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9 Bridge Aesthetics

9.1 General

Aesthetics is an important consideration in the design and construction of highway systems. The public's interest in promoting their local communities with aesthetics has grown over the years. In response, the Iowa Department of Transportation has taken a more proactive approach in designing structures that enhance or blend in with their environment. Because bridges play an important role in our visual environment, designers must be aware that bridge details have visual consequences. Additionally, addressing aesthetic considerations at the front end of the design process will produce a better result than adding them at the end.

Two states have taken the lead in bridge aesthetics and have prepared highly detailed design manuals. In 1993, the Maryland DOT released the "Aesthetic Bridges Users Guide". This guide and a similar one published by the Minnesota DOT in 1995 entitled "Aesthetic Guidelines for Bridge Design" present detailed information about the how, where, and when of aesthetic bridge design. The guides are good resources that illustrate how to determine proper structural form and proportions for bridges in both urban and rural settings.

9.1.1 Policy overview

Not all structures will warrant aesthetic details. District personnel will make the final determination of the extent of aesthetic enhancement for projects under their jurisdiction. Consultant designers shall contact the Aesthetic Bridge Specialist at the Bridges and Structures Bureau for direction on the level of aesthetics required on a structure before beginning design.

When a structure has been identified for aesthetic treatments, the Bridges and Structures Bureau will recommend a level of treatment based on a percentage of the project costs that is acceptable to the District Office responsible for the project. Typically, aesthetic costs have been 1 to 7 percent of the overall project costs depending on the visibility and special design requirements of the structure.

The Bridges and Structures Bureau will direct the application of all aesthetic bridge designs.

9.1.2 Design information

Reserved

9.1.3 Definitions

Articulation is the shaping of a bridge or bridge component.

Baseline refers to the appropriate least cost solution given normal project parameters.

Concrete Stain is a semi-opaque penetrating medium for coloring cured concrete.

Concrete Colored Sealer Coating is an opaque, high silicone content pigmentable sealer.

Concrete Integral Colorant is a coloring pigment added to concrete mix prior to placement.

Context refers to the physical, social, historical, economic and political environment.

Context Sensitive Design is a design process that acknowledges project constraints and design opportunities that go beyond the normal scope of project planning and development, including consideration of the social, environmental and cultural environments.

Form Liner is a foam, plastic or rubber form insert used to create texture.

Mitigation is an improvement intended to offset or alleviate negative project impacts.

Reveals refer to narrow and usually shallow rustication lines.

Rustication refers to shallow surface features in concrete, such as grooves and recesses.

Texturing refers to a varied concrete surface treatment over broad areas.

Theme is the basic design premise or principle applied to a group of elements.

9.1.4 Abbreviations and notation

BSB, Bridges and Structures Bureau
CSD/CSS, context sensitive design/context sensitive solutions
DB, Design Bureau
FHWA, Federal Highway Administration
Iowa DOT, Iowa Department of Transportation
LEB, Location and Environment Bureau
SHPO, state historical preservation office
TS&L, type, size, and location

9.1.5 References

Committee on General Structures, Subcommittee on Bridge Aesthetics, Transportation Research Board (TRB) and the National Research Council. *Bridge Aesthetics Around the World*. Washington, 1991.

Maryland Department of Transportation. *Aesthetic Bridges Users Guide*. Maryland: State Highway Administration, Office of Bridge Development, 1993.

Minnesota Department of Transportation. *Aesthetic Guidelines for Bridge Design*. Minnesota: Bridges and Structures Bureau, 1995.

Transportation Research Record No. 1549, Design. *Transportation Aesthetics*. Washington: Transportation Research Board (TRB), National Research Council, 1996.

Bacow, A.F. and Kruckemeyer, K.E. *Bridge Design: Aesthetics and Developing Technologies*. Massachusetts: Department of Public Works, Council on the Arts and Humanities, 1986.

Gottemoeller, F. *“Bridgescape: The Art of Designing Bridges”*. John Wiley & Sons, 1998.

Federal Highway Administration (FHWA). *Flexibility in Highway Design*. Washington: 1997

Texas Transportation Institute Research Report 2113-3. *Guidelines for Aesthetic Design in Highway Corridors: Tools and Treatments for Texas Highways*. Texas: Texas Transportation Institute and the Texas Department of Transportation, 2001.

9.2 Public Involvement

When aesthetics are planned for a structure in or near a defined community, local community members are encouraged to participate in an aesthetics advisory group to aid the Iowa DOT in the course of aesthetic concept development. The Iowa DOT retains final decision-making authority on any aesthetic projects. Any questions about implementation of this policy shall be directed to the BSB.

The extent of public involvement is tied to the Aesthetic Level Classification of the project [BDM 9.4] and is managed by District Office staff. Aesthetic advisory groups should generally be formed for Level “A” and “B” bridges, may sometimes be appropriate for Level “C” bridges, but should not be used for Level “D” bridges. Except for significant corridor projects or for signature bridge projects, local community advisory or beautification groups should be limited to ten (10) non-DOT staff participants or fewer. District Office staff shall be relied upon to ensure that interested, representative individuals are offered the opportunity to participate in such groups.

Oftentimes, local public interest in a bridge construction project will generate the inclusion of aesthetic enhancement during the planning and budgeting process [BDM 9.3]. Evidence of this is usually found in the project description within the project envelope. (The project envelope contains a complete collection of project-related information and is kept in the BSB. Consultants may request copies of items from the project envelope for use as reference material. Consultants are advised to send pertinent information and correspondence regarding the project to the BSB for inclusion in the project envelope). On occasion the inclusion of aesthetic treatments can occur later in the process of developing plans for the project. In these cases, the designer is advised to make inquiries into the possibility that the project could eventually include enhancements. Consultant designers shall contact the BSB. In-house designers should contact the Aesthetic Bridge Specialist or the Assistant District Engineer to confirm the intention of including aesthetic enhancements in the design plans. All correspondence regarding aesthetics in relation to the project should be entered into the project record by the designer.

Projects that include a public involvement component will often have a public process which may parallel the project's engineering design effort for a time. This will usually occur during the preliminary and early final design phases of the project. It is important for the designer to remember that there may be periodic approvals to be gained from a local advisory group. Certain milestones may be achieved, beyond which the designer may not be able to continue without first receiving word from District personnel that approvals have been granted for the current design concept. Design work may be held up for some time before being allowed to proceed. The designer shall avoid getting ahead of the public involvement review and approval process, since the risk of rework or redesign is increased.

9.3 Establishment of an aesthetic project

Only selected projects will receive aesthetic enhancement. There are several different ways by which a project is identified for enhancement. The following sub-articles list some typical examples of this process but should not be considered a complete list of the possible mechanisms for including aesthetics.

9.3.1 Initiation by district office

The initiation of an aesthetic project by the District office will be documented in the project description. This documentation can be found in the project envelope. When the addition of aesthetic enhancements occurs after the project description is written, the information governing the proposed enhancements may arrive in the BSB through other channels, such as directly from the District office to Bridges and Structures Bureau office personnel. The designer shall consult with the Unit Leader to verify the inclusion of aesthetic enhancements before beginning any design work on the project.

District personnel will make the final determination of the extent of aesthetic enhancement for projects under their jurisdiction.

9.3.2 Identification by Bridges and Structures Bureau

In some cases, the designer or other personnel in the BSB may propose that a project be considered for aesthetic enhancement. This can occur when it becomes apparent to BSB personnel that the project is likely to attract significant public attention or is subject to the parameters established by the Aesthetic Level Classification system used by BSB [BDM 9.4].

Even a type, size and location (TS&L) plan can present clues to the designer that a project may be a candidate for enhancements. The bridge’s location in or near an urban area would be readily apparent in the information provided on the TS&L and may indicate that aesthetics could be warranted. A field exam may raise the preliminary bridge designer’s awareness of important indicators immediate to the project site, such as unique contextual issues [BDM 9.5.1 and 9.5.2].

The District office should be contacted as soon as possible after the project has been identified by BSB as a candidate for aesthetic treatment. District personnel will make the final determination of the extent of aesthetic enhancement for projects under their jurisdiction.

9.3.3 Projects involving signature and historic bridges

In most cases, replacement or rehabilitation of a signature or historic bridge will result in some consideration of aesthetic or other enhancement of the new bridge. A “signature” bridge could include any bridge with a unique structure type, either in an urban or non-urban area. Regardless of whether an historic bridge is listed on the National Register of Historic Places/Structures, its replacement will likely draw attention from public citizens or groups concerned about its loss. Bridges listed on the Historic Register will need to be addressed by the Location and Environment Bureau (LEB), which will make the necessary contacts of personnel at the State Historical Preservation Office (SHPO). Keep in mind that aesthetic enhancements can become important contributions to mitigate the loss of the historic structure.

9.4 Aesthetic level classifications and cost guidelines

Although all bridges deserve a minimum level of aesthetic consideration, some structures will warrant additional attention. Our Bureau has developed a classification system, designed to relate the visibility and importance of a structure to an appropriate level and cost of aesthetic enhancement.

Bridges will be classified into one of four enhancement categories: A, B, C, or D level bridges.

9.4.1 Level “D” bridges

Level “D” bridges are designated as lower visibility structures. For example, this category includes rural bridges over ditches or small streams. Because of their lower visibility, the need for aesthetic details may be limited, as may be the budgetary commitment made to fund any included enhancements. There will typically be no public involvement in the design of Level “D” bridges.

9.4.2 Level “C” bridges

Level “C” bridges may include typical overhead standard bridges and the need for aesthetic details shall be determined on a case-by-case basis by the District Office. Project budget increases for enhancements in this category will generally be between 1 and 5 percent of bridge construction costs. There will typically be little or no public involvement in the design of Level “C” bridges except at the discretion of the District Office.

Figure 9.4.2. Level “C” bridge examples in Iowa

Consultants shall contact the Aesthetic Bridge Specialist at the BSB for direction on aesthetic design details to be included in the design plans.

9.4.3 Level “B” bridges

Level “B” bridges may include bridges located in or near urban environments, along heavily traveled corridors, in resort/recreation areas, and in commercial areas where there is a high degree of exposure and/or there have been public requests for enhancements. Project budget increases for enhancements in this category will generally range from 3 to 10 percent of anticipated bridge construction costs. The usual target increase for aesthetics in this category is 5 percent of overall bridge cost.

If aesthetic details are to be incorporated, then public involvement considerations will likely need to be taken into account early in the planning process if there is enough public interest. Public involvement may continue into the preliminary design phase in some cases.

Figure 9.4.3. Level "B" bridge examples in Iowa

Level "B" bridges will always be considered for additional aesthetic details. Occasionally, it will be appropriate to use an existing design precedent as a starting point for the development of aesthetic concepts. Nevertheless, it is likely that the development of new, unique details will be required.

Consultants shall contact the Aesthetic Bridge Specialist at the BSB for direction on aesthetic design details to be included in the design plans.

9.4.4 Level "A" bridges

Level "A" structures include bridges with unique structure types, some major river crossings or other highly visible structures, and any historic bridge replacement project. Structures may also be designated as Level "A" when they are located in specific portions of interstate corridors such as I-74 in the Quad cities or I-235 in Des Moines.

