WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
Division of Highways
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Joe Manchin III
Governor

January 25, 2007

MEMORANDUM

TO: ALL HOLDERS OF BRIDGE DESIGN MANUAL

FROM: GREGORY L. BAILEY, P.E.
DIRECTOR
ENGINEERING DIVISION

SUBJECT: 2006 INTERIM TO THE 2004 BRIDGE DESIGN MANUAL

Attached for your use is the 2006 Interim to the 2004 Bridge Design Manual. This interim revision is necessary to revise the West Virginia Department of Transportation, Division of Highways, Bridge Design Manual dated March 1, 2004.

This package contains the revised pages and an Errata section. They have been designed to replace the corresponding pages in the book and are numbered accordingly. Revisions, additions, and deletions are marked in the revised pages by the use of vertical lines in the margins and "Interim 2006" in the footer. Errata pages are not marked and only correct misspellings, grammar, punctuation, etc.

To keep your manual up to date, please replace the appropriate pages in the book with the pages in this package. Additional copies of this Interim as well as the Bridge Design Manual itself are available on the WVDOT web site at:

www.wvdot.com/engineering/TOC_engineering.htm.

If you should require additional information, please contact this office at 558-2885.

GLB:lf

Attachments

PRINTING INFORMATION
This document contains extra pages so that when it is printed double sided it will be a direct replacement for the pages in the hardcopy of the manual.

Summary of changes in 2006 Interim to WVDOT Bridge Design Manual

Please replace the following pages in the Bridge Design Manual.

Section	**Page(s)**	**Brief Description of change**
2.1.7 Hydrology and Hydraulics	2-3	Removal of references to .01 ft of backwater
2.3.1 Introduction (Geotechnical Investigations)	2-8	Clarification of preliminary foundation design
2.4.2.3 Prestressed Concrete Beams	2-19	Clarified Min. number of beams
2.4.5.3 Drilled Caissons	2-25	Deleted first paragraph
3.2.1.1 Deck Overhangs	3-8	Clarification of overhang reinforcement
3.2.4 Deck Drainage	3-11	New modifications to criteria
3.8.5 Wingwalls	3-60	Corrections to min. thickness
3.12.3 Pile Foundations	3-84	Corrections to min. thickness
3.15.2 Conversion Factors for Refined Analyses	3-108	Clarified definition of Live Load Distribution Factor
Appendix A (A.1.1) Blast Cleaning & Painting	A-2	Now includes the word “semi-integral”
Appendix A (A.1.3) Steel Stud Shear Connectors	A-5	Consolidated language from Specs and new notes

data or a published study for the stream, from Federal Emergency Management Agency (FEMA) or another agency, then that data or study shall be obtained and appropriately considered in the analysis. Where a FEMA regulatory floodway has been established, the Designer's model (preferably based on the original study) shall match published water surface elevations for the 100-year event, with no increase in the water surface elevation.

The proposed water surface elevation must be submitted to the local Flood Plain Coordinator. A Conditional Letter of Map Revision (CLOMR) and/or a Letter of Map Revision (LOMR) may be required when the water surface elevation will be increased by the proposed bridge or at the request of the Flood Plain Coordinator.

See WVDOH Drainage Manual for additional information.

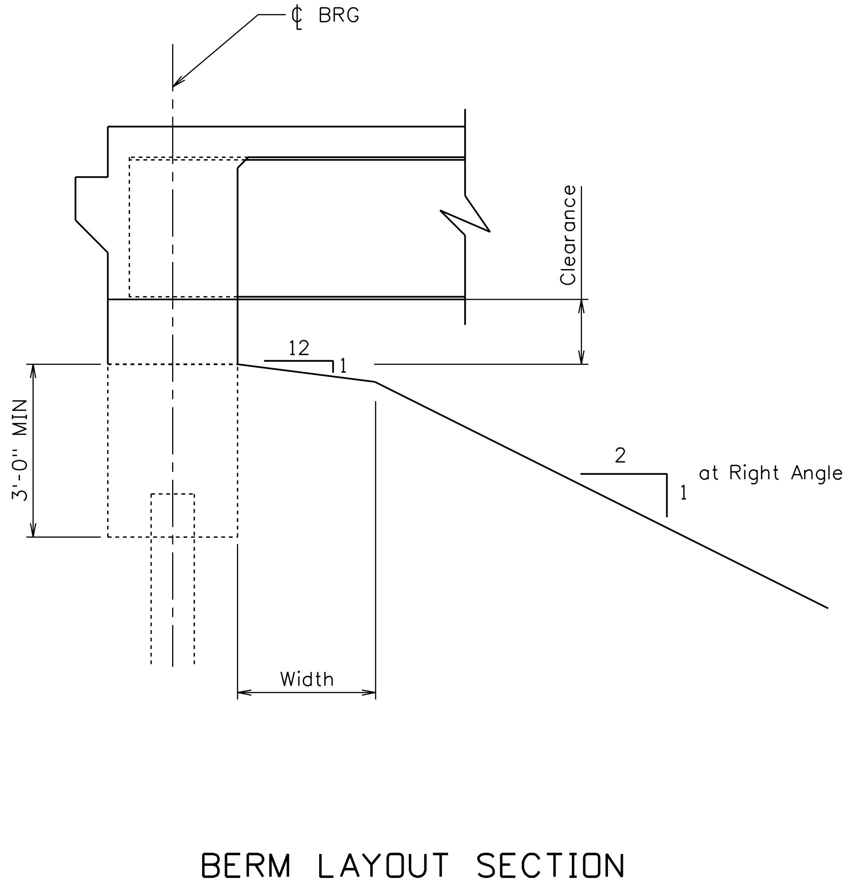
A scour analysis shall be performed on all waterway or stream/river crossings and a DS-34 Form submitted (see Appendix C).

2.2 BRIDGE LAYOUT CRITERIA

2.2.1 Geometric Guidelines

The following are guidelines in the geometric layout of new or replacement structures:

- The desirable berm width in front of an abutment shall be as follows (see Figure 2.2.1A):
  - A minimum berm width of 3 FT shall be used under dry conditions.
  - For wet conditions, a berm width of 5 FT is preferred.
  - When very steep terrain is encountered, a berm width of 10 FT is desirable to facilitate safe construction practices.
- The berm should be at an elevation below the bridge seat that will allow access to the bridge seat for future maintenance (see Figure 2.2.1B).
  - A minimum 1.5 FT clearance between the berm and superstructure is required. However, if the berm width is greater than 10 FT a minimum 3 FT clearance should be used to provide clearance for ventilation, vegetation and access.
  - Where conditions warrant (e.g., steep terrain or where additional construction clearance is required) a 3 FT minimum clearance is preferred.
- The maximum desirable skew is 30°; however, elimination of skew is preferable.



℄ BRG
Clearance
12
1
3'-0" MIN
2
1
at Right Angle
Width
BERM LAYOUT SECTION

Figure 2.2.1A

2.2.2.2 Highway Crossings

Bridge layouts for highway crossings are usually controlled by the cross section of the roadway below. Minimum vertical underclearances, horizontal safety clearances and adequate sight distances will frequently control not only the overall length of the bridge, but the span arrangement as well.

Relatively extreme gradients at either roadway grade require careful consideration of the vertical clearances. The point of minimum underclearance can be beneath any of the superstructure members at any point in the traveled way below. The superelevation rates for both alignments must be evaluated throughout the layout process. The Designer should consider the effects of future widening and the final grade shall provide the minimum vertical clearance.

When possible, obstructions (abutments, piers, etc.) should be placed outside of the clear zone. If an obstruction is within the clear zone, appropriate safety measures shall be incorporated, such as (but not limited to), guardrails, crashwalls, etc.

Table 2.2.2.2 shows horizontal and vertical clearances for highway crossings. For additional information, see DD-601.

2.2.2.3 Railroad Crossings

The two principle railroads currently operating in West Virginia are the Norfolk Southern Corporation (NS) and CSX Transportation, Inc. The proposed bridge length is determined from the embankment slopes and berm requirements similar to those for highway crossings. See Section 2.10 for clearance and additional railroad requirements.

2.2.2.4 Cultural and Natural Resources Crossings

The Designer should avoid any cultural and/or natural resources in the project area. The Designer must receive permission from the Director of Engineering Division when these areas cannot be avoided, prior to the advancement of the bridge layout.

2.3 GEOTECHNICAL INVESTIGATIONS

2.3.1 Introduction

The purpose of this information is to provide Design Engineers a guide to the proper procedures in the performance of geotechnical investigations. Specifically, this section is

Horizontal and Vertical Clearances for Highway Crossings		
Classification*	**Horizontal Clearance to Obstructions**	**Minimum Vertical Clearance**
Local Roads	10 FT from edge of traveled way.	14.5 FT over the entire roadway. This value includes a 6 IN future resurfacing allowance for new structures.
Rural Collectors	Design speeds of 40 MPH and below - 10 FT from edge of pavement. Design speeds of 50 MPH and above - see the current edition of the AASHTO Roadside Design Guide.	14.5 FT over the entire roadway. This value includes a 6 IN future resurfacing allowance for new structures.
Two-Lane Arterial	See the current edition of the AASHTO Roadside Design Guide	16.5 FT over the entire roadway and usable shoulder. This value includes a 6 IN future resurfacing allowance for new structures.
Divided Arterial	See the current edition of the AASHTO Roadside Design Guide.	16.5 FT over the entire roadway and usable shoulder. This value includes a 6 IN future resurfacing allowance for new structures.
Freeway	See the current edition of the AASHTO Roadside Design Guide.	16.5 FT over the entire roadway and usable shoulder. This value includes a 6 IN future resurfacing allowance for new structures. A minimum of 17.5 FT should be provided to pedestrian overpasses, sign trusses, and from the bridge deck to cross bracing on through trusses.

