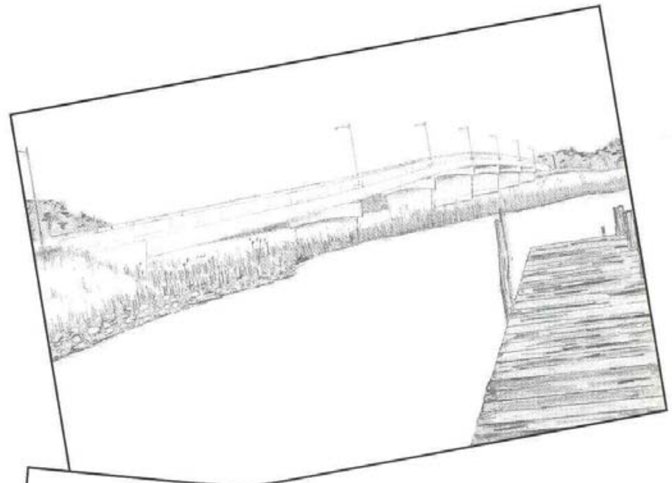
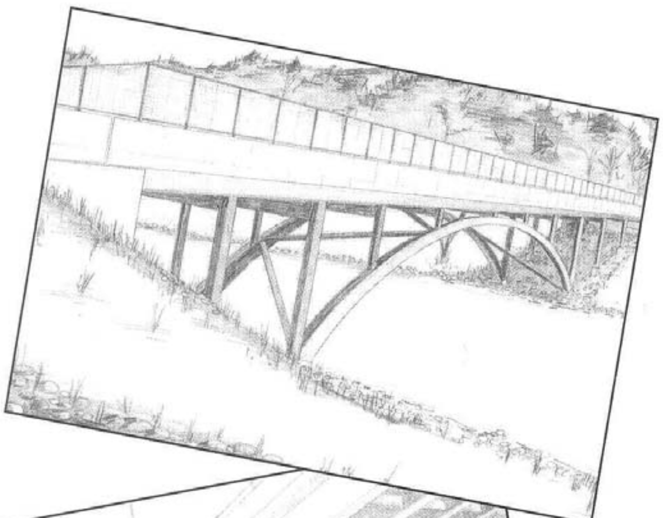
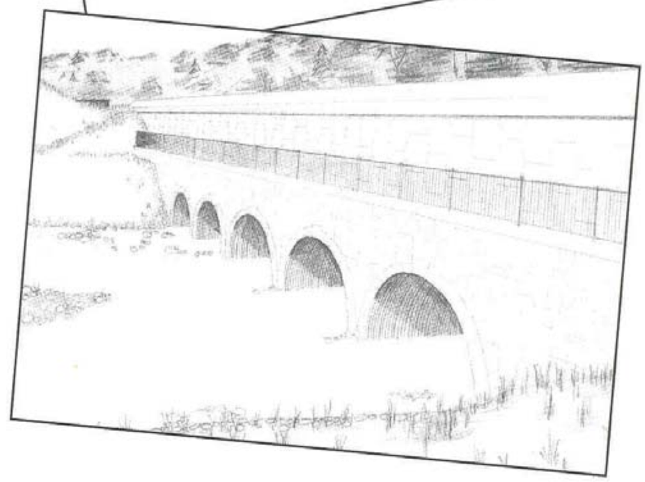
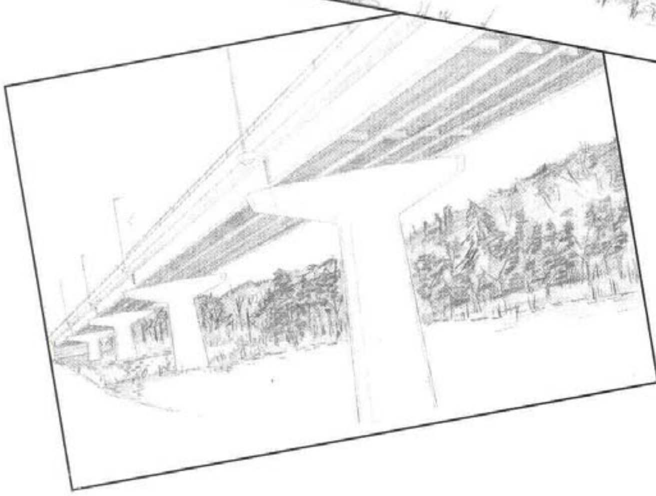
Aesthetic Bridges

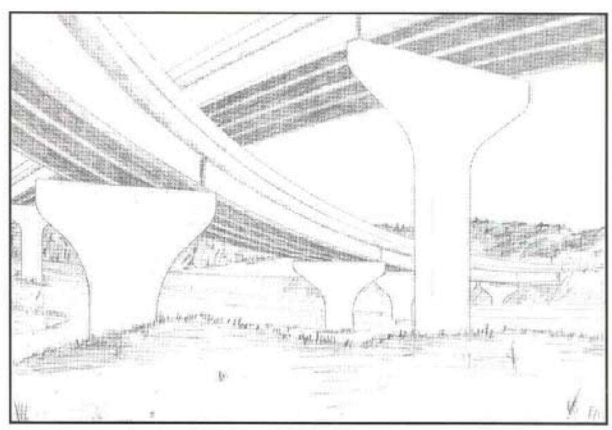
USERS GUIDE











Maryland Department of Transportation
State Highway Administration
Office of Bridge Development
August, 1993
Revised, January 2005

WE MUST NEVER LOSE SIGHT OF THE MISSION:

TO BUILD A STRUCTURALLY SOUND CREATION THAT ALSO HAPPENS TO BE PLEASING TO THE EYE.

AESTHETIC BRIDGES
Table of Contents

PREFACE

Bridge design is an art which uses science and mathematics to support many of its decisions. Other judgments are made during the bridge design phase, including those about appearance. The purpose of these guidelines is to give bridge designers a basis to make those aesthetic judgements, which can be just as definitive as those made about structural members, safety or cost (Figs. 0.01 and 0.02).

Fig. 0.01
Most would agree that this is an attractive bridge. (Beaverdam Road over I-83, Baltimore County, MD)

Fig. 0.02
Most would agree that this is not as attractive as the bridge above. What are the factors that make the difference?

These guidelines present ideas about how aesthetic quality can be achieved, with special emphasis on "workhorse bridges." The term "workhorse bridges" encompasses the majority of the bridges built. They are not necessarily unique in setting, nor monumental in span length. Yet, they are typically prominent features in their immediate setting, and, therefore, have a visual impact on their surroundings.

The ideas were initially assembled by a group of bridge engineers, architects, landscape architects and traffic engineers brought together at a conference on this subject at Solomons Island, Maryland. An initial draft was further refined during a series of seminars with participants from the State Highway Administration's Office of Bridge Development and consulting engineering firms.

Aesthetic ideas change over time as people bring new insights, respond to new materials or technologies and learn from their experiences. While these guidelines present rules of thumb and comparative examples, their goal is to encourage the bridge designer to develop his own talents and insights as he thinks about the aesthetic appearance of any structure. The result hopefully emphasizes lightness, slenderness, horizontal continuity, openness and a pleasing appearance.

This document should be used as a thought provoker, not a thought inhibitor. It should be used as a tool in observing bridges, in becoming more aware of aesthetic responses and in making judgments about what works well. Every bridge is unique, and only its designers can recognize which guidelines might apply, which guidelines must be adjusted and which situations mandate the development of new guidelines.

One concept, however, is common to all cases. Designers should always consider a structure's aesthetic impact. As Fig 0.03 shows, the aesthetic impact of a bridge is primarily a product of the structural members themselves. Details and color are important, but secondary.

Fig. 0.03
It is the bridge structural members that dominate the viewer's impressions. By shaping the structural members, the designer controls the aesthetic impact. (MD 7A over AMTRAK, Harford County, MD)

We have added a sheet in the back for your comments. Please take the time to send these in with your suggestions, comments and thoughts.

We realize an overly wordy document sits on a shelf gathering dust. We have attempted to make this document more readable by separating the specific guidelines from the "commentary" on that subject. For ease in use, **the guidelines are in bold type** and *the commentary is in italic type.*

Aesthetic success relies on the proper relationships between key dimensions. The following abbreviations are used for these dimensions throughout these guidelines (Fig. 0.04):

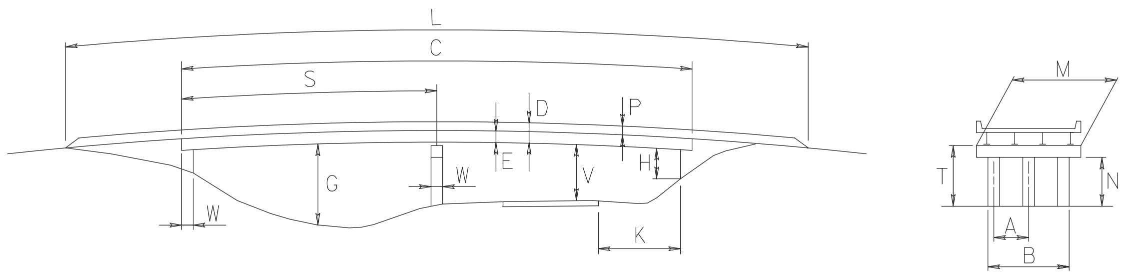


Fig. 0.04 Abbreviations used in these guidelines

L = Total Bridge Length (end of end post to end of end post)
C = Bridge Length (center line bearing abutment to center line bearing abutment)
S = Span Length (center line of bearing to center line of bearing)
D = Total Depth of Superstructure (without rail and/or fencing)
P = Parapet Height (top of parapet to bottom of slab)
E = Exposed Girder Depth
G = Vertical Clearance to Ground
V = Vertical Clearance to Roadway
K = Clear Distance from Edge of Roadway (does not include shoulder) to Face of Abutment
H = Height of Exposed Abutment Face (from groundline/slope protection at face of abutment to bottom of superstructure)
T = Height of Pier (from groundline or normal water surface elevation to top of cap)
M = Length of Pier Cap
N = Height of Pier Stem (from groundline or normal water surface elevation to bottom of cap)
W = Width of Pier at Cap or Width of Abutment at Beam Seat
B = Length of Pier (at groundline or normal water surface elevation)
A = Spacing of Columns for Multi-Column Piers

I. INTRODUCTION

A. BRIDGE DESIGNERS AND AESTHETICS

All bridges make an aesthetic impact. The design engineer is responsible for this aesthetic impact.

When a bridge is built, a visible object is created in the environment. People see it, and they respond to what they see.

Bridges become the symbols of their communities: Maryland and the Chesapeake Bay Bridge, New York and the Brooklyn Bridge, San Francisco and the Golden Gate Bridge, and now, Tampa Bay and the new Sunshine Skyway. The arch bridge carrying Ridge Road over I-70 has become the gateway to Western Maryland (Fig. 1.00). These bridges become symbols because people believe that the way the bridge looks, especially if it is handsome, is a worthy reflection of their community.

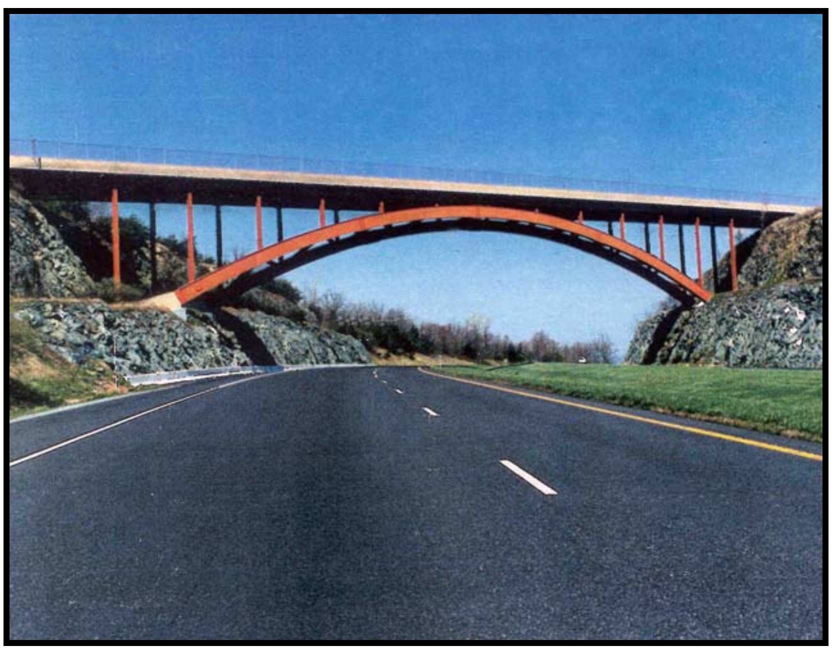


Fig. 1.00
Gateway to Western Maryland (Ridge Road over I-70, Frederick County, MD)

"Everyday" bridges also have an impact. The bridges on the Beltways are seen by thousands of people every day (Fig. 1.01). They are a significant part of their users' daily environment. They create an impression. The bridge designers must make that impression the best that it can be (Fig. 1.02).

Fig 1.01
Thousands of people view this bridge every day. (US 1 over I-695, Baltimore County, MD)

The issue cannot be avoided by taking care of the technical matters, and leaving the visual quality to someone else. The structural elements--the superstructure, the piers and the abutments--create most of the visual impact. Design engineers cannot delegate those to anyone else. Once established, they will dominate the aesthetic impact of the structure, no matter what is done with the details, color and surfaces. Aesthetic quality is not achieved by adding details to a structurally adequate design concept; aesthetic quality must be present in the basic structural configuration.

Then, if the bridge is to be a complete aesthetic success, the details, colors and surfaces have to blend with the structural concept (Fig. 1.02).

Fig 1.02
A very attractive bridge. Is this the best it can be? (MD 7 over the Gunpowder River, Baltimore County, MD)

B. AESTHETICS AND COST

Aesthetic quality is often associated with bridges that efficiently respond to the flow of forces in the structure, and an efficient structure is usually an economical one. It follows that it is not always necessary to spend more money to achieve an attractive bridge.

In bridges, the overriding visual impression is created by the shapes of the structural elements themselves (Fig 1.03). Some of the most aesthetically pleasing bridges are those whose structural elements verify what the viewer would expect. They are thick where the stresses are highest, and thin where the stresses are lowest (Fig. 1.04). Since low cost usually follows efficiency the best-looking structure may be the least expensive. In fact, the engineers of the best-looking bridges, men like John Roebling, Gustav Eiffel and Christian Menn, often got their commissions because their proposals were the least expensive among competing designs.

Fig. 1.03
The structural elements developed from a need to reduce cost and still provide the long spans required. Once the concept proved itself in those terms, the designer could refine the shapes to enhance their visual appeal. (I-64, Virginia)

Fig. 1.04
Shaped for maximum efficiency and low cost. (MD 543 over I-95, Harford County, MD)

Improvement in aesthetic quality should be viewed in the same way as any other standard of quality: structural integrity, safety, durability, or maintainability. Sometimes such improvements cost more money, and sometimes they do not. Always, the challenge is to find ways of making improvements without spending more money. Such improvements can be made in aesthetics as in any other quality. If the improvement does cost more money, then, as with any other quality, the question is: Is the improvement worth the increased cost, keeping in mind that the bridge may be a feature of the landscape for almost a century?

If cost-effectiveness can be applied to aesthetics as well as safety, durability, and maintainability, then aesthetics can be evaluated as a criterion with all the others. It can be applied within the same constraints of budget, function, availability of technology, materials, and time for design as all the others. It is not more important than these others, nor is it less important.

Though it is true that the most attractive structures will be efficient and economical, it is not true that every low-cost structure will be beautiful. Engineering problems permit many solutions. No matter how objective an engineer may be, he must still make choices when alternative designs perform equally well. It is in these subjective decisions that the differences will be found between what is and is not beautiful.

C. DETERMINANTS OF APPEARANCE

The most important determinants of appearance for a bridge are geometry and position in the environment, superstructure type and shape, pier placement and type, and abutment placement and height. It is in the design of these elements that aesthetic success can be achieved.

How people react depends on what they see first. First impressions are rarely overridden by later information. People first see the shapes of the major structural elements (Fig. 1.05).

Fig. 1.05
How you react depends on what you see, and in what order. The first and strongest impression is made by the shape of the structural elements. (Gorman Road over I-95, Howard County, MD)

The color of the major elements is next, then, if time and distance permit, the shape and layout of the details. It follows, then, that the most important determinants of a bridge's appearance are, in their order of importance:

1. *The vertical and horizontal geometry and their relation to surrounding topography and structures; in other words, how high the bridge is, whether it is curved in one or two planes and what is around it that is seen at the same time. This is an important factor, but for most "workhorse" bridges these criteria are dictated by the highway layout and the bridge designer has very little control.*
2. *Superstructure types: arch, multi-girder, rigid frame, curved girder etc.*
3. *Pier placement*
4. *Abutment placement, shape and exposed height*
5. *Superstructure shape, especially the depth/span ratio*
6. *Pier shape*
7. *Abutment shape*
8. *Parapet and railing details*
9. *Surface colors and textures*
10. *Ornamentation*

The first five determinants are usually thought of as strictly "engineering" decisions. However, they are inescapably aesthetic decisions as well. The last five elements are the ones most often thought about when speaking of bridge aesthetics. Yet it is almost impossible for decisions regarding the last five elements to compensate completely for poor decisions made about the first five-- though the attempt is often made (Fig. 1.06).

Fig. 1.06
After-the-fact "aesthetic treatment" cannot transform the basic appearance of a bridge. (US 50 WB over US 301, Queen Annes County, MD)

A better idea is to make the best possible decision about the first five elements, and then use the final five to accentuate and improve the positive qualities that have been created (Fig. 1.07).

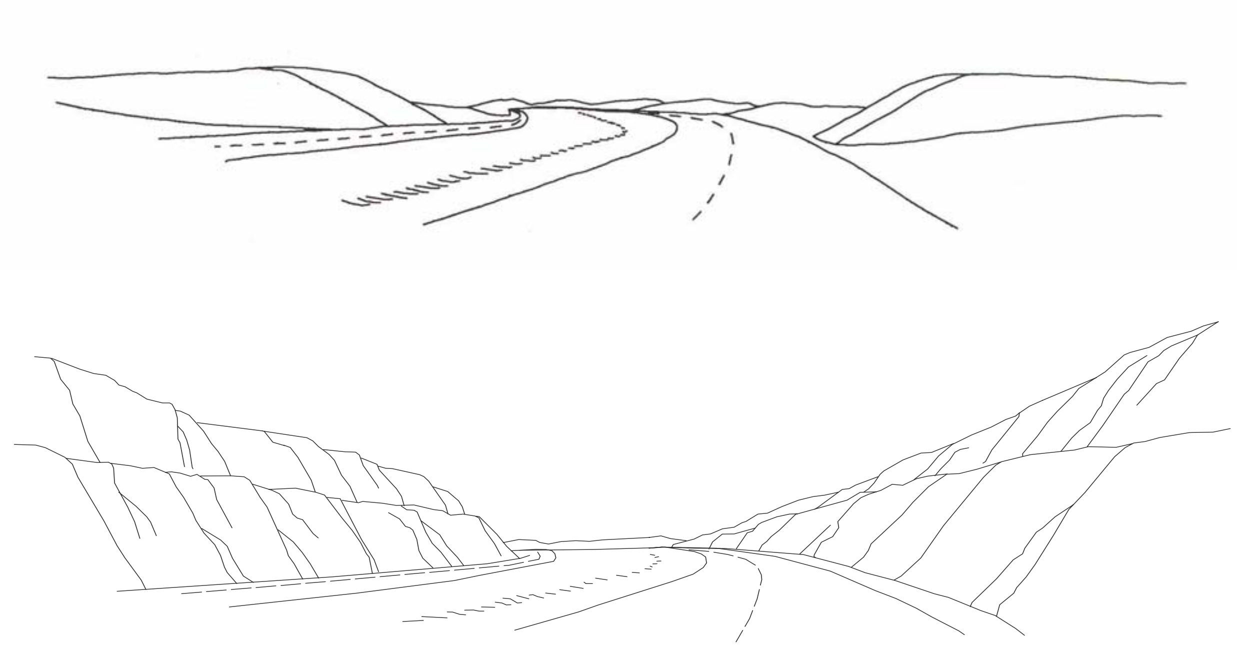


Fig. 1.07 The designer's choice: what type of bridge should go here?

D. THE KEYS TO SUCCESS

The keys to success are: strength through form, a clear display of how the forces actually flow, unity, economy, proportion and appropriateness.

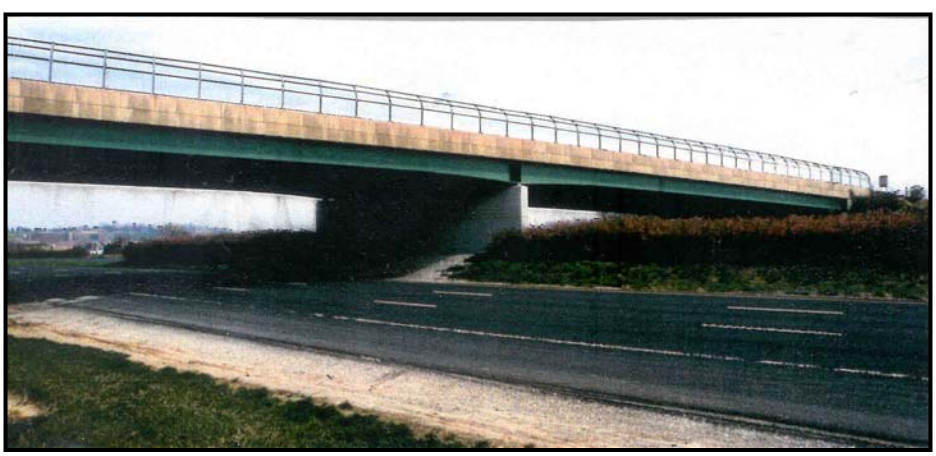


Fig 1.08
The small difference between haunch depth and midspan depth gives the appearance that only essential material was added. (Beaverdam Road over I-83, Baltimore County, MD)

The first two criteria for aesthetic success in bridge design are:

Strength through form:	*Elements should be shaped to respond to the structural job they do (Fig. 1.08).*
Clear display of structure:	*What each element does and how the forces act should be visible (Fig 1.09).*

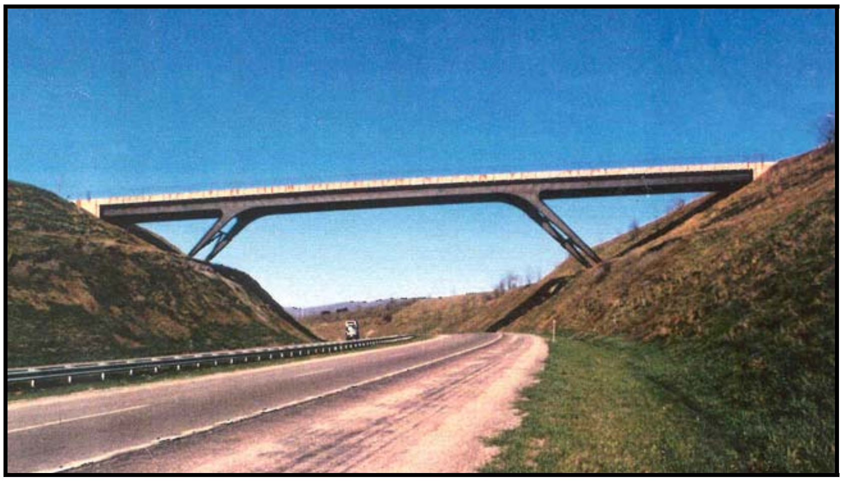


Fig 1.09
This bridge creates a strong visual impression because of the shape of the structural members. (Blooming Rose Road over I-68, Garrett County, MD)

Then there are four more criteria, applicable to all areas of aesthetic effort:

Unity:	*All elements should contribute to a single whole; for example, all elements should usually come from the same family of shapes, such as shapes with rounded edges.*
Economy:	*The bridge should do its job with a minimum amount of material. Not only should the bridge be economical, it should look structurally sufficient.*
Proportion:	*The size of each element should be clearly related to the overall structural concept (Fig. 1.10).*
Appropriateness:	*The bridge as a whole should have a clear and consistent relationship to the things around it. A bridge placed in an industrial area will be different aesthetically from a bridge in a residential or rural area.*

While these criteria cannot be stated as definitively as a technical specification, they can and should be the basis of judgments about structure that will influence the basic design.

