Section 23
Aesthetics

23.1 Appearance in Design

When designing a structure, its appearance should be considered from the very beginning. The aim of this chapter is to analyze what constitutes aesthetic quality and to establish criteria that will serve as an aid in the design of visually pleasing bridges.

It is easy to see the importance of appearance in major bridges like the Brooklyn Bridge and the Verrazano Narrows Bridge. These bridges are viewed and remembered by thousands of residents and visitors to New York City every day. However, the thousands of New York’s less spectacular bridges also produce aesthetic reactions. Highway users are exposed to these more typical bridges on a daily basis. On a moderately busy expressway, this exposure adds up to hundreds of thousands of "person hours" of viewing every single day.

There is a misconception that improving appearance always costs more. The tendency among engineers is to view aesthetics by a bridge's surface features: color, materials, ornaments, etc. In truth, the aesthetic impact on the viewer is the effect made by every aspect of the bridge, its totality and its individual parts. It follows that every decision involving the visible parts of a structure is important, whether the designer considers it or not. Even those features beyond the designer’s control have an aesthetic impact.

Just as structural integrity, safety, and maintainability govern bridge design, so should appearance. A decision about any one of these features will typically involve some or all of the other criteria. Sometimes an improvement in one area will increase the cost, and sometimes it will not. The challenge is always, through creativity and ingenuity, to find ways of improving these qualities without increasing the cost.¹

While aesthetic response can be reliably measured and predicted, this is very different from the usual engineering task of defining a problem and finding its solution. While there is a statistical basis for determining what is aesthetically acceptable to most people, what may be judged as visually appealing by some may be viewed quite differently by others. Rather than to attempt to please everyone, therefore, the goal of aesthetics is to avoid a negative emotional reaction. Certain rules can be followed to make a bridge look acceptable. A notable quote from an expert in bridge aesthetics states, "... a good looking bridge is one which responds most gracefully to the structural requirements that it must meet." - David P. Billington.

¹ See references at the end of this section.
It is easy for an engineer to become overwhelmed with matters of schedules, cost, specifications, structural analysis and to not consider the basic appearance of the structure. These guidelines are intended to enlighten the bridge designer and to assist in producing visually pleasing structures through consideration of the following:

- Location and Surroundings
- Horizontal and Vertical Geometry
- Superstructure Type and Shape
- Pier Shape and Placement
- Abutment Shape and Placement
- Parapet and Railing Details
- Colors
- Textures
- Ornamentation

This section will discuss these topics in more detail.

### 23.1.1 Location and Surroundings

When determining the appearance of a bridge, the designer must consider it in context with its surroundings. The designer must decide what color, shape and type of bridge will look best at a given location. In other words, the surrounding area, be it industrial, urban, or rural should impact the type of bridge details used. For example, a bridge that looks pleasing on a rural road in the Adirondacks may look totally out of place in New York City. The location of the structure tends to separate bridges into categories.

The first category is individual bridges that span a major land area or body of water. Due to their large size, dramatic location, and carrying capacity, these major structures will tend to dominate their surroundings. While these structures must harmonize with the surroundings, their importance and size requires that the aesthetic qualities of the structure stand on their own. Given the importance of these bridges, preliminary sketches and artist renderings should be made to determine the best possible selection for a given site.

Multiple bridges seen in succession form the second major bridge group. When a series of similar bridges is seen one after the other, either in a viaduct configuration or many individual bridges closely spaced, their cumulative aesthetic impact on the landscape must be considered. In these cases, there is more reason for uniformity and there should be no noticeable differences between structures without an obvious reason. A specific theme for a particular route, such as a parkway, is often appropriate.

The third major bridge group consists of routine bridges, such as our highway overpasses and stream crossings. It is important that these bridges be simple, with minimal changes and all of the elements in clear relationship with one another. To handle the large quantity of these types of bridges being designed in any given year, standard details have been created with a broad range of details to allow designers to react to specific conditions. Since many of these bridges are viewed in elevation by those traveling on a roadway below, the structure type, span lengths, and proportions as viewed in elevation should be carefully considered.
The last major bridge category to consider is made up of infrequently viewed bridges. Some rural bridges on lightly traveled roadways are rarely seen by anyone. In this case, attention to the elements that can be seen from the roadway surface such as parapets, railings, transitions, and road surface, is important.