* The AASHTO functional classification system is to be used as a design type of highway for design purposes.

Table 2.2.2.2

intended to define the procedures that may be involved in performing a subsurface investigation and the various geotechnical aspects of the design and construction of roadways and roadway structures. For the purpose of preliminary foundation design, existing geotechnical data or presumptive values found in the Governing Specifications may be used at the service limit state. All foundations, including pile foundations, must be designed in accordance with the Governing Specifications.

Each project presents unique considerations and requires engineering judgment based on a thorough knowledge of the individual situation. This section is not intended to serve as the geotechnical scope of services for individual projects. The scope of services dictates the specific practices, which are to be used on a particular project. Additionally, the

2.4.2.2 Box Beams

For short span bridges of 100 FT or less, prestressed concrete box beams may be considered an economical solution.

Three basic cross-sectional configurations are commonly used. They are:

- adjacent box beams with or without a hot-laid bituminous concrete (HLBC) wearing surface,
- adjacent box beams with a composite reinforced concrete deck, and
- spread box beams with a composite reinforced concrete deck.

Factors involved in the choice of box beam configuration design should include but are not limited to: economics, traffic type and volume, time constraints, and method of construction (whether by contract or state construction crews which generally have limited construction capabilities). The Bridge Designer should verify capabilities with the District prior to designing a structure that will be built with state forces.

2.4.2.3 Prestressed Concrete Beams

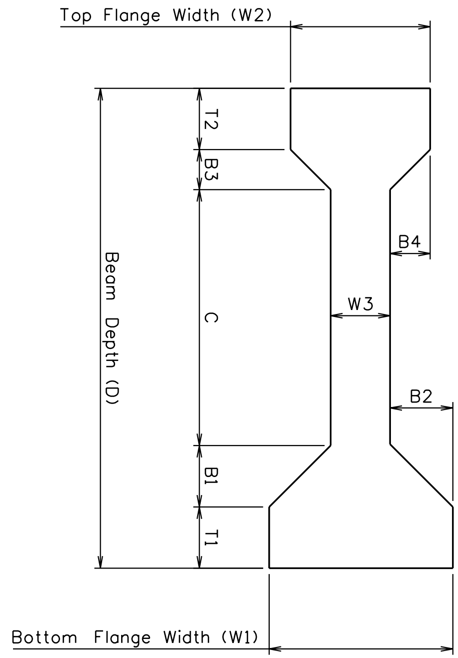
AASHTO Type I, II, III, IV or Type IV Modified prestressed concrete beams should be considered for bridges with spans from 25 to 145 FT. The maximum span length is based on the haul capacity for a particular project site and shall be verified with a prestressed concrete beam supplier familiar with the project location. For continuous spans, the bridge system shall be designed simply supported for dead load and continuous for live load and superimposed dead load only. The Designer should minimize the number of beam lines. Prestressed concrete beam bridges should have a minimum of three stringer lines.

The design of all structures that utilize prestressed concrete I-beam sections will be accomplished using one of the beam sections from Figure 2.4.2.3. AASHTO Type V and Type VI sections shall not be used unless approved by the Director of Engineering Division.

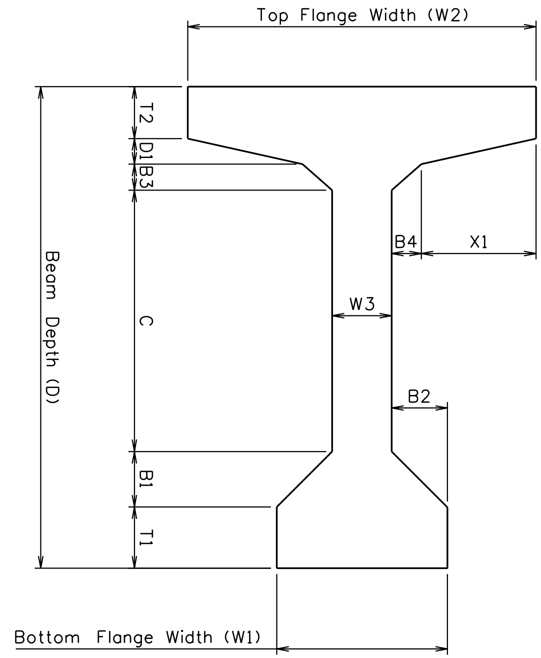
Alternate beam sections may be used for special design situations. Proposed sections, other than those shown in the following tables must also be approved by the Director of Engineering Division.

Prestressed concrete beams shall be spaced to optimize girder size and strand usage. Examples of beam types, spacings and span lengths are shown in Table 2.4.2.3.

WVDOT-DOH STANDARD PRESTRESSED CONCRETE I-BEAM SECTIONS



AASHTO I-BEAM
Typical-Type II, III & IV



AASHTO I-BEAM
Typical-Type IV MOD, V* & VI*

Beam Designation	Top Flange Width (IN) W2	Bottom Flange Width (IN) WI	Depth (IN) D	Depth (IN) T2	D1	B3	C	B1	T1	Flange (IN) X1	B4	B2	Web Thickness (IN) W3	Basic Beam Properties Area (IN^2)	Y_b (IN)	I_{xx} (IN^4)
II	12	18	36	6	-	3	15	6	6	-	3	6	6	369	15.8	50,980
III	16	22	45	7	-	4½	19	7½	7	-	4½	7½	7	560	20.3	125,390
IV	20	26	54	8	-	6	23	9	8	-	6	9	8	789	24.7	260,730
IV MOD	36	26	60	4	2	3	34	9	8	11	3	9	8	860	28.8	384,248
IV MOD	36	26	66	4	2	3	40	9	8	11	3	9	8	908	31.6	491,660
IV MOD	36	26	72	4	2	3	46	9	8	11	3	9	8	956	34.4	615,361
IV MOD	36	26	78	4	2	3	52	9	8	11	3	9	8	1,004	37.3	756,222
IV MOD	36	26	84	4	2	3	58	9	8	11	3	9	8	1,052	40.2	915,113
V*	42	28	63	5	3	4	33	10	8	13	4	10	8	1,013	31.9	521,180
VI*	42	28	72	5	3	4	42	10	8	13	4	10	8	1,085	36.4	733,320

* Use only when specifically approved by the Director of Engineering Division.

Figure 2.4.2.3

2.4.5.1 Spread Footing

Spread footings have been found to be economical for depths to 20 FT. Spread footings are to be founded on competent rock unless an alternate founding material is approved by the WVDOH. Spread footings on rock fill or soil may be considered only if significant savings in cost and/or time can be achieved and if all other concerns are addressed. In situations where a cofferdam may be required for the construction of a spread footing, the cost of the cofferdam shall be included when comparing foundation options. Spread footing foundations shall be placed below the scour depth. Other concerns to consider include the stability of approach embankments, differential settlement, etc.

2.4.5.2 Piling

Piling must be designed for both axial and lateral loads as appropriate. Loads may include external (non-structure related) as well as structural loads. For example, pile foundations might be used to enhance stability of the approach embankment if the embankment factor of safety is questionable.

Piling to competent rock will normally be designed as end bearing and driven to refusal. Additional loading from negative skin friction (downdrag forces), resulting from embankment settlement, must be added to that from structural loads and any other external loads. Battered piles may be required to help resist lateral loads. The cost for pile tips, if necessary, shall be included in the cost estimate for the pile foundation.

With permission of the Bridge Project Manager, friction piles and end bearing piles on non-competent rock strata may be considered when site-specific conditions warrant and when all other concerns (such as settlement or scour) are addressed.

The minimum piling length shall be 10 FT. See Section 3.12.3 for further discussion.

For integral abutments, single-line piling systems shall be used.

Foundations supported on piling should be placed below the scour depth. When the bridge scour computations indicate that the steel piling may be exposed due to scour, then the piling cap placement must be designed in accordance with Section 3.12.3.

2.4.5.3 Drilled Caissons

Drilled caissons provide: superior scour protection versus traditional steel piling, greater resistance against high lateral and uplift loads, accommodation of site concerns associated with the pile driving process (vibrations, interference due to battered piles, etc.), and in some cases exclude the need of cofferdams. In addition, drilled caissons may eliminate the need of caisson caps, for certain configurations such as single or multiple column piers.

The high cost of equipment mobilization should be considered for the installation of a limited number of drilled caissons. If integral abutments are utilized, the cost of mobilization may decrease with the equipment required to pre-drill the steel piling.

Construction techniques shall be in accordance with the Standard Specifications. These include, but are not limited to, pre-installation core holes, providing a test hole and crosshole sonic logging (CSL) testing. Higher project costs could arise from these testing methods for large projects.

Results from the CSL testing may show inadequate structural integrity and continuity. Further investigations such as core drilling for each of the unacceptable caissons would then be required, causing construction down time and added expenses.

2.5 ADDITIONAL DESIGN CONSIDERATIONS

2.5.1 Curved Bridges

Bridge Designers are cautioned to design curved structures for all relevant forces as specified in the Governing Specifications, even if the girders are straight and the deck is curved.

For moderately curved bridges, the use of straight steel girders or prestressed concrete beams with spacings satisfying the minimum and maximum deck overhang requirements shall be investigated.

Slab bridges, cast-in-place and precast segmental bridges are other options for curved concrete bridges.