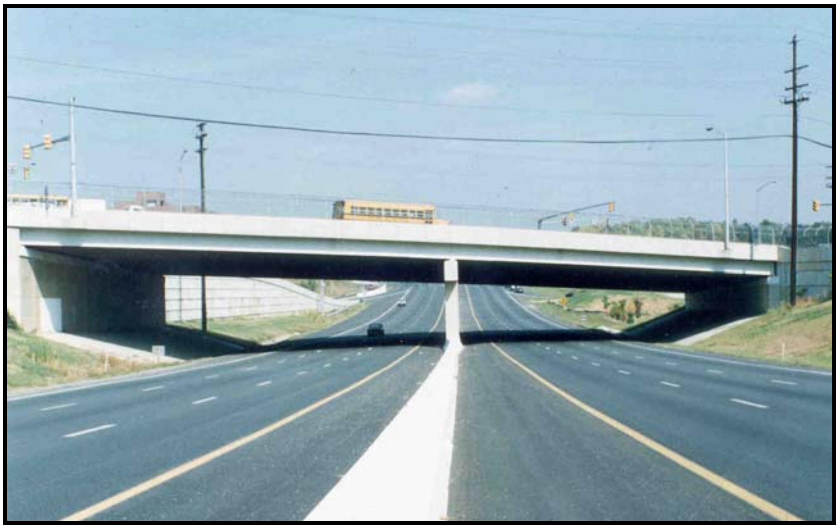


Fig. 1.10
This pier looks thick enough, the girders slender enough. The bridge is well proportioned. (MD 193 over MD 201, Prince Georges County, MD)

E. ANALYZING THE APPEARANCE OF BRIDGES

1. The Perception of Bridges

Success in bridge aesthetics depends on recognizing the effects of light, shade and shadow and the likely position of viewers of the bridge.

The perception of a bridge is primarily visual. Viewers most often perceive the bridge through the windows of a vehicle. Exceptions exist where people can approach some part of the bridge, such as the columns of a viaduct over a city street. Here, the sense of touch, the feeling of safety, or the noise of vehicles passing overhead helps to form the perception of the bridge. These exceptions will be discussed elsewhere in the guidelines. However, the dominant sense is always visual. The discussions which follow pertain to visual perceptions.

For most bridges, daylight is the medium of visual perception. Therefore, the orientation of the bridge is a major influence on how it will be perceived. Surfaces that face south will be consistently the brightest. Their shadows will change relatively little during the day, but may change significantly from season to season; their colors will tend to fade quickest. Surfaces facing east or west will be in shade half the day, and with strong, rapidly changing shadows the other half. Surfaces facing north will be in shade at all times; their colors will stay bright the longest.

Designers cannot control daylight, and can rarely control orientation, but shadow and shade are susceptible to control. Overhangs, grooves and recesses create areas and patterns of shade and shadow which help create an aesthetic impression (Fig. 1.11). The brightness of surfaces can be changed by changing their orientation to the sky. Surfaces slanted backward will be brighter than vertical surfaces or surfaces slanted toward the *ground (Fig. 1.12). The reflectability of surfaces can also be changed by using white or rubbed concrete to accentuate the effect of light and shadow.*

Fig. 1.11
The overhang and horizontal stiffener create lines of shadow which make the girder seem thinner and emphasize a horizontal visual impression. (MD 198 Ramp over I-95, Prince Georges County, MD)

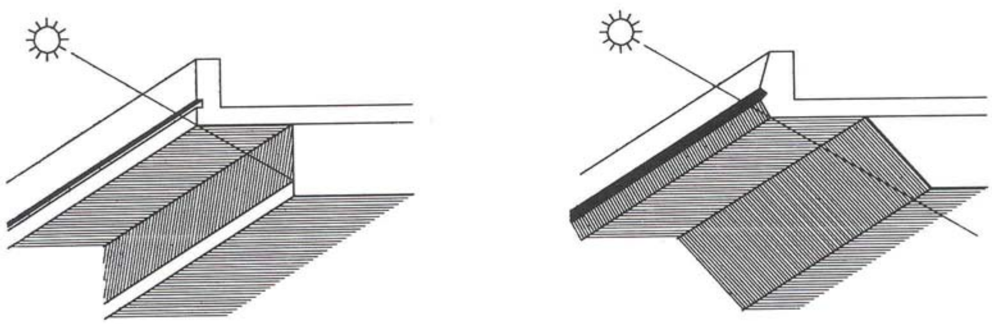
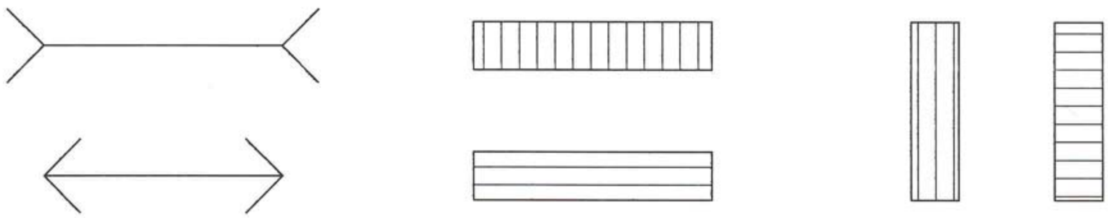


Fig. 1.12 Orienting surfaces to create areas of shadow

Nighttime illumination with headlights, or from roadway lighting luminaires, is rarely sufficient to do more than pick out major shapes. Given these limitations, plus the fact that most nighttime highway drivers are pre-occupied with the difficulties of the driving task, it is probably not worthwhile to be too concerned with the appearance of "workhorse" bridges at night. The major exceptions would be those circumstances where the bridge itself deserves lighting because of its place in the environment or its symbolic importance, or where the use of the bridge requires lighting the space on or below it. Such situations are discussed later in Chapter VI.

Designers must be aware that what people perceive is not always what is there. The visual sense is susceptible to manipulation and illusion. Illusion can work to one's advantage or to one's detriment. It is the designer's job to recognize where the potential for illusion exists and to put it to use. The sketches below give examples of common visual illusions which have applications to bridges (Fig. 1.13).



Which line is longer? Which rectangle is deeper? Which rectangle is thicker?

Fig. 1.13 Visual illusions applicable to bridge design

2. Viewpoints, Fixed and Moving

When a designer develops his aesthetic intentions for a bridge, the first thought must be the likely position of viewers of the bridge. The background against which a bridge is seen also influences the impact the bridge will make.

For a bridge over a park valley, the viewers would be park users on the trails or roadways below (Fig 1.14); for a viaduct over a city street, these would be pedestrians and drivers on the street (Fig 1.15). For most bridges, there are several such viewpoints depending on the location. (A bridge over a limited access superhighway is the exception; it probably will be seen only by the highway user--in a vehicle--at a fast speed.) For prominent bridges, the area of viewing may cover several square miles, and incorporate whole communities within sight of the bridge.

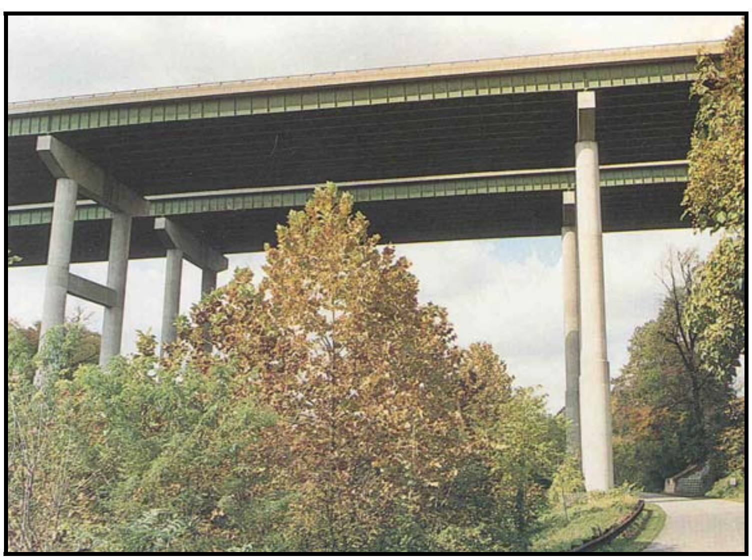


Fig 1.14
The park user's viewpoint is important for this bridge. (I-95 over Patapsco Park, Baltimore County, MD)

The bridge itself creates new viewpoints of the surrounding environment. For a bridge over a major barrier (river, etc.) or at an entrance to a town, the crossing may have great symbolic importance. In the past this was recognized by the placement of statues, plaques, elaborate lighting fixtures or viewing platforms on the bridge.

Obviously, not all viewpoints can be accommodated to the same degree; it is often necessary to assign priorities among them, giving more weight to the predominant observers, or more weight to the view from the downtown shopping area, for example, than to the view from the town warehouses (Fig. 1.15).

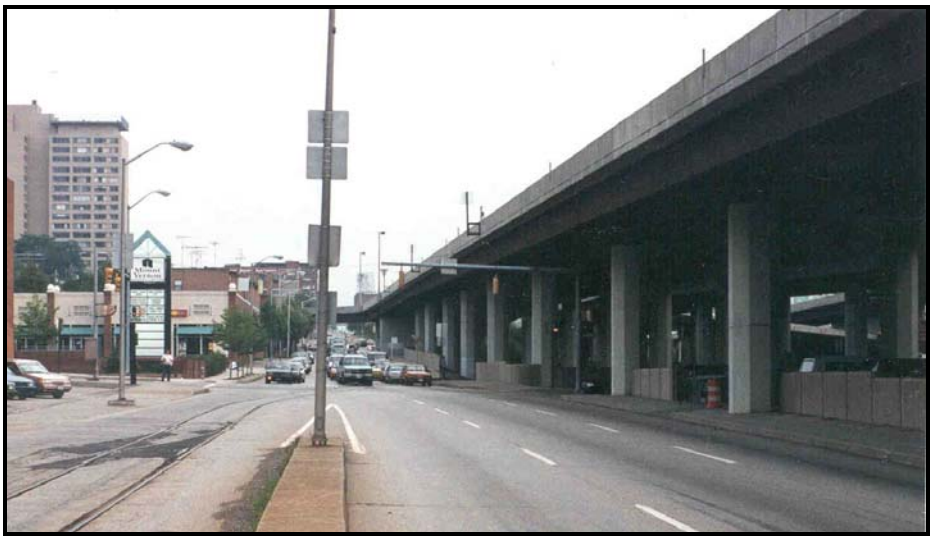


Fig. 1.15
The view of downtown, as well as the view from downtown are affected by this structure. (I-83, Baltimore City, MD)

For stationary or pedestrian viewers, the most important variables are distance and height. For bridges viewed primarily from a half-mile away, the major concern must be for overall shapes and the colors of large areas. Details will not matter. For bridges to be viewed close at hand, details and surface texture will become more of a concern.

Many highway bridges are seen primarily by motorists on highways passing beneath them (Fig. 1.16). This is a very controlled situation. The viewers are typically moving along a prescribed line (their highway lane) at a constant eye height and at a constant rate of speed. The point at which the bridge first comes into view, the length of time that it is within view, and the size of the bridge within the visual frame at each point can all be predicted, and are relatively the same for each observer. The visual experience is analogous to that of a movie, in which the windshield functions like the screen and the designer controls what is presented on each frame.

Fig 1.16
The driver's view: predictable in line and scope, constantly changing, and quickly over. (Access Road over I-97, Anne Arundel County, MD)

For viewers in cars, the most important variable in perception is speed, followed by distance to the bridge. As we travel faster and faster, three things happen to our visual perception: our constantly changing field of view narrows (less and less is noticed on the periphery), our point of focus moves farther and farther ahead, and our attention to objects such as bridges diminishes.

Partially, this is a result of the physics of the situation: as we travel down the highways, the periphery of the visual field moves across the field faster than the center, until it is moving too fast for the eye/brain to process, and it becomes blurred. The only thing that stays in focus is the center of attention, the highway itself. Also, people have a subconscious sense of stopping distance: how far ahead are the events that they must react to right now? At highway speeds, those events are 300 to 500 feet or more ahead, depending on how fast one is going, and that's where one focuses.

This means that at 55 mph, the last and best view of a highway overpass is at about 300 feet. By the time one gets to the bridge, he is looking 300 feet beyond. The bridge itself, at that point, is a blur in his peripheral vision. The parts of the bridge that are seen best are those that are visible in front elevation (Fig. 1.17). The undersides, the sides of the abutments and piers are simply part of the peripheral blur. (People can, of course, make the effort to turn their heads and look at an abutment wall, but even then the view will flash by so fast that few details will be recognized.)

These basics of perception also mean that at highway speeds the field of view in focus has narrowed to the point that the highway itself and its features occupy 80% of it, which means that the bridges are always on stage, front and center.

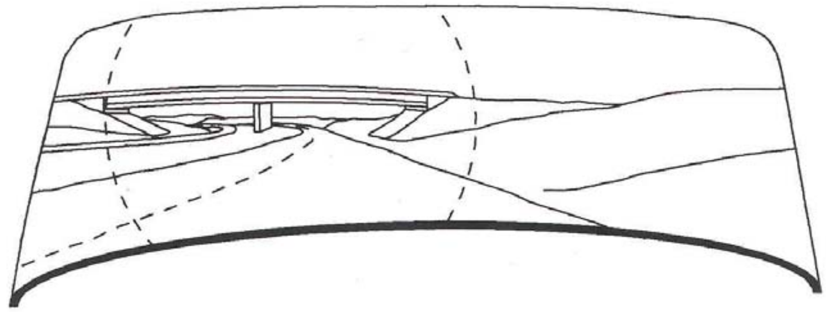


Fig. 1.17 The driver's area of focus at highway speeds

What are the implications of these facts? One is that any feature of the bridge that is meant to have a visual impact must be large enough to be seen at 300 feet. A second implication is that continuous horizontal lines parallel to the line of movement stay in focus and are easily understood and appreciated. If pleasingly shaped, they can be major sources of visual satisfaction; conversely, flaws in the horizontal alignment will be jarringly evident. That is why misalignment of a median barrier can be visually annoying.

Vertical lines, on the other hand, quickly move into the peripheral blur. A long, evenly spaced series of them will be perceived as an annoying flicker in the peripheral vision. Vertical elements which stand out in the peripheral blur because they are large or close to the point of focus become prominent, out of proportion to their physical position. This is why piers and abutments close to the edge of travel are seen as prominent and threatening, though they may be well outside the actual physical clearance envelope.

3. The Highway Environment

The essence of the highway environment is high-speed movement of vehicles which occasionally merge and diverge. At interchanges, the patterns become quite complex, and can involve vehicle paths crossing at multiple levels and locations. A concern for safety would indicate large clear openings through structures requiring a minimum of barriers, and, when barriers are necessary, their orientation should be parallel or at slight angles to the lines of travel (Fig. 1.18).

Fig. 1.18
Both safety and appearance are improved when the structure provides large clear openings with plenty of space at the driver's level. (I-395 at I-95, Baltimore, MD)

These same features work to improve the driver's psychological comfort and aesthetic reaction. Large openings mean that the driver can see through to the other side, and know what is coming next. They also mean that potentially threatening vertical lines from piers, abutments and walls are out of the field of focus, leaving potentially pleasing horizontal lines as an undistracted opportunity to create a positive impression.

Full realization of these potentials requires early and comprehensive communication between the road designers, bridge designers, traffic engineers, and landscape architects. Opportunities to coordinate all aspects of the highway at an early stage will result in improved safety, improved appearance and probably less cost as well. Early attention to the appearance of the structures might result in slight alignment adjustments which are equally safe but which significantly improve bridge appearance. Early evaluation of signing needs might create safer alternative locations for sign supports. Coordinated multidisciplinary attention can affect interchange layout as well. For example, moving a ramp gore from underneath a bridge moves it from the shadows into the light, which makes a significant difference in its visibility and safety (Figs. 1.19 and 1.20).

Fig 1.19
The visibility of a ramp gore is much improved if it is out from under a bridge shadow. (Bay Dale Road over US 50, Anne Arundel County, MD)

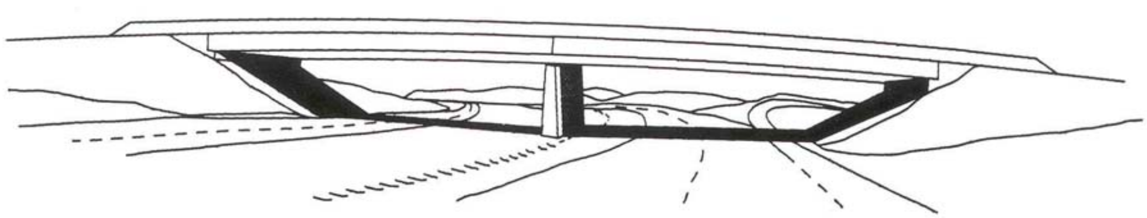


Fig. 1.20 Making a ramp gore more visible

Modern highway environments have been expanded to accommodate safety grading and ramps with large radii. Most bridges in Maryland occur within a gently sloped, landscaped area, where the bridge itself is only a small part of a visual scene which is predominantly spread out and horizontal. This varies from the absolute flatness of Maryland's Eastern Shore fields to the relative confinement of an Appalachian mountain valley. The basic point remains that the bridge itself is a relatively small object in a much larger landscape where the dominant dimensions, compared to the bridge, are horizontal. The horizontal elements of bridges should be emphasized in most cases. (Fig. 1.21)

Fig. 1.21
The modern highway environment: wide, rolling side slopes, plenty of clearance, horizontal emphasis. (I-70, Frederick County, MD)

There are exceptions. Within a multi-level interchange, a single multi-level structure, or a series of closely spaced and overlapping structures, will be dominant enough to establish their own environment. The visual impact of this assembly needs to be studied to determine the structural/aesthetic approach that is appropriate.

Urban environments are usually more confined. Urban structures often require retaining walls and are sometimes overshadowed by buildings (Fig. 1.22). Here, where every visual surface is man-made and often hard-edged, the vertical dimensions are of the same order of magnitude as the horizontal dimensions, and more emphasis on the vertical may be in order. However, the continuity of the driver's line of vision is still paramount. Horizontal lines should follow the highway geometry as much as possible, with as much "visual space" as possible evident to the driver.

The viewpoints of pedestrians and slow-speed drivers become more important in an urban environment. Sidewalks become more than just routes for passage. Opportunities to stop and enjoy a view should be considered, and hidden corners and exposure to high-speed traffic should be avoided. Small-scale textures and details and special materials may not be noticed on a freeway, but they can be valued components of an urban structure.

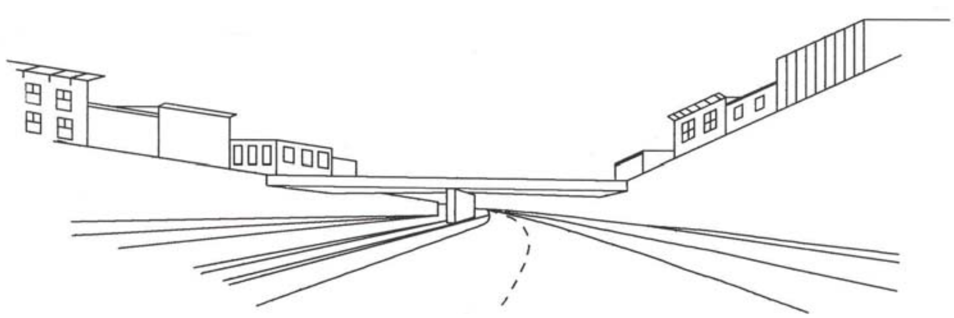


Fig. 1.22 The hard-edged urban environment

4. Tools of Analysis

To accurately analyze the appearance of a bridge we have to use tools which illustrate what people will see from typical viewpoints. The standard engineering tools are two-dimensional drawings: plan, section and elevation. However useful these drawings might be to contractors, they are too deceptive to use to analyze what the bridge will actually look like.

The tools which must be used are those that attempt to portray the three-dimensional reality of the structure: models, perspective views, and photographs with the bridge inserted.

But even these tools can be deceptive unless they are taken from an appropriate viewpoint. The typical aerial oblique rendering of a bridge is essentially irrelevant for this purpose. That view will only be available to occasional low-flying helicopter pilots (Fig. 1.23). Photographs must be taken from the viewpoints of the most likely observers.

Fig. 1.23
An attractive, but irrelevant viewpoint. (MD 213 over Sassafras River, Cecil and Kent Counties, MD)

The use of computer aided design and drafting (CADD) is especially useful for "workhorse bridges" where expensive models and renderings are unlikely. Another very useful tool, where bridge appearance is to be conveyed to a "lay" audience, involves modifying a photograph with a true-to-life rendering of the bridge (Fig. 1.24).