All structures do not fall neatly into one of the preceding categories. Some bridges will be a combination of these categories. The designer should determine what is appropriate for each structure.

23.1.2 Horizontal and Vertical Geometry

At one time, bridges dictated the alignment of the roads they carried. Bridges were built at right angles to the features they crossed. Often, the approaches required steep grades and tight radii to meet the existing roads. The geometric design standards for today’s highways often dictate the orientation of the bridge. The emphasis is on the need for safe, convenient driving and providing a more attractive highway system. Bridges must adapt to the highway alignment. So today, bridges often lie within the curvature of the road and follow the slopes or curvature in elevation. Curves on the highway are generally large because of safety considerations such as adequate sight distance. Such large curvature is also desirable for aesthetics.

Often, skewed structures are unavoidable. When it is necessary to orient the substructure parallel to the feature crossed, a wide bridge presents a greater visual impact and additional aesthetic treatments may be necessary. Piers in waterways should be placed as close to parallel as possible to the stream’s direction of flow for hydraulic reasons and to reduce scour action. Abutments that lie parallel to the river banks look better than those placed perpendicular to the crossing road.

If an alignment requires a curved bridge, then the external longitudinal lines, traffic barriers, and fascia lines of the structure should follow the curved centerline to provide a smooth visual flow.

In elevation, bridges should follow the profile. On shorter span bridges, the vertical curve should be extended onto the approaches. For longer bridges it is desirable to extend the vertical curve over the total length of the bridge. A smooth transition helps the structure fit in with the local topography. Parallel lines should be maintained by matching barrier, sidewalk, curb and fascia depth across the structure and U-wingwalls.

23.1.3 Superstructure Type and Shape

The appearance of a bridge is greatly influenced by different aspects of the superstructure. These include the superstructure type, depth, overhang width, number of spans, and span lengths. One way to make the structure light and slender, without making it appear weak and unsafe, is to use a favorable visible slenderness ratio (the ratio of span length to the visible structure depth, including the decking and any concrete traffic barrier or steel railing). The typical visible slenderness ratio will vary from approximately 10 to 40 depending on the type of superstructure chosen. Steel trusses are usually around a slenderness ratio of 10, although they may be more or less. Steel girders may vary from 15 to 30, with simple spans usually less than 25 and continuous spans often more than 25. The slenderness ratio for concrete beams is
usually between 20 to 30 for spans 12 m to 35 m long. Rigid concrete frames are typically closer to a visible slenderness ratio of 40.

Figure 23.1 shows different girder depths for the same simple span length. A depth that is too shallow gives the appearance that the bridge is not structurally safe. A girder that is too deep makes the bridge look bulky and overpowering. Bridges with a well proportioned slenderness ratio denote strength without excessive materials.

For very short spans, a good visual proportion may control over the low slenderness ratio. This is shown in the three sketches of Figure 23.2 where a slenderness ratio of less than 10 looks better on the short span. With the longer spans, a slenderness ratio of 10 or more has a better appearance.
For a two-span structure that has short abutments, the visible slenderness ratio should be between 25 and 30. For a two-span structure with tall abutments, the visible slenderness ratio should be between 18 and 22. Multi-span structures should have a slender superstructure on normal sized piers to give the most pleasing appearance as seen in Figure 23.2.

![Aesthetically Better](image1)

**Figure 23.3**
Slender Superstructures

An additional guideline that enhances the appearance of multiple spans is to avoid changing girder depths from one span to another. This gives a very awkward appearance and does not allow the structure to flow evenly across the bridge. An option is to use constant depth fascia girders and more economically designed interior girders.

![Aesthetically Better](image2)

**Figure 23.4**
Continuous Girder Depth

For a three-span bridge there are structural as well as aesthetic advantages to have the middle span longer than the end spans.
On the superstructure a slender appearance can be achieved through methods such as the use of horizontal joints or the shadow effect from the overhang. The shadow created by the overhang reduces the dominance of the girder. The deck overhang should be proportional to the girder depth. From an aesthetic standpoint the desired overhang is about $\frac{2}{3}$ the girder depth. Maximum and minimum overhang requirements are discussed in Section 5.