2.5.2 Slope Stability

Instability of approach embankments has been a very costly problem. A stability analysis should be performed on approach embankments. Some concerns that may be addressed during this geotechnical analysis are:

- excess pore pressure during construction,
- ground water seepage during wet weather on hillsides on which the approach embankments are founded, and

When these thresholds are exceeded, specialty computer programs (Grid or Finite Element) shall be used.

Curved bridges shall be evaluated for construction during the design process. The evaluation shall consider erection and handling of the girders, the effects of deck casting and the calculation of camber; properly accounting for deflection due to primary bending and torsion.

Hybrid sections are not allowed for curved girders.

3.2 DECKS

3.2.1 Design of Concrete Deck Slabs

Class K or H concrete shall be used in all bridge decks and barriers conforming to Section 3.1.5.1. The bridge deck width shall not be less than that of the approach roadway section (see DD-601).

The Empirical Design Method for the design of concrete deck slabs (AASHTO 9.7.2) shall be used, provided all required design conditions are met (AASHTO 9.7.2.4). If the Empirical Design Method is not applicable, then the deck shall be designed using the Traditional Method (AASHTO 9.7.3).

The following information is for monolithic concrete bridge decks:

- The minimum allowable thickness is 8.0 IN,
- 1.0 IN clearance at the bottom of the slab,
- 2.5 IN clearance at the top of the slab, and
- 2.0 IN clearance elsewhere.

The following information is for bridge decks utilizing a specialized concrete overlay (SCO):

- The minimum allowable thickness is 8.5 IN,
- 2 IN composite SCO,
- 1.0 IN clearance at the bottom of the slab,
- 3.0 IN clearance at the top of the slab, and
- 2.0 IN clearance elsewhere.

The top ¼ IN of slab is to be considered a wearing course and shall not be included as part of the structural capacity of slab.

The deck haunch shall be vertical from the flange tips.

For bridges with a skew angle of 25° or less, the transverse reinforcement may be placed parallel to the skew where economy warrants; otherwise it shall be placed perpendicular to the bridge centerline. For bridge decks skewed greater than 25°, additional reinforcement shall be added in the end zones of the deck (AASHTO 9.7.2.5).

Concrete Appurtenances (curbs, barriers, sidewalks, etc) shall be made structurally continuous.

Typical deck details including end zone reinforcement placement are available from the WVDOH.

3.2.1.1 Deck Overhangs

The reinforcing for deck overhangs is not included in the Empirical Design Method. The WVDOH has prepared deck overhang design drawings for our standard barriers referenced in Section 3.2.2. As long as the deck overhang meets the dimensional criteria shown in these drawings, the reinforcement is adequate and no further design work will be required. If the deck overhang does not meet this criteria or an alternate crash tested barrier is employed, the overhang shall be designed for all loads including the railing impact loads of AASHTO 9.7.1.5 and the provisions of AASHTO 9.7.2 and detailed to be compatible with the empirical deck system. For bridges with structurally continuous concrete barriers, the minimum total overhang width shall be 3.0 times the depth of the deck, measured from the center of the exterior girder (AASHTO 9.7.2.4). The maximum total overhang width shall be the smaller of 0.625 times the girder spacing and 6 FT.

Plan notes shall be added requiring the contractor to ensure that precautions have been taken to prevent permanent lateral deformations of the exterior girder, caused by overhang brackets used during the deck pouring operation (See Section 615.2.2 of the WVDOH Standard Specifications).

3.2.1.2 Removable Forms

Removable formwork on interior bays is not permitted without permission from the Director of Engineering Division.

When removable forms are to be used, approval of the forming plan will not be required, except when the slab overhang at the fascia girder is greater than 2 FT from the edge of the flange. If this occurs, see Appendix A for the plan note to include in the General Notes sheet.

3.2.1.3 Permanent Metal Deck Forms

All bridge decks shall be detailed with permanent metal deck forms, unless the Director of Engineering Division approves another type.

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- The live load portion of Load Group III of Table 3.22.1A shall be used, including impact.
- The live load will be the HS25, 125% of HS20 as specified in Article 3.7.6, applied as specified in Article 3.11 for maximum positive moment.
- The provisions for reduction in load intensity of Article 3.12 apply.

3.2.3 Construction Sequences

A deck placement sequence shall be provided on the bridge plans for all multiple span bridges with a cast in place concrete deck (see Figure 3.2.3). The purpose of the placement sequence is to reduce deck cracking over the piers. In general, the recommended deck placement sequence shall specify that all positive moment regions of the deck shall be placed first. The negative moment areas shall not be placed until the positive moment regions have reached the minimum strength required in the Standard Specifications. The positive moment region pours shall be limited to a length that can be completed prior to the initial setting of the concrete. If special structural situations warrant, consideration may be given to an alternate deck placement sequence. The bridge superstructure shall be analyzed for the proposed deck placement sequence.

Under some circumstances, the deck may be placed in one continuous pour. These circumstances include, but are not limited to, single span bridges or multi-span bridges of a length that can be placed in one casting operation. On multi-span bridges, the initially placed concrete must remain plastic during the entire casting operation.

The Designer shall be aware of, and take into consideration, the proximity of concrete facilities, pour volumes and quantity of concrete a contractor can place when determining the deck placement sequence.

3.2.4 Deck Drainage

Provide sufficient inlets to drain a 2-year design discharge from the highway or bridge surface. For roadways designed for speeds of 40 mph or greater, spread of the flow on a bridge deck or curbed section of pavement is generally limited to 5 feet or the shoulder width, whichever is greater. If the design speed is less than 40 mph, spread is generally limited to 5 feet, or the shoulder width plus 2 feet into the traveled way, whichever is greater. If a parking lane is present, then the spread will be limited to 8 feet.

FHWA publication *Design of Bridge Deck Drainage*: Hydraulic Engineering Circular No. 21 shall be utilized for deck drainage design methodology. Deck drains shall be placed, as required, based on the hydraulic computations for the subject bridge (AASHTO 2.6.6.2). The design storm for deck drainage shall be as described in the preceding paragraph. Deck drainage systems shall be designed and sized to efficiently and quickly remove surface water from bridge decks and direct it away from bridge superstructure and substructure elements.

The drainage system shall be designed to be accessible for cleaning.

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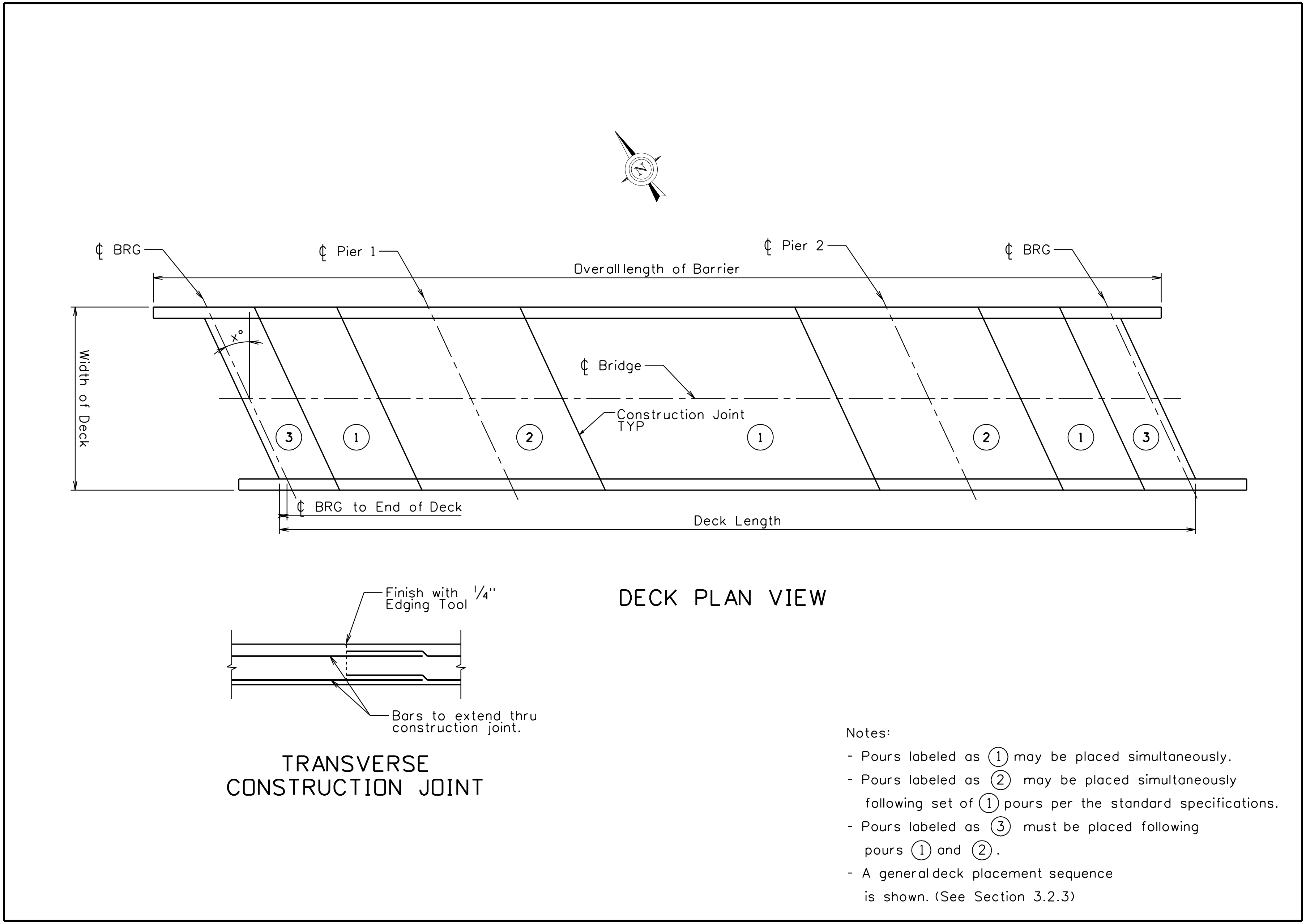
N
℄ BRG
℄ Pier 1
℄ Pier 2
℄ BRG
Overall length of Barrier
Width of Deck
x°
℄ Bridge
Construction Joint
TYP
3
1
2
1
2
1
3
℄ BRG to End of Deck
Deck Length
DECK PLAN VIEW
Finish with 1/4" Edging Tool
Bars to extend thru construction joint.
TRANSVERSE CONSTRUCTION JOINT
Notes:
- Pours labeled as (1) may be placed simultaneously.
- Pours labeled as (2) may be placed simultaneously following set of (1) pours per the standard specifications.
- Pours labeled as (3) must be placed following pours (1) and (2).
- A general deck placement sequence is shown. (See Section 3.2.3)