Fig. 1.24
The use of perspective rendering in a photograph of the area to judge design. (I-95 over Potomac River, Prince Georges County, MD)

Views of bridges over highways should be taken at the driver's eye-height, from positions in the traveled lanes of the underpassing roadway, at distances of 300 to 500 feet. Views of bridges over water should be taken from the most important points along the nearby shore (Figs. 1.24 and 1.25). Each bridge will have its own set of relevant viewpoints. Not all viewpoints can be covered by drawings. One may have to extrapolate from one drawing to other locations, or build a model (for very special cases) and view it from a scale eye-height. Models need not be elaborate.

Fig. 1.25
The relevant viewpoint. (MD 213 over Sassafras River, Cecil and Kent Counties, MD)

Quick three-dimensional sketches are the best way of trying out multiple ideas at the early stages of design development. (Sketching and photographing existing bridges is also a great way to develop your abilities to analyze and observe aesthetic results.)

However, at the final decision-making stage, perspective drawings should be to scale and accurate.

> *Small differences in girder depth or pier width can make enormous differences in the final appearance of the structure. In a non-scale drawing these effects would never be realized.*

All visible elements, such as signing, lighting, and w beam traffic barrier, should be included. Conversely, all elements which will be below ground or hidden should be eliminated so as not to distort the analysis.

F. THE PLACE OF STANDARDS

While the functional aspects of standard details must be respected, their appearance should be considered for each bridge to make sure they fit the bridge's aesthetic concept.

> *Standard details have an important place in bridge design. They are especially important where they represent the distillation of hard-won functional experience, as in a crash-tested railing. Indeed, it is tempting to design a bridge by incorporating standard details. It is particularly tempting to apply some surface detail which has proven to be attractive on one bridge to all subsequent bridges.*
>
> *Any success experienced through these approaches will be sheer coincidence. Bridges are too unique. Each deserves a fresh look. The functional aspects of standards will always apply, but the visual aspects need to be reconsidered for each bridge. Some will apply, some will apply partially and have to be modified, some will not apply at all, and new details will have to be developed to fit the specific situation.*

BRIDGE ELEMENTS

A basic axiom in geometry is: The whole is equal to the sum of its parts. Such is the case in the creation of an attractive structure, as long as the elements relate to one another. In design, this same philosophy follows: Lack of attention to how a detail fits in with the remainder of the structure can detract from the overall appearance. A poorly placed light fixture or an exposed downspout are just two examples of details which can spoil the overall effect. On the other hand, a special light standard or an unusual color of structural steel can make the bridge a landmark.

This section is divided into discussions of the basic elements that form a bridge structure. It deals with each element as a separate component. However, the designer must never lose sight of how each unit fits into the overall expression that is desired.

II. GEOMETRY, LAYOUT AND CONCEPT

Geometry, layout and concept are major determinants of appearance and should be addressed at the initial stages of a project. Design criteria often allow sufficient flexibility to improve the appearance of a bridge. The key is early contact with the other design disciplines (road, lighting, traffic, landscape), because at early stages modifications have less impact.

A. GEOMETRY

Vertical and horizontal alignments made up of long, continuous curves and tangents will look better than alignments made up of short, discrete segments.

Highway geometry consists of connecting a series of tangents with curves. In laying out both horizontal and vertical alignments, designers look for economy by minimizing earthwork while meeting sight distance and other design requirements including safety and capacity. Vertical and horizontal alignments made up of long, continuous curves and tangents (Fig. 2.00) will look better than alignments made up of short, discrete segments (Fig. 2.01). The latter looks "kinked" and disrupts the visual flow of the highway.

When grade separating two highways, the resulting profile is often a crest vertical curve. This vertical curve should be as long as conditions permit. When a curve is long enough is a question that can only be answered in the context of the specific bridge, but it is almost always substantially longer than the AASHTO minimums.

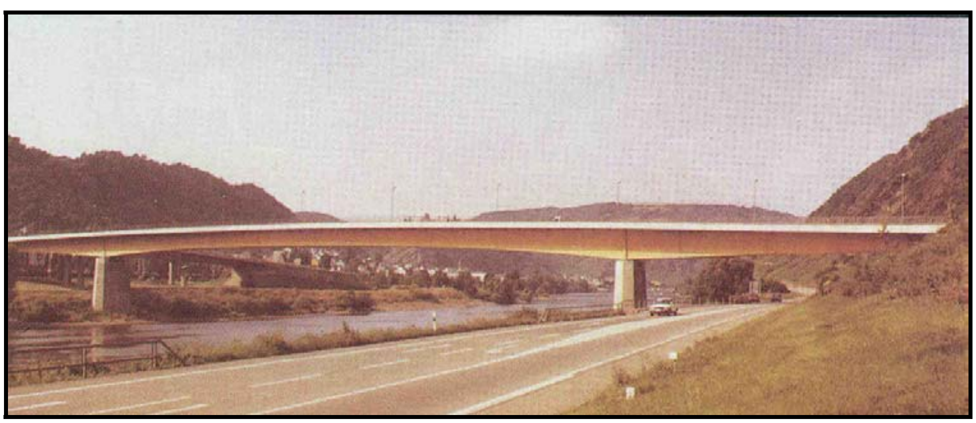


Fig. 2.00
A crossing with a long vertical curve. (Germany)

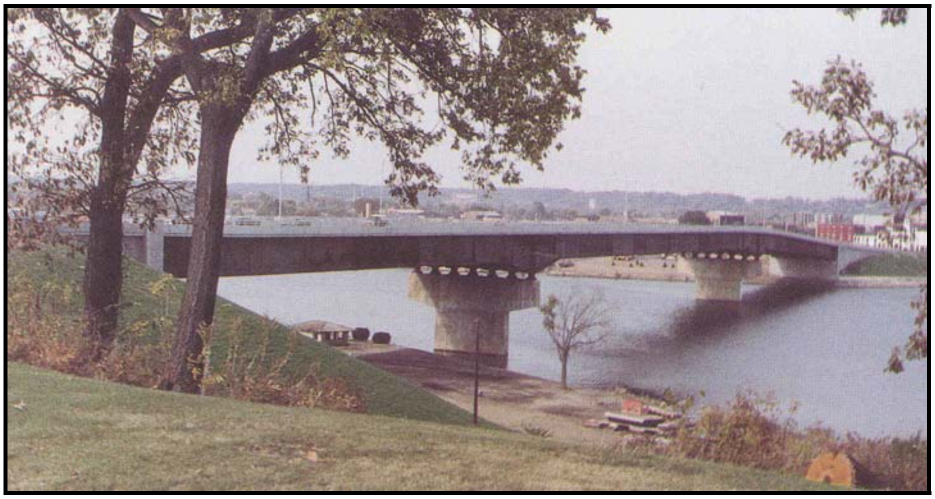


Fig. 2.01 *The short vertical curve at the second pier "kinks" the bridge.*

B. LAYOUT

Layout is a matter of placing the substructure units so as to minimize disruption to the continuation of whatever the bridge crosses.

Once the span to vertical clearance ratio is established (S/G) for the main span, it should be held constant, when possible, so that the spans decrease proportionally as the height decreases.

The proportions of the major elements of the bridge are the strongest determinants of its visual impact. For pier placement, the key proportion is span versus vertical clearance, or, a better way to look at it, span versus the overall shape of the space beneath the bridge. Generally, the bridge will look better the more the horizontal dimension of this space (the span) exceeds the vertical dimension (Figs. 2.02 and 2.03).

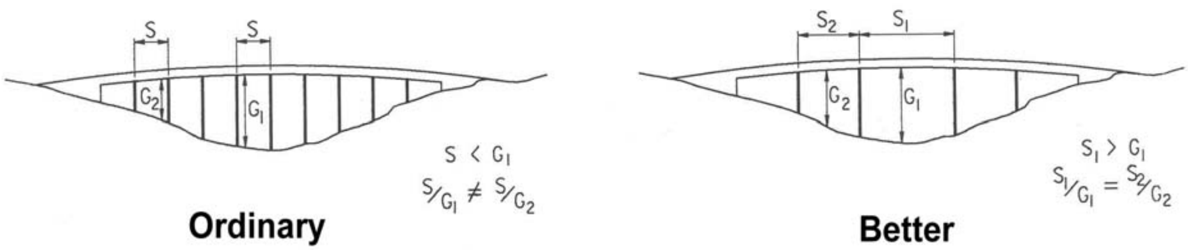


Fig. 2.02 Emphasizing horizontal proportions in pier placement and keeping the S/G ratio constant

Fig. 2.03
This is an excellent example of keeping the spans proportional to the height. The generous open space beneath this bridge minimizes the visual disruption caused by the bridge. (Thomas Johnson - Lower Patuxent River Bridge, St. Mary's and Calvert Counties, MD)

The width of the space beneath the bridge (spacial corridor) should be made as generous as feasible.

The intrusiveness of the bridge will depend on the degree that this is accomplished. It is particularly important in interchanges, where the ability to see beyond the bridge is a safety as well as an aesthetic issue (Fig. 2.04).

Fig. 2.04
This bridge maintains the complete spatial corridor of the highway, allowing views through to the merge areas. (MD 175 over I-95, Howard County, MD)

The ideal is to minimize the number of columns.

Actual sight lines need to be recognized. For example, a multi-column bent will look simple when seen end-on (as in an elevation drawing), but the hidden columns will be very apparent in the more typical diagonal views. A group of such bents can become a real forest when seen from the usual angles (Fig. 2.05). The ideal is to minimize the number of columns and the space that they occupy (Fig. 2.06).

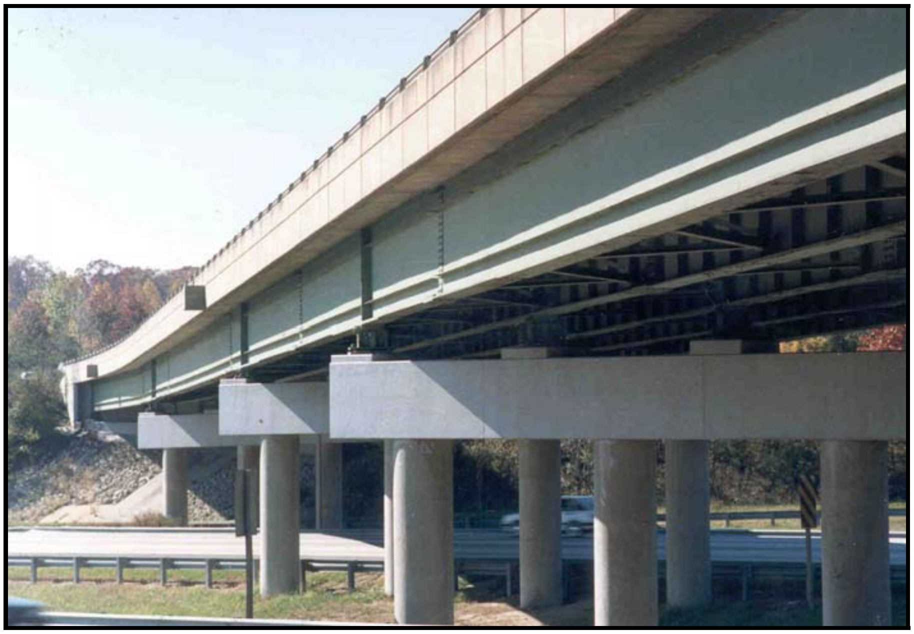


Fig. 2.05
The elevation view will only show the first of these columns. In reality, they will all be seen. Short spans and wide piers tend to give viewers a closed in feeling. (MD 198 over I-95, Prince Georges County, MD)

Fig. 2.06
By keeping the piers narrow, the diagonal views through the structure can be maintained. (MD 80 over Monocacy River, Frederick County, MD)

To properly proportion the space beneath a bridge, the designer should consider the relationship between the span length (S), the pier cap length (M) and either the width of the pier shaft (B), for single column piers, or the width of the column group (A), for multiple column piers.

For single shaft piers, span lengths and overhangs should be adjusted so that the pier length at the base is about 1/8 of the span length or less (Figs. 2.07, 2.08 and 2.09). This rule works well for relatively short pier cap lengths (say, M ≤ 40') and most common span lengths (say, 50' ≤ S ≤ 200').

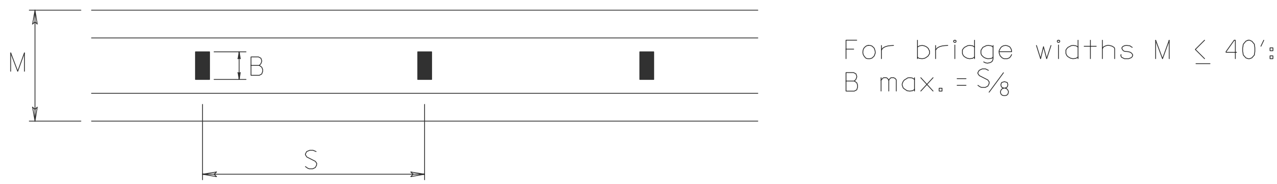


Fig. 2.07 Ratio of pier length at the base to span length for single shaft piers

However, once the pier cap length increases beyond 40', the use of a single column pier becomes problematic. In these cases, a multiple column bent may become a better choice, both structurally and aesthetically.

Fig. 2.08
These wide solid shaft piers create a closed in tunnel effect. (I-270 under MD 28, Montgomery County, MD)

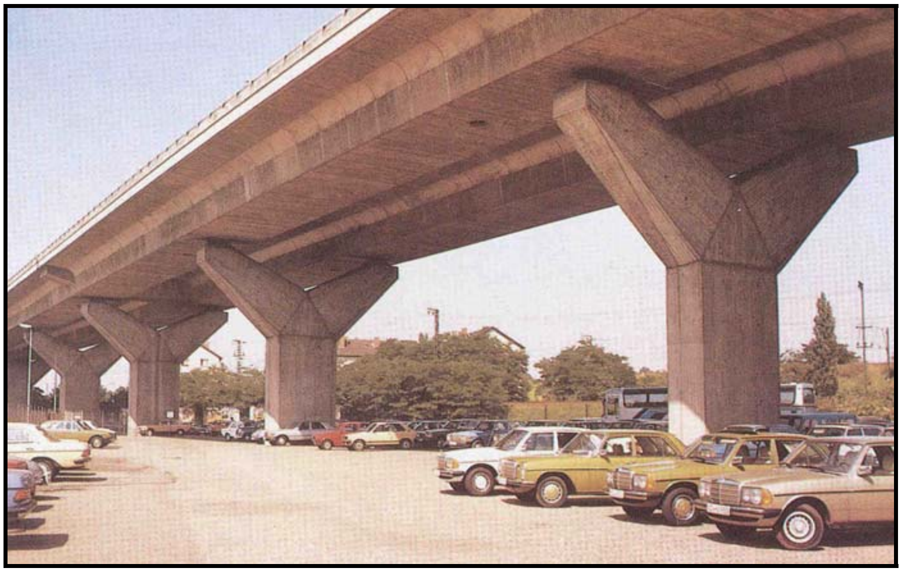


Fig. 2.09
These narrow pier shafts allow the diagonal views through the structure to be maintained and give an open feeling. (Germany)

For multiple column piers, the total width of the column group (A) should be about ½ of the span length (S) or less (Fig. 2.10). For relatively narrow bridges and longer spans, this guideline is not practical. The designer should also consider the pier cap length, M, and limit the value of A to about 0.7M.

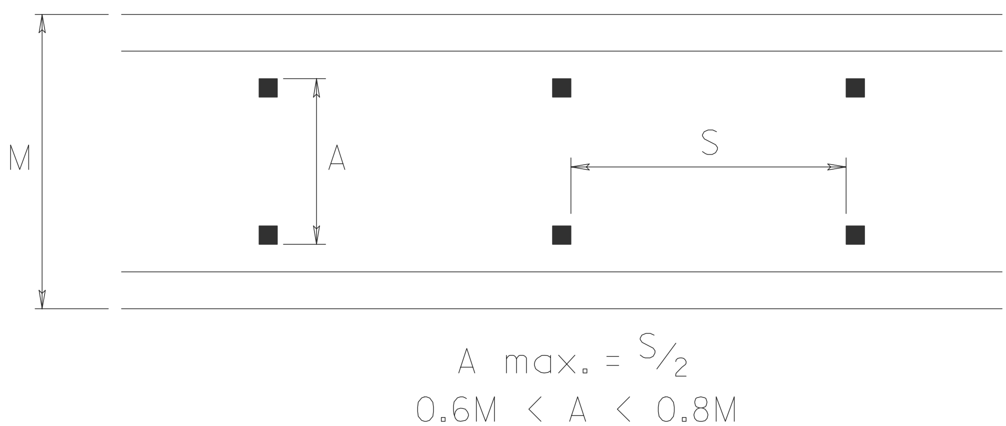


Fig. 2.10 Ratio of column spacing and span length for two column piers

Generally, the locations of the abutments are determined based on factors such as site conditions, geometric and structural requirements.

Layout of the abutments is very important to the overall look of bridges, especially on structures with one, two or three spans. If the bridge being proposed has a special treatment, such as stone or brick facing, or striations, then the height and width of exposed areas of the abutment become very important. The designer should try to locate the abutments so that the treatment is exposed enough to enhance the structure.

C. CONCEPT

The designer should develop an overall concept from the requirements of the site. All decisions, major and minor, should be consistent with that concept. For example, similar shapes should be used for the various elements of the bridge.

Bridges should harmonize with their surroundings.

Developing a bridge to blend with its surrounding area is a concept that all designers should consider at the beginning of their project. Special attention must be given to the surrounding area. The questions that the designers should ask themselves are: "Am I taking anything away from the given area with the proposed bridge? What kind of bridge will enhance the given area? What kinds of features are needed on the bridge?" The answers to these questions must be fully understood at the initial stage of the project. For example, in a scenic area, the view may be obstructed by a solid parapet rather than open railing.

In the attempt to create aesthetically pleasing bridges, the designer should refrain from adding too many features to enhance their appearance. It is not the number of features a bridge has that matter, but rather, how these features enhance and blend with a given area. The designer should try to incorporate features that are complementary to the surrounding area, rather than create a contrast. Proposing a red brick bridge where stone masonry structures are prominent would be inconsistent with the area. Also, featuring some material on certain types of bridges might diminish the overall look of the bridge. For example, proposing a gray metal traffic barrier rather than a wooden or a brown one on a stone bridge might reduce the aesthetic effect of the bridge.

The designer should consider what the bridge will look like from its approaches. Special attention must be given to the background against which the bridge will be viewed. Some materials will blend with the background better than others to produce an aesthetically pleasing structure. The colors, materials and fixtures should not be understated, because they create the visual perspective of the bridge.

Use a material the same way throughout the structure.

If the piers are formed with planes and straight edges, the parapets and abutments should be too; if the piers are formed with curved surfaces, the parapets should be curved.

All connected elements in an area need to be developed together: bridges, retaining walls, noise barriers, traffic barriers and landscaping.

Major highways incorporate a number of bridges, often seen in close succession or even at the same time. Concern for this sequential experience requires that the appearance of all of the bridges be considered together. Concept themes should be considered on all *new and reconstructed routes during the earliest stage of design. This is particularly important when some of the bridges are to be done by different designers or different agencies.*

A design theme can be developed by selecting a common concept for bridge elements and applying that concept more or less consistently to all of the bridges on a given route or in a given area.

For example, a standardized parapet profile can be developed and used consistently throughout a series of bridges. Standardized colors, certain surface materials, or a standardized texturing for retaining walls and abutment walls are other obvious choices to develop a theme. Quite often, proprietary walls are used on a project, giving the contractor options. The selection of the option shall be controlled so that the result is not a hodgepodge.

A concept/theme does not require that all structures be identical. Variations along a route can be used to influence the user's frame of mind, such as gradually reducing spans as the highway moves into an urban area. The theme becomes one of change or difference rather than one of consistency. But the change or difference must be controlled and compatible over the entire route.

The major challenge is to reconcile the common features of the theme with the need for each bridge to address its particular structural requirements. If all of the bridges are similar in their structural aspects, the problem is simplified. However, where there are a wide variety of structural situations, it becomes more challenging to find a theme which allows each structure to develop its own "strength through form" and still be a contributing part of a larger ensemble. In such cases reliance on a structural element, such as a standardized pier configuration, may produce disappointing results when the element gets stretched to meet all of the different situations (such as a hammerhead pier with drastically different heights). It may be better in those cases to rely on non-structural elements (parapet profile, color, surface texture) to carry the theme.

There will be situations where the layout and structural demands severely restrict the engineer and seem to prevent application of the normal guidelines for attaining aesthetic quality. Designers should see these situations as challenges to discover the inherent and perhaps unconventional beauty that lies hidden in the problem and persist until it is found. Maryland 7A at Havre de Grace is an excellent example of what can be done with a "difficult" situation (Fig. 0.03).

Structures in interchanges must be given special consideration, since several of them are usually visible at one time.

This means not only applying the common elements of a design theme, but also close coordination by the designers for each structure to insure that any variation in theme will achieve an harmonious whole.

When renovating and reconstructing bridges, it is usually neither possible nor desirable to reconstruct or reproduce the older structure exactly.

New structural techniques, new materials, and new functional requirements all will make that an unreasonable solution. However, it is possible to incorporate new requirements and techniques into the reconstruction of old bridges while still respecting the original design intent. It is also possible to construct new bridges alongside old so that the two are visually consistent and attractive. Thought should be given to the future replacement of the remaining old bridge and how that would fit into what is being planned for the new bridge.

If the old bridges have very few features which are consistent with these guidelines, or if the old bridge stands alone rather than as part of a group of similar structures, then it may be better to make the new bridge completely independent. However, if the old bridge has very good qualities, then these should be carried over to the new bridge and preserved on the old bridge. Features which are not consistent with these guidelines should be minimized.

The desirable features can be made the basis of common details, common proportions, and common structural systems which are used in both new and old structures. The new features need not be literal reproductions of the old. For example, it may not be necessary to construct new fieldstone abutments to match old abutments. However, the new abutments could be made similar in size, shape, color, and/or proportion to achieve the desired consistency. It could be disastrous to attempt to reproduce the fieldstone in cast concrete, since the differences in color will detract from the look of both the old and the new.

III. SUPERSTRUCTURE

The major visual design goals of the superstructure are:

- **apparent slenderness**
- **continuity**
- **a strong consideration for its relationship with the substructure.**

Utilizing the above design goals can give the superstructure the appearance of a slender, horizontal ribbon running from abutment to abutment and resting lightly on the piers.