![Figure 23.5 Overhang Shadowing](image)

Vertical stiffeners make steel girders seem heavier and should be avoided on the fascia side of fascia girders, except for the bearing stiffeners.

![Figure 23.6 Avoid Stiffeners on the Exposed Side of the Fascia Girders](image)
Haunched girders can make the bridge seem more slender and help demonstrate the flow of forces in the bridge. The following is a guideline for haunched girders. The length of the haunch should be as long as is economical, up to 40% of the span length. Vertical clearances must always be considered for both existing and future conditions.

![Diagram of haunched girders](image)

**Figure 23.7**
Haunched Girders

The depth of the girder at the haunch should be between 1.3 and 2 times the depth of the girder at the midspan. The angle of the haunch should be between 135° to 160°.

![Diagram of depth and angles](image)

**Figure 23.8**
Haunch Details
Haunches should be formed by curves or parabolas. Straight or fishbelly haunches should be avoided. Fishbellys look heavy and awkward and do not follow the flow of forces.

![Figure 23.9 Fishbellied Girders](image)

Trapezoidal steel box girders and concrete segmental superstructures are visually elegant due to their simplicity and structural efficiency. The form and shape of the superstructure have clean, simple lines and allow the option of inclining or slanting the girder fascia to reduce its visual impact.

The arch is one of the most natural bridge types and generally considered one of the most aesthetically pleasing. The arch should be stronger and thicker than the deck and the supporting walls and spandrels. The deck supports should be uniform in size and shape and have the same column spacing throughout the entire length. The arch’s appearance is best brought out when it is spanning across a void, such as a valley or deep highway cut and yet strongly supported by land at both ends. Both thru and deck arches should be considered.

### 23.1.4 Pier Shape and Placement

The impression one gets from a pier is primarily influenced by the proportions, the relative width and height, and the configuration of the pier cap with respect to the pier columns. Pier proportion, in turn, is determined by the bridge geometry and superstructure type and shape. Piers can broadly be classified as either short or tall. Typically, short piers are more difficult to design with aesthetic proportions.

![Figure 23.10 Pier Height](image)
Care should be taken in proportioning a pier to make sure that horizontal lines of the superstructure are not interrupted. While larger piers will tend to direct attention away from the superstructure, piers that are too slender may convey a feeling of instability. Figure 23.11 establishes guidelines for better proportioning of the pier width with respect to superstructure depth.

A majority of the piers designed in New York are short piers (height/width ratio < 1.0). Typical short piers have one of these shapes: hammerhead, TT (pi) shaped, solid, solid with battered sides, multi-column on plinth, or just a multi-column configuration. The selection of the proper pier type can be dictated by the site, bridge geometry and design considerations. However, there are aesthetic issues that are common to all pier types involving the shape of the columns and the pier caps.

On multi-column piers, the column spacing should be kept uniform or at least symmetrical. The clear spacing between columns should balance the exposed distance between the capbeam and the footing. Structurally, large spans between columns require massive columns to handle the larger loads. On the other hand, columns that are spaced too closely create a ‘forest’ effect that is unattractive and structurally uneconomical.
The dimensions shown in Figure 23.13 represent a pleasant general appearance for some basic pier types and configurations. The member sizes and proportions should be adjusted to minimize stresses and produce a relatively economical design that is consistent with a good general appearance. The positioning of columns may be adjusted to balance beam and column moments caused by an unfavorable number and location of stringer reactions, as well as stage construction details.

The shape and location of the columns affect the appearance of the piers. The light reflecting from a surface controls how it is perceived by the viewer. A square or rectangular column with beveled corners will appear more slender due to the edge lines and varying shades of reflected light. The designer can use this principle to offset the look of a massive column under a shallow superstructure. The designer should always assure that the treatment used is in harmony with the rest of the structure.

Figure 23.12
Alternate Column Treatments
NOTE "A"
THE TALLER THE PIER, THE LARGER L' MAY BE AND STILL LOOK PROPORTIONAL.