Examples of level "A" bridges are the Des Moines River bridge at Keosauqua, the cable stay bridge over the Mississippi river in Burlington, Iowa, the new pedestrian bridges over I-235 and the unique Lake Okoboji Bridge in northwest Iowa. Virtually any pedestrian-only or bicycle trail bridge, regardless of location, should be considered a Level "A" structure. Project budget increases for enhancements in this category will generally be between 5 and 15 percent of anticipated bridge construction costs.

Figure 9.4.4. Level "A" bridge examples in Iowa

There will likely be significant public involvement both early in the planning phase and throughout the preliminary design phase. Several review meetings with a community advisory group are also likely to occur, with the expectation that feedback and input received will noticeably affect the course of the project's design.

Level "A" bridges will always be considered for additional aesthetic details. Development of unique features and details is very likely to be required for Level "A" bridges. Consultants shall contact the Aesthetic Bridge Specialist at the BSB for direction on aesthetic design details that will be developed and included in the design plans.

9.4.5 Cost

Enhancement cost is figured as a percentage of structure construction costs beyond what is necessary to build a bridge that meets the project requirements in terms of roadway geometry, structural capacity and other functional needs. Do not include special or unusual cost items such as staging cost increases in the basic bridge cost estimate, as these items will artificially decrease the cost of the enhancements when figured as a percentage of bridge cost. Generally, a prestressed beam type bridge with standard barriers and railings will be considered the basis for estimating the cost of a conventional or baseline bridge.

Exceptions should be made in the case of replacements of existing bridges that have unique features. Unusual or unique features on such bridges will, in most cases, increase the baseline bridge cost estimate for the replacement. For example, when replacing an existing bridge which has a painted steel picket railing, a chain link fence should not be used as a baseline pedestrian railing cost item.

When a local community requests project enhancements that go beyond the Iowa DOT's budgetary commitments to the enhancements, a cost participation agreement may be executed for the local government to pay the excess costs. In such cases the District will initiate agreements with the appropriate local government agencies. These agreements can be used for aesthetic treatments such as city street lighting, shared use path lighting, and other shared use path features such as benches or lookouts, aesthetic railings, and community identity features. The Iowa DOT may also assist the local municipality in locating other funding sources for the enhancements. District personnel will make the final determination of the acceptable cost of aesthetic enhancement for projects under their jurisdiction.

9.5 Aesthetic design guidelines

9.5.1 Aesthetic and context sensitive design

The final built form of an aesthetic bridge may be determined by an overriding design concept, theme or organizing idea. The background principles affecting the design of the various components of the bridge will likely be different for each unique bridge location. It is therefore impossible to enumerate all the possible concepts or themes in this manual, as they are unlimited in number and description. It is possible, however to list some of the likely influences that may help to establish the design concept for the project. A thorough investigation into each of these influences is a task that can prove rewarding for virtually any project, regardless of its location. This is also a task that can be made much easier by relying on local participants for their uniquely regional insight.

Some possible influences on design concept/theme include:

- Architectural context
- Historical context or events
- Natural environment
- Geographic location
- Existing aesthetic guidelines for interstate corridors
- Nearby infrastructure
- Presence of pedestrians
- Viewing opportunities (or lack thereof)
- Community identity and/or goals
- Tourism opportunities
- Commercial interests
- Future development planned

9.5.2 Context sensitive design/context sensitive solution

The surroundings of the bridge should be taken into thorough account before attempting to incorporate any kind of enhancement treatment into the design. The general character of the surroundings - scenic, rural, semi-urban, urban - are a good starting point. The aesthetic treatment of an urban bridge will usually be quite different from that of a rural structure. The number and position of potential observers of the bridge is a related area of inquiry that can begin to inform the designer about the kinds of treatments that can be effective once built. If the bridge is built over a roadway, the speed of traffic will be an important factor in determining which enhancements are appropriate. For example, color can have great effect for both slow- and fast-moving traffic, but fine rustication or texturing of concrete surfaces may be lost on the freeway motorist and may be more effectively employed on bridges observed by slow-moving traffic and pedestrians.

Consult the References article [BDM 9.1.5] for more information and guidance about the analysis of project context.

“Placemaking” is a term used by architects and urban designers to describe the effort to make a memorable place within an urban landscape. Bridges in both urban and rural settings can aspire to establish a sense of place in the same way as a building, a public art installation, a park or an urban square. Place can be established through special accommodation of pedestrian or bicycle traffic, and then incorporating design elements that only those slow-moving observers can fully appreciate. It can be done through architectural manipulation of the piers, abutments and railings of the structure to create a unique vision that reflects the aspirations of the community. It can also be done by making great effort to fit the structure into its immediate context, blending it seamlessly with surrounding streetscape or thoroughfare. One cannot create a sense of place by ignoring the context and designing a standard bridge, or even a standard aesthetic bridge. Aesthetic design should not be begun without thought about where the bridge is to be built, what is nearby, and who will use and observe it upon its completion.

9.5.3 Basic aesthetic guidelines (preliminary and early final design)

There are some features of visually pleasing bridge structures that have been repeatedly identified by numerous publications on bridge aesthetics. The following are discussions of each but should not be considered complete documentation of the subject matter. The References article [BDM 9.1.5] contains several good sources of detailed information on these topics.

9.5.3.1 Long, slender appearance

It is almost always best to enhance the appearance of the basic bridge structure by ensuring that its details allow for the longest and most slender appearance. This can be achieved through careful span arrangement, reduction in the number of supports, maximizing the distance between supports, and using the shallowest beam possible for the span. The designer may even consider using shorter barriers, when allowed.

Changes in depths of beams on adjacent spans should be avoided, when possible. Concrete bridges should employ the same depth of beam for all spans. Steel bridges should be carefully designed so that changes in girder depth are logical in appearance, and haunched depth changes should generally be favored over abrupt changes in girder depth.

See BDM 9.5.4.1 for a discussion of recommended span to depth ratio targets. Keep in mind that structural guidelines and available beam depths may ultimately control superstructure depth.

Note in Figure 9.5.3.1 how the extension of slab lines through the wing, rustication on the barrier, and elimination of the pier end diaphragm help the bridge to appear longer.

Figure 9.5.3.1. Bridges with long, slender appearance

Horizontal lines of structure should be made continuous or to appear continuous. Details that break the superstructure's long horizontal lines - such as pier end diaphragms - should be avoided. Carrying the slab edge lines through the abutment wing extension and wing is another effective technique toward maximizing the bridge's apparent length.

9.5.3.2 Equal and/or balanced span arrangement

When laying out a structure's span arrangement, it is important to consider the overall visual effect of the spans, and to avoid thinking only about each span individually without regard to the whole.

When a single structure contains spans of different lengths, care should be taken to achieve symmetry in the elevation of the bridge if it is to be viewed from below. If symmetry is not achievable, the layout should be studied carefully for other logical organizing principles. Visual balance can be achieved in an asymmetrical span arrangement. Consult References [BDM 9.1.5] for more detailed information on asymmetrical and other atypical span layouts.

9.5.3.3 Wide overhangs

Wide overhangs cast deep shadows on bridge beams, which can exaggerate the apparent slenderness of the structure. A 3'-0 slab overhang dimension (from the centerline of fascia beam to edge of slab) should be considered a minimum.

9.5.3.4 Reduced column count for multiple-pier structures

Unless the column count is somehow dictated by the pier's aesthetic design concept, it is generally best to design piers with the least number of columns. T-pier or wall pier configurations may be considered on some over-land bridges with multiple spans, to decrease the total column count.

Figure 9.5.3.4 illustrates how T-piers may be used to reduce total column count on a ramp interchange.

Figure 9.5.3.4. Bridges with minimal column count

9.5.3.5 Member sizes

On some structures, it is advisable to use larger, thicker members where the forces are the greatest and thinner elsewhere. Proper proportioning of pier columns to span depth is also an important consideration. Consult the References article [BDM 9.1.5] for more detailed information.

9.5.3.6 Static vs. dynamic lines

Straight, plumb vertical lines, such as those at piers and abutment faces and mask walls, generally convey a static image. Sloping or angled verticals can generate a more dynamic appearance in the bridge. Mask walls in particular, can serve to lengthen or decrease the apparent length of the bridge, depending on which direction they are angled (e.g. toward or away from the span). Be careful to include enough slope so that the observer is convinced that the slope was intentional, not merely a mistake by the builder. A minimum of 10 degrees is a good starting point.

Figure 9.5.3.6 demonstrates how a sloping mask wall can create a dynamic appearance.

Figure 9.5.3.6. Bridge with sloping mask wall

9.5.3.7 Ornamentation

It is always best to try to find ways of enhancing the necessary components of the bridge, rather than bolting on aesthetic treatments at the end.

Figure 9.5.3.7-1 display bridge examples with ineffective bolt-on aesthetic details. Figure 9.5.3.7-2 gives examples of complementary bolt-on aesthetic details.

Figure 9.5.3.7-1. Bridges with ineffective bolt-on aesthetic details

Some elements, such as railings or fences, do create fine opportunities for enhancements that can be built off-site and installed to complete the appearance of the bridge. In general, however, a bridge's appearance is not greatly enhanced by the addition of an extravagant railing or other add-on. The entire structure must be thought of as a visual composition, incomplete without any of its parts. The designer should attempt to articulate, rather than merely ornament, the bridge's necessary components to create that composition. The shaping of piers, abutments, barriers, etc. will be more effective in creating architectural character than can be achieved by most bolted-on details.

Figure 9.5.3.7-2. Bridges with complementary bolt-on aesthetic details

9.5.3.8 Individual structures

The designer should be advised that single structures that have been identified for aesthetic enhancement in or near communities may be seen as community gateways by the local residents and municipal leaders. This may bring the following considerations into play:

- Local constituents may seek to have the bridge express community identity through its design, including through its basic shape, colors, or through the addition of signage or emblems.
- There may be other enhancements planned for the area surrounding the bridge, which may be a freeway interchange or part of a city streetscape. Improvements may include landscaping, signage, special paving, ornamental street lighting, artwork, trails, or other amenities. The design of the bridge should be coordinated with the characteristics of these adjacent features. The color scheme associated with surrounding work will be of particular importance if the bridge will include any colored coatings for steel or concrete components.

9.5.3.9 Multiple structures/corridors

If there are multiple aesthetic structures within the same area or corridor, a unified design theme is strongly advised. This is especially applicable to new bypasses and renovations of existing freeway corridors. Sometimes new underpass structures or other amenities are located near an aesthetic bridge, and it may be appropriate to develop aesthetic treatments for them that match or complement treatments used on the bridge.

The designer should become familiar with any aesthetic theme that has already been established and ensure its applicability to the structure being designed. Adjustments of the concept may have to be made at individual sites due to differing functional design parameters, but the theme chosen for the grouping must be translated effectively at each structure. Likewise, if the designer is working an aesthetic theme into the first of several affected structures, he/she should become familiar with all the structures to be enhanced by the aesthetic theme. This will help to ensure that all structures are able to accommodate the concept in a reasonable way and prevent single structures from deviating unacceptably from the theme.