Since the superstructure is a major structural element in any bridge, the challenge is to make it seem thin and light through a selection of the superstructure type, continuity of the spans, superstructure depth and shape characteristics, and details. For example, the haunches, bearings and continuity of the spans of the bridge in Fig. 3.00 create the impression that the bridge must be very light, resting on a single point at each pier.

Fig. 3.00
This is a good example of a haunched girder resting lightly on a point, lifting the continuous superstructure clear of the piers, and giving the impression that the structure is slender and light in weight. (I-83 over Gunpowder River, Baltimore County, MD)

A. SUPERSTRUCTURE TYPE

These guidelines are primarily about multi-girder bridges, which fit most of Maryland's bridge needs and the philosophy of fail safe redundancy.

Given the high proportion of the bridge cost associated with this element, the type of main support mechanism for the superstructure will usually be determined by a combination of economic and structural considerations. The decision to use steel or concrete as main superstructure elements is based on cost (initial as well as long-term maintenance), geometry, and aesthetics. The main advantages associated with steel include its ability to span longer distances with a shallower structural depth, its flexibility in accommodating a wider variety of geometric conditions (vertical camber, horizontal curvature, etc.), and its ability to be repaired after being hit by an oversized vehicle. The main advantages associated with concrete are lower long-term maintenance costs (no painting required) and reduced fabrication time. Regardless of the type of material selected for the main superstructure elements, there are general principles and guidelines that are applicable in designing an aesthetic structure.

The use of redundancy to provide one or more alternate load paths is an accepted design criterion. A series of stringers is strongly preferred over configurations that create a non-redundant condition.

Relative slenderness should be sought when selecting a superstructure type.

Relative slenderness is an advantage (Figs. 3.01 and 3.02). Continuous girders will be better looking than simple span girders due to the advantages of structural continuity.

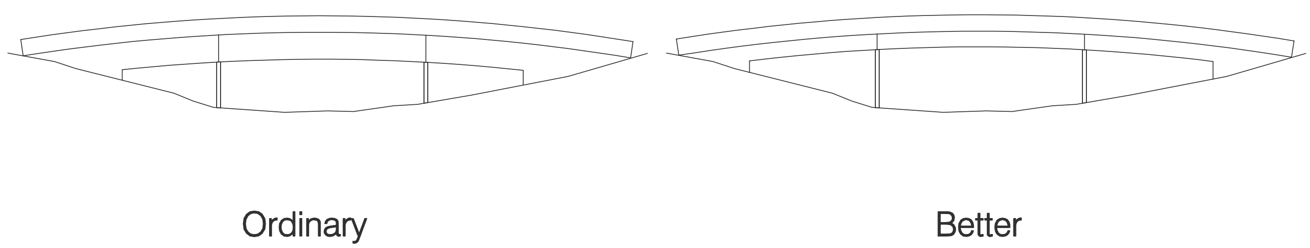


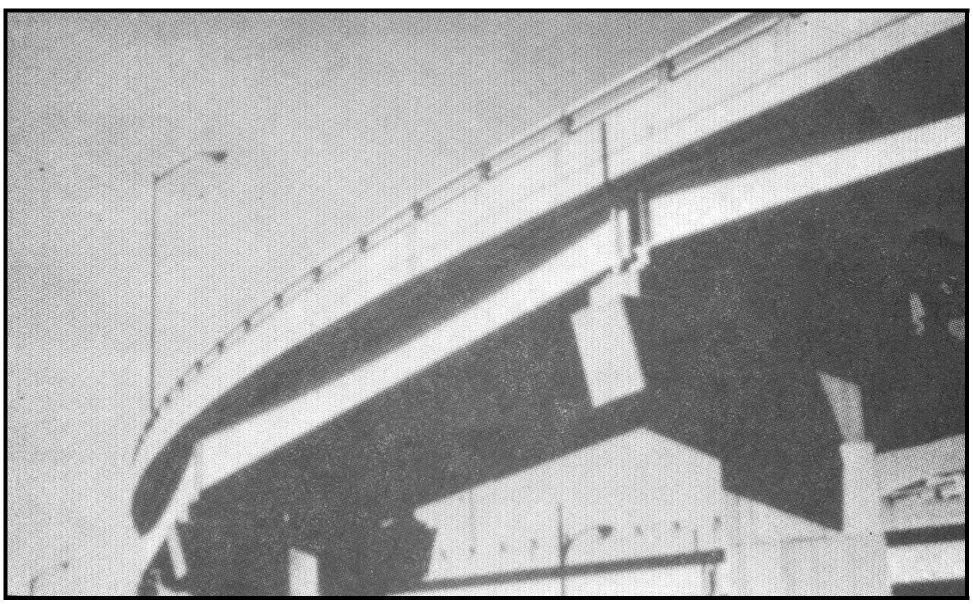
Fig. 3.01 Slender is better than deep.

Fig. 3.02
This is a good example of a very slender structure achieved by making the superstructure continuous over the pier. (MD 291 over US 301, Kent County, MD)

Use curved girders for curved roadways.

Curved girders are better on all but the most slight curvatures, because the structure reflects the lines of the highway. Curved girders also eliminate variable deck overhangs (and shadows) of spans placed on chords. In addition, straight girders require structural adaptation to fit to circular curves and still meet vertical and horizontal clearance requirements (Fig. 3.03).

Fig. 3.03
Placing straight girders on a curved bridge produces unappealing scalloped shadows.



Aesthetics should not compromise safety by reducing redundancy and creating fracture-critical elements. For example, box girders, integral pier caps and through girder bridges should not be used if redundant design is possible.

In cases where non-redundant elements are unavoidable, the burden is on the designer to develop ways to reduce the problems associated with these structure types, such as providing "fail safe" mechanisms that eliminate the criticality of an element failure.

Box girders, both steel and concrete, have been used in prominent locations because of their relative thinness, the clean, simple appearance of their undersides, and their more flexible pier locations. However, they may be considered non-redundant, and can be difficult to maintain and inspect. Deck replacement can be difficult or impossible if traffic is to be maintained.

Integrally framed steel cross girders have also been used in locations of high visual exposure because they minimize the size of the pier, provide for more flexible pier location, and emphasize the continuity of the superstructure (Fig. 3.04). However, these elements may also be non-redundant and, therefore, unless carefully designed and detailed, may share the problems outlined above. Through girder bridges are similarly non-redundant.

Fig. 3.04
This viaduct has more flexibility in pier placement, smaller piers, and a superstructure that looks continuous and relatively light, all because of the integral cross girder. (I-83 Viaduct, Baltimore City, MD)

B. SUPERSTRUCTURE DEPTH/SHAPE

Structural continuity improves bridge appearance by allowing more slender girders.

Slender is better than deep. Visual continuity makes the girder seem longer, and because the eye judges relative thinness by comparing length to depth, a girder that seems longer will also seem more slender (Figs. 3.05 and 3.06).

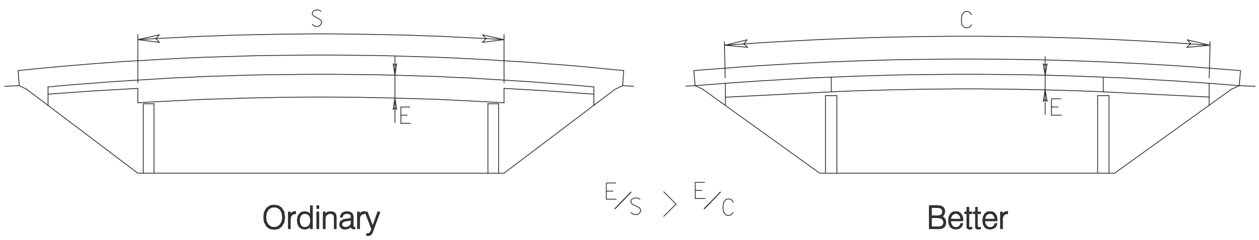


Fig. 3.05 Visual continuity makes the girder seem more slender.

Fig. 3.06
The tapered end spans of the bridge help it look longer, but the center span is still very deep because the end spans are not long enough to influence the depth of the center span. (North Carolina)

Use tapered spans to transition between girders of different depths (Fig. 3.07).

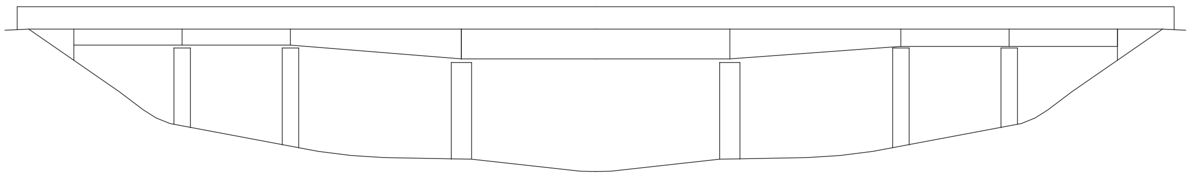


Fig. 3.07 Use of tapered spans to transition between girders of different depths

Haunches will make the bridge seem more slender by giving the appearance of lifting the superstructure off the piers while continuity of the girders will reduce their average depth (Fig. 3.08).

Haunches visually demonstrate the flow of forces in the bridge.

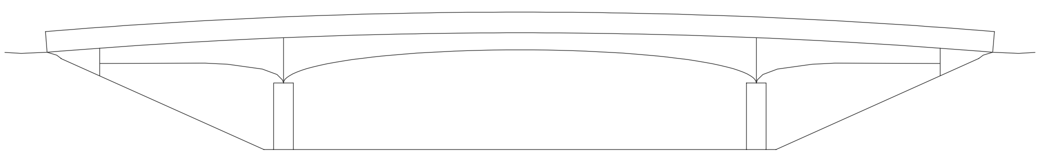


Fig. 3.08 Haunches and continuity make the bridge seem thinner.

Haunches should be formed by curves (parabolas work well); a haunch formed with straight lines may work if long enough and relatively shallow.

Forming a haunch with short straight lines makes the haunch seem contrived. Haunches formed with straight lines tend to look too short because the angular break at the inflection point visually separates the girder into segments (Fig. 3.09). This effect disappears if the inflection angle is small enough, say less than ten degrees (Fig. 3.10).

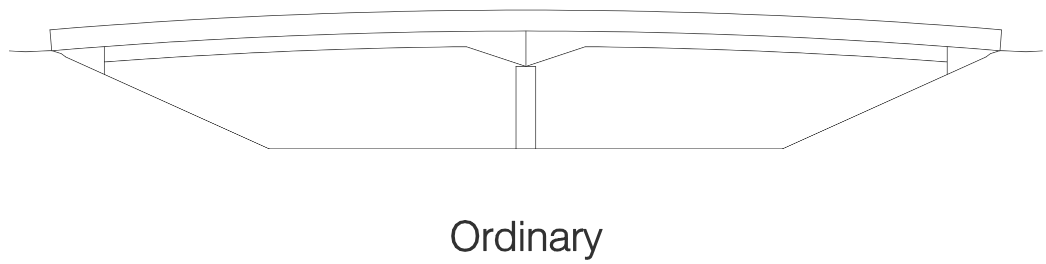


Fig. 3.09 Short straight lines make the haunch seem shorter by emphasizing the break between the haunch and the rest of the girder.

Fig. 3.10
Long, shallow haunches using straight lines can look good, as this example shows. (Joppa Road over I-95, Baltimore County, MD)

Haunches between 20 and 40 percent of the span length are more attractive.

Haunches should be long enough to be in proportion to the span length. The moment diagram is a good guide, i.e., bring the haunch out to the point of inflection (Figs. 3.11 and 3.12). This is not always achievable as it may encroach on the underclearance of the facility being spanned. This is an example of why it is extremely important to develop concepts early, for in some situations it may be possible to modify road grades to accomplish the desired bridge appearance.

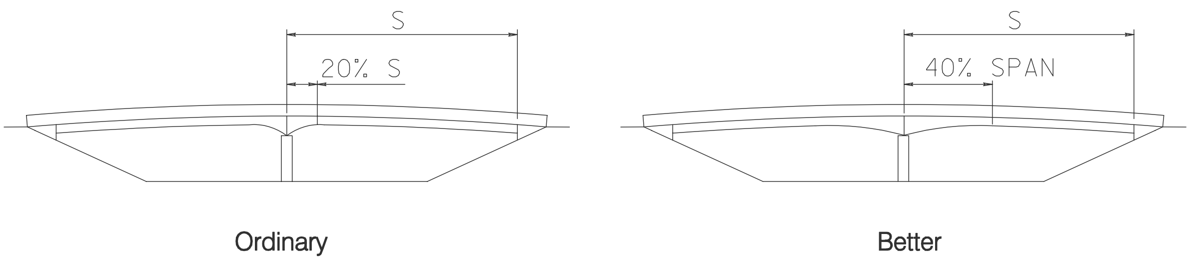


Fig. 3.11 The effect of short versus long haunches

Fig. 3.12
Don't make haunches short. This one is too short to convince the viewer that it has any structural purpose. (MD 198 over I-95, Prince Georges County, MD)

Haunch depth should not exceed two times the midspan depth, nor be less than 1.3 times the midspan depth.

Haunches shouldn't get deeper than twice the midspan depth, or the midspan will look too fragile and the haunch will look too heavy. Conversely, the depth at the haunch should not be too close to the midspan depth or the haunch will be imperceptible (Figs. 3.13 and 3.14).

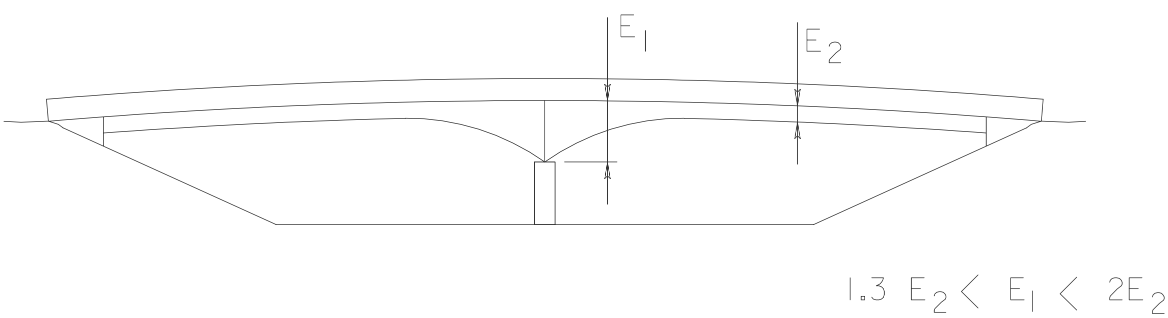


Fig. 3.13 Recommended limits for the depth of an attractive haunch

Fig. 3.14
This haunch gets so deep it looks like it belongs to another girder; it even begins to interfere with the view through the structure. (MD 355 over I-495, Montgomery County, MD)

Haunches should come to a point (the width of the bearing) at the pier; the angle at the point of the haunch should be between 135 and 160 degrees (Fig. 3.15).

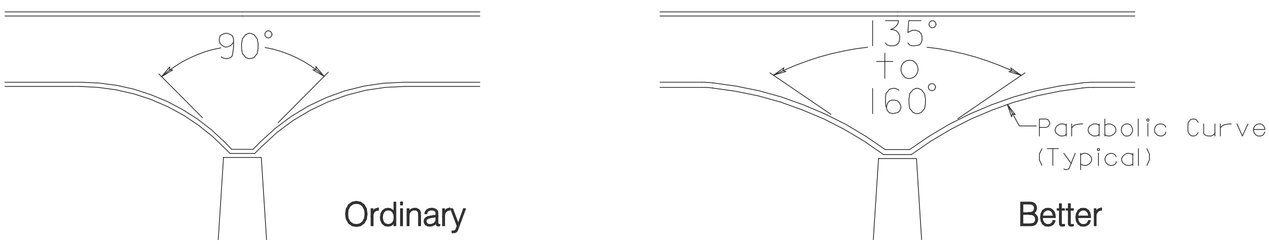


Fig. 3.15 The effect of different haunch angles at the bearing point

Use pointed haunches because they concentrate visual interest at the point of force transfer and better reflect the flow of forces. "Fishbelly" shapes make the haunches look heavier, waste material, look forced and should be avoided. (Figs. 3.16 and 3.17)

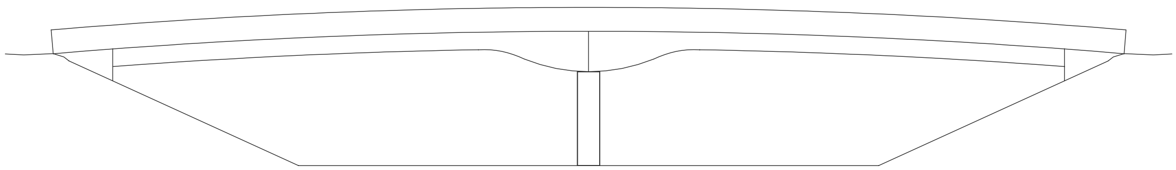


Fig. 3.16 Visual (and structural) weight added by a "fishbelly" haunch

Fig. 3.17
This fishbelly is an example of a haunch that does not follow the flow of forces. (Old Montgomery Road over I-95, Howard County, MD)

Girders with integral columns, frames, and abutment-restrained girders are other structural types that can be considered for medium-span structures. They can be very slender at midspan (Fig. 3.02). These elements usually will be more successful visually the more they are shaped to reflect the change in stresses across the structure (Fig. 3.18).

Fig. 3.18
Steel frame with integral support. (Gorman Road over I-95 in Howard County, MD)

C. FASCIA DETAILS

The design of the cross section of the superstructure (and the edge profile in particular) has a major impact on the overall appearance of the bridge, because the parapet and fascia girder are often the most visually prominent parts of the bridge.

The parapet fascia and overhang provide the strongest opportunities to make the bridge seem more slender than it really is. The following techniques are suggested (Fig. 3.19):

- **Divide the fascia surfaces by shadow and/or physical breaks.**

- **Change the relative brightness of different fascia surfaces by changing their angle so they reflect more or less sunlight.**

- **Remove the divisions between fascia surfaces by introducing curvature.**

  This leaves the viewer no clues by which to judge thickness, which is good.

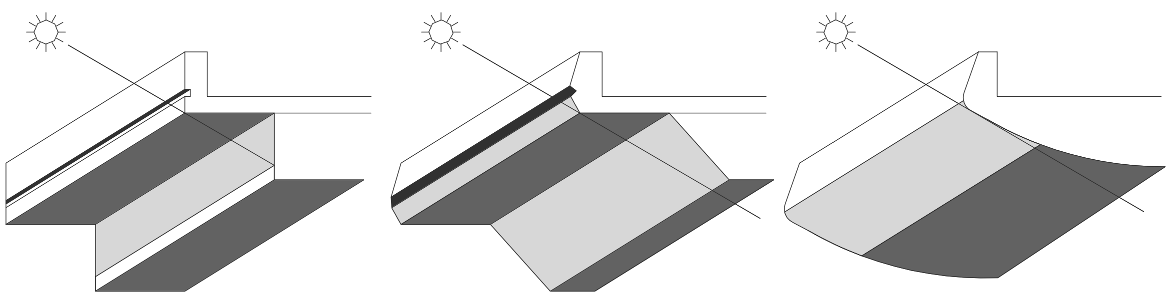


Fig. 3.19 The effects of cross section differences on appearance

The overhang should be as large as possible in order to create a strong shadow on the fascia girder or place the girder entirely in shadow (Figs. 3.20 and 3.21).

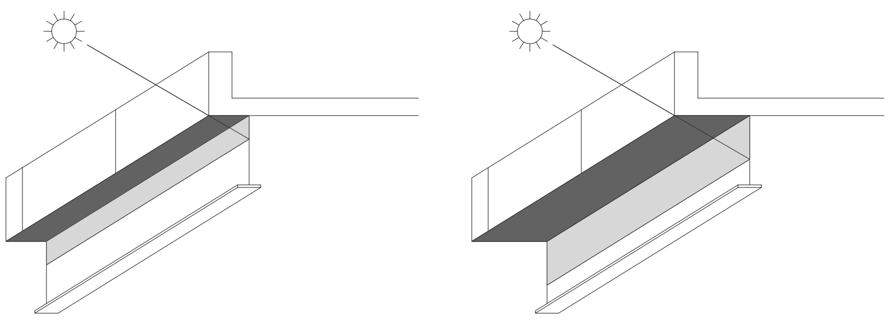


Fig. 3.20 Larger overhangs create a deeper shadow line which makes the fascia girder seem shallower.

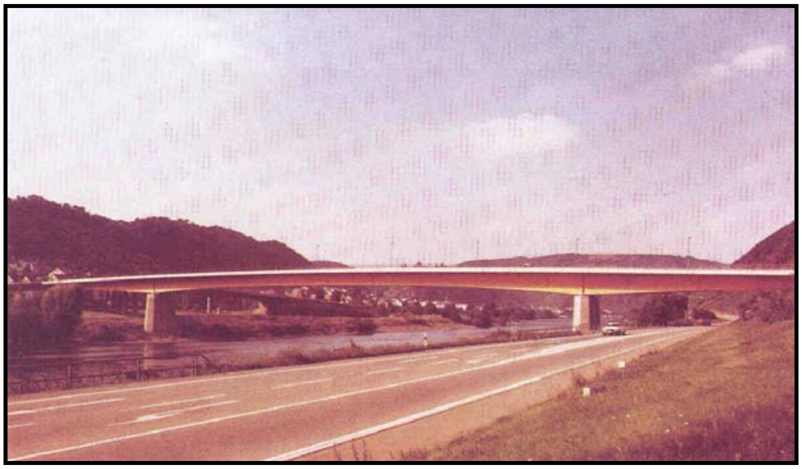


Fig. 3.21
The large overhang makes this relatively deep girder appear more slender. (Germany)

A large overhang may offer benefits at other locations within the structure, by reducing the number of girders and the width of piers, which can be advantageous for skewed and interchange structures. The designer should be cautious with the overhang width, for too large of an overhang may create other problems.

Large overhangs in combination with sharp skews create their own set of problems. For instance, the acute corner at a roadway joint may be quite a distance away from a beam; consequently, the deck will need heavier reinforcing. Large overhangs can also make deck replacements very difficult.

The need to have scupper outlets inside the fascia girder is often given as a reason to limit the width of overhangs. There are several solutions to this problem discussed later in this chapter.