NOTE "B"
THE SHORTEST VISIBLE LENGTH OF A PI PIER COLUMN SHOULD BE EQUAL TO THE CAPBEAM DEPTH + 1m.

IF THE EXPOSED COLUMN HEIGHT IS LESS THAN 3m, A SOLID PIER IS RECOMMENDED.

BATTER "X" = 12 ON 1 TO VERTICAL DEPENDING UPON THE HEIGHT OF THE COLUMNS.
BATTER "Y" = 10 ON 1 OR VERTICAL

TREAT L1 PORTION OF PIER SIMILAR TO THE PI PIERS SHOWN ABOVE, WHERE

\[ L_1 = S + 2C \]

1 3/4 E < C < 2/5 S

S (MIN.) = D
S = 3.9m to 6m

Figure 23.13
Pier Layout Details
A capbeam that is well proportioned (see Figure 23.13) with cantilevered ends balances the positive and negative moments in its design. This allows the designer to reduce the size of the capbeam and the column spacing and make the pier appear more graceful. A cantilevered end of a capbeam can reduce the size and cost of the rest of the pier.

However, when viewed from a position approaching the bridge, the end of the capbeam protrudes from the shadow of the superstructure and appears more pronounced as shown in Figure 23.14. This effect distracts the eye from the smooth horizontal flow of the superstructure and should be minimized as shown in Figure 23.15. Designers are cautioned to not design capbeams with excessively large overhangs. This can lead to long term durability and maintenance problems.

![Figure 23.14](End View of Capbeam)
For hammerhead piers, the stem width and height, and the cantilever length and depth should be carefully balanced. Long cantilevers on short piers appear out of proportion as do shallow cantilevers on wide stems. There are no specific rules that can encompass all of the possible variations. It is important to draw scale drawings of the pier and to select the one that appears the best and conforms to the rest of the structure. Figure 23.13 gives some basic guidelines.
Solid piers can be battered to improve their appearance. As a rule, the rate of the batter should be determined by the pier height and the relative design dimensions at the top and the bottom of the pier. The higher the pier, the more gradual the batter should be.
Tall piers are less common than short piers. They do, however, allow a greater opportunity for aesthetic treatment. The key to designing tall piers is to accentuate their vertical orientation. The sketches in Figure 23.18 establish some general rules:
When a bridge has a series of piers with varying heights, the designer should select a shape which, by varying its proportions, will look good as a tall pier as well as a short pier. Any pier selection should take into account the potential vulnerability from collision. For more information, see the Bridge Safety Vulnerability Manual.

![Diagram of different pier groupings showing structural and aesthetic considerations.]

23.1.5 Abutment Shape and Placement

For most simple span bridges and some multi-span bridges, the abutments are the most visible elements. While the abutment's function is to support the superstructure and transfer loads to the ground, it is important to maintain proper proportion and order to create a good appearance.

Good proportions between various elements of the bridge give character to the bridge. For the abutments it is important to consider the relationships between the exposed abutment height and length, the size and type of wingwall, and the superstructure depth. An attempt should be made to achieve a balance among these elements.
The designer must maintain order between the lines and edges of the structure. Too many lines, or lines that are close to, but not parallel to each other, can disrupt the eye and diminish the appearance of the bridge. Chamfered pour lines and barriers that follow the profile of the feature carried provide a smooth continuous flow across the structure and can be continued on U-wingwalls.

Long and tall wingwalls and bridge seats adjacent to and visible from the under feature could use form liners or stone facing to improve the appearance of a blank concrete wall. These surface textures can be used to integrate the structure with its surroundings by using or simulating natural stone or building materials used around the area of the bridge. Other textures such as scoring, recessing, or grooving may be used to break up the monotony of a large flat wall.

The dimensions and characteristics of a superstructure are greatly influenced by the location of the abutments which are in turn influenced by the orientation of the superstructure and the features over and under the bridge. The aesthetics of a structure are also affected by these features. For instance, a bridge over a waterway will generally have abutments that follow the direction of flow or the topography of the stream bank.