9.5.3.10 Bridge widenings

Bridge widening projects rarely include aesthetic enhancement unless the existing structure has unusual and identifiable characteristics that can be carried into the new addition. When exceptions occur, it should be generally understood that, due to the typically lower overall costs of such projects relative to total bridge deck area, the enhancement cost premium can be higher than for a completely new bridge. If the work planned for the existing structure is more substantial, for example replacing the entire bridge deck, then the enhancement percentage could be in compliance with the usual cost guidelines.

Figure 9.5.3.10 is a widened bridge with work that included existing pier repairs, replacement of the entire bridge deck and existing slope protection. Note in the figure how the new pier shape was derived from the existing pier shape.

Figure 9.5.3.10. Example of handling aesthetics on a bridge widening

9.5.3.11 Sidewalks and trails

Sidewalks or trail accommodations on bridges invariably bring requirements for pedestrian fences or railings. Standard chain link fence will almost never fulfill the aesthetic vision for an enhanced project. The final railing or fence appearing in the plan for an aesthetic bridge will usually be of a custom design with significant complexity in its detailing and construction.

By the nature of the inclusion of sidewalks, the bridge and the physical execution of its component parts will be assumed to be under greater visual scrutiny. Slow-moving pedestrians and bicyclists have the opportunity to stop and linger. Details (and oversights) that are invisible to the freeway motorist come plainly into view for these observers. The designer should keep this in mind while assembling the parts of the bridge, including custom fences or railings, abutment features, concrete barriers, trail paving, and even piers.

Figure 9.5.3.11 contains some examples of aesthetics that are easily viewed by pedestrians and are therefore subject to more visual scrutiny.

Figure 9.5.3.11. Example of handling aesthetics on a bridge widening

The designer should be well-versed in the specification requirements that are in effect when pedestrian and/or bicycle accommodations are part of the project. See BDM 9.5.6 and 9.5.7 for further information.

9.5.4 Superstructure

9.5.4.1 Span to depth ratio

A span to depth ratio of 30 or higher is considered excellent; between 20 and 30 is considered good; 15 to 20 is acceptable, though not ideal; under 15 is undesirable, except in short end spans of bridges with constant beam depths for all spans. Keep in mind that structural guidelines and available beam depths may ultimately control superstructure depth.

9.5.4.2 Girder bridges: steel and concrete

Many bridges can be aesthetically successful with either concrete beams or steel girders. The Iowa DOT's BT series beams exhibit desirable span to depth ratios and yield a highly articulated fascia surface with strong shadow lines. If desired, concrete beams can be coated with pigmented stains or sealers to differentiate them from other surfaces on the bridge elevation, which can exaggerate the horizontal lines of the bridge and increase the appearance of slenderness. Concrete beam depth should remain consistent throughout contiguous spans, if possible.

Because of the opportunity to add color to a bridge without the use of coatings by employing weathering steel, steel can be a more aesthetic choice for a girder bridge. However, it is important to gauge the opinion of interested public groups relative to the subjective aesthetic qualities of weathering steel. Some constituents have expressed negative views of weathering steel's visual characteristics, especially during the initial period after installation when areas of contrasting color or construction-related staining may be present.

Higher span to depth ratios can also be achieved with steel, which is aesthetically desirable. Steel also allows haunched and curved girders, which can lend intrinsic aesthetic quality to the structure.

Steel girder bridges are generally considered to have higher cost per square unit deck area. In many cases, the final choice of girder type is driven by this cost assumption. However, consideration should be given to the associated reduction in substructure component costs when longer steel girders are used. When fewer piers are required, as is the case in some steel girder span layouts, cost differences with a normal concrete beam bridge may be significantly reduced. This is especially important when the conditions make the construction of piers more expensive than average, as is the case when building in a difficult river environment.

For horizontally curved bridges, steel will almost always be aesthetically preferable. Chorded concrete beam bridges yield undesirable results due to their varying soffit widths, inconsistent shadows cast on the fascia beam, and their generally stilted appearance. Pier end diaphragms are often impossible to eliminate, which results in broken or discontinuous superstructure lines.

9.5.4.3 Span arrangement

Refer to BDM 9.5.3.2 of this manual for specific recommendations on span arrangement.

9.5.4.4 Continuous structure lines

Horizontal lines of structure should be made continuous or to appear continuous. Details that break the superstructure’s long horizontal lines - such as pier end diaphragms - should be avoided. Carrying the slab edge lines through the abutment wing extension and wing is another technique effective in maximizing the bridge’s apparent length.

9.5.4.5 Haunched steel girders

Care should be taken in configuring the precise geometry of haunched girders. Haunches should always be formed by smooth curves, never by straight lines. The length of the haunched section of the girder should be neither too long (which may eliminate any sense of curvature in the haunch) nor too short (which can lead to poor visual proportions). Generally, haunches that reach a third of the span are considered superior, but in some cases the haunch may extend over the entire span. The depth of the haunch should be between 1.3X and 2X the mid-span girder depth. Consult References [BDM 9.1.5] for more detailed information.

9.5.5 Substructure

9.5.5.1 General

Design continuity between pier and abutment wing concrete shaping and surface treatments typically yields visual success in terms of making the whole bridge convey a consistent theme. Concrete shaping, color, rustication, and texture consistencies can help create a unified composition. Implications on formwork and concrete cost must be considered when developing aesthetic design features.

While some bridges will include aesthetic features throughout their construction, i.e. at piers, abutments, barriers, fencing, and even fascia beams, other bridges have limited need for substructure aesthetics due to a lack of vantage points. For example, a bridge may carry a high-volume roadway and a pedestrian facility that indicates aesthetic design features are warranted in the roadway barriers, bicycle railings, and fencing. However, if there are no significant views of the substructure from public areas surrounding the bridge, and there are no roadways or trails underneath (e.g. a typical stream crossing), there is little reason to incorporate substructure aesthetic features. Standard substructure may be the prudent choice. If necessary, contact the Aesthetics Coordinator for guidance.

The extent of substructure aesthetic treatment will greatly depend on the visual exposure of the bridge and its prominence in the landscape or community. Budgeting established for project aesthetic enhancements will also directly affect decision-making related to aesthetic design choices.

9.5.5.2 Pier shape

The multicolumn frame pier is usually the most economical solution for grade separation bridges. However, minor adjustments may be necessary to improve aesthetics or to better fit an established visual theme. The pier cap cantilever may be eliminated in some circumstances if they are aesthetically undesirable. Additional columns beyond the minimum required for a typical frame pier will often be necessary if this choice is made. It is generally unwise to add columns beyond what is necessary to eliminate cap cantilevers, since additional foundation elements are required for each additional column.

Some grade separation bridge piers require Vehicle Collison Force (VCF) design in accordance with BDM 3.7.4. There may be aesthetic benefits when using a wall pier, T-pier, or a T-pier hybrid shape to meet collision force design requirements. Larger surface areas parallel to mainline or other high volume roadway traffic beneath the bridge may represent excellent opportunities for aesthetic surface treatments. Custom concrete shaping may also be an option when unique pier types such as a “capless” T-pier hybrid shape are explored.

Refer to BDM 6.6 for general pier configuration recommendations and requirements, including cantilever length, outermost bearing locations, and overall geometry. It is recommended that these characteristics either be retained or be changed only with caution and rigorous analysis.

Proposed pier shape manipulations must be carefully studied for their implications on concrete forms and costs. Rectilinear shapes will almost always be more constructable and less expensive. Concrete shapes with curved or reverse-curved features beyond those that can be created with standard bullnose-type forms or adjustable-radius steel forms can be expensive due to high custom (typically steel) form costs. Sometimes curves can be created with shallow recesses and texture or color accents on otherwise rectilinear pier shapes for better economy while still conveying aesthetic themes that rely on curves.

When it comes to pier count and the level of detail proposed, there are some additional architectural design factors to keep in mind. Bridges with many piers will usually be more successful if a more simplified pier design is employed, since there are architectonic benefits from a repeated form that can outweigh a perceived lack of architectural detail in the individual unit. Oversaturation of detail in piers that are repeated many times within the same viewshed can be detrimental to the overall perception of the design and may result in a visually overwhelming or cluttered appearance. Careful study using 3-dimensional modeling and rendered views from various vantage points is recommended to ensure that the level of detail is appropriate for the number of piers involved.

Additional features can be considered as extensions of a typical pier shape. A pier outer column vertical projection or tower that extends above the deck is one example. Cap-supported mask wall elements that extend only to the bottom of bridge deck (as a way of hiding a pier diaphragm or expansion joint) are also possible. A horizontal construction joint at the top of pier cap will help maintain constructability of these features. Keep in mind the consequences that additional dead load from such features may have on the pier’s foundation design.

Piers on some past projects have included secondary concrete pours to create extended surfaces at the base of columns or pier stems. Columns have been enhanced in this manner by creating a “plinth” with more articulation than would be appropriate to include as part of the column concrete pour. When this sort of design feature is used, show a construction joint at the basic column or stem’s vertical limits (as if there were no extended features), and incorporate embedded or drilled-in dowels to engage with the additional layers of reinforcing necessary for the extended surfaces. If a horizontal construction joint is also allowed at the top of the column “plinth” or other column shape extension, a contractor may prefer to pour the feature integrally with the column or stem base, then form and pour the remaining column above that point. These detailing efforts will ensure maximum constructability of these features.

Piers with horizontal construction joints and stage-constructed piers that have aesthetic features can be a particular challenge if construction joints interrupt pier shape or surface treatments. Additional notes controlling the desired result are often necessary to ensure that construction joints don't have a permanent negative effect on pier aesthetics. The use of rustication, textures, and post-applied coatings can alleviate some of the concerns of splitting pier construction into 2 or more parts, but continuity of surface treatments across both vertical stage construction joints and other allowable horizontal construction joints must be carefully maintained. Post-applied aesthetic coatings can reliably hide concrete color and texture changes that can occur across construction joints, but the desired results must often be specifically detailed in the plans to ensure a satisfactory outcome in the concrete work.

9.5.5.3 Pier formwork

When articulating concrete or impacting finished surfaces with rustication and liners, always keep implications on formwork in mind, and engage Construction and Materials Bureau staff as appropriate when it comes to proposals that significantly impact formwork, especially custom components that must be made of steel. Custom formwork is more easily justified if the re-use potential is high, both on individual bridges with many piers and on corridors containing multiple bridge construction projects that will employ the same pier design.

Sometimes it is considered appropriate to reach out to potential contractors during the design phase on questions of custom formwork. This can typically be done most efficiently through the Iowa DOT's contacts at the Iowa Association of General Contractors (Iowa AGC). Minor formwork implications that can be solved using sheet products, milled urethane foam, hotwire-cut expanded polystyrene (EPS) foam inserts, plastic rustication strips and panels, or other available means are less concerning from a constructability standpoint and do not require investigation prior to project letting. Formwork material requirements such as steel, Medium-Density Overlaid (MDO) or High-Density Overlaid (HDO) plywood can be desirable when the as-cast finish of the concrete is especially important to aesthetic success. The use of steel forms for all pier forming work on a project can sometimes be justified by the pier shape and by formwork stability requirements during concrete pouring operations (e.g. a delta pier poured initially as freestanding columns with a separate cap pour). Generally, it is best to leave formwork material and construction choices up to contractors and to specify only the required results.