Figure 3.2.3

When the beam longitudinal grades are less than 2%, the beam seats shall be sloped parallel to the beam grades. Otherwise, the beam seats shall be level to true elevation. The bridge seat elevations at the centerline of bearing shall be shown on the plans.

Minimum reinforcement shall be according to the Governing Specifications. The bearing area under each beam may be subjected to very large localized compressive and shearing stresses. Additional reinforcement directly under the bearing may be necessary to prevent the formation of visible cracks or possible spalling. This additional reinforcing may be required for beam seats that are stepped 4 IN or more or when the standard reinforcing is not sufficient to prevent cracking or spalling.

3.8.3 Backwalls

A backwall shall be provided on all bridges to retain the embankment behind the bridge, support the approach slab (if applicable) and to protect the bridge seat from water intrusion. However, with the approval of the Director of Engineering Division, some prestressed box beam bridges may not require the use of a backwall. The minimum thickness for a backwall shall be 1 FT. For backwall requirements on jointless bridges see Section 3.9.

A roughened horizontal construction joint shall be provided between the bridge seat and the backwall extending the entire width of the abutment. This construction joint may be optional for small abutments. Another method is to provide an optional construction joint 1 FT below the paving notch. Concrete above this joint shall not be placed until the deck slab is in place.

The roadway elevations at the face of the backwall shall be given on the plans.

3.8.4 Stem

The stem is a structure that retains the embankment behind the abutment and transmits the loads from the superstructure to the foundation. While there is no minimum thickness requirement, the stem thickness shall be designed to support the required loading and provide sufficient space for bearing devices.

Stems may be level, stepped or sloped based on bridge geometry (see Section 3.8.2).

3.8.5 Wingwalls

Wingwalls must be long enough to retain the roadway embankment based on the embankment slopes. The positioning of the wingwalls depends on the site itself (e.g., cut vs. fill, etc.). The Designer must study the existing and proposed contours and determine which type of wingwall best fits the site. Approach roadway slopes must be considered.

Generally, an embankment slope of 2:1 is used. When this is not possible, 1½:1 may be acceptable, with approval of the Bridge Project Manager. Wingwalls may be placed parallel to the roadway, at some angle or on the same alignment as the centerline of abutment bearings.

The following calculations and Figure 3.8.5 are representative examples of how to determine wingwall lengths. The Designer must consider the requirements stated above when laying out wingwalls and determining their length.

Calculation of wingwall lengths:

D	=	Distance from shoulder to berm
S	=	Embankment slope (S = 2 for a 2:1 slope)
q	=	Angle from backwall to wingwall
d	=	Width of bridge seat
WL	=	Wingwall length

Wingwalls where $q > 90°$ (right wingwall in Figure 3.8.5):

$$\text{WL} = \frac{\text{D (S)}}{\cos(q - 90)} - d + 1FT$$

Wingwalls where $q \leq 90°$ (left wingwall in Figure 3.8.5):

$$\text{WL} = D\,(S) - d + 1FT$$

Wingwalls shall be designed as horizontal cantilevers when supported by the abutment or as vertical cantilevers if they are supported by a foundation. The minimum thickness of a wingwall supporting a barrier shall be the base thickness of the barrier in question and designed for strength; otherwise, it shall be 1 FT.

A vertical construction joint may be required between the wingwall and abutment. The need for a construction joint is determined based on size and configuration. There are situations where the wingwall is a separate structure from the abutment. This requires an expansion seal or other expansion material between the two components.

3.8.6 Foundation

Abutment and wingwall foundations shall be designed and located as specified in Section 3.12, FOUNDATIONS.

Multi-column piers should generally not be used in a flood plain. Single circular column, T-type or wall type piers may be used in the flood plain with rounded ends and shall be oriented parallel to the stream flow.

3.11.3 Pier Foundations

Pier foundations shall be located and designed as specified in Section 3.12, FOUNDATIONS.

3.12 FOUNDATIONS

3.12.1 General

Unless directed otherwise by the Director of Engineering Division, all substructures are to be founded upon bedrock; whether by spread footings, piles or drilled caissons. Only end bearing piles, either driven or predrilled and driven, are acceptable. Friction or combination friction and end bearing piles shall not be used.

The Geotechnical Report shall list design assumptions and recommend appropriate foundations. The Designer shall determine if the structure can accommodate the design assumptions (i.e., settlement, lateral movement, etc.).

3.12.2 Spread Footings

Spread footings shall be proportioned to distribute the total vertical and horizontal forces in such a manner that the required structural stability is obtained and that the allowable design bearing pressures are not exceeded.

Minimum thickness for a spread footing is 3 FT and shall be keyed into rock a minimum of 1 FT. Allowable bearing pressures shall be used to size the footing.

For grade separation structures, the top of the footing shall be a minimum of 1 FT and preferably 2 FT below the finished ground line. The top of the footing should be at least 1 FT below the bottom of any adjacent drainage ditch. Deeper footings may be necessary to found the spread footing on competent material. The Designer shall consider constructibility with regard to adjacent structures such as railroad tracks, existing foundations, etc. Cofferdams may be necessary to facilitate construction. The designer shall review railroad requirements to assure compliance.

For water crossing structures, the bottom of footings should be founded on competent bedrock. Unless directed otherwise, the top of the footing shall be located below the anticipated scour event. An exception to placing the top of the footing below the scour event may be founding the footing in non-scourable bedrock. Non-scourable bedrock is defined as rock having a minimum RQD of 50% and is resistant to slaking, as determined by the Engineer. Cofferdams may be required for construction and shall be anticipated in the plans.

Due to the possibility of stream meander, footings placed in the overflow section of the water crossing shall be investigated to assure the footings will remain stable should the stream migrate.

3.12.3 Pile Foundations

In order to facilitate the driving of non-predrilled steel bearing piles the following minimum size of piles shall be specified:

- HP 10x42 for lengths up to 40 FT
- HP 12x53 for lengths between 40 and 80 FT
- HP 14x73 for lengths over 80 FT

The design may require larger piles, for the above lengths, based on vertical and/or lateral loads. The minimum piling length shall be 10 FT. The pile embedment is a minimum of 1 FT into the cap. The Designer shall verify the availability of any section and pile accessories necessary for construction. See Section 2.4.5.2 Piling, for additional information.

For water crossing structures, the top of the pile cap shall be placed below the anticipated scour event (see AASHTO 2.6.4.4.2).

Steel H piles, as a minimum, shall conform to the requirements of AASHTO M160, and M270, Grade 36. High strength steel piling such as Grade 50 may be used.

The Geotechnical Engineer shall determine the required bearing capacity and perform a drivability analysis to determine if the pile can be installed to the required elevation without damage. The Geotechnical Report should also recommend if pile tips are required.

Pile footings shall be proportioned to distribute the total vertical and lateral forces in such a manner that the required structural stability is obtained and that the allowable design bearing values are not exceeded. Minimum thickness for a pile footing is 3 FT. Generally, the pile footing should be designed so that no pile experiences uplift. If uplift is anticipated, the pile-cap connection shall be checked along with the pullout resistance of the pile.