On box girder structures, a sloped fascia is sometimes used to put the entire girder in shadow and make it seem more slender (Fig. 3.22). However, this can have the opposite effect if the overhang is not wide enough. A generous overhang is crucial to the appearance of slenderness, regardless of whether the fascia is sloped or plumb.

Fig. 3.22
In spite of the sloped girder face, this ordinary bridge still seems heavy. Perhaps a larger overhang would have helped. (I-83 over I-695 in Baltimore County, Maryland)

D. SUPERSTRUCTURE ELEMENTS

Bearings:

Bearing types are generally selected based on performance and preferred practice of the owner. Pier bearings that appear high and narrow will usually make the bridge seem more slender and light. However, a designer should never select a bearing type based solely on this criteria. The use of pedestals or chamfers at pier tops or bearing areas can be used to accentuate the bearing point (Fig. 3.23).

The point at which the girder connects to the pier is crucial visually as well as structurally.

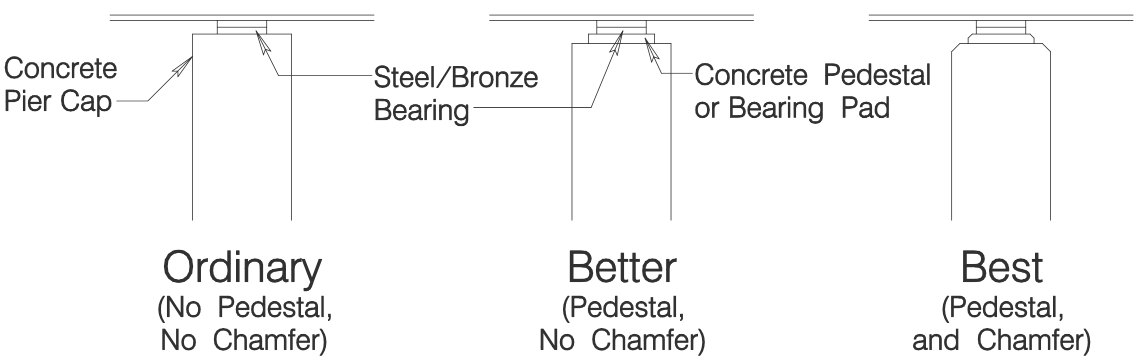


Fig. 3.23 The use of pedestals and chamfers to accentuate the point of bearing

Bearings, particularly at piers, are very important tools in creating the impression that the superstructure is slender and light in weight. Fig. 3.24 shows one way this can be accomplished. Raising the bearing on a small pedestal so that it is silhouetted against the sky, visually separates the superstructure from the pier with what appears to be a tiny element. Not only does this make the bridge seem light in weight, it avoids any visual interruption of the horizontal lines of the superstructure, which makes the structure seem longer and more slender.

It is not recommended that the bearings be hidden at piers.

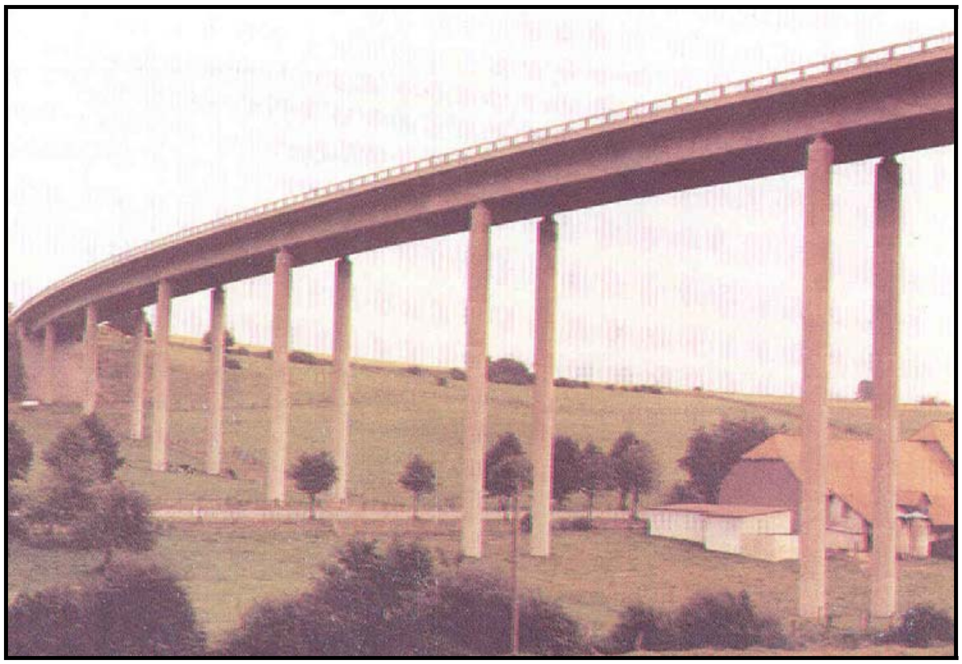


Fig. 3.24
Bearing silhouetted against the sky. (Germany)

Abutment bearings:

No subject produced more passionate debate at Bridgescape and at the seminars than whether to hide bearings at abutments (Fig. 3.25). The consensus was that they should be hidden. A minority felt the question should be answered by the nature of the girder-abutment joint: when the girder is acting integrally with the abutment, the bearing should be hidden. Otherwise it should be exposed. Designers should explore the question for themselves. There is no hard, fast rule. The usual practice in Maryland is to hide the abutment bearings behind concrete cheekwalls.

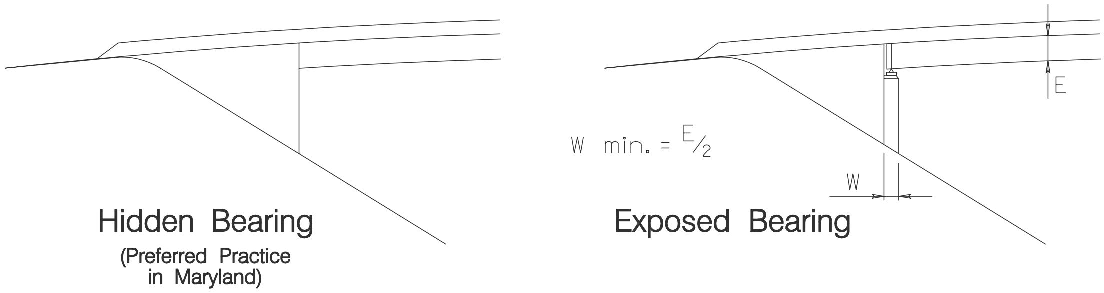


Fig. 3.25 Suggestion for bearings at abutments

Stiffeners on steel girder bridges:

Vertical stiffeners, at points other than bearings, should not be placed on the exterior of the fascia girders because they divide the girder and make it appear deeper (Fig. 3.26).

Fig. 3.26
The use of vertical stiffeners makes the fascia girder appear deeper. (I-895 WB over I-95, Baltimore City, MD)

If vertical stiffeners are necessary on a fascia girder, they should be placed on the interior face of the girder (Fig. 3.27). Even this is not a good practice from an aesthetic standpoint; the webs of these girders are thin and the welds for these stiffeners reflect to the outside of the fascia girder and show as wrinkles in the sunlight.

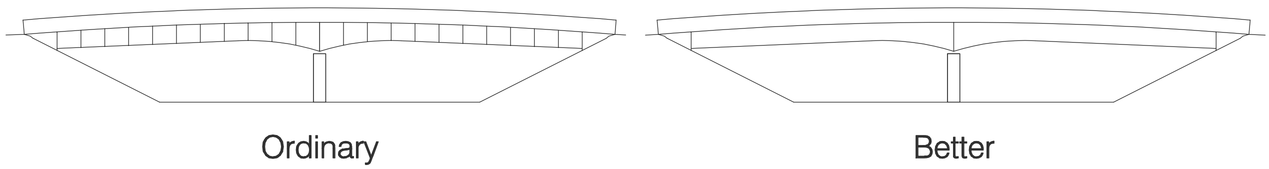


Fig. 3.27 Vertical stiffeners will make the girder seem heavier than a comparable girder without stiffeners.

Wherever possible, girder web plates should be made thick enough so that intermediate stiffeners are not required.

An exception is at bearing points, where vertical stiffeners are typically required structurally and confirm one's expectation that something important is happening at that point (Fig. 3.28).

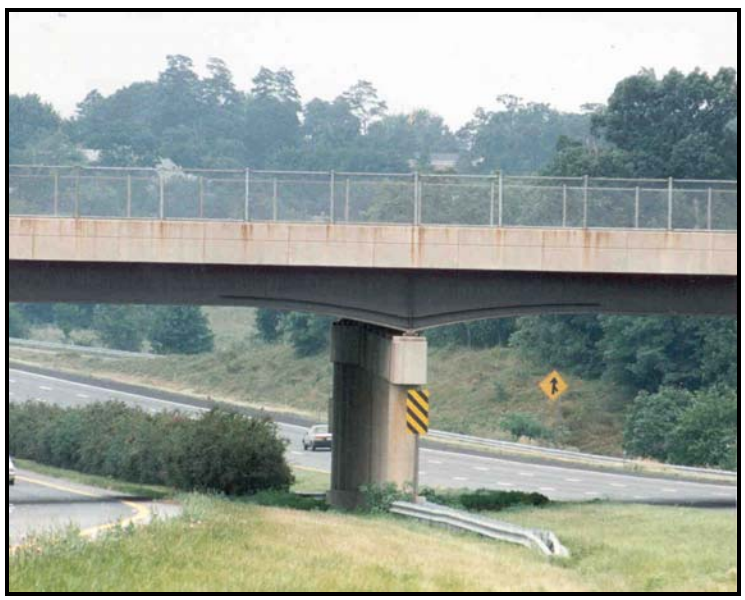


Fig. 3.28
This is a good example of two functional elements, the bearing stiffener and the curved longitudinal stiffener, providing a visual bonus: they focus attention on the curve of the haunch and the transfer of forces to the pier. The effect would have been even more striking if the bearing had been higher. (MD 75 over I-70, Frederick County, MD)

Although longitudinal stiffeners are not as detrimental to the appearance of the superstructure as vertical stiffeners, the designer should try to eliminate them from the structure. Use of longitudinal stiffeners should be avoided as their use typically produces detailing and fabrication issues. Longitudinal stiffeners are rarely required on all but the longest spans with very deep superstructures.

Longitudinal stiffeners will emphasize the horizontal nature of the structure. The simpler the girder and its components, the better the girder will appear (Fig. 3.29).

Fig. 3.29
The horizontal stiffeners make this girder appear longer and more slender. The best idea may be to eliminate all stiffeners (except bearing stiffeners) on the outside of fascia girder. (MD 198 Ramp over I-95, Prince Georges County, MD)

Splices:

Bolted field splice locations should be balanced on fascia girders.

> *For example, on a two-span bridge, a field splice should be required on either side of the pier (Fig. 3.30). On interior girders, one of these splices may be eliminated, if all design, fabrication and erection issues can be resolved.*

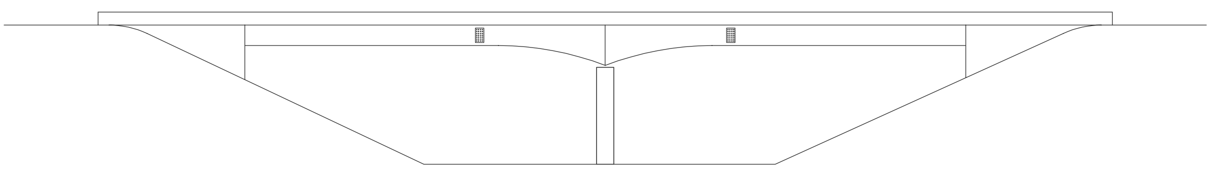


Fig. 3.30 Field Splices in fascia girders should be balanced on both sides of the pier.

Lateral Bracing and Cross Frames:

Bottom lateral bracing is rarely required on most bridges, except in the case of very sharp curvature. Designers should take every measure possible to eliminate the need for lateral bracing in order to avoid the issues associated with design, detailing, fabrication and erection, not to mention the associated aesthetic difficulties.

If lateral bracing is unavoidable, simplifying the details will enhance the appearance of the underside of the superstructure.

On any bridge where a view of the underside is likely, the arrangement of bracing and diaphragms has a visual consequence. The goal should be to minimize the amount of such features, simplify those that remain, and design them so that they generally follow the main lines of the structure.

Consider "compact" steel plate girder sections with less girder depth, wider flanges and thicker webs, for they require fewer or no stiffeners, less bracing and perhaps offer overall economy as well. Be cautious to satisfy the structural minimums for the girder depth to span length ratio. Cross frames should be uniform and clean in detail.

When establishing patterns for lateral bracing, use as few members as possible, and in ways which do not compete with the main lines of the structure (Fig. 3.31).

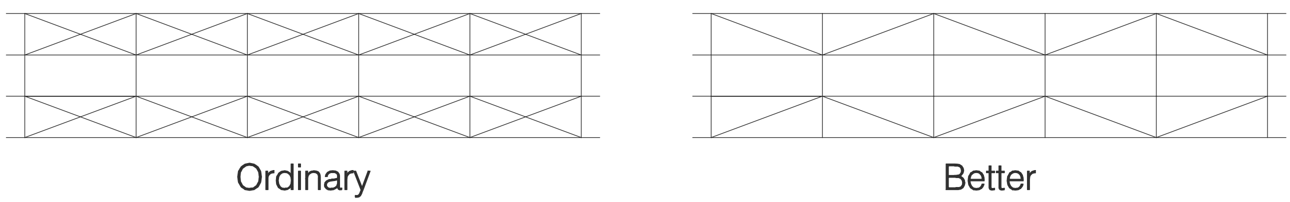


Fig. 3.31 Simplified bracing patterns will enhance the appearance of the underside.

Drainage:

Eliminate scuppers on bridges where possible.

If scuppers are absolutely necessary, look first for a location where water can be permitted to outlet just below the bottom of the girder with no complex drainage system. For bridges over bodies of water, this can be almost anywhere on the bridge, provided environmental concerns are addressed. For bridges over land, scupper locations cannot be over roadway areas and must fit into drainage patterns of the area below. A splash block on the ground directly below the outlet will usually be required. Outlets through the parapet may be used over water but must be carefully evaluated as to their appearance in highly visible areas.

Scupper outlet pipes should be located on the inside of the fascia girder. The scupper outlet pipe should be straight and extend to just below the bottom of the girder.

Placing a scupper in the deck generally requires a thicker deck in the area of the scupper. If the scupper must be in the overhang area, a parapet should be selected that will mask this area, or details developed so as to minimize the visual impact--deepening the parapet at outlet, etc.

Simplify drainage systems as much as possible. Internal drainage systems should be avoided.

If drain pipes must be installed, acknowledge them as another design element. Pipe systems should be kept as simple as possible, using large-radius curves and as few fittings as possible. For example, it is better to place a pipe in one simple run down the face of a column than to install five elbows to get it around to the rear. Complex systems are difficult to maintain and will usually clog.

Hide drain pipe systems wherever possible.

Pipe systems within columns should be avoided because of their associated maintenance problems. Pipe systems should be placed where they would least likely be seen--not behind a pier column but rather on the side of the pier opposite the approaching traffic on a dual highway.

Paint drain pipes and conduits the same color as the structural element against which they are mounted.

Through-parapet scuppers should be carefully considered and integrated into the design of the superstructure.

Scuppers which outlet through the parapet can be used if the outlet design is suitably integrated with the design of the parapet (Fig. 3.32). This will place restrictions on scupper locations because, as visible elements, their locations must be coordinated with the overall concept of the bridge. This must be shown on all sketches and elevations of the bridge plans so that their impact can be evaluated.

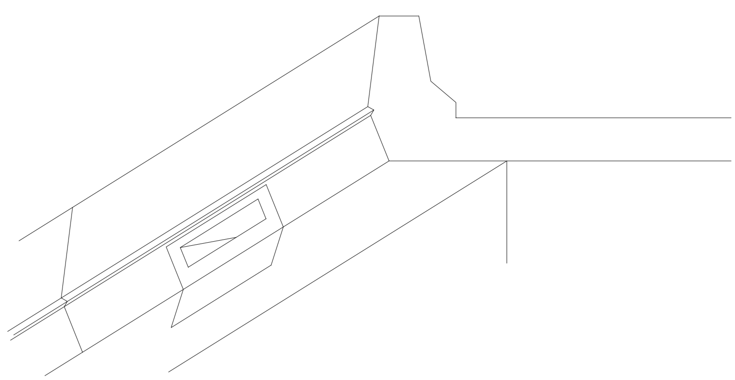


Fig. 3.32 Example of a through-parapet scupper with its outlet integrated in the parapet design

Utilities:

Place utilities between girders and above the lower edge of girders.

Wherever drain pipe conduits and utilities are exposed, run them in lines which are either parallel or at right angles to the main lines of the structure. The utilities should never extend below the bottom of the nearest adjacent girders.

E. PARAPETS, PEDESTRIAN SCREENS AND RAILINGS

Parapets:

Parapets are the only elements in a bridge which are visible both on the bridge and below the bridge. Since each side has its own visual requirements, the two have to be reconciled during the design process.

The first issue to be addressed is whether any of the parapet can be open, or whether it will be entirely solid. The overall superiority of the F-shape barrier parapet from a safety point of view has settled this issue in most cases in favor of a solid barrier. This tends to block the view from the bridge, and also restricts the options available in using the parapet to influence the appearance of the bridge elevation (Fig. 3.33). Development of open bridge railings with equivalent safety characteristics has progressed to the point where they can now be considered, as long as the specific design has been crash-tested. The use of full height railings, with their inherent anchorage problems, should only be utilized in very special locations.

Fig. 3.33
An open railing allows the concrete fascia to be as thin as the slab. The girder appears thicker by comparison, but the bridge as a whole appears thinner. A railing design in which the horizontals are larger than the verticals would have made this good example better.

The parapet is an important influence on the overall appearance of a bridge because it and the girder determine the visual depth/span ratio of the superstructure, which is one of the strongest determinants of appearance. The key dimension is the outside height of the parapet relative to the exposed depth of the girder. The German engineer Fritz Leonhardt suggests the following guideline:

It is desirable to keep the parapet height between 1/4 and 1/2 of the exposed girder depth with a minimum of 1/80th of the span length (Fig. 3.34).

For short spans, this is not possible, and for most medium span bridges the standard F-shape barrier parapet and other recommended AASHTO parapets will be higher than this ideal. In most cases, the height of parapet is not a parameter within the designer's discretion to adjust. A designer should not change the parapet height merely to meet this criteria.

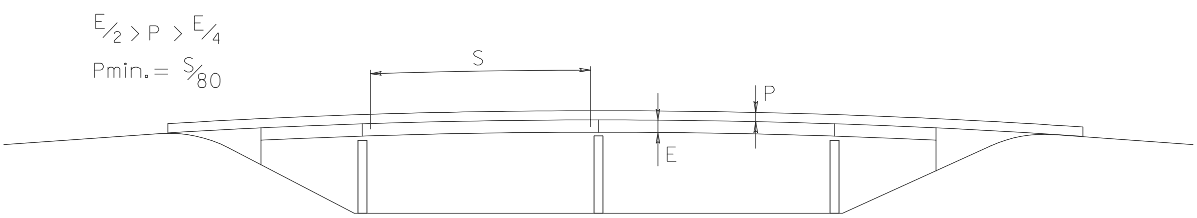


Fig. 3.34 The visually desirable parapet height

For those situations where the parapet is higher than the ideal, attention should be directed to ways of making the barrier appear thinner:

- **Divide the face of parapet horizontally by using recesses or sloped planes.**

  The horizontal divisions will be more effective if they are unequal (Fig. 3.35).

Fig. 3.35
The horizontal divisions created by the sloped faces divide the parapet into two surfaces with different brightnesses, so that it appears thinner. (McDonogh Road over I-795, Baltimore County, MD)

Horizontal lines should be emphasized in the selection of patterns for the parapet. Vertical details will tend to interrupt the dominant lines of the bridge and make it look deeper (Fig. 3.36).

Fig. 3.36
Vertical railing and joint details should be carefully selected so that they do not break up the horizontal line and make the superstructure seem thicker.

- **Space any vertical divisions in the parapet at a distance equal to at least 2 ½ times the parapet height (Fig. 3.37).**

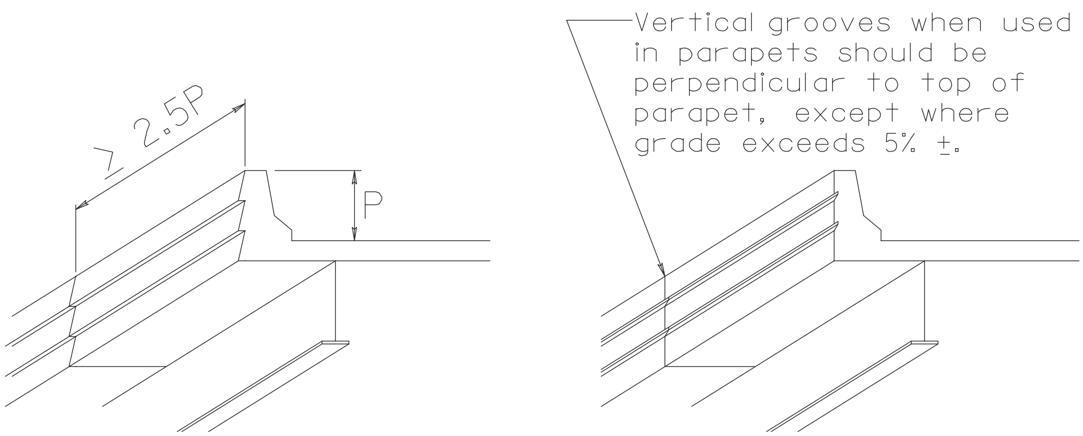


Fig. 3.37 Criteria for vertical divisions

- **Stress the horizontal lines as the most dominant lines on the parapet fascia (Fig 3.38).**

Fig. 3.38
A large recess and a groove divide the parapet so that it seems thinner and has more horizontal emphasis. This is an example of a good location for a groove but the groove is too small to make much of a contribution. (Bridge over I-95, Harford County, MD

Accent the slab/parapet joint with a significant groove or recess incorporated in the parapet design.

The slab/parapet construction joint must be recognized (Fig. 3.39). It should be incorporated into parapet patterns with the intention to make the parapet look thinner. The "ordinary" detail indicated in Fig. 3.39 tends to emphasize any imperfections in the deck pour. Since the top of the parapet will be a line following the grade of the bridge, the overall concrete depth may vary substantially. The two details suggested as "better" in Fig. 3.39 tend to hide this situation and emphasize the horizontal groove.