Reconditioning of steel forms, including weld metal filling of drilled holes and removal of welded steel rustication strips, is known to be expensive for contractors whether they own their steel forms or rent them from a supplier. Whenever possible, plan the work such that forms may be reused within the project from pier to pier, or from bridge to bridge within a corridor, to help limit the potential reconditioning costs. For specially-shaped piers, especially those with sloped or curved limits in the columns or stems and those with open voids, maintaining continuity of shape typically involves keeping the same geometry from the top of pier down. This means piers of differing heights do not have unique geometry throughout their configuration but can be extended or shortened as necessary at their lower region above the footing, which can minimize the need for custom form components. To ensure forming continuity, plan the pier shape around the tallest and shortest instances to be constructed within a project before establishing final, consistent geometry. For piers with delta (aka "V-pier" or "Y-pier") or similar shapes, it is best to incorporate a vertical stem at the base which can be easily extended or shortened as necessary using standard forming techniques, thus simplifying the forming of different height piers of the same basic shape. When steel forms are prescribed or are likely to be used, keep in mind the available heights of standard plate girder-type forms, which typically come in 1-foot increments. Bridges with varying width or variable superelevation will require additional studies and investigations into forming implications related to an aesthetic pier shape.

Pier surface features that can be created by shallow inserts or sheet products such as plywood are generally easily constructed and do not need special review by contractors prior to final plan preparation. Such features may be kept consistent from pier to pier or bridge to bridge, but if proportional changes are appropriate to the aesthetic design for individual piers, there is no reason to avoid changes that only impact the configuration of shallow formwork inserts. When articulating pier surfaces, follow general recommendations for a maximum of 4 inches of unreinforced concrete. This limits surface articulation to a maximum of 2 inches in most cases. Exceeding 2 inches of articulation will trigger an additional layer of reinforcing for all projected surface elements.

Rustications can be included on round columns, if desired. Strips used for concentric reveals must be flexible enough to precisely follow the radius, but this type of material is readily available to contractors through third-party suppliers. Vertical rustications on round columns may have implications on stripping of forms, and the construction of the form should be kept in mind, i.e. how many pieces (typically 2 or 4) that make up the full cylindrical shape at the size needed. When appropriate, reiterate the note found within the General Notes for Concrete Rustication that specifies rustication strips shall remain in place during stripping of the main forms. This allows concrete to further cure and avoid damage to rustication corners when the strips are removed. This requirement may mean the strips must be attached through the back of the form with screws or nails that can be pulled out prior to column form removal. Attachment with some kind of adhesive that will release the strips from the form may also be possible.

9.5.5.4 Abutment shaping

Abutment mask walls and wing wall surface treatments are typically used to support an aesthetic theme. Mask walls may significantly extend beyond the front face of abutment, typically by overlapping the abutment footing and extending several feet in front of the footing. Do not risk exposure of the bottom of this extended mask wall from future grade settlement by extending it too far. A maximum distance of 2.5 feet in front of the footing is recommended.

Mask walls may also angle or curve outward in the direction of the span while remaining independent of the bridge deck, thus creating a cantilever. Mask wall cantilever length and subsequent load must not adversely affect abutment performance. Mask walls on a traditional integral or stub abutment are typically separated from the bridge deck via 1-inch preformed joint material along a horizontal joint at the bottom of deck and are typically formed and poured ahead of the deck and abutment diaphragm. Mask walls of a semi-integral abutment are typically located entirely outside the edge of deck and are separated from the deck by a vertical joint along the deck edge. These minor differences in abutment configuration can result in slightly different overall appearance and can influence aesthetic decision-making.

Because of the longstanding standard method of constructing an abutment in separate concrete pour segments, i.e. footing, diaphragm and wing extension, wing, and mask wall, there are impediments to design and construction of aesthetic wingwalls that are unencumbered by construction joints. Depending on the desired outcome of a design, consideration should be given to changing or reconfiguring the pouring sequence. Elimination of vertical joints is often desirable for the exposed wing, wing extension, and mask wall to appear as one unit and to avoid problems associated with form alignment and surface continuity from one pour to the next. Jointless wingwall construction is especially desirable when textured form liners or integral thin veneer brick surface treatments are included on the exposed faces. With an integral abutment, this approach often means separating the abutment diaphragm concrete from the wing area by means of a transverse vertical construction joint that is hidden behind the wing where the diaphragm meets the wing outward of the fascia beam. Since the deck and diaphragm are poured concurrently, the deck must also be separated from the wing at a line corresponding to the abutment front face. Reconfigure pour joints as necessary to preserve constructability while supporting aesthetic goals. Sometimes it may be appropriate to develop a unique approach to separating the wingwall/mask wall pour from other abutment construction to achieve the desired result. Make clear through extra notes near the abutment wingwall details that no construction joints (other than those shown) are allowed.

When articulating abutment surfaces, follow the general recommendation for a maximum of 4 inches of unreinforced concrete. This limits surface articulation to a maximum of 2 inches in most cases. Exceeding 2 inches of articulation will trigger an additional layer of reinforcing for all projected surface elements.

Vertical features such as small towers, monuments, etc. may be included as part of abutment construction or nearby on separate foundations. The decision of whether to support them on an extension of the abutment footing or on a separate foundation may rest on the implications to abutment performance. Additional heavy loads on the abutment footing or inclusion of supplementary footings must not negatively impact the performance of the bridge abutment nor impede maintenance of the bridge. Additionally, truck layover concerns at the bridge traffic barrier typically dictate a minimum offset of 3'-3" from the top traffic face corner of the bridge barrier to any obstructions, including those mounted on or near the abutment and that extend above the height of the barrier. Additional foundation piles will often be necessary to support special abutment monuments, especially those that fall outside the normal limits of a standard abutment footing and footing extension.

9.5.5.5 Abutment forms

Abutment forms are often prescribed to have surfaces other than plain plywood for exposed concrete to be cast against, such as MDO or HDO plywood. Smooth or textured liners can also perform the task of preventing wood grain appearance when forms are constructed of wood materials, which is typically the case.

Abutment wing formwork is not highly standardized and is usually job-built of lumber and plywood for each bridge. While there may be some benefit to re-use of formwork for opposite corners of a single bridge, there is little potential for re-use of abutment formwork from bridge to bridge, and oftentimes a contractor builds both abutments at the same time so forms can't be re-used at all. Consistency in details from abutment to abutment within a single bridge project is wise from a constructability standpoint, as this approach has less potential for causing confusion on the jobsite. Since each corner may have a slightly different overall height from top of footing to top of deck in the region of the front face of abutment, mask walls of a single bridge should generally use the same geometry as described from the top down to ensure consistency in appearance.

9.5.5.6 Substructure enhancement cost estimation

Estimate the enhancement cost for aesthetic pier designs by computing the volume of additional concrete required beyond what would be necessary to build a typical multi-column frame pier or T-pier, whichever baseline option is the most viable for the application. This includes extra columns used in frame piers that, for aesthetic reasons, have no cap cantilevers. VCF design considerations may impact how much additional concrete is considered an enhancement. Compute additional abutment concrete volume for mask wall extensions and other such features as part of enhancement cost. Custom formwork should also be considered when establishing enhancement cost. This can often be estimated by increasing the concrete cost for the affected additional volume by a percentage premium. Premiums of 150 to 200 percent of normal concrete cost have been used, depending on the custom formwork associated with the special shaping at either piers or abutments. Also compute the surface area affected by form liner textures and use a multiplier that approximates the current cost of in-place textures.

For some projects with unusually wide and large piers, such as those necessary to support multilane highway bridges over major rivers, there is no standard shape that is easily applied to the conditions. It may be harder to establish the baseline pier shape for such projects, thus it makes less sense to attempt to establish a baseline cost that doesn't include any pier shape enhancements. For these projects, figure the enhancement cost of the piers based on special formwork needs that are strictly for aesthetic purposes, and include surface area costs of any texturing, rustication, or post-applied treatments.

9.5.6 Barriers

See BDM 5.8.1.2.5 for information on aesthetic barriers.

9.5.7 Pedestrian and bicycle railing/fence

See BDM 5.8.1.2.5 for information on aesthetic pedestrian railing/fence.

9.5.8 Special lighting on bridges

When a new or replacement bridge project is located within or near a community, the local municipality will sometimes request lighting be placed on the bridge to light the roadway, pedestrian facilities (if present), or to enhance aesthetics. Pedestrian and bicycle tunnels constructed and owned by the DOT regularly have lighting installed by the local municipality or trail authority. DOT policy is to accommodate this lighting if it is not anticipated to negatively affect bridge or roadway function, for example through excessive glare, distraction, or impacts to sight distance. Additionally, the DOT does not allow red-colored lighting within the roadway operating environment.

Project locations within city limits, existing lighting along the bridge or approach roadway, streetscaping, and lighted sidewalks or trails in the project vicinity are clear indicators that the local municipality may desire lighting on the DOT project. Pedestrian tunnels are typically lighted for proper function. District staff should be contacted during the project's early planning to see if discussions with municipal officials regarding lighting have occurred or are planned.

DOT costs associated with municipality-supplied lighting on its bridges or pedestrian tunnels are limited to the embedded conduit, junction boxes, integrated structural light pole or fixture supports, and any embedded anchorages for the light fixtures. All remaining costs and responsibilities including lighting design and analysis, fixtures, conductors, power supply, installation, controls, connectivity, maintenance, and utility billing costs are borne by the municipality.

If the DOT develops a working 3D model of the project, it may be possible to perform comparative visualizations of different lighting scenarios, including total fixture count, pole spacing, fixture locations, etc. on behalf of the municipality. Such renderings would not be accurate representations of the lighting provided by the fixtures but would be for lighting concept comparison purposes only. Lighting design and any associated photometric analysis, accurate graphical representations (if desired), fixture specification, energy usage, cost estimation, etc. would remain responsibilities of the municipality.

9.5.9 Decorative concrete

9.5.9.1 General

There are multiple ways of creating concrete surfaces that can enhance a bridge's aesthetic design theme. Techniques used on past Iowa DOT projects are described here, but there are other available means of manipulating concrete material, forms, and surfaces that have been used elsewhere in the construction industry. Some of these may be explored for use on future bridge projects. BDM Table C9.5.9.1 includes a partial listing of examples of each decorative concrete treatment described in this section, excepting concrete coatings [BDM 9.5.10].

9.5.9.2 Articulation

Concrete surfaces and forms may be articulated with some level of freedom since liquid concrete will generally flow to the shape the forms allow. It is essential to keep in mind the implications that concrete shaping and articulation have on reinforcing requirements and on form complexity. When articulating pier surfaces, follow general recommendations for a maximum of 4 inches of unreinforced concrete. This limits surface articulation to a maximum of 2 inches in most cases. Exceeding 2 inches of articulation will trigger an additional layer of reinforcing for all projected surface elements, except for some form liner textures.