The Designer shall check steel H piles as a structural column when determining the necessary pile size. This is especially critical for trestle type bents after the anticipated

Negative flexure over Pier 1

$$\text{IRF} = \frac{\phi M_n - [1.3(M)_{DL1} + 1.3(M)_{DL2} + M_s]}{2.17(M)_{LL+I}}$$

$$\text{IRF} = \frac{-5{,}286 - [1.3\ (0) \ \ + 1.3\ (\text{-}473) + 0]}{2.17\ (\text{-}1{,}213)} = 1.77$$

$$\text{ORF} = \frac{\phi M_n - [1.3(M)_{DL1} + 1.3(M)_{DL2} + M_s]}{1.3(M)_{LL+I}}$$

$$\text{ORF} = \frac{-5{,}286 - [1.3\ (0) \ \ + 1.3\ (\text{-}473) + 0]}{1.3\ (\text{-}1{,}213)} = 2.96$$

Shear rating at critical section of Span 1 (at H/2 from Pier 1)

- Applied shear and design data:

V_{DL1}	=	108 K
V_{DL2}	=	24 K
V^*_{LL+I}	=	84 K (live load shear based on one lane)
ϕV_n	=	458 K
LLDF	=	0.849 (AASHTO LRFD live load distribution factor)

- Convert live load shear:

$$V_{LL+I} = \text{LLDF}\,(V^*_{LL+I})$$

$$V_{LL+I} = 0.849\ (84) = 71\ \text{K}$$

Shear capacity at the critical section of Span 1

$$\text{IRF} = \frac{\phi V_n - [1.3(V)_{DL1} + 1.3(V)_{DL2} + V_s]}{2.17(V)_{LL+I}}$$

$$\text{IRF} = \frac{458 - [1.3\ (108) + 1.3\ (24) + 0]}{2.17\ (71)} = 1.86$$

$$\text{ORF} = \frac{\phi V_n - [1.3(V)_{DL1} + 1.3(V)_{DL2} + V_s]}{1.3(V)_{LL+I}}$$

$$ORF = \frac{458 - [1.3\,(108) + 1.3\,(24) + 0]}{1.3\,(71)} = 3.10$$

3.15.2 Conversion Factors for Refined Analyses

When structures are designed using refined analyses, conversion factors shall be developed. The refined analyses methods include line girder analyses based on refined live load distribution factors, grid analyses and finite element analyses. The conversion factors indicate the relationship of live load design moments and shears, obtained from the refined analysis, to the live load moments and shears obtained from a standard line girder analysis with a live load distribution factor of 1.0 for a single lane (a single lane equals two wheels). Do not use AASHTO distribution factors for the line girder analysis.

- The conversion factors for refined analyses shall be computed using the following equation:

$$CF = \frac{\text{Moment (refined analysis)}}{\text{Moment (line girder analysis)}}$$

- Use of conversion factors

Subsequent analyses of the structure may be completed using a standard line girder analysis with a live load distribution factor 1.0 for a single lane (a single lane equals two wheels). Do not use AASHTO distribution factors for the line girder analysis. For additional loadings, or re-evaluation of the design vehicle, the live load moments and shears obtained from the standard line girder analysis shall be multiplied by the conversion factors obtained from refined analysis at appropriate girder location under investigation. For example, for Girder 3 at mid span of span 2, the equivalent refined moment can be calculated as follows:

Girder 3, Location: Span 1.5

CF	=	1.026	(listed in the table on the original plans)
$M_{(LG)}$	=	3175.8 K-FT	(live load moment from line girder analysis)
$M_{(refined)}$	=	3175.8 K-FT (1.026)	
	=	3258.4 K-FT	(equivalent refined live load moment)

APPENDIX A – MISCELLANEOUS PLAN NOTES

A.1 MANDATORY PLAN NOTES

A.1.1 Weathering (Unpainted) Steel Bridges

Note: All references in these notes are to the WVDOT, DOH Standard Specifications, Roads and Bridges, Adopted 2000 as amended by the Supplemental Specifications dated January 1, 2003.

STRUCTURAL STEEL

All structural steel, except as noted, shall meet AASHTO M270 Grade 50W, except girder flanges, webs, and splice plates shall meet Grade 50W-T2.

Anchor bolts, nuts and washers, and deck drainage components may be manufactured from ordinary mild steel and shall be hot-dip galvanized according to AASHTO M 111 after fabrication. The fabricator's shop drawings shall identify the material specification and grade for each item and are subject to approval of the Engineer.

High strength fasteners shall meet Section 709.24 and shall be black (uncoated) Type 3 (weathering steel). The high strength fasteners used in regions of the structure that require painting shall be Type 1 or 3 and shall be mechanical galvanized.

Before assembling the high strength bolted connections, remove all loose and non-adherent rust that may have formed on the connection areas by hand or power wire brushing.

BLAST CLEANING AND PAINTING

Upon completion of all fabrication operations in the shop, and before shipment to the project site, all weathering steel bridge components shall be blast cleaned to a Near White surface condition according to SSPC-SP 10. Prior to the start of any blast cleaning, all oil, grease, cutting fluids, or other foreign matter shall be removed from the surfaces of the steel by solvent cleaning according to SSPC-SP 1.

The members or portions of members listed below shall be blast cleaned and shop painted according to Section 688 of the Standard Specifications, PAINTING STEEL STRUCTURES, using the Zinc Rich, Low VOC System, Section 711.22. Apply the full paint system in the fabrication shop, except faying surfaces of high strength bolted connections, which shall be shop painted with primer only. The color of the final top coat shall be 30045 according to Federal Standard 595 and the Gloss at angle of 60 degrees shall not exceed 25.

a) For integral and semi-integral abutment structures, paint the ends of the girders and all other structural components encased in the concrete abutment plus one additional foot in length.

b) Where expansion joints are specified, paint all steel components under the joint and in both directions from the centerline of the joint for a distance of 1.5 times the girder depth, or 10 feet, whichever is larger. Components specified to be hot-dip galvanized do not require painting.

Areas of the shop applied paint system which are damaged during erection and high strength bolted connection areas that were only prime painted shall be properly cleaned and painted according to Section 688 of the Standard Specifications, PAINTING STEEL STRUCTURES, and to the satisfaction of the Engineer.

After completion of all tightening operations, mechanical galvanized fasteners shall be solvent cleaned and field painted as specified for the structural steel.

Include cleaning and painting costs in Item 615001-*, Steel Superstructure.

For integral and semi-integral abutment structures, the crevice/interface between the embedded steel and the concrete shall be suitably chamfered to provide for placement of a sealant. Seal the crevice with a sealant material meeting the requirements of ASTM C920, Type S, Grade NS, Class 25, Uses NT and M. Sealant shall be suitable for bonding between concrete and the top coat of the specified paint system. Acid-cure sealants are not allowed. Include payment in Item 615001-*, Steel Superstructure.

IDENTIFICATION MARKING STEEL MEMBERS

All steel mill and fabricator identification markings for steel plates, shapes, or fabricated members shall be by metal tags, soapstone, or some other readily removable material; or, shall be marked in an area of the completed member which will be encased or covered with concrete. Marking methods and locations are subject to approval of the Engineer.

Do not use paint or wax-based crayons for marking.

A.1.3 Steel Stud Shear Connectors

STEEL STUD SHEAR CONNECTORS

When design requires the use of welded stud shear connectors, they shall meet the requirements of Section 7 of the ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

No shop installation of welded stud shear connectors shall be permitted except as follows:

The contractor may shop install shear studs to the beam or girder for the purpose of attaching a worker fall protection system. Only the shear studs required to properly install and support the worker fall protection system may be installed in the shop. The remaining shear studs for an individual row across the beam or girder flange may also be installed in the shop. All shop installed shear studs shall be shown on the shop drawings.

The field installation of the welded stud shear connectors shall not commence prior to the installation of the deck forms in the area surrounding the welded stud shear connectors. Overhanging deck forms may be installed after the welded stud shear connectors are installed. The welded stud shear connectors and deck forms shall be installed in a sequence that permits workers access through the deck area without walking through installed welded stud shear connectors.

A.2 TYPICAL PLAN NOTES

A.2.1 Elastomeric Bearing with Load Plate

Exercise caution while making field or shop welds while an elastomeric bearing pad is in contact with the steel. In no case shall the elastomer or elastomer band be exposed to instantaneous temperatures greater than 400°F. Any damage to the elastomeric bearing due to welding will be cause for rejection. The temperature shall be monitored by heat crayons furnished by the Contractor.

A.2.2 Strip Seals

The strip seal gland shall be delivered to the jobsite in lengths suitable for continuous one-piece installation for each individual expansion joint. Field splicing of a strip seal gland is not permitted.

Special conditions such as doglegs, tees, and crosses shall be shop fabricated in a mold under heat and pressure.

A.2.3 Finger Joints

The fabrication and erection of the fingerplate shall be in accordance with the approved shop drawings and bridge deck grade and crown (profile). The openings shall be preset prior to shipment and assembled with temporary shipping angles. The fingerplate shall be installed under the supervision of the supplier.

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The drainage trough shall not be spliced unless indicated on the approved shop drawings. When splices are indicated, the splices shall be shop vulcanized by the Manufacturer. Longitudinal splices are not permitted.

The Manufacturer shall be required to submit a detailed report substantiating the testing performed on its joint design and showing the corresponding fatigue resistance line generated from the actual fatigue testing data.

After the expansion joint is installed, it shall be tested for water tightness by flooding the expansion joint with water and inspecting from below.

A.2.4 Retaining Walls

The quantity of earthwork shown in the plans should NOT INCLUDE any work within the wall pay limits shown in the plans. Any excavation inside the pay limits of the wall is included in the price of the wall. The contractor is responsible for any cost of changes in waste, borrow, or earthwork quantities from those shown in the plans caused by the requirements of the proposed wall system. Any adjustments to the required amount of embankment or select granular backfill due to the particular wall system proposed by the contractor shall be considered incidental to the project.

The measurement of a particular wall systems item quantity shall be the gross area in square feet lying in a plane outside the front face of the wall from the minimum embedment depth (i.e. top of the footing or leveling pad) to the top of the wall excluding barriers.

The price of an MSE wall item shall include (in place): facing elements, soil reinforcing and attachment devices and associated hardware, coping and trim or similar items that are normal parts of the wall construction. Additionally, the price shall include all the following items shown within the pay limits on the plans (in place): select granular backfill, excavation, embankment, foundation preparation and leveling pads.

Barriers are considered a separate item.

The price of a cast-in-place wall item shall include (in place): concrete, reinforcing steel, joint materials, underdrains, weepholes or similar items that are normal parts of wall construction. Additionally, the price shall include all the following items shown within the pay limits on the plans (in place): select material for backfill, excavation, embankment and foundation preparation.