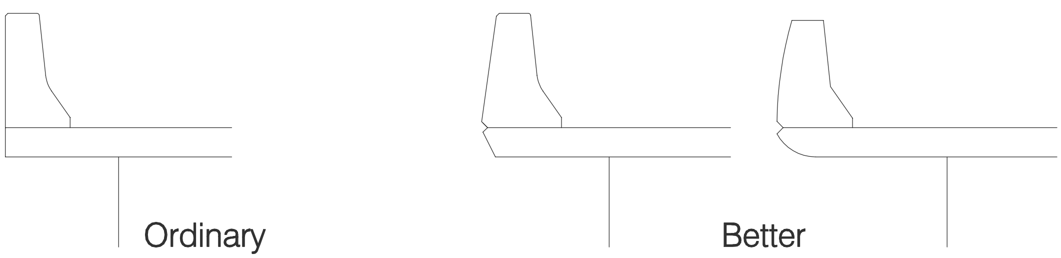


Fig. 3.39 Accent the slab/parapet joint in the parapet design.

Pedestrian Screens and Railings:

Pedestrian screens should have materials, details and colors which are as transparent as possible. Make it clear that the screen is separate from the parapet.

A pedestrian screen on the bridge complicates matters because it can make the parapet seem three times as high, with comparable negative effects on the proportions of the whole structure.

As with the parapet itself, the details of the pedestrian screen should maintain a horizontal emphasis. As Fig. 3.40 illustrates, instead of using vertical posts in the fence detail, a sloped post detail is used to emphasize the horizontal lines in the pedestrian screen. The same rules would apply to any railings.

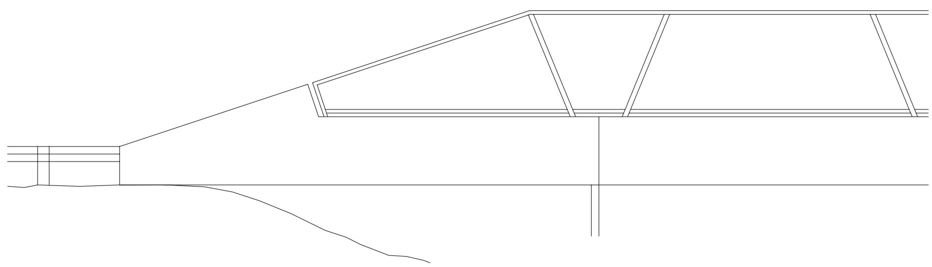
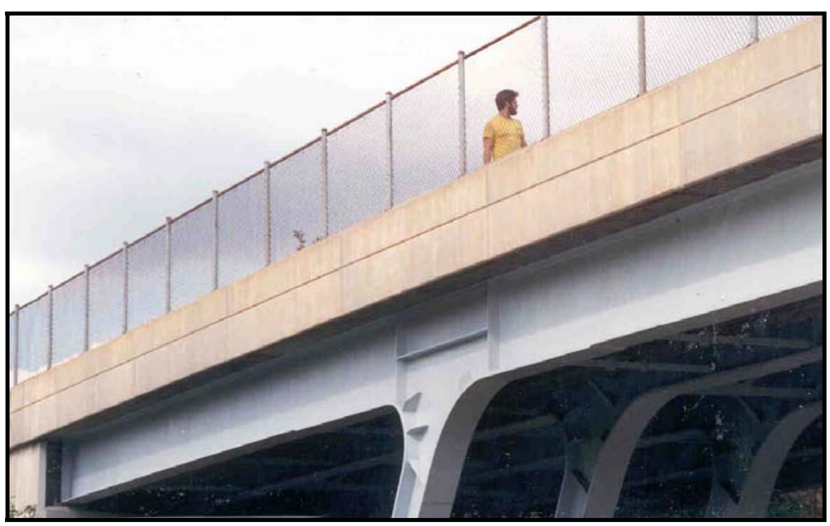


Fig. 3.40 A Screen End Detail that stresses the horizontal

The screen and railing post spacing should have a consistent relationship with the vertical divisions set in the parapet fascia (Figs. 3.41 and 3.42).

Fig. 3.41
Ordinary - The vertical screen posts run through the horizontal rail and are the same size: the effect is domination by the vertical. (Vollmerhausen Road over I-95, Howard County, MD)



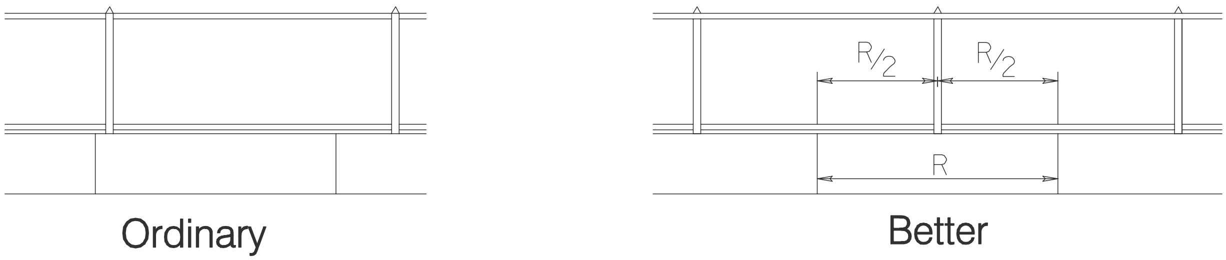


Fig. 3.42 The relationship of posts to parapet divisions should be consistent.

In most cases, the rail and screen posts should be set perpendicular to the parapet. When the parapet grade becomes steep (>5%) consideration should be given to setting the posts plumb.

Clamps, junctions and other fittings should be compact, simple and rust-proof. They should be integrated with the major members wherever possible.

Use corrosion-resistant pedestrian screen and railing materials, and coat the parapet with a stain-resistant finish, if necessary.

Staining on the parapet may have a significant effect on the bridge's appearance. The stains result primarily from dirt and corrosion products from the pedestrian screen or railing, and are worse at the railing posts (Fig 3.43).

Fig. 3.43
Notice the staining. (Stewart Ave. over I-97, Anne Arundel County, MD)

Parapet profiles along superelevation transitions may create a visual kink which can be eliminated by moving the superelevation transitions onto the roadway approaches, if possible.

Because the top of the parapet is a nearly horizontal line parallel to the driver's line of sight, any flaws in the alignment, whether due to design or construction, will be magnified. At the design level, problems most often appear at superelevation transitions, since the parapet alignment is driven by pavement and shoulder cross slopes.

End railings, pedestrian screens and solid barriers (over Electrified Railroads) must be protected. Tapered or curved endings are desirable (Figs. 3.44 and 3.45).

Parapets and pedestrian screens need to be considered from the viewpoint of people on the bridge. Simple assemblies with a horizontal emphasis should work to the benefit of bridge users as well as bridge viewers.

The parapet has the visual job of gracefully ending or beginning the bridge at each end, and the functional job of providing a place for anchoring the approach traffic barrier. The overall goal is to emphasize the horizontal nature of the bridge and its continuity with the approach roadway.

Incorporate attachment details for the traffic barrier and right-of-way fence.

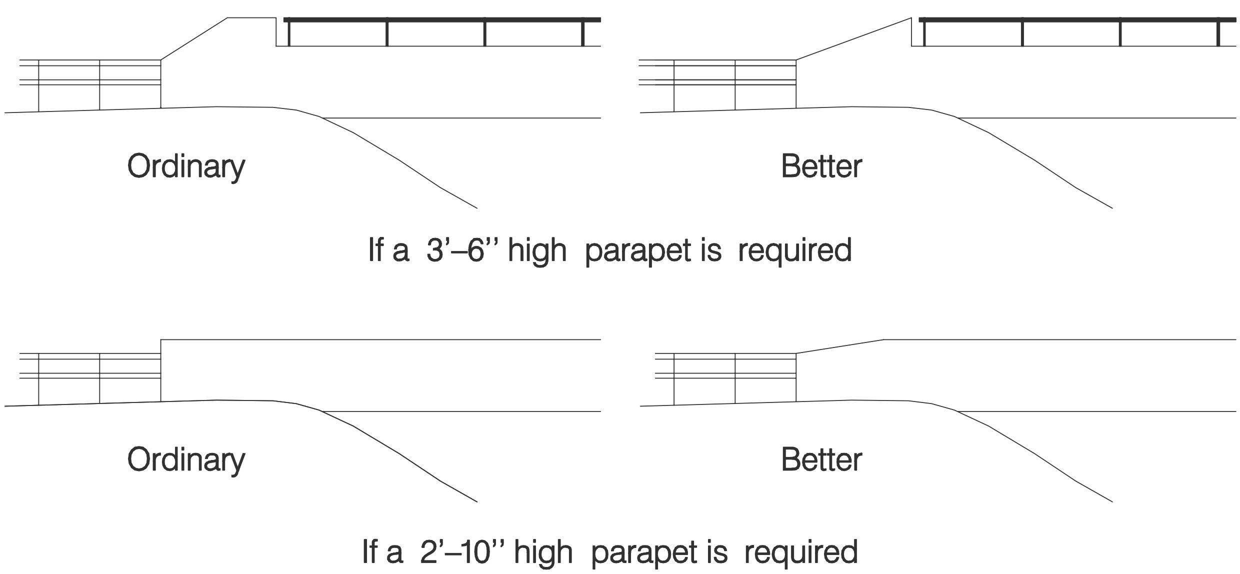


Fig. 3.44 Enhancing a transition by tapering the parapet

Fig. 3.45
Use of a full height solid barrier with a tapered transition to the bridge railing. (Falls Road over Light Rail, Baltimore County, MD)

The approach traffic barrier must always be tied into the parapet for safety reasons. The goal is to make the transition as smooth and continuous as possible while preserving the safety aspects of the connection.

Aligning the abutment wing wall with the approach roadway helps by allowing the parapet end block and wing wall to be combined (Fig. 3.46). The parapet end should be designed to receive the approach traffic barrier.

Consideration shall be given to replacing the approach traffic barrier with concrete barrier where the approach traffic barrier is not of significant length.

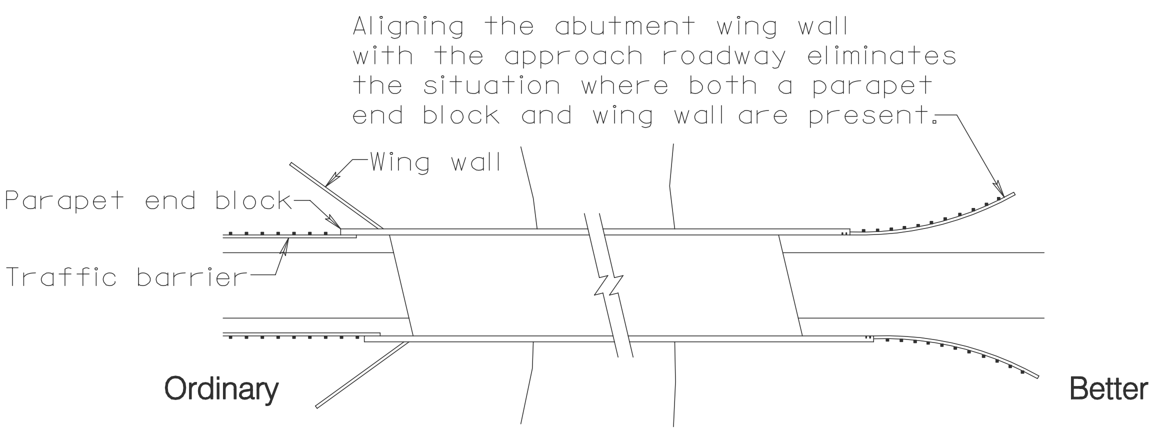


Fig. 3.46 Integrating the parapet end block into the wing wall

All elements at parapets must be coordinated so that light standards, signs, etc. are placed symmetrically and carefully.

Use of shorter light standards on bridges should be considered, especially on structures that are not included in interchanges and are in special locations with heavy pedestrian use.

It is an absolute must that all of the add-ons to a bridge (light standards, scuppers, signs, etc.) be shown in all the development and final plans, so that there are no surprises when the structure is finished.

Precast Elements:

Precast parapets have proven to be difficult to align and at times difficult to anchor; consequently, they should be used with caution.

> *Precast parapet facings (panels) can provide many options for shape (form liners), color and finish, and they can be produced to higher tolerances with a denser surface than field-placed concrete. They also are easier to align. Precast panels attached to poured-in-place parapets are another option (Fig. 3.47).*

Fig. 3.47
An example of precast panels being used instead of a field placed finish. (Ridgely Avenue over US 50, Anne Arundel County, MD)

IV. SUBSTRUCTURE

This section encompasses the three basic substructure elements: piers, abutments, and wing walls (retaining walls). There is not a correct type of substructure unit for all cases; what is appropriate and aesthetically pleasing for a narrow ramp overpass will be different from what is appropriate and aesthetically pleasing for a wide dual structure. What follows, therefore, are basic guidelines that should be modified for the particular case that confronts the designer.

A. PIERS

Piers are best analyzed in two categories: short piers (wider than they are tall) and tall piers (taller than they are wide).

The appearance of piers is heavily influenced by their proportion: how wide they are relative to their exposed height. As piers get taller, the engineering challenge may increase, but the aesthetic challenge decreases. In other words, it is easier to proportion a tall pier so that it will be aesthetically pleasing than to do the same for a short pier. In order to highlight these inherent differences, these guidelines offer separate recommendations for short piers and tall piers (Fig. 4.00). Obviously, distinguishing between the two categories is totally arbitrary, as there is a wide range of shapes involved. However, there are enough definite differences in the aesthetic problems involved with the two types of piers to make the distinction useful.

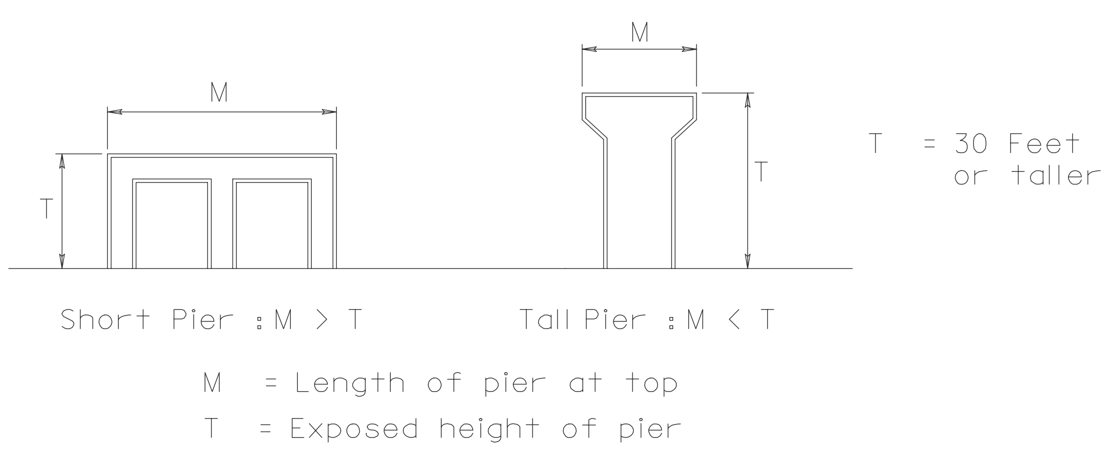


Fig. 4.00 Definition of short vs. tall piers

1. Short Piers

Short piers fall into four major categories: solid shafts, multi-columns with or without pier caps, pile bents and hammerheads.

Multi-columns with a cap are probably the most frequent type. Further variations can be created by tapering piers toward the bottom (inverted trapezoidal) or the top (trapezoidal). Every attempt should be made not to use short hammerheads.

Short multi-column bents and hammerheads are difficult to make attractive because the pier cap is such a large portion of the total pier. Short pier design should be focused on eliminating or minimizing the pier cap (Fig. 4.01).

Fig. 4.01
This pier effectively reduces the pier cap. (Reisterstown Road over I-695 in Baltimore County, MD)

Pier caps and particularly their end elevations are distracting elements that make the superstructure seem deeper.

The pier cap introduces a third element into the visual scene. The overcrossing roadway/superstructure is one element; the columns with their vertical lines are another, having an obvious support function. The pier cap is clearly not part of the superstructure, but also not part of the columns either, especially if the columns are geometrically separate shapes. The mind and the eye have a hard time dealing with the complication introduced by this third element, and it becomes a distraction (Figs. 4.02, 4.03 and 4.06).

Fig. 4.02
The brightest surface of the bridge is the pier cap end, which means it is the first thing that draws the eye. Because the parapet is almost as bright and the columns are in shadow, the eye ties the pier cap to the superstructure. The cap interrupts lines of the superstructure and makes the superstructure appear deeper. (MD 198 over I-95, Prince Georges County, MD)

Fig. 4.03
There are five separate elements in this pier: four cylinders and one rectangular prism. (MD 198 over I-95, Prince Georges County, MD)

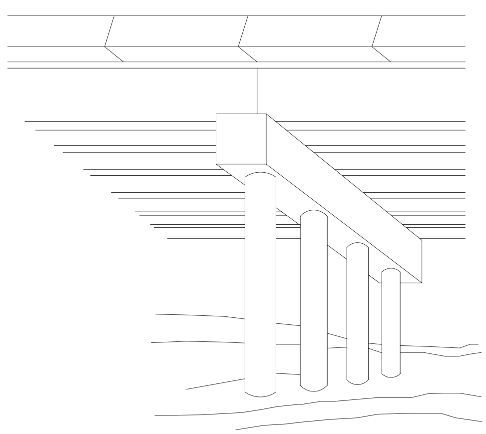


Fig. 4.04
The prominence of the pier cap and especially its end surface

The end of the pier cap compounds the distraction (Figs. 4.04, 4.05 and 4.09). The end of the pier cap is at about the same plane as the outside face of the parapet and fascia girder. It is generally out from under the shadow of the overhang and is a relatively bright surface. Visually the end of the pier cap "reads" as part of the superstructure, which interrupts the lines of the superstructure and makes the superstructure appear deeper.

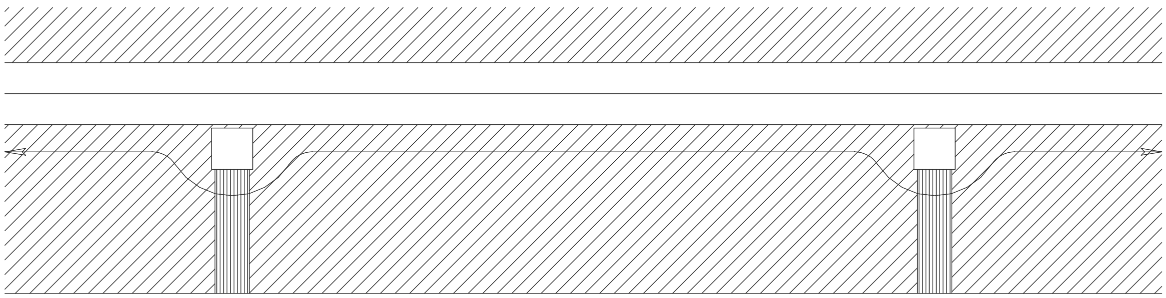


Fig. 4.05 The pier cap end visually attaches to the superstructure and makes the bridge superstructure appear thicker.

Fig. 4.06
This design attempts but does not fully succeed in integrating five elements (four columns and a cap) into one, while minimizing the visual impact of the pier cap end. (I-97 NB under MD 3 to join MD 3, Anne Arundel County, MD)

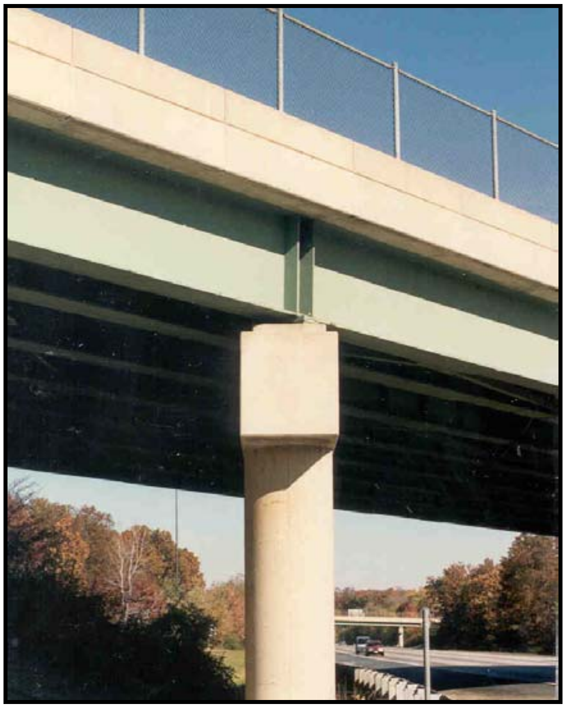


Fig 4.07 **Fig. 4.08**

Here is a side-by-side comparison of a typical cap and column pier (Fig. 4.07 - MD 32 WB over I-95 SB, Howard County, MD), with a multi-faceted cap and column (Fig. 4.08 - Farm Road over I-97, Anne Arundel County, MD). The keystone shape and slanted lower panel minimize the pier cap while the faceted pier stem creates three panels of differing brightness, making the stem seem thinner.

Fig. 4.09
Using a tapered mound to protect a median pier not only shortens the pier height, but emphasizes the size of the pier cap as well.

Alternatives for Eliminating Pier Cap Effect:

The following are presented as options for eliminating or minimizing the pier cap, or incorporating it in the superstructure. Some are more effective than others, and some have other drawbacks that may be overriding.

- **Use a solid shaft.**

The wall can be made relatively thin, resulting in an elegant structure. Indeed, care needs to be taken that the wall does not look too thin for the depth of the superstructure (Fig. 4.10). When the wall gets long because of overcrossing width or angle, the lack of visibility through it may be a problem. (See Chapter V, Colors and Textures for options on aesthetic treatments for the wall.)

Fig. 4.10
Solid shafts. (Benfield Boulevard over I-97, Anne Arundel County, MD)

- **Use multiple columns without a pier cap.**

Provide one column for each girder or one wider column per two girders.

This works best where the girders are widely spaced and in situations where the skew angle is sharp, so that the columns are spread out (Fig. 4.11). In other situations it can degenerate into a maze of columns.