9.5.9.3 Rustication

Rustication is a longstanding and effective means of accentuating concrete shape and providing surface interest. Whenever rustication strips or panels are intended methods of concrete treatment, include the "General Notes for Concrete Rustication" in the plans. Previously mentioned guidance on surface articulation should be followed when establishing rustication depth(s).

Shallow, beveled rustication is allowable on barrier traffic faces with certain restrictions on depth and orientation [BDM 5.8.1.2.5 and Bridge Rail Guide]. Additional concrete thickness must be added to barriers that include rustication to maintain clear concrete cover over reinforcing.

Minor construction issues have been experienced on some past projects related to main form removal with rigidly attached wooden rustication strips. These wood strips may not have been properly presoaked in accordance with the standard notes, therefore they may have swelled (via absorption of mix water) while the concrete took on its initial set during curing. Nonetheless, the notes also call for rustication strips to be fastened to main forms in a such a way that they remain in the concrete during form stripping, which allows concrete to further cure and diminishes changes of breakout along rustication edges. This requirement does not apply to steel forms, which have typically not been associated with breakout issues at rustications.

9.5.9.4 Form liner concrete texture

The use of textured form liners within concrete forms is a very common method for accentuating concrete surfaces. Form liners are available in a myriad of different texture patterns, depths, and different base materials (expanded foam, plastic, urethane, etc.) depending on how many re-uses of the liner the contractor may desire to achieve. Whenever textured concrete and form liners are specified, include the “General Notes for Textured Concrete Form Liners” in the plans. Combining concrete texture with post-applied color treatment can be a particularly effective aesthetic enhancement, especially when subtle multicolor treatments are used [BDM 9.5.10].

The recommended 4-inch maximum depth of unreinforced concrete for articulated surfaces may not rigorously apply to some form liners, depending on the characteristics of the chosen texture. Textures that exceed 4 inches of unreinforced concrete (including clear cover to reinforcing) may be acceptable if the percentage of projected concrete surface is limited to 50 percent or less of the affected surface.

When specifying acceptable form liners, list at least 3 preapproved liner manufacturers and products or pattern numbers in the plans. Attempt to identify all comparable liner patterns from known major manufacturers/suppliers for each application to ease acceptance during the construction submissions process. No physical sample submissions are typically required except for unlisted products submitted as proposed alternates to the preapproved liners.

The “General Notes for Textured Concrete Form Liners” include a list of allowable materials from which form liners may be manufactured. Expanded polystyrene (EPS) foam are generally the most economical for a contractor but can be used only once. Plastics including ABS can be used up to 10 times and are somewhat more expensive than EPS. Rubber and urethane liners are typically the most expensive and are sometimes the only materials available in very deep texture patterns. There may be circumstances where the design would benefit from limiting the material type or eliminating certain materials. For example, form liners made from single-use EPS may be undesirable for concrete that can be closely scrutinized by pedestrians due to reduced texture detail and the “pebbled” surface that results. Disallowing EPS liners or prescribing multi-use plastic liners at a minimum may be a better choice in these cases. Certain kinds of deep textures or those that include undercut projected surfaces can only be formed by rubber or elastomeric form liner material, since a high degree of liner flexibility is required to ensure that the liner can reliably be removed from cured concrete.

Liner materials can easily be cut to fit many different applications. Narrow strips, unique shapes, curved limits, etc. typically present no constructability problems for contractors or their suppliers regardless of the liner material used. However, re-usage of liners may be limited by design choices, so consider the implications on the contractor’s costs especially when it comes to textures that can only be formed by the most expensive rubber or urethane liners.

Many of the common form liner suppliers advertise the ability to produce custom patterns. However, significant investigation into the costs associated with custom form liners is necessary to determine if this approach is feasible given project budgetary constraints. While re-usable custom liner textures may be economical for applications such as MSE wall panels where re-use potential within the project is typically high, the same may not be true for a bridge project. Designs that instigate manufacturer processes involving an artist or experienced artisan form liner developer are known to be quite expensive. To comply with DOT non-proprietary procurement requirements, at least 3 manufacturers would have to be able to provide an acceptable custom product and be listed in the plans. Likewise, investigations into the capacity of manufacturers to provide these customized materials would have to involve as many suppliers as could be identified within the general construction marketplace.

When construction involving textured concrete surfaces is staged, include plan notes to ensure use of the same form liner manufacturer, pattern type and number, as well as the same liner material on subsequent stages as was used on the initial stage. There can be minor yet perceptible differences in the results produced by different form liner materials, even if the identical supplier and pattern is used. This is especially important when stage construction joints are present within the textured surfaces. Under DOT guidelines, use of proprietary form liner selections in plans for later stages of bridge work is justified by the presence of the texture on the first stage work.

Only certain types and depths of textures are allowable for use on concrete barrier traffic faces for some conditions [BDM 5.8.1.2.5 and Bridge Rail Guide]. Additional width must be added to barriers with texture on either face to maintain minimum clear concrete cover.

9.5.9.5 Integral thin veneer brick

Integral thin brick for structural concrete has been used extensively by the Iowa DOT on bridge and retaining wall projects since 2010. It is a constructable and permanent means of introducing color into concrete structures. Two different available systems for incorporating thin brick into formwork have been used. One system uses individual gaskets for each brick that can be connected on the jobsite into multiple orientations or coursing of brick inside the concrete forms and is highly versatile for virtually any application. Another system uses custom-fabricated gasket panels made to order for the needs of a specific project, thus limiting the amount of on-site assembly work performed by the contractor's crew. Both options are allowed by the contract documents, and the choice is made by the contractor and their supplier(s) depending on project characteristics.

Thin veneer brick units are available in corner pieces that can help to replicate the appearance of real, full modular brickwork in the completed concrete. It is critical to use an 8-inch module as the basis for overall concrete dimensions when brick wraps the corners of any constructed element. When wrapping corners, the designer should be aware that it is sometimes difficult to maintain the alignment of forming panels around corners, especially on four-sided construction items like a rectangular pier column. Corner bricks are the most likely items to fall out of the forms before or during pouring if adjacent forms aren't properly aligned. To allow the utmost flexibility and some construction tolerance in these cases, some designers have held the brick away from corners, essentially creating brick inserts framed with plain concrete on each column face. A more effective method of maintaining the visual appeal of real brick construction is to leave a brick-sized (4-inch by 8-inch) reveal at the corner and wrap both resulting outside concrete corners with corner bricks, leaving a small gap at the inside corner to allow adjacent forms to shift vertically as necessary during form fit-up. Examples of this technique can be seen on several bridges carrying I-29 over local roads in Sioux City.

The contract documents should allow for multiple acceptable thin brick finish types in plans (e.g. "velour or wire cut") to ensure product availability, which can fluctuate throughout the construction season and over multiple years, depending on general demand. Bricks of a desired color may be available in one finish but not others, so it is wise to allow more than one finish type to be used.

While it is easiest and most constructable to employ integral thin veneer brick in rectilinear applications with only horizontal and vertical limits for the brick surfaces, thin brick can also be cut to fit angled or curved limits within flat surfaces. Framing brick treatments like these in shallow recesses may work best for appearance, but this can also be done on flush surfaces. Keep in mind that small pieces of bricks are harder to keep in place prior to and during the concrete pour, and often must be glued into the form using approved adhesive. It is advisable to specify that any cut brick unit be omitted if it does not have at least one side measuring 2 inches or more. The finished result will not suffer any significant reduction in visual quality because small brick pieces are excluded.

Thin brick is considered acceptable for use on concrete barrier traffic faces for some conditions [BDM 5.8.1.2.5 and Bridge Rail Guide]. The 0.625-inch nominal thickness of thin brick can be considered part of the clear concrete cover over reinforcing in most applications, including traffic barrier faces.

9.5.9.6 Integral concrete color

Integrally colored concrete is generally reserved for precast or cast stone elements due to its high cost and the inconsistencies that can be experienced in vertical concrete cast in a field application. While the colorants themselves are not particularly expensive, all concrete mixing and batching equipment must be thoroughly cleaned and not contaminated with regular gray concrete mixes during the time used to batch colored concrete. This greatly increases the cost of plant-provided material. One solution might be a dedicated, temporary mixing and batching setup near the project site, but this is a prohibitively expensive proposition for all but the largest projects and the most capable contracting teams.

Cast-in place concrete construction with integrally colored concrete comes with additional complications beyond basic material cost upcharges. If forms are not perfectly watertight along the exposed surfaces, mortar leakage will create obvious inconsistencies in color and texture of the cured concrete. Multiple concrete lifts can create layers of varying color in a finished surface. When patching concrete, difficulties in color-matching are seriously compounded by the presence of colorant. Integrally colored concrete is generally not appropriate for cast-in-place field application on bridges, but some retaining walls have been moderately successful.

Integral colorant is well suited to precast concrete applications such as Mechanically Stabilized Earth (MSE) and tilt-up retaining wall panels. Other acceptable applications include small precast accent items or panels that can be mounted to the structure via mechanical fasteners or grouted into prepared cavities. Precast concrete plants and cast stone suppliers have environmental controls and well-established work procedures for addressing the special needs associated with integrally colored concrete and can assure quality and consistency in the resulting products.

Occasional flatwork, such as colored and texture-stamped raised medians infrequently used on bridges where approach medians include aesthetic treatment, is another example of a manageable application of colored concrete in the field. Colored flatwork concrete is often color-sealed with an approved sealer pigmented to match and enhance the integral color. If there is interest in this type of application, search past Special Provisions for “colored stamped concrete paving”. These have most commonly been used on Local Systems projects, so a thorough review is advised before use of such provisions on State projects.

9.5.9.7 White cement concrete

White cement is generally acceptable to specify for concrete patching material to help patches blend with or remain slightly lighter than surrounding concrete. White cement may also be used as a constituent ingredient in a rubbed concrete finish. However, fully white cement concrete is very expensive to use in large quantities for cast-in-place work due to the combination of white cement cost and the need to use white or near-white sand for fine aggregates. White aggregates are not easily or readily sourced, and often require more long-distance transport of material and potentially new contractual arrangements for concrete suppliers. White or near-white manufactured sand, for example from crushing limestone, creates angular grains that can cause consolidation issues in cast concrete surfaces. These problems typically manifest in the form of larger than normal bugholes and concentrations of air voids at the form surface. Additionally, no fly ash or GGBFS is allowed, and form release agents must be verified as non-staining for white concrete. As with integrally colored concrete, concrete mixing and batching equipment must be thoroughly cleaned and not contaminated with regular gray concrete mixes during the time used to batch white cement concrete. This greatly increases the cost of plant-provided material. One solution might be a dedicated, temporary mixing and batching setup near the project site, but this is a prohibitively expensive proposition for all but the largest projects and the most capable contracting teams.

9.5.9.8 Post-casting surface treatments

Post-casting concrete surface treatments can sometimes be used if appropriate for the aesthetic theme, level of visual exposure, or opportunity for scrutiny by pedestrians. The following articles outline some treatments employed on past Iowa projects.