Errata Sheets

Please replace the following pages in the Bridge Design Manual.

Page(s)
Foreword - First Page after Cover
Entire Table of Contents
Pg. 2-1
Pg. 3-68
Glossary – Page 6-7, 20, 26 and 30

FOREWORD

This Bridge Design Manual was prepared by SITE-Blauvelt Engineers, Inc. for the West Virginia Division of Highways (WVDOH), Engineering Division. This manual is intended to be a guide for Engineers working on bridge design projects for the WVDOH. It provides policies, procedures and methods for developing and documenting the design process. It is not intended to replace the engineering analysis and judgment that must be applied to each project. The benefits of this Manual will be the standardization of: the structure design process, common details, and the layout of the contract plans. In addition, it will provide minimum design standards for structures in West Virginia and provide interpretation and consistency in the application of the AASHTO Specifications.

The layout of the Bridge Design Manual follows the general steps involved in the bridge development process. It begins with Section 1 - Introduction, which discusses scope and limitations. Next, in Section 2 the information necessary for the preliminary design process is presented. Following the preliminary design process, the criteria for final bridge design and detailing are given in Section 3. Section 4 focuses on general plan presentation, including CADD standards. Sections 5 and 6 contain WVDOH standard drawings and generally accepted computer design software, respectively. Shop drawing requirements are given in Section 7. Finally, the Appendices provide additional information regarding plan notes, permit checklists, bridge design forms, coatings and references. A Glossary and Index are also provided for convenience.

Revisions to this Manual will be made on a yearly bases. The revisions will be handled, as interims and the Manual will be republished as deemed necessary by the WVDOH.

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SECTION 2 - BRIDGE DEVELOPMENT PROCESS

2.1 PROJECT DESIGN CRITERIA

All designs shall be in accordance with the latest edition of the *AASHTO LRFD Bridge Design Specifications* (Governing Specifications), including all interim specifications and the *West Virginia Division of Highways Standard Specifications, Road and Bridges* (Standard Specifications) including the latest supplemental specifications.

See Section 600 of the Design Directives (DD) for information that is applicable to the roadway design criteria associated with bridge planning. Reference is also made to DD-202, which contains the Bridge Submission Checklists for each phase of the project.

When a project consists of total Bridge Replacement or a Bridge Rehabilitation Project is converted to a Bridge Replacement, the Project Manager shall verify that the Bridge Sufficiency Rating is less than 50 if Federal Funding is being utilized.

2.1.1 Typical Deck Transverse Section

The typical deck transverse section shall be determined by the Project Manager (see DD-601).

Generally, the bridge width shall not be less than that of the approach roadway section and barriers shall be provided in accordance with the Governing Specifications.

2.1.2 Environmental Documentation

The WVDOH and/or Consulting Engineer will perform environmental evaluations. These documents will be supplied to the Project Manager for use in the design. Design Directives 201 and 206 discuss the environmental process and the necessary documentation.

Under most circumstances, bridge rehabilitations, reconstruction, and replacement projects will require a Class II (categorical exclusion) environmental action as defined in 23 CFR Section 711.117 (Code of Federal Regulations, U. S. Congress). Those structures requiring a Class I or Class III (Environmental Impact Statement or Environmental Assessment, respectively) environmental action are generally on a new alignment and will be part of a larger corridor study.

When requested by the Division of Highways, representatives from the WVDOH and/or the Consulting Engineer shall attend public information meetings to answer questions and provide information about the environmental study.

2.1.3 Right-of-Way

Right-of-way requirements shall be coordinated with the Right-of-Way Division of the Division of Highways (see DD-301).

2.1.4 Line and Grade Geometrics

The WVDOH will determine the line and grade on a project. If a Consultant is designing the project, then the line and grade will be determined by the Consultant, pending approval from the Project Manager. See DD-601 through 620.

2.1.5 Highway Drainage

See Design Directives Section 500 for information dealing with highway drainage.

The Governing Specifications requirements for hydraulic studies shall be met. The depth of the study is dependent on the classification of the highway.

2.1.6 Existing Project Related Information

Early in the project, the Bridge Designer should gather as much existing information about the project as possible. This information could prove to be extremely useful during the planning phase of the project. Available information could consist of inspection reports, bridge replacement studies, as-built plans on the existing bridge and roadway, among other items.

2.1.7 Hydrology and Hydraulics

The WVDOH has developed a comprehensive Drainage Manual that shall be utilized in establishing design frequencies for new and replacement structures.

Hydraulics is the study of stream valley cross-sections and bridge geometry data to determine flow velocities and water surface elevations along a stream or river. In most cases, a one-dimensional steady flow model will suffice. The HEC-RAS computer model (Hydrologic Engineering Center – River Analysis System) can be used to determine the flow velocities and water surface profile. When a more detailed or site-specific analysis is needed, unsteady flow and/or two-dimensional models may be used.

When determining water surface elevations, two conditions must be analyzed for comparison: the existing conditions and the proposed conditions. If there is published

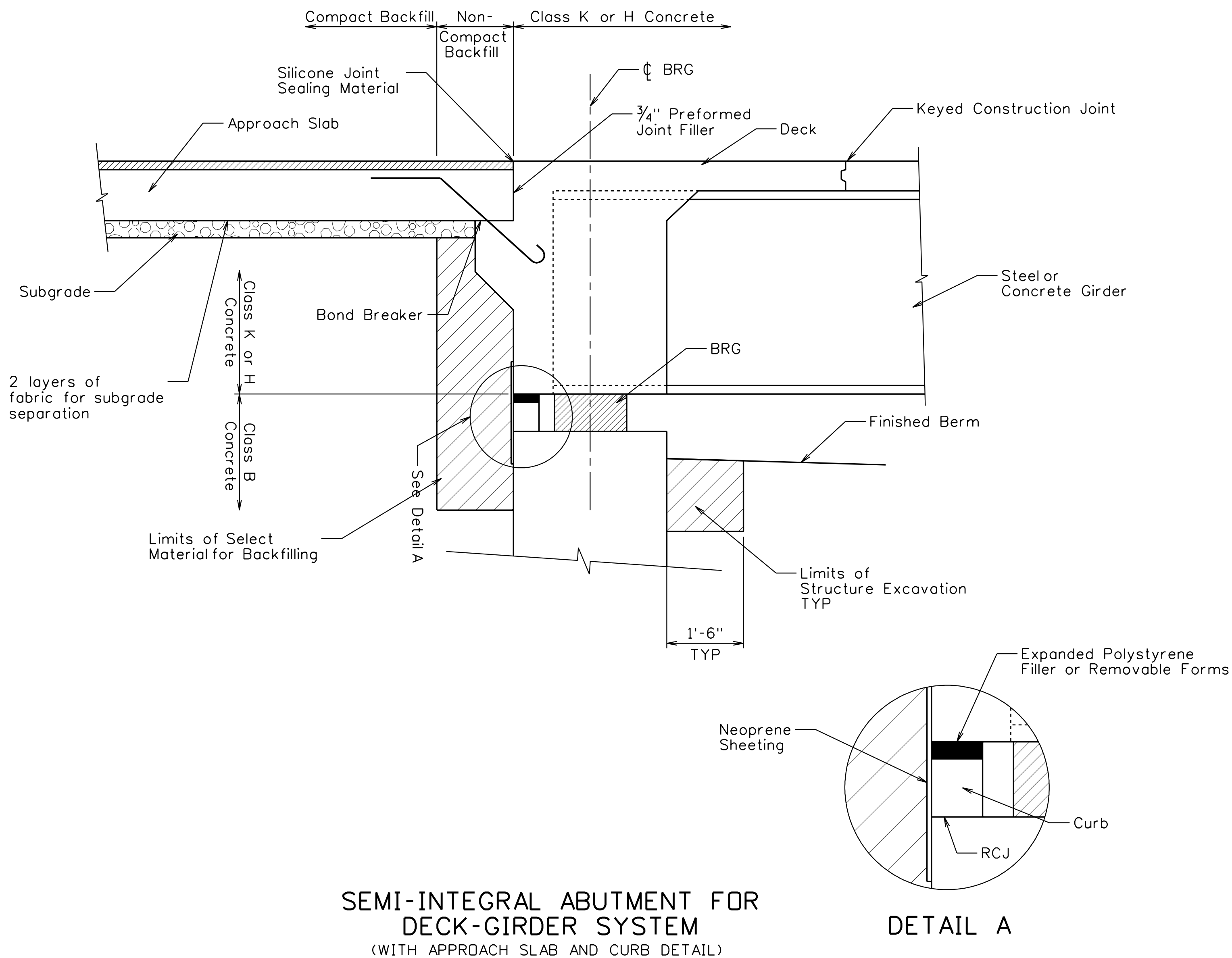
Compact Backfill
Non-Compact Backfill
Class K or H Concrete
Silicone Joint Sealing Material
℄ BRG
¾" Preformed Joint Filler
Deck
Keyed Construction Joint
Approach Slab
Subgrade
Bond Breaker
Steel or Concrete Girder
Class K or H Concrete
Class B Concrete
BRG
2 layers of fabric for subgrade separation
Finished Berm
See Detail A
Limits of Select Material for Backfilling
Limits of Structure Excavation TYP
1'-6" TYP
Expanded Polystyrene Filler or Removable Forms
Neoprene Sheeting
Curb
RCJ
SEMI-INTEGRAL ABUTMENT FOR DECK-GIRDER SYSTEM
(WITH APPROACH SLAB AND CURB DETAIL)
DETAIL A

Figure 3.9E

The beam seat shall be sloped parallel to the beam grade for integral abutments.