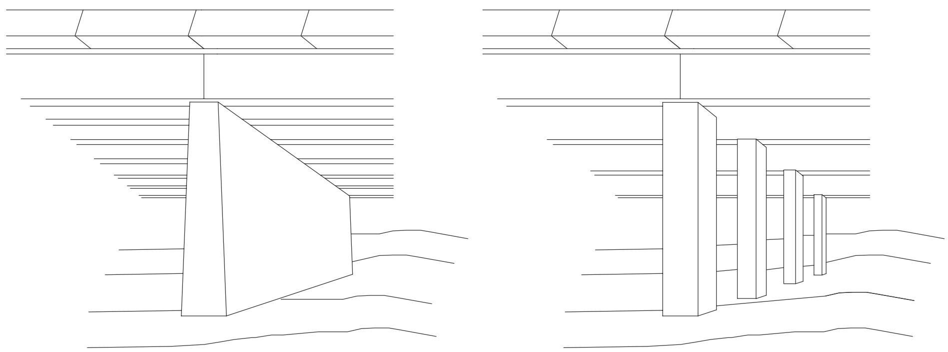


Fig. 4.11 Alternatives for eliminating the pier cap

A variation which is particularly effective for skewed bridges is to use individual rectangular columns normal to the stringers. This creates a "venetian blind" effect for traffic on the roadway passing beneath the bridge.

- **Integrate pier cap.**

Eliminate the pier cap cantilever by placing a column under the fascia girder or as an outside leg of the pier (Fig. 4.12).

To minimize pier cap prominence, make the cap thinner than the columns or vary the shape of the pier cap so that cap and columns take one continuous form (Fig. 4.12). This option may not be appropriate in situations involving a family of adjacent piers, some of which are hammerheads.

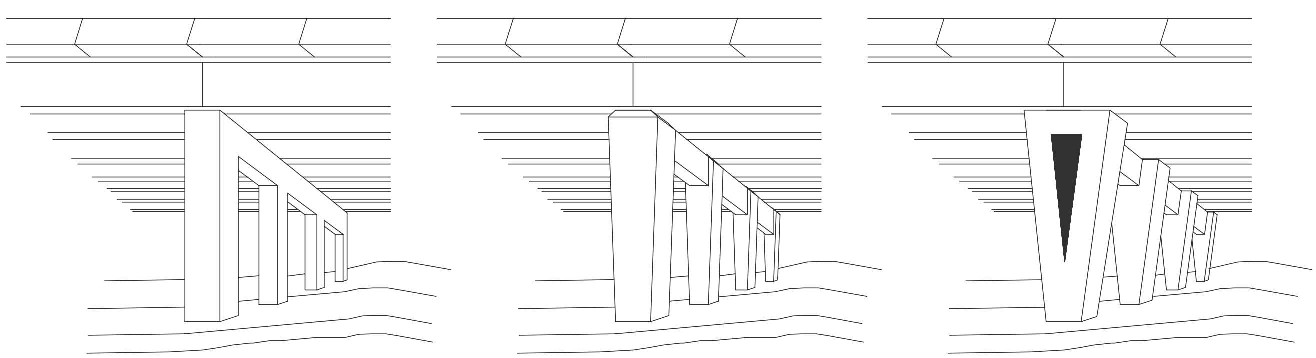


Fig. 4.12 Alternatives for eliminating the pier cap end by eliminating the cantilever

- **Alter shape of pier cap end.**

  Minimize the visual prominence of the pier cap end by reducing its vertical dimension.

  A few ways to achieve this include: tapering the pier cap cantilever in one or two dimensions or by sloping all or part of the end surface, by sloping the pier cap sides so that the end elevation is a keystone shape, or by rounding the end of the cantilever arm (Figs. 4.06, 4.08 and 4.13).

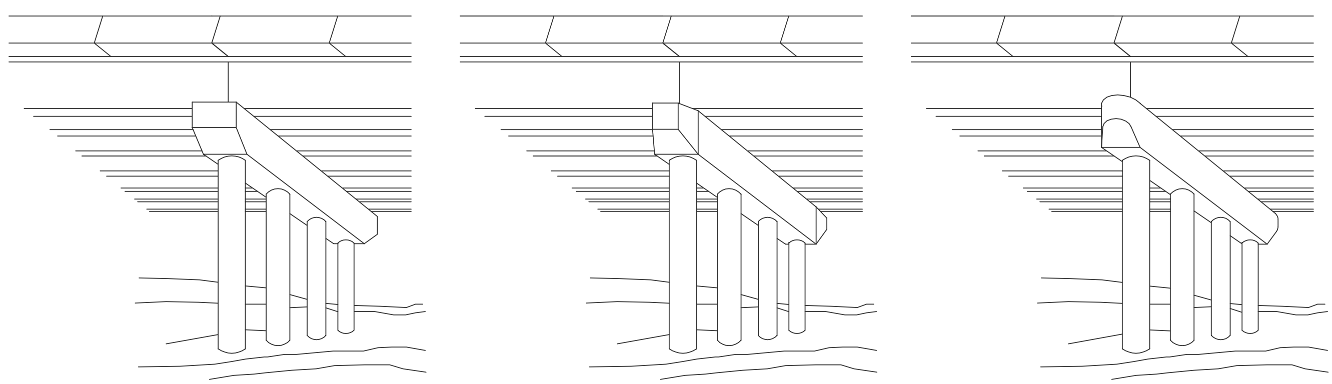


Fig. 4.13 Alternatives for minimizing the pier cap end

- **Utilize a pier cap that is integral with the superstructure.**

  Use of a pier cap that is integrated into the superstructure will eliminate the end view of the pier cap altogether (Fig. 4.14). These systems appear aesthetically pleasing, but create fracture-critical members. From a practical design standpoint this should be avoided wherever possible. Maryland SHA avoids this type of design. See the discussion of integral pier caps in Chapter III.

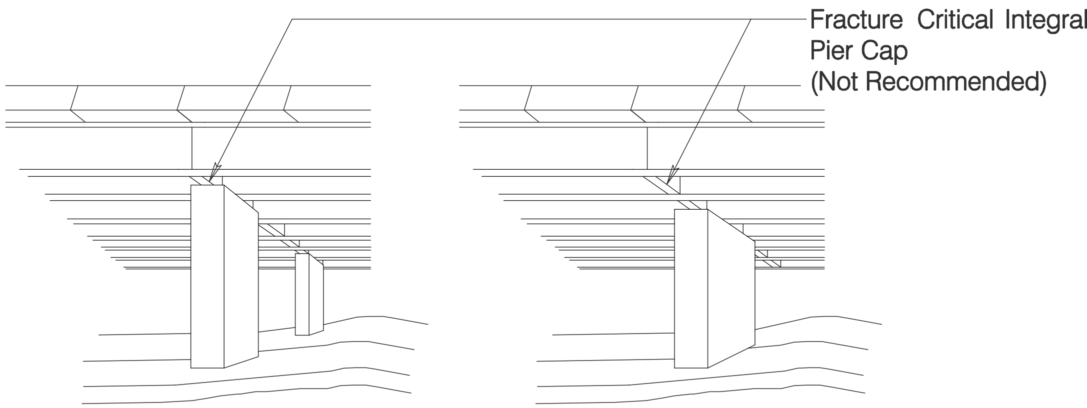


Fig. 4.14 De-emphasized and incorporated pier caps

Inverted Trapezoidal Piers:

The use of piers with tapered sides can be aesthetically pleasing with the proper batters (Figs. 4.15 and 4.16). If their batter is too extreme in the pier elevation view, it can create an element that is awkward in appearance. Another area to be carefully considered is the width of the shaft at the bearing area. A very wide top with a single bearing can create a cumbersome element (Fig. 4.17).

When considering inverted trapezoidal or trapezoidal piers, the rate of taper should be influenced by pier height (the higher the pier, the less the rate of taper) and by the relative design dimensions at the top and bottom of the exposed face of the pier.

Inverted trapezoidal piers eliminate the pier cap. However, they create other visual problems. They are shaped contrary to natural physics, i.e., they are thinnest where visual and structural logic says they should be thickest: at the bottom. A tree is an example of nature's order: thick at the base and tapered to the top. If the taper is too extreme, the piers will look illogical. The viewer will ask, why the big overhang just above the ground; why not just carry the pier right down to the ground? When the pier base gets too narrow compared to the top width or thickness, these piers will appear to be unstable, as if they were about to topple over.

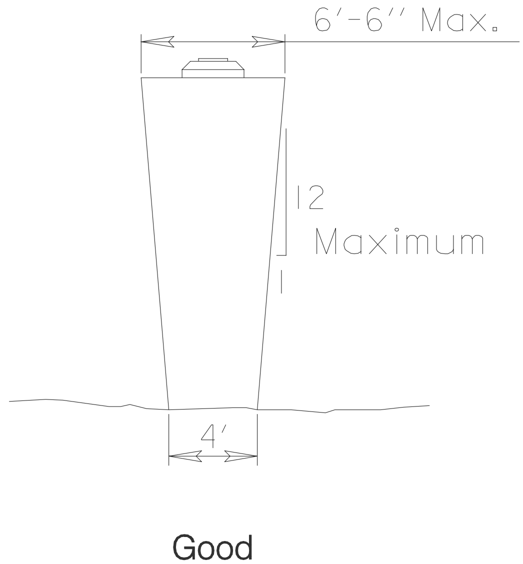


Fig. 4.15 Suggested shape for inverted trapezoidal pier

Fig. 4.16 *Properly proportioned. (Brokenland Parkway over US 29, Howard County, MD)*

Fig. 4.17
The batter causes this pier to look massive. (Jefferies Road over I-68, Allegany County, MD)

Trapezoidal Piers:

Trapezoidal shaped piers suffer a complementary problem if the taper is too extreme: they will look too wide at the bottom, as if material is being wasted (Fig. 4.18).

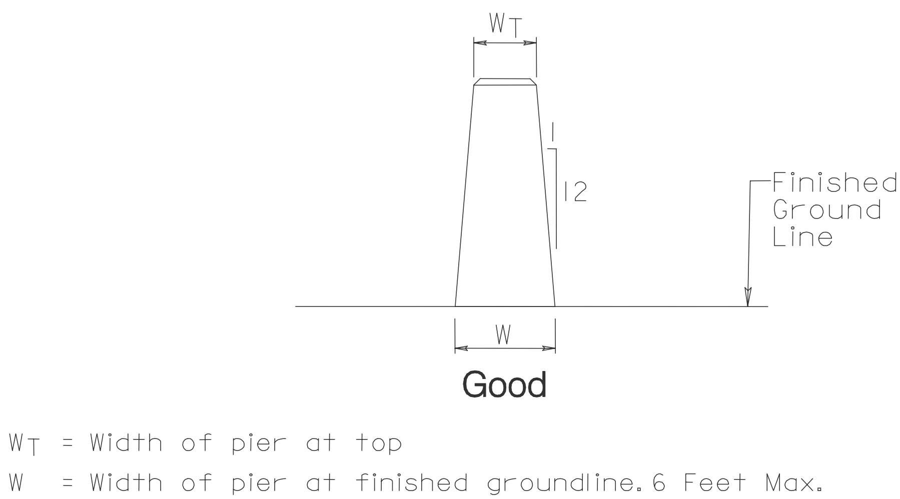


Fig. 4.18 Trapezoidal piers which are too wide at the base will look as if material is being wasted.

Check trapezoidal shaped piers to make sure they are not too wide at the ground line; for most short piers the limits are probably about two times the top width and 1½ times the top length.

See Figs. 4.19, 4.20, 4.21 and 4.22 for other examples or versions of pier shapes.

Fig. 4.19
A gentle taper from stem to the cap with an ornamental inset. (MD 100 over US 29NB Ramp D, Howard County, MD)

Fig. 4.20
(MD 335 over Fishing Creek, Dorchester County, MD)

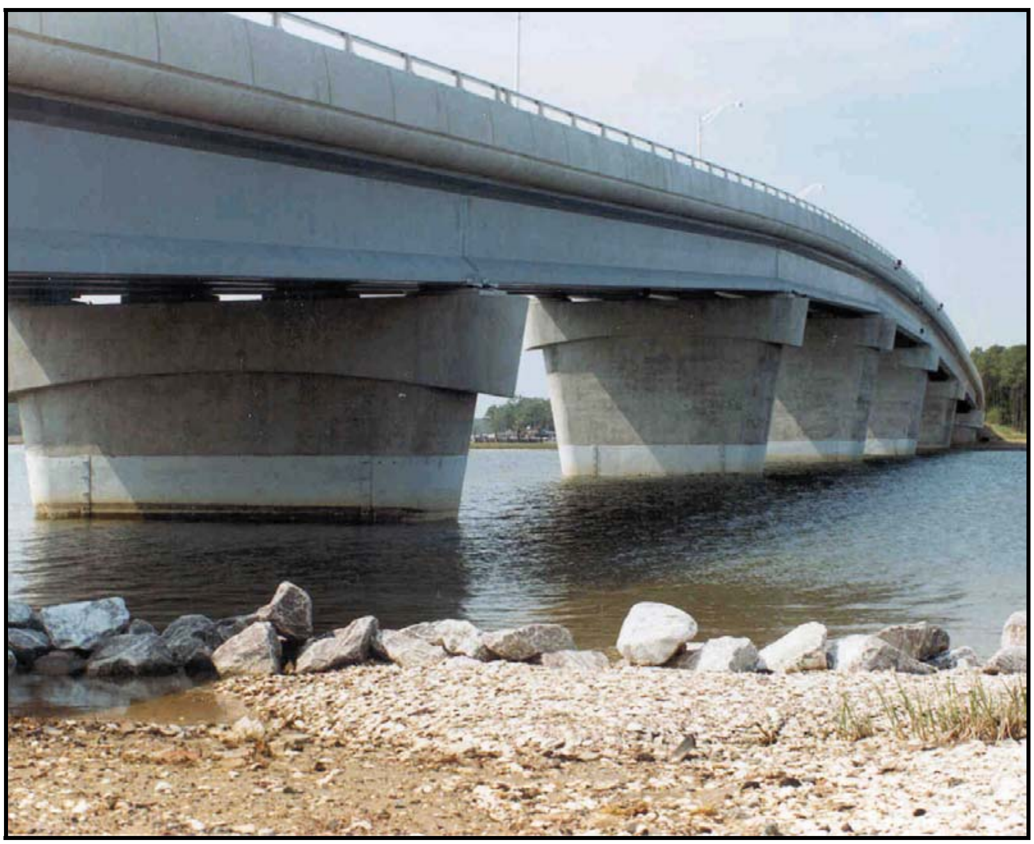


Fig. 4.21
(MD 648 over Patapsco River, Anne Arundel County, MD)

Fig. 4.22
(MD 175 over US 29, Howard County, MD)

Short Hammerhead Piers:

Short hammerhead piers should be avoided because they can appear to be disproportionate (Fig. 4.23).

One can easily encounter this situation when working on a longer, narrow bridge with many piers that rises up to cross a river. The tendency is to design a well-proportioned pier for the tallest and keep the same hammerhead cap for all the others. For the shorter piers this results in a low pier with a short shaft and a heavy cap. The appearance is not pleasing.

The problems with short hammerhead piers can be minimized with proper proportions. The key relationships are:

- *Cantilever length compared to pier height. Long cantilevers on short piers appear unnecessary and wasteful.*

- *Base width compared to top width. As the pier gets shorter, base width should approach top width.*

- *Cantilever depth at the shaft compared to shaft width. Shallow cantilevers on wide shafts will look fragile and appear as "add-ons".*

It is difficult to give specific rules, since much of aesthetic design is by judgement or opinion and what appears to be pleasing to one person may look out of proportion to someone else. The following sketches may help. Generally, shapes that are structurally logical also will be visually logical. Increasing the depth of the hammer or overhang may cause a hammerhead to change from a cantilever design to that of a corbel. (Designer is cautioned to be aware of this.)

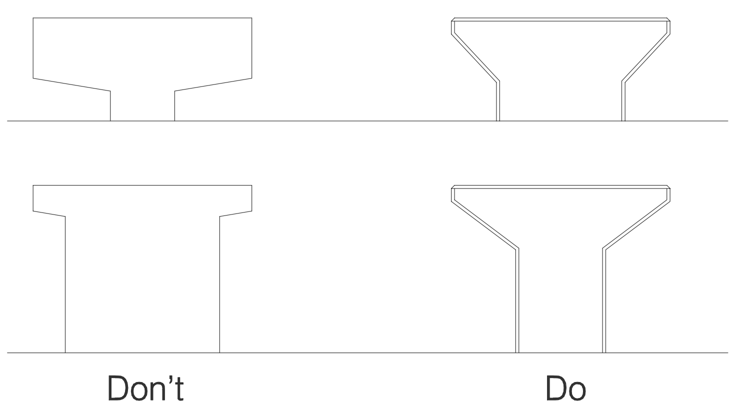


Fig. 4.23 Do's and Don'ts of short hammerhead piers

Unless used in a family of piers, the use of hammerheads for short piers is not recommended.

For all short pier types determine pier thickness in proportion to superstructure depth, span, and apparent pier height (Figs. 4.24 and 4.25).

On short piers, thickness should be considered for its visual effect. (On tall piers structural and economic issues tend to make this decision.)

Pier width must be proportional to superstructure depth, span lengths, and visible pier height. Because an open railing significantly changes the apparent thickness of the superstructure, the proportions should change accordingly. Use of a vegetated mound in lieu of a traffic barrier for pier protection will shorten the visual height and may dictate a thinner pier (Figs. 4.09 and 4.41). The designer is cautioned that the mound can only be used with relatively wide medians.

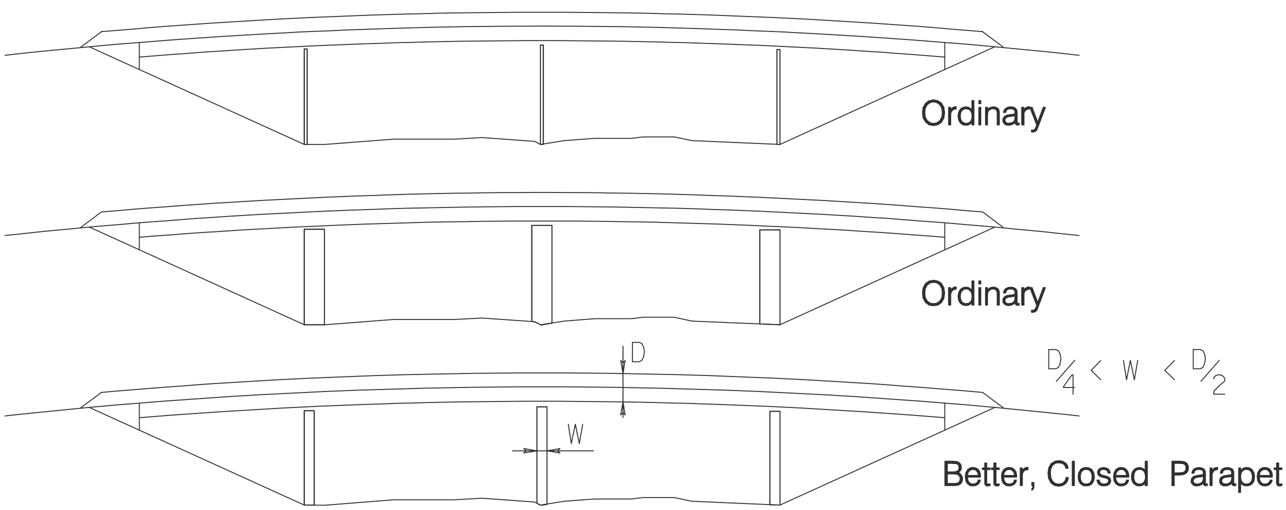


Fig. 4.24 Pier width should relate to superstructure depth.

Designers are often tempted to keep column and shaft thickness the same over several different bridges for the purpose of economy. Some cost savings may result, but the potential savings should be weighed against the loss of visual quality. It should be remembered that this cost savings is temporary while the loss of visual quality will remain for the life cycle of the bridges involved.

Fig. 4.25
This solid shaft is too thin. (Cherry Hill Road over I-95/I-495, Prince Georges County, MD)

Pile Bents:

Pile bents are often an economical choice for a support located in waterways. Pile bents consist of a cap placed atop the foundation piling, thus creating a multi-column bent with a cap. The reader is advised to take into consideration all comments from the previous discussion on multi-column piers with caps when designing pile bents.

Every effort should be made to minimize the number of piles used for the bent, providing redundancy is not compromised.

When more than two piles are present, battered piles should be avoided. Lateral loads should be accounted for in the design of plumb piles. (See Chapter IX, Bridges over Waterways.)

Use only rounded piles for exposed pile bents.

When H pile shapes must be used, then the use of round, one-piece pile jackets should be considered to enhance the appearance of the piles.

2. Tall Piers

Use simple, continuous vertical shapes, not a series of short piers piled one on top of the other (Figs. 4.26, 4.27 and 4.28).

Tall piers are easier to create aesthetically because both structure and aesthetics point in the same direction: consolidation of vertical members into a shaft. Engineer and layman alike can appreciate the economy of consolidating reactions into fewer members for the longer journey to the ground.
The keys to designing tall piers are to recognize and accentuate their vertical emphasis,

to taper the vertical members, and to visually (as well as structurally) integrate the pier cap.

Use simple, vertical shapes. If both horizontal and vertical members are present, emphasize the vertical members. If the required length of pier at the top is narrow, a single shaft will suffice. (Vertical shafts on wide bridges may look and be too massive.)