23.1.5.1 Skew

The orientation of the abutments to the feature crossed will create different visual appearances. The length of the abutment is dependent upon the width of the bridge and the skew. For structures with skews of 10° or less, the designer should consider eliminating the skew. However, the designer should consider the impact that eliminating skew may have on the hydraulic features, horizontal offsets, utilities, roadway intersections and constructability of the project. In narrow medians, skews must be retained to avoid shoulder or clear distance encroachments.
Abutments with severe skews can have very long stems and wingwalls. Consideration should be given to the aesthetic impact of concrete surfaces adjacent to the under feature. The impact of these surfaces can be reduced by increasing setback, using flared U-wingwalls, and by using formliners or veneers on the exposed surfaces.

### 23.1.5.2 Wingwalls and Curtainwalls

The wingwalls are the predominant feature viewed for the majority of abutments. As the abutments are pulled closer to the feature being crossed, the abutment stem becomes more visible and should be considered a candidate for aesthetic treatment. As a rule of thumb, a minimum height of 2.5 m should be provided below the beams if an aesthetic treatment is to be used. When an aesthetic treatment for the wingwalls is used, the use of curtainwalls should also be considered to create a more uniform appearance.

The orientation of the wingwalls also allows for more or less exposure. The view presented from the direction of travel on divided highways as opposed to the view seen in a full two-way operation should be considered. Plantings may create full or partial obstructions and should also be evaluated. The Regional Landscape Architect is responsible for developing a landscape plan.
23.1.6 Parapet and Railing Details

The railings or barriers, along with the deck fascia and fascia girders, are sometimes the most dominant visual aspect of the bridge. The railings are viewed by people traveling under the structure who see it in elevation and by people in vehicles on the bridge traveling parallel to it. When vehicle speeds are high, the railing or barrier should have simple and pronounced details because passengers cannot notice fine details.

In the Adirondack and Catskill Parks, timber railing or galvanized steel railing painted rustic brown should be used.

The most important aspect of the railing or barrier is its ability to prevent vehicle penetration and safely redirect an errant vehicle. Aesthetic treatments shall not jeopardize this safety consideration. The shape of the railing or barrier system should relate to its function and the overall aesthetic design of the bridge. Tapering of the end of the barrier will decrease the abrupt visual changes and will smooth the horizontal flow. It also improves the safety aspect of the railing transition.
On concrete barriers, the joint between the barrier and the slab can be unattractive. Figure 23.24 shows ways to improve the aesthetics of the concrete traffic barrier.

The fascia side of crash tested barriers may have an architectural treatment. However, the interior core dimensions and reinforcement of the barrier must be retained. The inner face, however, shall not be modified without crash testing and proper approvals.

The design and appearance of any fencing to be placed on the bridge should be consistent with the railing or barrier system. The vertical supports of the screening should align with the railing post spacing. Fencing on concrete barriers should be detailed to match the construction joints and the ends of the barriers.
23.1.7 Colors

When there is a reason to color the concrete, steel, or railings, a decision should be made whether the color should complement or contrast with the surrounding environment. Strong consideration should be made to the fact that colored concrete or steel will require a high level of maintenance. The designer should also consider the appearance if regular maintenance is not performed (e.g., peeling paint, rust spots showing, etc.).

The majority of today’s steel bridges use ASTM A709M Grade 345W weathering steel. Weathering steel changes over time from medium brown to dark brown in color. Weathering steel does cause staining of the abutments and piers. This can be reduced by redirecting runoff water, by providing drip edging on the steel, or by coating the concrete.

A Regional Office may request that a bridge be painted in a high visibility area for aesthetic reasons, such as when concrete staining by weathering steel would be objectionable, or to match a nearby painted bridge.

The Department’s current paint policy requires the color of the finish coat be specified in the Contract Documents. The description must include a reference to one of the following standards:

1. Colors defined in Section 708-05.
2. Federal Color Standard No. 595 with proper color number.
3. Munsell Book Notation with proper color notation.
For any of these cases, viewing shall be done under North Standard Daylight and should be so noted on the plans.

Coloring agents are not frequently used in the concrete for piers, wingwalls, etc. because of complicated quality control and the high cost of materials, but the idea has not been discounted completely. Some problems have occurred in coloring concrete. It is difficult to get an identical color of concrete from one pour to the next. Staining concrete can create a mottled appearance. External coatings are not always applied correctly and can have durability problems.

