake off or break off.
3. Horizontal Alignment and Vertical Plumbness
   a. Improper vertical plumbness will cause the top of the wall not to fit in properly.
   b. Improper horizontal alignment will cause wall to be misaligned.

GLOSSARY

Abutment: The part of a structure that directly receives thrust or pressure i.e. end bent and caps.

Allowable Bearing Pressure: The bearing pressure which cannot be exceeded if design criteria is met.

ASD: Allowable Stress Design, method of designing structures that involves the use of safety factors selected based on experience and judgement.

Bearings: The support devices that transfer the superstructure loads to the substructure.

Bent: Independent transverse frame used to support bridge spans.

BFI: Bridge Foundation Investigation report. Contains the recommendations on which the foundations are designed.

Butt Weld: End to end full depth, full width welds used to connect structural units. Butt welds, also called groove welds, shall be tested by the Office of Materials and Testing (OMAT).

CFI: Culvert Foundation Investigation report. Contains the recommendations on which the foundations are designed.

Cofferdam: Temporary structure from which water is pumped to permit construction access and which encloses and protects a work area from lateral water and soil pressure.

Continuous Beam: A structural member continuous over three or more supports.

Coping: The additional concrete over the beam necessary to ensure that no part of the beam or cover plate extends into the slab thickness. Coping depth is measured at the centerline of the beam.

Dead Load Deflection: The vertical deflection of a structural member due to the weight of its sustained "dead" loads (slab, coping, barriers, sidewalk and parapet, etc.)

Deck Form Ordinates: Dimensions from top of beam to bottom of deck. Used to grade forms or deck panels.

Diaphragms: Can be of either concrete or steel. Purpose is to stiffen the beam, provide lateral support, and to help distribute loads.

Driving Resistance: The force delivered from the soil to a pile through end bearing and/or side friction, resisting the driving action of a pile hammer.

Edge Beams: Concrete beams that are part of the deck and are poured parallel along the edges of the transverse joints at the ends of each span.

Estimated Tip Elevation: Elevation shown in (B.F.I.) Bridge Foundation Investigation report, estimating pile tip elevation.

Falsework: Temporary structure used to support permanent structures during construction or until the permanent structure can stand alone.

Fillet Weld: Welds forming fillets used to connect diaphragms, stiffeners and plates to main structural steel members. Careful visual inspection is required.

Jetting: The process of injecting water under high pressure adjacent to or ahead of a pile so as to loosen dense material and aid in achieving plan driving objective. See Subsection 520.3.05G.

Live Load Deflection: The vertical deflection of a structural member due to the weight of its transient "live" loads (traffic).

LRFD: Load Resistance Factor Design, method used to design the structure that accounts for statistical uncertainties to show that the resistance is greater than the load.

Load Test: The process of physically loading a pile with weights or loading by mechanical or hydraulic jacks to verify the bearing capacity of a pile.

Minimum Tip Elevation: The pile tip elevation identifying the minimum acceptable embedment of a pile into the foundation material.

PDA: Pile Driving Analyzer, A machine that is hooked up to a pile during driving that gathers data that is used to set the driving criteria for the pile. It will also allow the inspector to know if the pile is damaged during driving.

Seal: Concrete placed in water to seal a cofferdam and provide a foundation for footing construction. See Section 500.

Shear Connectors: Studs welded to top flange of structural steel to resist horizontal shear between the concrete slab and the steel beam. See Section 512.

Screed: Mechanical device designed to strike-off and finish concrete.

Span: The length or area between two support points.

Spudding: Process of loosening dense material or hard strata through the use of a specially designed tool (Spud), i.e.: heavy hammer or ram. Purpose is for pile installation or material removal. See Section 520.

Substructure: That portion of the bridge below and including the caps. This includes the caps, the columns, the footings and the foundation.

Superstructure: The superstructure of a bridge is that portion of the bridge above the caps. This includes the bearing devices, beams, decks, and barrier or railings.

Test Pile: Pile used to determine order length of remaining piles in foundation as required by the plans or as directed by the engineer.

Tremie: Pipe or tube used in concrete placement. Allows concrete to be dropped over 5 feet without segregation problems.

Web Wall: Walls constructed between columns on bridges located in flowing water. Used to protect columns and prevent buildup of debris, i.e. logs/trees.

WFI: Wall Foundation Investigation report. Contains the recommendations on which the foundations are designed.

WEAP: Wave Equation Analysis of Pile driving is a report performed prior to construction and after the PDA is ran in the field. Both reports are to be submitted to the Geotechnical Bureau at Geotechnical_submittals@dot.ga.gov . They have 10 calendar days to provide comments or approval.