Integral abutments shall be designed using a single row of piling. Wingwalls requiring more support than that available from the integral abutment shall be structurally isolated.

The following parameters apply to integral abutments:

- Piling shall be a single row and aligned so that the webs are parallel to the centerline of bearing.
- Piling shall be embedded into the abutment at least 1.0 FT unless the analysis requires more.
- The distance from the side of any pile to the nearest edge of the abutment shall be greater than 9 IN.
- Piling lengths of 10 FT (minimum) to 15 FT shall be predrilled to the top of rock. Piling lengths greater than 15 FT shall be predrilled a minimum of 15 FT. Pre-drilling is in accordance with Section 616 of the Standard Specifications. Pile points are permitted to facilitate pile driving, but are not considered a substitute for pre-drilling integral abutment piling.
- Wingwalls supported by the abutment shall be limited to 6 FT for straight wings and 12 FT for U-wings.

3.9.2 Semi-Integral Abutments

Semi-integral abutments may be used where foundation sites rule out the use of an abutment on a single row of piles, while retaining full integrity with the superstructure.

Consideration must be given to the following:

- When full height U-shaped wingwalls are used, provisions shall be made to allow for thermal expansion of the superstructure without interference from the wingwalls.
- The Designer must account for these items:
  - Uplift resulting from the span arrangement
  - Buoyancy
  - Excessive grade; greater than 5%
  - Potential roadway settlement
- Seal between the abutment seat and cap to retain the backfill and for waterproofing. Add a full-length curb to the top of the semi-integral stem to help retain the backfill when the bearing height exceeds 1 ½ IN (see Figure 3.9E).

When the beam longitudinal grade is less than 2%, the beam seat shall be sloped parallel to the beam grade. Otherwise, the beam seats shall be level to true elevation.

CHEMICAL STRIPPING
Use of paint removers or chemical strippers to soften existing coatings for removal by scraping and/or flushing.

CJP (Complete Joint Penetration Groove Weld)
A groove weld which has been made from both sides or from one side on a backing having complete penetration and fusion of weld and base metal throughout the depth of the joint.

CLOMR (Conditional Letter of Map Revision)
A *Conditional Letter of Map Revision (CLOMR)* is FEMA's comment on a proposed project that would affect the hydrologic and/or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodway or effective Base Flood Elevations. There is no appeal period. The letter becomes effective on the date sent. This letter does not revise an effective National Flood Insurance Program map; it indicates whether the project, if built as proposed, would or would not be removed from the Special Flood Hazard Area by FEMA if later submitted as a request for a Letter of Map Revision.

CLOSED ABRASIVE BLAST CLEANING
Compressed air or centrifugal blast cleaning done within a localized containment or enclosure that surrounds the abrasive stream. The enclosure is held to the surface to create a seal, and is equipped with a vacuum to remove spent abrasive and debris simultaneously with the blasting operation. When compressed air is used to propel the abrasive, the technique often is called "vacuum blasting". When wheels are used to propel the abrasive, the technique often is called "wheel blasting".

COATING SYSTEM
A protective film consisting of one or more coats, applied in a predetermined order by prescribed methods. A coating system description in a specification may include surface preparation and quality control requirements.

COAT OF PAINT
A layer of wet paint that is allowed to dry and harden before use or before application of a subsequent layer.

COFFERDAM
A watertight enclosure used for foundation construction where the founding elevation is below water level.

COHESION
The propensity of a substance to adhere to itself. The force holding a substance together. (Paint/Coatings Directory) The ability of a single coating layer to resist internal partitioning or fracturing.

COLORFASTNESS
The ability of a film of paint or varnish to show little change in original color after being exposed to light and weathering.

COMMERCIAL BLAST CLEANING
Moderate grade of blast cleaning. According to The Society for Protective Coatings Surface Preparation Specification No. 6 "Commercial Blast Cleaning" (SSPC-SSP 6), a commercial blast cleaned surface is free to all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, staining is limited to no more than 33 percent of each square inch of surface area. Commercial blast cleaning also is defined in NACE No. 3 "Commercial Blast Cleaned Surface Finish". NACE and SSPC have a joint effort underway to develop a unified consensus on blast cleaning standards.

COMPOSITE CONSTRUCTION
Action where the concrete deck and its supporting members work as one unit to resist superimposed dead loads and live loads.

CONSTRUCTION JOINT
A temporary joint used to permit sequential construction.

CONTAINMENT
A method to limit dust, debris, paint chips, paint dust, spent abrasives, and over-spray from contaminating the environment. The type, concentration, and toxicity of the contamination determine the extent of containment systems include free-hanging enclosures, partial structure enclosures, and total structure enclosures with or without negative pressure.

CONTAINMENT SYSTEM
A system that includes the containment structure (i.e., containment walls, floor, supporting structure, and entryways); ventilation system (forced or natural air input ports, and natural or mechanical exhaust); and, in some cases, dust collection equipment.

CONTRACTOR
One who undertakes responsibility for the performance of construction work, including the provision of labor and materials, in accordance with plans and specifications and under a contract specifying cost and schedule for completion of the work.

CORROSION
Deterioration of metal, concrete, or other materials by chemical or electrochemical reaction resulting from exposure to weather, oxygen, moisture, chemicals, etc.

CORROSION-INHIBITIVE PIGMENT
A pigment that, when made into a paint, has the property of reducing the rate of corrosion of the substrate to which it is applied.

COUNTERFORTS
Thin vertical slabs that are placed uniformally along the length of the stem and footing of a retaining wall. The slabs allow the wall to be designed as a beam between the slabs instead of a cantilever.

CREEP
Time-dependent deformation of concrete under sustained load.

CROSS-FRAME
A transverse truss framework connecting adjacent longitudinal flexure components.

CRSI
Concrete Reinforcing Steel Institute

D

DEBONDING
Wrapping, sheathing, or coating a prestressing strand to prevent bond between strand and surrounding concrete.

DECK
The superstructure component that distributes vehicular loads transversely to the beams and girders.

DEEP FOUNDATION
A foundation which derives its support by tansferring loads to soils or rock at some depth below the structure by end bearing, adhesion or friction, or both.

DELAMINATION
The separation of a coat or coats of paint from the previous coat or from the substrate.

DEVELOPMENT LENGTH
The length required to develop the design strength of reinforcement at a critical section.

DIAPHRAGM
A transverse flexural component connecting adjacent longitudinal flexural components.

DIAPHRAGM CONNECTION PLATES
Plates that are used to connect the diaphragms and cross frames to the girders.

DOUBLE-DIP GALVANIZING
(1) Immersing half of a structure at a time into a molten zinc bath when it is too large to be immersed in one dipping. (2) Passing an article through a molten zinc bath twice in order to acquire a thicker coat of zinc.

DRILLED CAISSON
A deep foundation unit, wholly or partly embedded in the ground, constructed by placing fresh concrete in a drilled hole with or without steel reinforcement. *Drilled caissons* derive their capacities from the surrounding soil and/or from the soil or rock strata below their tips.

DRY FILM THICKNESS
Thickness of an applied coating when dry, often expressed in mils or microns.

DRY FILM THICKNESS GAGE
An instrument used to measure the dry film thickness of a coating.

DRYING TIME
Time required for an applied film of coating to reach the desired stage of cure, hardness, or non-tackiness.

DRY SPRAY
A rough, powdery, non-coherent film produced when an atomized coating partially dries before reaching the intended surface.

DRY-TO-HANDLE TIME
The drying time needed for paint or varnish to harden before handling without damaging the coating.

DRY-TO-RECOAT TIME
The drying time required between the applications of successive coats of paint or varnish.

DRY-TO-TOUCH TIME
The drying time needed for a coating of paint or varnish to harden so that it is tack-free to the touch.

E

ELASTOMER
A macromolecular material (such as rubber or a synthetic material having similar properties) that returns rapidly to approximately the initial dimensions and shape after substantial deformation by a weak stress and release of the stress.

P

PAINT
(1) A mixture or dispersion of pigments or powders in a liquid or vehicle designed for application to a substrate in a thin layer that is converted to an opaque solid film after application. Used for protection, decoration, identification, or other functional purposes. (2) Application of a coating material.

PAINT FAILURE
(1) The condition of a paint film at the end of its useful life. (2) The premature deterioration of a coating. All paints fail eventually.

PAINTING JOB
The series of operations that includes surface preparation, pretreatment, and application of paint to a surface in the shop or in the field. It usually includes the supply of labor, material, and equipment as well as the drying and protection of the painted surface.

PAINTING SYSTEM
One or more coats of paint applied in a specific sequence to achieve a specified end result. See also COATING SYSTEM.

PENETRATING PRIMER
Coating developed to penetrate old, loose coatings, such as aged, red lead primers, and provide a good bond to subsequently applied coatings. Penetrating primers have low molecular weight and low viscosity. They are clear or lightly pigmented.

PERMIT VEHICLE
Any vehicle whose right of travel is administratively restricted in any way due to its weight or size.

PIGMENT
Finely ground, natural or synthetic, inorganic or organic, insoluble particles that, when dispersed in a liquid vehicle to make paint, may provide color and other properties, including opacity, hardness, durability, and corrosion resistance. The term is used to include extenders as well as white or colored pigments.

PIGMENT SOLIDS
The amount of pigment in a dry paint, expressed as a percentage. Pigment solids may be calculated by weight or by volume.