9.5.9.8.1 Abrasive blast finishing

Abrasive blast treatment such as dry abrasive blast finishing or combined sand- and water-blast finishing can be used to remove form lines, shiny areas, stains, and to change concrete surface texture. Use of dry abrasive blasting is conditional based on the potential environmental impacts and detrimental effects on adjacent properties or active traffic roadways. Impacts of abrasive blasting on surrounding areas of a project site can be mitigated by using combined sand- and water-blast finishing, but some of these concerns will remain. Cleanup of blast medium and concrete laitance adds labor cost, as well. Abrasive blast finishing of precast concrete (e.g. MSE wall panels) at the production facility can be performed without these concerns. When used, specify abrasive blast finishing in accordance with International Concrete Repair Institute (ICRI) Technical Guideline 03732 and provide a desired Concrete Surface Profile (CSP) number as a reference for the contractor for how deeply the concrete should be abraded. Additional notes may be appropriate for controlling the specific results desired in the finished surfaces.

9.5.9.8.2 Rubbed concrete finish

Like abrasive blasting, a well-performed rubbed concrete finish can cover or remove inconsistencies seen in concrete surfaces because of forming, pouring, and casting operations. While being somewhat labor-intensive, rubbed finishing doesn’t have the environmental concerns created by abrasive blasting. Class 2 strip down finishing in accordance with the Standard Specifications should be performed prior to beginning rubbed finishing. White cement may be specified as part of the mortar mix used in the rubbing process to lighten surfaces, if desired. Rubbed finishing has been used on several Iowa projects, with mixed results.

9.5.9.8.3 Decorative prefabricated inserts

An aesthetic theme for a structure may occasionally include some kind of prefabricated applique such as precast concrete or cast stone of special design, Terra Cotta tiles, or a bronze plaque. A shallow recess or cavity will often be necessary both to adequately receive the insert and to make it appear to be an intended part of the structure rather than merely applied to the surface. Some inserts, especially those of significant size or weight, will require mechanical fasteners for secure attachment. Bronze plaques are typically attached in this manner. Large, heavy pieces of precast concrete or cast stone will likely have grouted mechanical fasteners hidden behind the unit for the best appearance. Smaller items may only be grouted into receptive indentations in the concrete using adhesive setting mortar.

9.5.9.8.4 Broomed or raked slope protection

Intermittent coarse broomed or raked finishing has been used on concrete slope protection in at least two different patterns. This treatment can cross the normal joints in the concrete or be contained entirely within them. The contrast between heavy broomed sections and smooth floated areas provides a subtle effect that can complement other bridge treatments.

9.5.9.8.5 Acid etching and exposed aggregate

Acid etching and exposed aggregate finish treatments are typically only appropriate for use on precast concrete items while they are still in the production facility. Tightly controlled production environments are necessary to ensure consistency in the treatment of all elements intended for a single project. Surface retardation and subsequent pressure-washing after form stripping is a particularly sensitive series of operations that can be negatively affected by changes in conditions or timing. Acid etching may have environmental implications if performed on a project site. For these reasons, these treatments are reserved for precast items in production facilities.

9.5.9.8.6 Concrete coatings

Concrete coatings may also be considered for aesthetic enhancement of concrete surfaces [BDM 9.5.10].

9.5.9.9 Other decorative concrete techniques

Some decorative and innovative concrete materials and construction techniques that have not been used to date by the Iowa DOT but have been employed elsewhere in both bridge and general building construction include the following:

- Recycled material form liners
- 3D-printed form liners
- Fabric-formed concrete
- Photocatalytic cement concrete
- Concrete pavers embedded within bridge path or slope protection concrete
- Cladding with cast stone panels, real stone veneer, or metal panels
- 3D concrete printing - some related research has been performed at Iowa State University with support from Iowa DOT
- Photo-engraved concrete form liners
- Laser-engraved concrete

9.5.10 Coatings for structural concrete

For aesthetic purposes, it may be appropriate to apply a color-pigmented coating to some exposed concrete surfaces of a structure. However, concrete structure painting must be considered with caution and excessive painting of entire structures is generally discouraged. Painting should be limited to key portions of structures or only to accent surfaces whenever possible. Other means of incorporating color such as integral thin veneer brick, integral concrete color pigment, or painting steel elements of a structure should sometimes be considered as alternatives to painting concrete.

9.5.10.1 Surface preparation for coating

Specify the current versions of the “Developmental Specifications for Concrete Surface Preparation and Testing Prior to Coating Application” and the “Developmental Specifications for Structural Concrete Coating” in any structure plans that include coated concrete unless there are unusual circumstances of the types mentioned later in this section. Coating material type and any preapproved manufacturers and products must be covered in plan notes, as well as color and finish specifications for each color to be used on the project.

The use of the combined sand- and water-blasting specified in the “Developmental Specifications for Concrete Surface Preparation and Testing Prior to Coating Application” is critical to the performance of any concrete coating. This moderately aggressive blasting is expected to remove any loose surface concrete and aggregate that could potentially spall during the initial freeze-thaw cycles experienced by the structure. It also creates a surface profile that is conducive to coating penetration and adhesion. As prescribed in the DS, surfaces must be allowed to thoroughly dry and must be successfully tested for readiness to receive the coating prior to application.

9.5.10.2 Acceptable surfaces for painting

On bridges, portions of above-grade pier and abutment concrete surfaces, concrete fascia beam side and bottom surfaces, and outside faces of concrete traffic barriers are the usual surfaces considered for post-applied aesthetic coating treatments. For pedestrian tunnels, interior barrel surfaces and headwall parapet and wing surfaces can be treated. Cast-in-place and MSE retaining wall exposed faces can receive post-applied coatings, however for MSE wall construction it is generally preferred that color be incorporated using integrally colored concrete in the prefabricated panels. Concrete form liner texturing on bridge surfaces is often combined with post-applied pigmented coatings for the best aesthetic effect. Do not apply coatings to the top bearing surfaces of bridge piers or abutments, or to the floors of tunnels. The front face of standard abutment footings is typically not coated since it is short, heavily shaded, and is not prominent from most vantage points.

Painting of concrete fascia beams is an acceptable means of adding color to a bridge, and to visually separate the superstructure from other bridge elements. PPC beams have exceptionally high-quality surfaces that should never experience spalling throughout their service life. It is worth noting that if painted beams of an overpass bridge are ever struck by an over-height vehicle, the presence of a coating will complicate the beam repair process.

The vertical edges of bridge decks should never be painted. The reason is that during the deck pour, partially cured and dried concrete screeded off the top of the deck is often tossed by finishing workers toward the form boards at the edge of the deck where it is hand-screeded into place. This material may be inherently weak and can spall during the first several freeze-thaw cycles endured by the bridge, and perhaps continually throughout service life. Any coating on the deck edge, even if substantially vapor-transmissive, will spall with the weak concrete, leaving gaps in the color and creating a degraded appearance. Additionally, if the edge of deck is unpainted, it typically does not make visual sense to paint the underside of the deck overhang beyond the fascia beam. This area is also heavily shaded, which makes it difficult for any coloration to be seen by passing motorists.

Traffic face and top surfaces of concrete barriers are generally unsuitable for aesthetic coatings because of exposure to road salts, occasional vehicle strikes, and repeated snowplow blade contact. One exception is when an approved shallow stone-textured form liner is used and is painted in multiple colors to mimic real stone. This type of finish can hide minor spalls and scrapes better than a single continuous color on a smooth untextured surface. The outside faces of traffic barriers are generally acceptable surfaces for post-applied color treatments. Special plan notes are advisable to ensure that no incompatible curing agents or sealers are applied to barrier surfaces intended to receive post-applied coatings.

9.5.10.3 Coating material types, usage conditions, existing coatings

When structural concrete is identified for color through painting, use “breathable”, i.e. highly vapor-permeable, coatings for most applications. The preferred coating material is mineral silicate paint, both for its vapor transmission and its proven concrete surface penetration. See Materials I.M. 482.12 for information on approved products. 100% acrylic emulsion masonry coating and breathable concrete stains are also acceptable. Benefits of the use of breathable coatings include the ability to paint new concrete that may still exhibit internal moisture from its initial cure. Using sealers or other non-vapor-permeable coatings for aesthetic reasons risks entrapping internal moisture and continued spalling of the surfaces during freeze-thaw cycles even if painting is substantially delayed after construction and appropriate surface preparation is employed.

One exception to the use of breathable aesthetic coatings is when there is an existing coating of an incompatible type. Most concrete paints must be applied to uncoated concrete substrates only, so the presence of an existing coating presents a problem. The existing coating type must be verified and typically the same material is applied over the top, though some coating types may be applied over existing coatings. This must be thoroughly verified with the manufacturer before specifying materials.

When an existing coating is confirmed to be a high-silicone content acrylic sealer, only more of the same type of sealer should be used to topcoat the surfaces. This is because this coating is thermoplastic, and new applications will chemically react to the existing coating, leaving essentially one coat of material with no failure planes between coats. Do not topcoat this material with other paint types or with anti-graffiti coating. For graffiti remediation, cover graffiti by top-coating this material type with more of the same sealer in a matched color. The high-silicone acrylic sealer was typically specified on past projects with bid items 2403-7302000 “Colored Sealer Coating for Structural Concrete” and 2403-7304000 “Colored Sealer Repainting”. Presence of these bid items on existing structure plans indicates this material was used, and only the identical material should be used for repainting, including for graffiti remediation. High-silicone content acrylic sealers do not readily accept other materials as topcoats, and the adhesive bond between them would be very weak.

Another exception to the preferred use of vapor-permeable coatings may be when the surface will also receive non-sacrificial anti-graffiti coating. Anti-graffiti coatings are generally not vapor-transmissive in nature, but behave more like concrete sealers, so there is often no point in forcing vapor permeability in the initial aesthetic coating only to top-coat it with anti-graffiti coating. However, there may be other reasons to use a breathable paint which will be coated with anti-graffiti treatment, such as coating before all internal moisture has dissipated (i.e. concrete less than 45 days old), material safety factors, preference for low volatile organic compounds, or the required "open time" or workability of the paint to perform multicolor faux stone aesthetic treatments.

When non-vapor-permeable coatings such as sealers are used on new concrete because of unusual circumstances, allow entrapped moisture to escape by waiting 45 days or longer if possible before applying the coating. If multiple structures are expected to receive a non-breathable coating and there are delays to full project completion such as from staging or multi-year corridor work, wait to coat the entire project at the end so that some concrete has experienced freeze-thaw cycles prior to coating. This way, weak concrete surface spalls may have already occurred, and the structures may not shed coating in those zones during the subsequent service period. There will also be less chance of painted surface damage resulting from ongoing construction operations and related airborne dust and other contaminants.

Special applications of impermeable concrete coatings designed for sealing concrete or bridging small cracks while also creating an aesthetic finish are unusual and require thorough investigation into the properties of the material(s) and their appropriateness for the application. Product manufacturer representatives should be engaged to review the precise nature of the usage and for specific guidance on proper surface preparation, surface readiness testing, and coating application methods. Do not use the "Developmental Specifications for Concrete Surface Preparation and Testing Prior to Coating Application" or the "Developmental Specifications for Structural Concrete Coating" for these purposes unless these specifications precisely match the manufacturer's recommended procedures.