For coloring, the following guidelines should be considered:

- Determine if coloring is justified on the structure.
- Coloring should blend in with the structure and the surrounding environment.
- Lighter colors help to emphasize shadows and contrasts.
- Weathering steel and brown colors blend in with most backgrounds except sky blue.
- The colors on a bridge, including signs, lights and railings should be considered jointly.
- If only a portion of a bridge is to be coated for maintenance reasons, the appearance against the surrounding elements that are uncoated should be considered. If pedestals or pier caps are coated, they will stand out against the uncoated abutments or piers.

23.1.8 Textures

Texturing concrete can be achieved through formliners, panels, stone or brick veneer, or acid washing. Any texturing should fit in within the overall design and proportions of the structure.

The following features should be considered:

- The size and shape of the patterns should be in line with how it will be viewed. If they are only seen from high speed vehicles, they must be large enough; if they will be viewed mostly by pedestrians at close range, they can be made smaller.
- Patterns created by and incorporating expansion joints, construction joints, and weep holes should be considered in the overall design.
- Horizontal lines should be continuous across the structure. These lines should follow the profile of the roadway. Continuous horizontal and vertical form liner seams should be avoided when using random stone patterns.
- Form liners imitating stone, rock or brick should appear natural. Special consideration should be made at the corners and the top of the walls.
Several types of commercial form liners are available. Some can be purchased; others have to be rented. With rented units it is often required that a company representative’s services be included as part of the rental agreement. The complexity and cost of some form liners may have an effect on the construction schedule. This is a consideration when the area to be treated is large and the cost of the form liner is high, therefore placing a practical limit on the area of form liners to be used at any one time. It is also important that the form liners chosen have the structural strength to withstand the pressure of wet concrete when the height of the concrete placement is large.

Natural stone or brick facades can also be used. Stone is most often used for parkway bridges. The cost of this treatment is high and should be limited to areas of high visibility. Stone or brick facades should be placed to a 600 mm limit below the finished ground line.

When a concrete cap is used on the top of a wingwall or retaining wall, it should be proportioned to the wall.

23.1.9 Ornamentation

Ornamentation should only be added to a bridge in very special circumstances. The additional cost of add-ons is rarely justified except in cases of importance to the community (such as a gateway to a city) or of historical significance. Details such as ornamental light posts, columns or pylons, real or simulated gatehouses, plaques or reliefs may be added to a structure. The designer should consider these details carefully since it is just as easy to detract from the overall appearance of the bridge as it is to improve it. Such details are secondary to the primary purpose of the structure, to provide a safe and efficient crossing to the public. Ornamental and non-structural details require additional coordination, sketches and drawings to ensure that the...
details will add to the aesthetic characteristics of the structure in a way acceptable to all concerned. The additional costs for the various details need to be identified early, as they can have a significant impact on project costs.

References:

Bacow, Adele Fleet & Kenneth Kruckmeyer, Bridge Design-Aesthetics and Developing Technologies, Massachusetts Department of Public Works & Massachusetts Council on the Arts and Humanities, 1986

Aesthetic Guidelines for Bridge Design, Minnesota Department of Transportation Office of Bridges and Structures

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

Leonhardt, Fritz; Bridges-Aesthetics and Design, MIT Press, Cambridge, Massachusetts, 1984
APPENDIX 23A

Examples of Monumental Suspension Bridges

Brooklyn Bridge, circa 1884

Verrazano Narrows, circa 1964

January, 2008
Examples of Monumental Steel Arch Bridges

Thaddeus Kosciusko - I-87 over Mohawk River

Driving Park Avenue over Genesee River
Examples of Post-Tensioned Concrete Box Bridge

I-390 over Genessee River

I-390 over Genessee River
Examples of Steel Grasshopper Structures

Route 9W over Normanskill

Brooks Avenue over Barge Canal
Examples of Haunched Steel Bridges

Route 96 over Flood Control Channel

Route 28 over Barge Canal / Mohawk River
Examples of Designing
Steel Structures to Match the Surroundings

Route 13 over Cayuga Inlet

3rd Street over Steel Street