PILE
A relatively slender deep foundation unit, wholly or partly embedded in the ground, that is installed by driving, drilling, auguring, jetting, or otherwise and that derives its capacity from the surrounding soil and/or from the soil or rock strata below its tip.

PINPOINT RUSTING
Tiny, dispersed points of rust that can appear at pinholes and holidays in a coating. Very dense pinpoint rusting can appear on painted steel surfaces where the coating does not completely cover the blast cleaning profile.

PJP (Partial Joint Penetration Groove Weld)
A groove weld that joint penetration is intentionally less than complete.

PLAIN ELASTOMERIC PAD (PEP)
A pad made exclusively of elastomer.

PLATE
A flat rolled steel product whose thickness exceeds 0.25 IN.

POINT OF CONTRAFLEXURE
The point where the sense of the flexural moment changes; synonymous with point of inflection.

POLYURETHANE
A coating material formed by the reaction of an isocyanate with hydroxyl-containing substances (polyols) to produce an organic compound known as a urethane. Many different materials can be produced by this type of reaction. Polyurethane materials that are most suitable for coatings show good chemical, solvent, and abrasion resistance, and good gloss retention.

POST-TENSIONING
A method of prestressing concrete in which tendons are tensioned after the concrete has hardened.

POT BEARING
A bearing which transmits vertical loads by compression on an elastomeric disc confined in a steel cylinder and which accommodates rotations by deformations of the disc.

POWER TOOL
A tool powered by air pressure or electricity. Power tools clean a surface of old paint, rust, mill scale, or other contaminants by impact, rotary abrasive action, or a combination of both. Commonly used power tools include power chippers, needle guns, descalers, wire brushes, sanding discs, grinding wheels, and rotary peeners.

POWER TOOL CLEANING
The use of power impact, rotary, or rotary impact tools to remove loose paint, rust, mill scale, and other loose contaminants from a surface. The specification SSPC-SP 3, “Power Tool Cleaning,” is a consensus standard covering the procedures necessary for power tool cleaning of steel surfaces. Some tools can remove all paint, rust, and mill scale, and produce a surface profile in accordance with SSPC-SP 3, POWER TOOL CLEANING; SSPC-SP 11, POWER TOOL CLEANING TO BARE METAL.

SOIL LEAD LEVEL
The total lead in soil determined by atomic absorption spectroscopy or inductively coupled plasma atomic emission spectroscopy. Note that this value represents the total lead in soil rather than the leachable lead. (Leachable lead is used to establish whether debris is a hazardous waste.)

SOLIDS
Nonvolatile matter in a coating composition; the ingredients of a coating composition that, after drying, are left behind and form the dry film.

SOLVENT
Liquid, usually volatile, used in the manufacture of paint to dissolve or disperse the film-forming constituents. Since they evaporate during drying, solvents do not become part of the dried film. Solvents are used to control the consistency and character of the liquid paint material and to regulate its application properties.

SOLVENT CLEANING
The use of organic solvents, detergents, alkaline cleaners, and steam cleaning to remove oil, grease, dirt, soil, and other, similar organic compounds from a surface. The specification SSPC-SP1, "Solvent Cleaning," is a consensus standard covering the procedures necessary for solvent cleaning of steel surfaces. Consult the document for specific details and requirements.

SPALLING
The breaking away of surface concrete from an element.

SPAN LENGTH
The distance between two supports of a bridge, measured between bearings.

SPOT PRIMING
Application of primer paint to localize spots where the substrate is bare or where additional protection is needed because of damage to or deterioration of a former coat.

SPOT REPAIR
Patching, spackling, or other repair of small areas, normally prior to spot priming.

SPRAYING
An application method in which coating material is sprayed onto a surface after being atomized, usually by a compressed air jet (air spray) or by direct pressure flow through a small orifice nozzle (airless spray).

SSPC
The Society for Protective Coatings (formerly Steel Structures Painting Council).

SSPC-PA 1, SHOP, FIELD, AND MAINTENANCE PAINTING
The Society for Protective Coatings Paint Application Specification No. 1. The specification covers procedures for painting steel surfaces after the selection of the coatings material has been made. It does not cover surface preparation, pretreatments, or selection of primers and finish coats. SSPC-PA 1 is intended to be used for steel which, because of its exposure condition, will be subjected to corrosive attack, either from the weather or from the service environment, and where a high quality of cleaning and painting is essential.

SSPC-PA 2, MEASUREMENT OF DRY PAINT THICKNESS WITH MAGNETIC GAGES
The Society for Protective Coatings Paint Application Specification No. 2. The specification describes the procedures to measure the thickness of a dry film of a nonmagnetic coating applied on a magnetic substrate using a magnetic gage that is nondestructive to the film.

SSPC-PA 3, A GUIDE TO SAFETY IN PAINT APPLICATION
The Society for Protective Coatings Paint Application Guide No. 3. This guide defines methods and practices that are most practical in maintaining safety during application of protective coatings on steel structures. The objective of the guide is to itemize basic actions and care that should be considered while working in or on access facilities, using professional tools to apply materials having potential hazards.

SSPC-PA 4, GUIDE TO MAINTENANCE REPAINTING WITH OIL BASE OR ALKYD PAINTING SYSTEMS
The Society for Protective Coatings Paint Application Guide No. 4. This guide outlines the components of a complete maintenance repainting system. It covers the steps necessary for repainting steel structures, which previously were painted with oil base, alkyd, or other conventional oleoresinous paint systems, using the same generic paint system as the existing one.

SSPC-PA 5, GUIDE TO MAINTENANCE PAINTING PROGRAMS
The Society for Protective Coatings Paint Application Guide No. 5. The guide covers procedures for planning and carrying out a maintenance painting program for steel and other structures to prevent corrosion and maintain appearance. It may be used for one-time repaint programs or long-range paint programs.

SSPC-SP 1, SOLVENT CLEANING
The Society for Protective Coatings Surface Preparation Specification No. 1. Solvent cleaning is a method for removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants form steel surfaces. It is intended that solvent cleaning be used prior to the application of paint and in conjunction with surface preparation methods specified for the removal of rust, mill scale, or paint.

SSPC-VIS 3, VISUAL STANDARD FOR POWER- AND HAND-TOOL CLEANED STEEL
The Society for Protective Coatings Visual Standard No. 3. The standard consists of color photographs that represent various conditions of unpainted, painted, and welded steel surfaces prior to and after power and hang tool cleaning. The photographs are intended to be used to supplement the written SSPC power and hand tool surface preparation specifications.

STANDARD SPECIFICATIONS
The *West Virginia Division of Highways Standard Specifications, Roads and Bridges* including the latest supplemental specifications.

STEEL ABRASIVE
Cast steel shot or grit used for abrasive blast cleaning. Cast steel shot consists of nearly spherical particles of steel obtained by granulating a molten stream of metal with water or air, or by other methods. Cast steel grit consists of angular particles produced by crushing steel shot.

STEEL REINFORCED ELASTOMERIC BEARING
A bearing made from alternate laminates of steel and elastomer, bonded together during vulcanization.

SUBSTRUCTURE
Structural components of the bridge, which support the superstructure.

SUBTRATE
Any surface to be painted, including wood, concrete, masonry, steel, other metals, and various other materials. A previously unpainted surface sometimes is called the "original substrate."

SUPERSTRUCTURE
Structural components of the bridge, above the substructure.

SURFACE
(1)An area to be coated. (2) Characteristics of the area to be coated. (3) The kind of finish obtained after the coating work is finished.

SURFACE PREPARATION
Any method of treating a surface to prepare it for coating. Surface preparation methods include washing with water, detergent solution, or solvent; cleaning with hand or power tools; water washing or jetting with or without abrasive; or abrasive blast cleaning. The SSPC and NACE International have a number of written and visual standards describing the surface preparation of steel surfaces prior to painting.

SURFACE PROFILE
The roughened surface that results from abrasive blast cleaning or power tool cleaning to bare metal. For steel, surface profile is a measurement of the peak-to-valley height of the roughness, often expressed as an average, and typically ranges from less than 1 mil up to 5 mils (25-127 microns). For wood and concrete, surface profile is simply the texture of the cleaned surface.

SURFACE TENSION
The work required to enlarge the surface of a liquid, expressed as dynes/cm. Surface tension tends to minimize the volume and surface area of a liquid.

SURFACE-TOLERANT COATING
(1) A very loose, general description of a coating. A "surface-tolerant coating" must be further qualified as to the types of surfaces over which it can be applied successfully. For example, application over an aged alkyd coating, an oily or greasy, salt-contaminated, or damp or wet surface, loose, stratified, or tight rust, etc., can all require a different type of surface-tolerant coating. (2) A coating designed to be applied over a lesser degree of surface preparation than commercial blast cleaning (SSPC-SP 6).

SWEEP BLAST CLEANING
A fast pass of the abrasive blasting pattern over a surface to remove loose material and to roughen the surface sufficiently to successfully accept a coat of paint. This method of cleaning sometimes is specified as SSPC-SP 7, Brush-off Blast Cleaning.

T

TENDON
Wire, strand, or bar, or bundle of such elements, used to prestress concrete.

THROUGH DRYING
Drying of the complete coating film, including both top and bottom.

TIE COAT
A paint formulated specifically to provide a transition from a primer or undercoat to a finish coat. Tie coats are used to seal the surface of a zinc-rich primer, to bond generally different types of coatings, or to improve the adhesion of a succeeding coating.

TOP COAT
The last coating material applied in a coating system, specifically formulated for aesthetics and/or environmental resistance. Also referred to as the finish coat.

TOP DRYING
Drying of a coating film on the top or surface but not beneath it.