9.5.10.4 Specifying colors and finishes

Use of the SAE AMS-STD-595 (formerly Federal Standard No. 595C) color standard is preferred over other industry color standards. Colors can be found at AMS Standard Color Chart (https://ams-std-595-color.com/). Keep in mind that the first digit of any 5-digit color number indicates the finish of the paint, as follows: "1" = Gloss, "2" = Satin/Semi-gloss, "3" = Flat. However, most colors in the SAE AMS-STD-595 color chart can be manufactured by paint suppliers in any finish, so the designer is not limited to selecting, for example, flat finish colors only from those shown in the color chart with a prefix of "3". Select a color and change the prefix to the finish desired, then list the color number, the finish and a brief description of the color in the plan notes to ensure correct communication of the color to prospective contractors. For most concrete painting work, it is desirable to indicate a flat finish (prefix "3"), however some materials such as high-silicone colored sealer coating are only available in a gloss or satin finish. For those materials, colors should be indicated with prefix "2" to avoid bidder confusion.

It is generally advisable to use earth-tone colors, since they are less susceptible to UV fading than bright colors. Bright color accents on past projects, especially bright blue and red colors, have been performed in 100% acrylic emulsion paint for the best long-term color retention. If different material types are mixed on a single project to achieve bright colors for some portions, specify that the first coat of each material must be applied to raw prepared concrete surfaces and that overlapping of the materials is not allowed for any subsequent coats.

Multiple-color finishes that involve blending of different colors, such as for faux stone finish treatments on textured concrete, are sometimes desirable. If known, the preferred SAE AMS-STD-595 color numbers can be specified for each individual color to be used. A careful description of the desired color result and a suggested minimum number of colors to be used can also suffice for bidding purposes. Specify that all colors intended for use in such finishes be submitted as color draw-down samples for review prior to the contractor purchasing materials. Mineral silicate paints and breathable pigmented concrete stains are best suited to this type of blended multi-color work due to their longer "open time" both in the container and on the coating application devices used such as brushes, sponges, and rags. These treatments are not as easily achieved with high-silicone content sealers. Do not attempt to specify application techniques in the contract documents, only the desired results.

9.5.10.5 Pedestrian tunnel interior coating

The barrel wall and slab surfaces of pedestrian tunnels should be painted with a light color to enhance the effect of interior lighting. White or near-white color is typically used. A semi-gloss or gloss finish can also enhance the effect of the lighting and is preferred for that reason.

Tunnels can particularly become targets for graffiti, so some means of addressing graffiti potential is advised. As shown on Pedestrian Tunnel Standards PT-AD 1-20 and PPT-AD 1-20, the use of anti-graffiti coating over the top of a pigmented 100% acrylic paint will leave a semi-gloss surface, which can enhance the interior lighting. The same is true for the use of high-silicone colored sealer coating, which has a semi-gloss or glossy appearance and can act as its own graffiti remedy via top-coating. Both approaches essentially seal the tunnel surfaces and make them non-breathable, so allowing a preferred 45 days (minimum 28 days) between the last concrete barrel pour and the application of coating is essential to ensuring that concrete internal moisture levels are within specification.

9.5.10.6 Anti-graffiti coating

The choice of whether to include anti-graffiti coating on a structure is typically left up to District staff. Precedent issues with graffiti on the structure to be replaced or elsewhere in the vicinity of the project can certainly trigger inclusion of the protective coating.

When anti-graffiti coating is applied as a topcoat to an aesthetic coating, specify that compatibility between the 2 materials shall be verified with the manufacturer(s) by the contractor. Coating submissions post-project award should be double-checked for this compatibility.

Anti-graffiti coating products are covered by Iowa DOT Materials I.M. 491.23. Typical plan details associated with anti-graffiti coating of structures include application of the coating to the identified vertical concrete surfaces from ground level upward to 10 feet above grade. However, it is often advisable to extend coating coverage vertically to a logical surface break point. This is because some applications have noticeably changed the color of the concrete despite I.M. 491.23 requirements that such coatings are not allowed to change the substrate color. The potential color change may not be as noticeable if it occurs at a physical surface change, such as a form liner texture limit, a rustication, or a pier column-to-cap intersection. Color change may not be noticeable on surfaces that have already received pigmented aesthetic coating, in which case the vertical 10 feet limit may be acceptable. Sometimes it is best to coat the entire surface, for example an unpainted concrete retaining wall or abutment wingwall with only a minor portion of its surface that is taller than 10 feet above local grade. Include appropriate details and notes in the plans to indicate where anti-graffiti coating is required and to what dimensioned limits.

When anti-graffiti coating is applied to new concrete as part of a construction project, it is advisable to wait as long as possible to apply the coating. Up to 45 days after casting or longer is preferred.

Provide the District with appropriate documentation for their files. It is advisable for District maintenance staff to keep documentation on file of the projects and the surfaces that have been treated with anti-graffiti coating, since presence of the coating will indicate potentially different remediation efforts on those structures than on those without the treatment. For example, District maintenance staff may regularly paint over graffiti, but surfaces treated with anti-graffiti coating should never be painted as a remedy.

Permanent, non-sacrificial anti-graffiti products of the types listed in I.M. 491.23 typically advertise a coating service life of 15-20 years. That period may be shortened by repeated remediation treatments such as pressure washing or hand scrubbing with detergents. Proper surface preparation and coating reapplication may be required multiple times throughout the service life of a structure to maintain graffiti protection.

9.5.10.7 Repainting

See BDM 9.5.10.3 for related information. Repainting concrete surfaces that have an existing coating involves discovery of the precise nature of the existing material before specifying a topcoat material. In most cases, it is advisable to apply only more of the identical material after proper surface preparation has been employed, typically using the methods prescribed in the "Developmental Specifications for Concrete Surface Preparation and Testing Prior to Coating Application". If for some reason a different material type must be used, specify the manufacturer's recommendations be precisely followed for surface preparation and application.

It is highly impractical to attempt to specify complete removal of an existing coating from concrete with the intent of creating a raw, contaminant-free surface. Successful removal may not be ensured. Such efforts would probably require extremely aggressive abrasive blasting, which can present challenges on the jobsite if traffic or other sensitive conditions exist nearby. Persistent coating residues could impact adhesion or other performance characteristics of new top-coating material.

9.5.11 Coatings for steel railings

Coating systems are typically employed for weather and chemical protection and to prevent corrosion of structural steel pedestrian and bicycle fall protection railings, separation barrier bicycle railing attachments, and combination steel-on-concrete traffic railings. Galvanizing represents the most basic coating type used and is often the only coating included. Although paint can provide added weather and chemical protection to these components, paint coatings are usually a means of adding color and a higher-quality finish, typically to complement an aesthetic theme.

9.5.11.1 Galvanized-only railings

Galvanized-only railings and fences should be considered the baseline solution for most projects, even for those with extended aesthetic features. Sometimes the appearance of galvanized railings or fences can be complementary to the aesthetics, depending on the chosen character and color palette. The design and complexity of a custom railing can often be enough to convey the aesthetic design concept, and the addition of color is unnecessary.

For most structural steel traffic railings, unpainted galvanizing is preferred. Topcoat materials do not stand up well to the harsh conditions traffic railings are routinely subjected to, including vehicle strikes, chemical action from road salts, and snowplow blade contact. Damaged topcoat systems will have significantly worse appearance than plain galvanized steel surfaces when exposed to these effects. Therefore, top-coating is strongly discouraged from both a maintenance and visual quality standpoint.

For steel bicycle railing attachments to separation barriers, unpainted galvanizing is preferred due to the harsh conditions adjacent to traffic, even though vehicle strikes and snowplow contact are typically not concerns for back-mounted bike railings. Top-coating may be used at separators when aesthetic demands are high and where traffic volumes and speeds are reduced, as in some urban conditions.

For railings that are galvanized but not painted, call for galvanizing in accordance with ASTM A 123 in the plan notes. Depending on the types of details included in the fabrication of the railing, reference to ASTM A 384 may also be appropriate. This specification can encourage best practices in both fabrication and galvanizing associated with unusual details such as welded wire mesh, plates thinner than 0.25-inch, certain types of welded connections, and can address general tendencies for some fabrications to warp, twist, or otherwise distort during galvanizing. Include additional notes requiring abrasive blast cleaning to a minimum of Steel Structures Painting Council SSPC-SP6 "Commercial Blast Cleaning" prior to galvanizing.

9.5.11.2 Duplex coating system specifications

The preferred approach for adding color to bridge railings is to use a duplex coating system, i.e. polyester powder coating or high-performance paint applied to carefully prepared galvanized steel. The use of duplex systems is seen as an advantage due to the galvanizing having the ability to "self-heal" some scratches and scrapes that reach through the topcoat and damage the galvanizing underneath. This ability helps to prevent corrosion from minor damage and potentially allows the railing to remain in service much longer than a painted-only example.

Critical procedures must be followed in fabrication, galvanizing, and powder coating or painting to ensure success. While Iowa DOT Materials I.M. 568 provides clear specification control of the coating process for galvanized steel, additional plan notes are sometimes recommended for clarity and to cover unusual circumstances in the design of the railing that may impact the duplex coating process.

Plan notes should always reiterate that Materials I.M. 568 controls work associated with duplex systems. That specification also directs the contractor's attention to preapproved galvanizers and paint/powder coating shops, so no further direction on these items is needed in the plan notes. However, the material type of the coating must be established by plan notes, along with color specification and direction regarding sample submissions and approval processes.

Include plan notes requiring abrasive blast cleaning to a minimum of Steel Structures Painting Council SSPC-SP6 "Commercial Blast Cleaning" prior to galvanizing. Notes should call for galvanizing in accordance with ASTM A 123, and possibly ASTM A 384 when fabricated assemblies meet some of the characteristics mentioned in BDM 9.5.11.1. Reiteration of the I.M. 568 requirements to avoid quenching after galvanizing and to avoid application of chromate conversion coating is also advisable, since these are critically important to the condition of the galvanized surface prior to painting or powder coating.

Appendix F of Materials I.M. 568 adequately covers the surface preparation requirements for the galvanized surfaces to receive paint or powder coating, so reference to other specifications is unnecessary. Timing and travel log requirements documenting all processes are also thoroughly detailed in I.M. 568.

Powder coating is a reliable high-performance coating routinely used on galvanized steel railings and is the generally preferred coating type for pedestrian railings. Plan notes should include requirements that any visually unacceptable components must be completely stripped and recoated in the shop, since significant damage or quality problems with this type of coating cannot be repaired in the field.
When galvanized steel railings are painted, high performance 3-coat fluoropolymer paint systems should be used. Fluoropolymer paint is the preferred coating for galvanized structural steel traffic railings. Primer, intermediate, and finish coats are typically specified to be different colors to aid inspections during the application process.

I.M. 482.09 covers approval of fluoropolymer paint systems for use on structural steel but is not specific to galvanized steel painting. However, the same approved 3-coat fluoropolymer systems listed in the MAPLE for general structural steel can be used on properly prepared galvanized steel. While the MAPLE listing of galvanized surface systems approved under I.M. 482.08 and the listing of fluoropolymer systems are currently identical, in the future it is possible that systems not considered high performance could be added to the galvanized surfaces listing. Non-high-performance paints may be used for other purposes on galvanized structural steel items such as bolts and deck drain tubes but are not preferred for use on bridge railings.

Whether to use powder coating or high-performance fluoropolymer paint on galvanized bridge railings depends on several factors. Powder coating can be touched up in the field for minor repairs, but major repairs require removal to a shop. This can sometimes be accommodated if the railing is for pedestrians only, and the facility can be closed for service or kept open using a temporary fence. If the ability to repair the coating in place in the future is essential, fluoropolymer paint should be specified. This would certainly be the case for a structural steel traffic railing that is an essential part of a crash-tested barrier system, since removing such a device to recoat it in a shop would leave a partially functional or completely dysfunctional traffic barrier in service, requiring significant interim protective measures if traffic is maintained on the facility.

For the appropriate plan notes to be used, see the most recent examples of projects that included powder coating or painting over galvanized surfaces for the type of application desired. The Aesthetics Coordinator in the Bridges and Structures Bureau can provide these project examples.

9.5.11.3 Specifying colors and finishes

Use of the SAE AMS-STD-595 (formerly Federal Standard No. 595C) color standard is preferred over other industry color standards. Colors can be found at AMS Standard Color Chart (https://ams-std-595-color.com/). Keep in mind that the first digit of any 5-digit color number indicates the finish of the paint, as follows: “1” = Gloss, “2” = Satin/Semi-gloss, “3” = Flat. However, most colors in the SAE AMS-STD-595 color chart can be manufactured by paint suppliers in any finish, so the designer is not limited to selecting, for example, satin finish colors only from those shown in the color chart with a prefix of “2”. Select a color and change the prefix to the finish desired, then list the color number, the finish and a brief description of the color in the plan notes to ensure correct communication of the color to prospective contractors. For most railing powder coating or painting work, it is desirable to indicate a satin or semi-gloss finish (prefix “2”). For those materials, colors should be indicated with prefix “2” to avoid bidder confusion.

Designers should use caution when considering use of bright colors. Some colors can exhibit less UV stability and may be prone to fading. Earth tone and muted colors may perform better over the service life of the coated railing.

If the color palette of an aesthetic design concept indicates that a railing or fence should be a grey color, consider using a galvanized-only finish and eliminate the extra work and expense of the topcoat. Flat finish paints can be prone to chalking over time, so are discouraged. Gloss finishes can show evidence of field touch-up and repairs more obtrusively than satin or semi-gloss finishes, so are also discouraged.

For powder-coated finishes, specify submission of 3” x 5” powder-coated plates for review and approval prior to the contractor purchasing materials. For painted finishes, specify submission of color draw-down samples. Regardless of the material type, no samples typically need to be submitted for black or white colored coatings.

9.5.11.4 Specifying coating and color for chain link fences

It is often desirable on aesthetic structure projects that include chain link fence to use vinyl coated fence mesh in one of the available standard colors. While the mesh, the horizontal fence pipes, and many fence accessories are readily available from manufacturers with factory-applied PVC coating, fence posts configured for structure mounting are custom assemblies and are not generally available. This means the plans must cover the requirements for properly coating the fence post assemblies.

Powder coating over galvanizing is the preferred method for coating structure-mounted fence post assemblies to match the vinyl coated chain link mesh and the other available vinyl coated fence components.

For coating of custom structure-mounted fence posts, refer to a recent example project plan for the appropriate notes to include. These special notes typically cover surface preparation requirements prior to both galvanizing and top-coating, including reference to Materials I.M. 568. The notes also allow for post assemblies to be PVC coated, if available and compliant with all other plan requirements. The notes must indicate the color of the coating and the required sample as discussed in BDM 9.5.11.3. The Aesthetics Coordinator in the Bridges and Structures Bureau can provide these project examples.

For vinyl-coated chain link fence mesh, specify PVC coating in accordance with ASTM F 668, Class 2B. This specification ensures the PVC coating is properly fused to the wire and won’t easily peel off the wire if cut or damaged. Specify one of the standard colors in accordance with ASTM F 934. Standard colors include black, white, brown, green and red. Custom colors are currently not possible.

9.5.11.5 Repairs of coated bridge railings

Repair of coated railing surfaces may be necessary or desirable during the service life of a structure. The type of coatings and their condition will determine the required procedures for remediation.

Repairs on galvanized-only railings can be made in the field using procedures compliant with ASTM A 780. Surface preparation, re-coating methods, and materials contained in the ASTM should be thoroughly understood before attempting to specify a repair of such surfaces. The age of the galvanizing is of critical importance relative to the procedures used, since newly galvanized surfaces must be treated differently than fully weathered surfaces. Partial disassembly of the railing may be necessary in some cases to adequately reach all degraded surfaces that need attention. Surfaces in the vicinity of the field work must be protected to prevent contamination by repair materials.

Prior to developing plans to repair a duplex coated railing, the type of existing topcoat must be confirmed. Check the original plans and any subsequent repair plans to verify the coating type. Repairs of powder-coated galvanized railings must be approached much differently than repairs to painted galvanized railings.

Repairs on painted galvanized surfaces can be performed in the field. However, repairs can be complicated by the condition of the existing paint. All loose and poorly adhered paint must be removed via mechanical means, and remaining edges feathered by careful sanding to achieve finished results that are visually acceptable. Special notes are necessary to control this type of in-field preparation work. The preferred re-painting material is a 3-coat fluoropolymer paint system, regardless of the type of paint previously in place. If the railing is being spot-repaired rather than entirely re-painted, color-matching of the new paint to the existing must be performed to achieve a good result. Surfaces in the vicinity of the field painting work must be protected to prevent contamination by paint. The Aesthetics Coordinator in the Bridges and Structures Bureau can provide past project examples containing these special notes.

Repairs on powder-coated surfaces cannot typically be performed in the field unless the work involved is minor touch-up such as might be done immediately following installation. Touch-up must be performed in accordance with coating manufacturer recommendations. Surfaces in the vicinity of the field touch-up work must be protected to prevent contamination. Serious coating condition issues will involve complete removal of powder-coated railings from the structure for delivery to an approved powder coating shop. Existing powder coating should be specified for removal via blasting without damage to the galvanizing if present, and the assembly entirely re-coated. If complete coating removal can't be performed without damage to the galvanizing, the pieces should be re-galvanized as if newly fabricated. Investigation into the practicality of coating removal without galvanized surface damage is required before specifying. Partial or complete removal of existing galvanizing may also be required before re-galvanizing can be performed. Check with qualified industry representatives before specifying re-galvanizing.

If a previously painted-only, non-galvanized steel railing in need of repairs is encountered, consider removal of the railing to a shop for blast refinishing down to raw steel, then galvanize and topcoat in accordance with previous advice in this section. Repair of paint on non-galvanized steel railings in the field is not expected to provide significant additional service life in most cases and would not be cost-effective. Evaluate the general condition of the railing for continued serviceability before specifying repair procedures.

9.6 Aesthetic bridge design plan preparation

Reserved

9.7 Continuing project management

Reserved

9.8 Commentary on aesthetics and policy in the United States and Iowa

Roadway enhancement efforts have been a legislated part of the American highway culture for the last five decades. Beginning with The Highway Beautification Act of 1965, funding earmarked for enhancements has been included in every major highway bill passed by Congress. In 1968, the Federal Highway Administration (FHWA) began an annual program to award projects with scenic enhancement features. An accompanying FHWA document made a list of recommendations, among them was the following: “Encourage a high level of visual quality in every proposed freeway”, and “adopt the systems concept of an interdisciplinary team approach to urban freeway planning on every level”. The interdisciplinary team almost invariably included additional specialist designers to assist freeway and bridge engineers when aesthetic value was incorporated into project planning and design.

The National Environmental Policy Act (NEPA) of 1969 established environmental goals that directly affected federally-funded highway projects. Included in the Policy’s directives were the following: “Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings”, and “preserve important historic, cultural, and natural aspects of our national heritage.” It is important to remember that due to the limited staffing of federal and state agencies charged with overseeing NEPA, local community participants are often enlisted by those agencies to assess the performance of state DOTs against NEPA standards. Memoranda of Agreement with local municipalities are often the vehicles by which NEPA compliance is assured.

The National Highway System Designation Act of 1995 declared that “design for new construction… of a highway on the National Highway System may take into account… the constructed and natural environment of the area (and) the environmental, scenic, aesthetic, historic, community, and preservation impacts of the activity…”. This Act officially moved design considerations already in place for bridges on the Interstate Highway System onto virtually all bridges on the NHS.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 set aside ten percent, or $3.6 billion, of its transportation program for enhancements that increase the environmental, historic or aesthetic value of a project. It was also at this time that the National Scenic Byways program was implemented. More recently, the Transportation Equity Act for the 21st Century (TEA-21) continued the Transportation Enhancements (TE) program when signed into law in 1998. The FHWA describes the TE program’s purpose as “to strengthen the cultural, aesthetic and environmental aspects of the Nation’s intermodal transportation system”.

Other nation-wide agency activities related to enhancements of transportation infrastructure have paralleled the FHWA and legislative lead. The Transportation Research Board (TRB) established a Subcommittee for Bridge Aesthetics as part of its structures group. TRB also published the seminal guidebook, “Bridge Aesthetics Around the World” in 1991 as a designer’s reference. The American Association of State Highway and Transportation Officials (AASHTO) has incorporated aesthetics into its guide publications for roadway and bridge designers since the 1980s. The current edition of the AASHTO LRFD Bridge Design Specifications includes a section entitled “2.5.5 Bridge Aesthetics” in its “Section 2: General Design and Location Features”, which states that “bridges should complement their surroundings, be graceful in form, and present an appearance of adequate strength”, “Engineers should seek more pleasant appearance by improving the shapes and relationships of the structural components…”, “… engineers should seek excellent appearance in bridge parts…”, and “The bridge as a whole has a clear and logical relationship to its surroundings”. Incidentally, the Iowa DOT had two prominent names appear on the AASHTO LRFD document: former DOT Director Mark Wandro, who served on the Executive Committee for 2003-2004 as Regional Representative in Region III, and; DOT Research and Technology Bureau Director Sandra Larson, who was Vice Chair of the AASHTO Subcommittee on Bridges and Structures.

With the recent introduction of Context Sensitive Design/Context Sensitive Solutions (CSD/CSS), the FHWA has infused the transportation enhancement effort with new directives for state agencies. The

Iowa DOT has trained many of its supervisory engineers in the basics of CSD/CSS through FHWA-sponsored "Thinking Beyond the Pavement" seminars. FHWA has recognized that CSD/CSS can ease public involvement efforts on controversial projects and can help to streamline the often-problematic NEPA process that must be followed on many new works. Aesthetics can even be considered as mitigation for other negative project impacts. The FHWA has also launched a new website to showcase CSD/CSS projects from around the country. Iowa's first posting to this website was the Sioux City Gateway "Prairie Bridge" project.