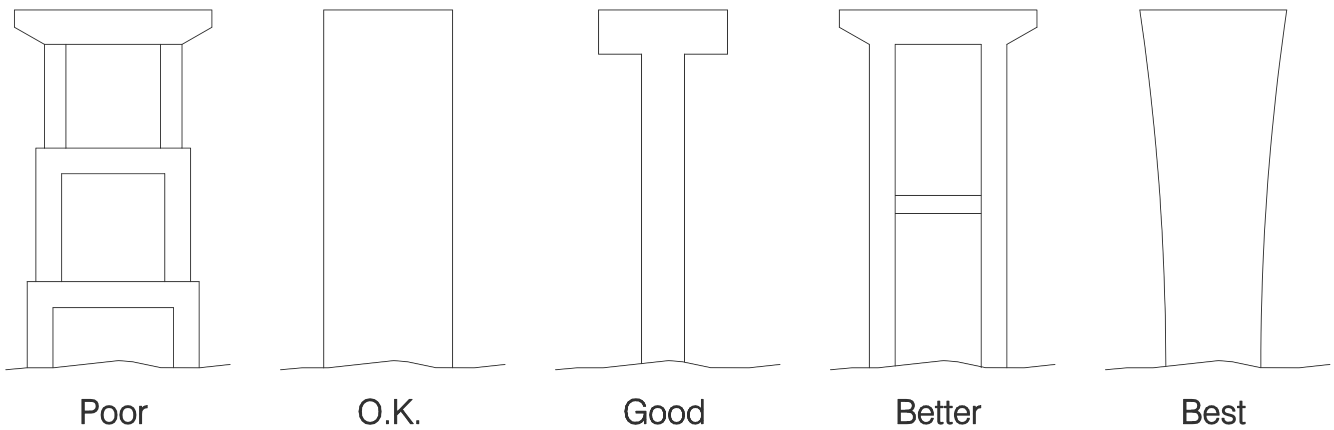


Fig. 4.26 The emphasis for tall piers: simplification and verticality
(See also Figs. 4.27 and 4.28)

Same tall pier problem, two different solutions:

Fig. 4.27
Each pier is made of stacked smaller piers; the excessive complication per pier is made worse because of the number of piers in view. (I-95 over Patapsco River, Baltimore and Howard Counties, MD)

Fig. 4.28
Simplicity equals elegance; the tapered columns accommodate structural needs within a single smooth shape. (I-83 over Gunpowder River, Baltimore County, MD)

Taper vertical members at 1:24 to 1:40.

Taper the vertical members. (The loads are largest at the bottom; the pier should be, too.) Piers will look too massive if the taper is too great. Tapers of 1:24 to 1:40 work well in most situations, with the lesser tapers applicable to taller piers (Fig. 4.29).

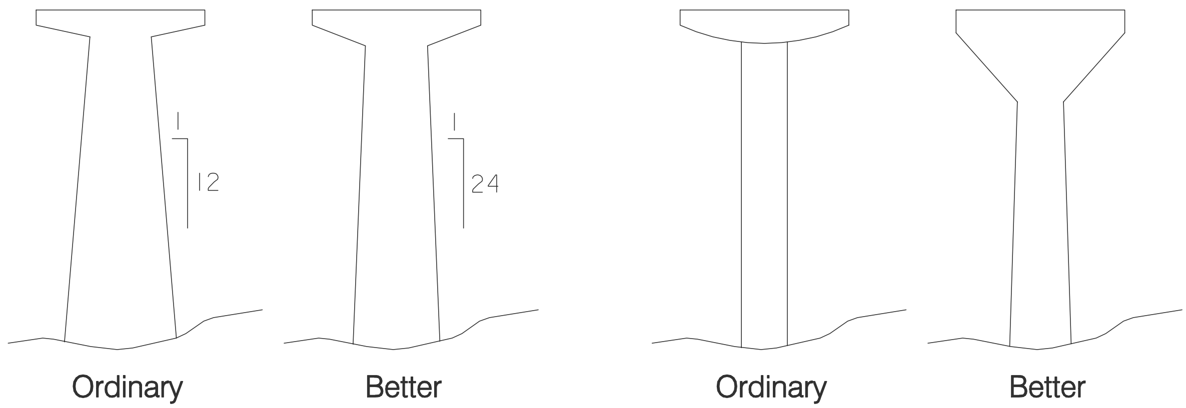


Fig. 4.29 The effect of too much taper and the necessity of integrating pier cap and shaft

For hammerhead piers, visually integrate shaft and cap.

The pier operates as one element structurally; it ought to look like one element (Figs. 4.30 and 4.31).

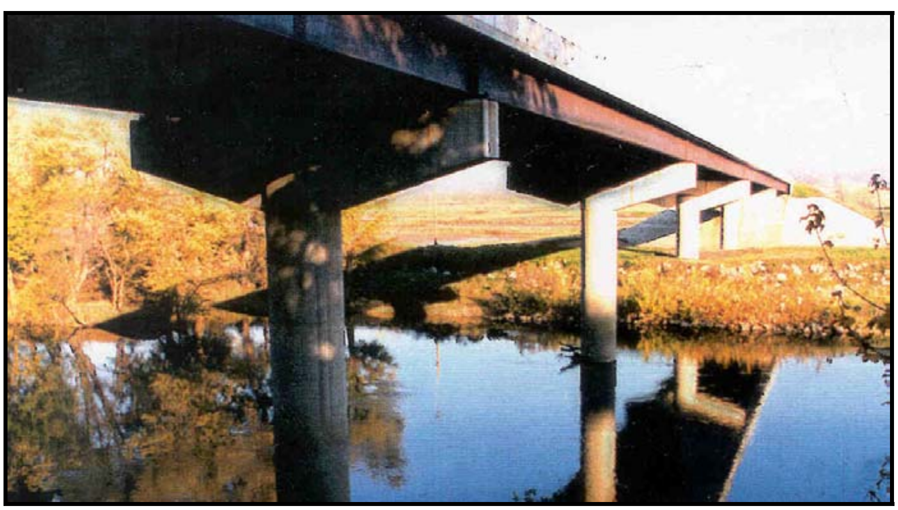


Fig. 4.30
Direct integration of pier cap and shaft. (MD 80 over Monocacy River, Frederick County, MD)

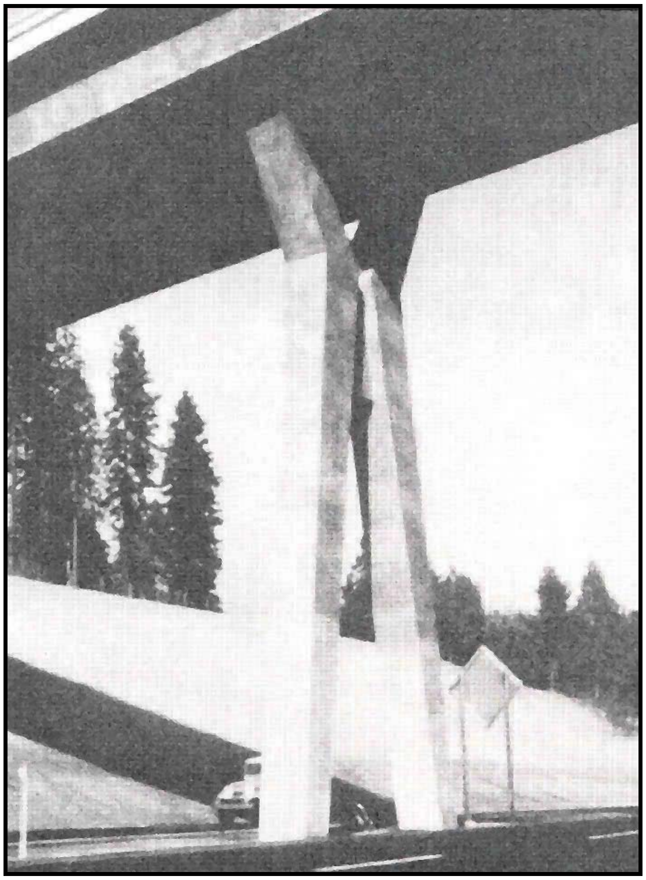


Fig. 4.31
A more expressive shape, but still clear, direct and structurally logical.

Proportion piers so that they appear graceful and not massive.

The tree analogy, specifically the trunk/branch joint, can provide clues about the shaping of the shaft/hammerhead or corbel intersection. The common thread is that the hammerhead/branch is thicker at the joint and thinner at the end. There is no structural reason to be restricted to straight lines. Curves more accurately reflect the flow of stresses, and they add visual life to the structure.

There is a temptation to be overzealous with this shaping process and venture into the realm of non-structural design. The shapes indicated by structural needs are predominant in themselves.

3. Families of Piers

For a series of piers which vary in height or width through a structure, pick a shape or series of shapes which, by varying its proportions, will look good both tall and short, wide and narrow (Figs. 4.32, 4.33, 4.34, 4.35 and 4.36).

It is not uncommon for multi-span bridges to have piers of widely varying heights. A bridge over a shipping channel or a bridge over a deep ravine are examples. The *designer is then challenged to create a family or set of pier shapes which appear well individually and as a group, whether tall or short. Simply changing from one type to another--for example, multi-column bents for the short piers and hammerheads for the tall piers--will appear to be an error in judgement. Usually it is preferable to choose a single type--a hammerhead or a two-column frame, for example--and then vary its proportions throughout the different piers in a logical and continuous way (Figs. 4.32 and 4.33).*

It is important to look at all the piers in the structure at one time, since pier heights will vary, giving various appearances. The whole family shall be studied before setting the geometric relationship.

Fig. 4.32
This is an excellent example of a consistent variation in form that creates a family of piers. (Thomas Johnson - MD 2/4 over Lower Patuxent River, St. Mary's and Calvert Counties, MD)

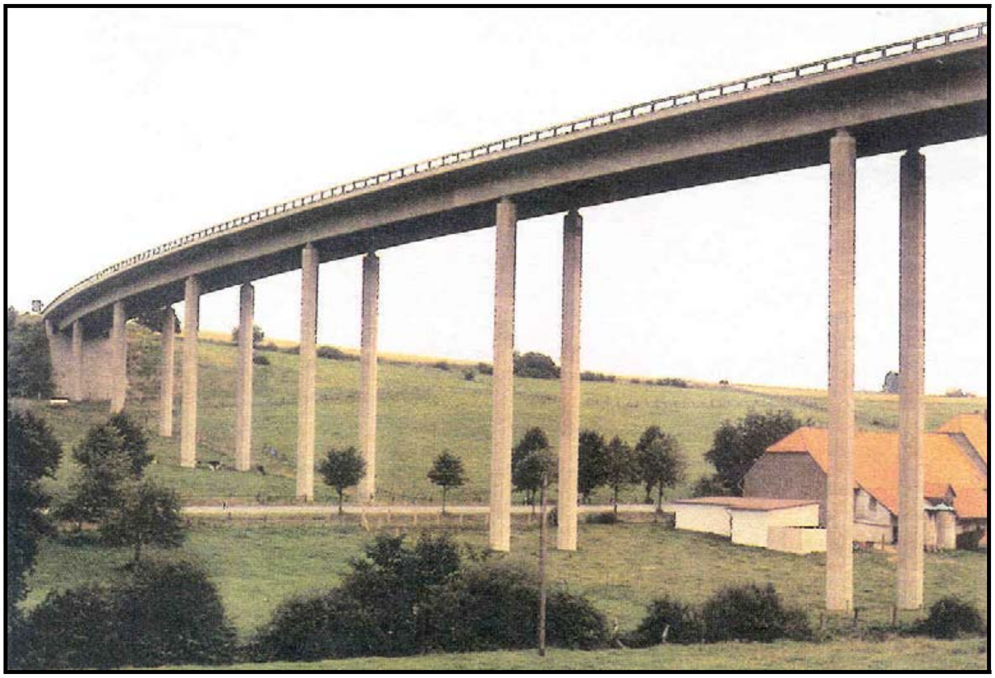


Fig. 4.33
This example solves the height variation problem by keeping things simple, at the cost of a lack of interest. Hammerheads might have been a better choice.

Fig. 4.34
The differences in pier sizes overwhelm the attempt to maintain consistency through the use of similar shapes. The result is a mismatch.

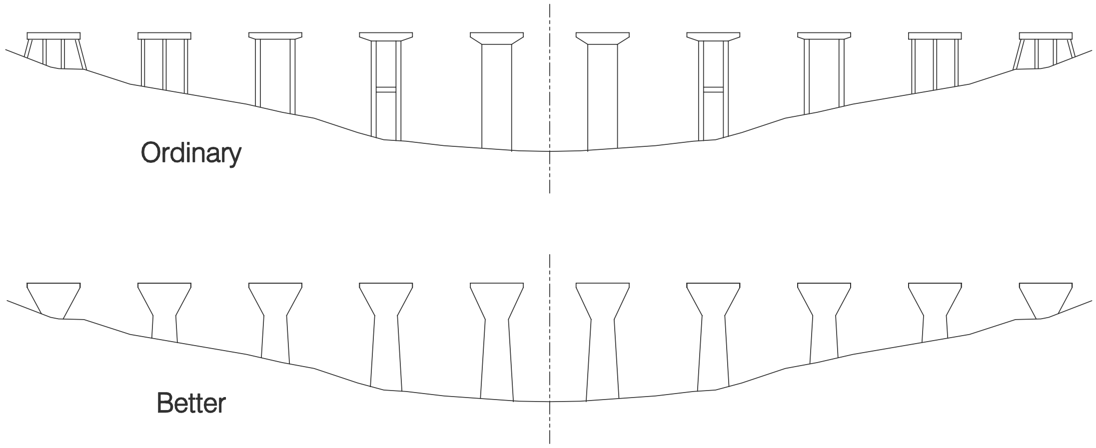


Fig. 4.35 Families of piers varying by height

An even more difficult problem is introduced when a bridge varies in width over multiple spans, or branches, as when a ramp leaves a main line. Alternatives for this situation are:

- *Hammerhead piers, with the wider piers essentially being a series of hammerheads placed tip-to-tip. As the bridge widens or branches, it is a fairly simple matter to add another hammerhead to carry the additional structure. The side-by-side hammerheads can be connected structurally to improve their efficiency without changing the basic concept or its visual impact. Since they then become rigid frames, their shape continues to be consistent with structural logic.*

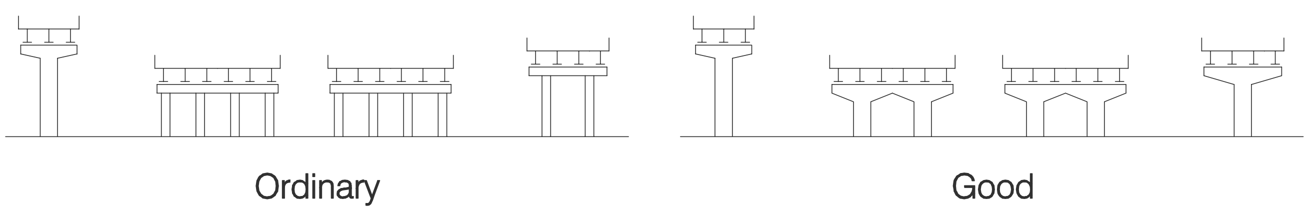


Fig. 4.36 Families of piers varying by width

- *One-Column-per-stringer. More stringers are handled by just adding more columns. The major difficulty with this approach is that, with closely spaced stringers or piers with slight skews, it can quickly get out of hand and degenerate into a maze of columns.*

- *Integral pier caps have major visual advantages in this situation. The bridge becomes a structural ribbon riding above a few simply shaped columns, with considerable flexibility in their placement on the ground. However, major functional problems may be created.*

4. Nuances of Pier Shape

Shape piers at the top to reflect their function: bearing or moment connection.

Naturally, the majority of the time it will be the bearing connection.

Where appropriate, as part of the overall design, columns can be made to appear thinner by breaking them up into multiple surfaces with vertical facets, curves, scallops or incisions. The technique used should be consistent with techniques used for other elements of the structure (Figs. 4.37, 4.38 and 4.39).

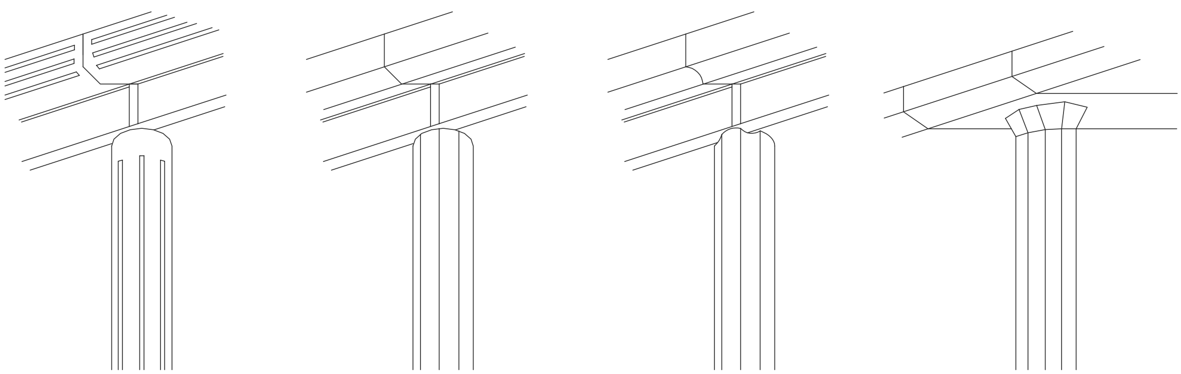


Fig. 4.37 Sample techniques for making piers appear thinner; note consistency with parapet patterns

Fig. 4.38
An example of an attractive pier design. (Rendering of MD 450 over Severn River, Anne Arundel County, MD)

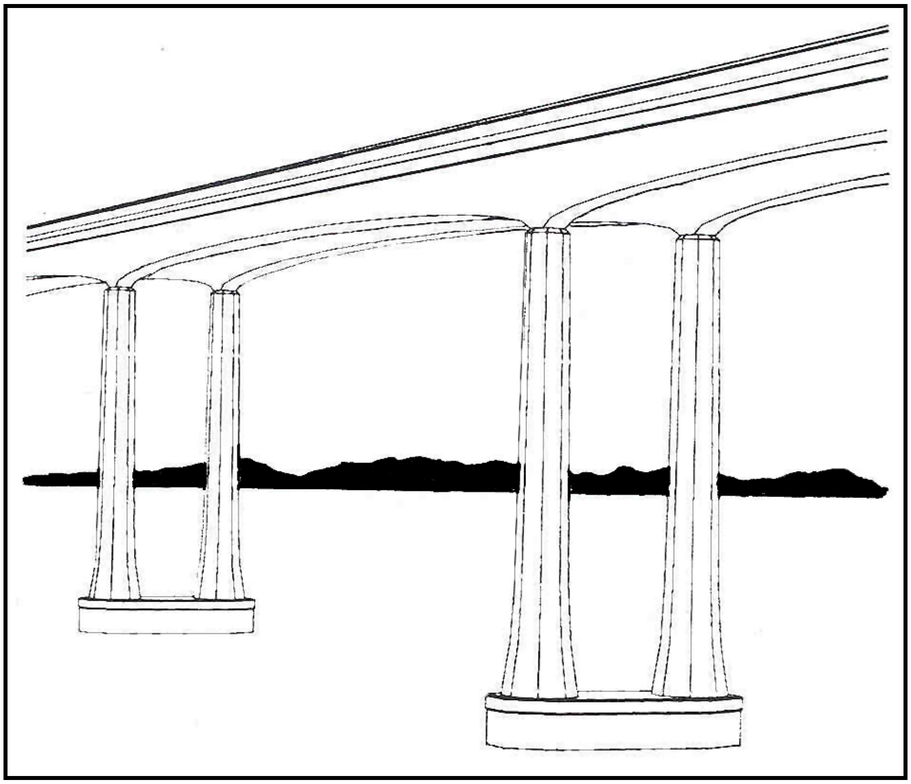


Fig. 4.39
Champagne piers with parapet. (I-95/I-495 Interchange, Prince Georges County, MD)

The connection between pier and superstructure is as crucial to the appearance of the bridge as it is to its performance. The connection should be designed to make clear its structural function, which means that a connection with a bearing will look noticeably different than a moment connection. The discussion on this subject in Chapter III - Superstructure calls for the bearings to be pronounced in order to accentuate the horizontal sweep and apparent slenderness and lightness of the superstructure. This applies to piers. With abutments there are two schools of thought. However, Maryland has the policy of covering bearings at abutments unless special bearing types are utilized. The top of the pier cap can be chamfered to assist in this effect. This shape also reflects the stress transition from the small base plate to the larger area of the pier.

These recommendations also bring the pier to a clear visual termination, so that it does not appear to be a short piece of a longer shape (cylinder, etc.) that happened to be sliced off by the superstructure.

Avoid pilasters at pier caps.

Pilasters or closure walls were sometimes utilized on pier caps to hide the bearings. They have the effect of interrupting the horizontal sweep of the bridge, breaking it up into segments which then appear thicker than they otherwise would (Fig. 4.40). Since the bearings are hidden, the viewer is left in doubt as to how the bridge is held up.

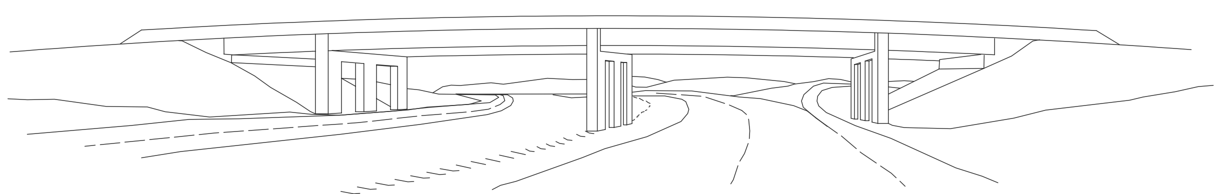


Fig. 4.40 Pilasters break up a bridge superstructure and make it appear thicker.

5. Pier Protection (Fig. 4.41)

When a pier is in a median or next to a shoulder and the required recovery area is not available, protection for errant vehicles must be provided. The standard solution is the use of traffic barrier, which introduces still another element into the visual field while changing the appearance and proportion of the pier. Better solutions should be pursued and quite often can be found.

Consider the use of a tapered mound to redirect vehicles; the design of the pier should reflect the change in proportions which will result (Figs. 4.09 and 4.41). However, the mound can only be used on a sufficiently wide median.

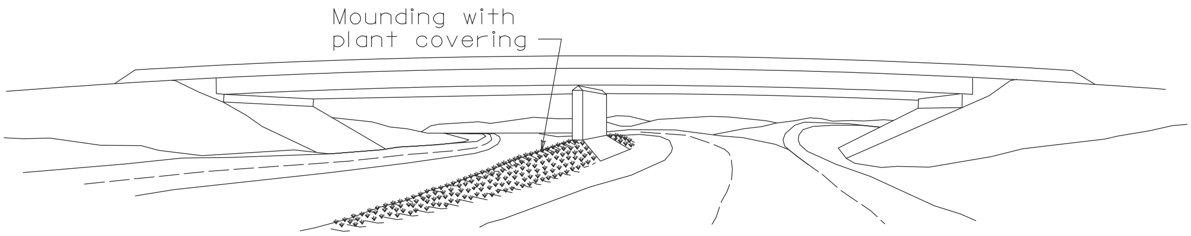


Fig. 4.41 The desirability of integrating protective devices into the pier design

Integrate the pier design with an F-shape barrier.

Quite often an F-shape-shaped pier base will be incorporated into the base of the pier and the traffic barrier will be bolted to either end to eliminate the opportunity for a vehicle to hit a blunt end. A better approach should be to evaluate how much approach traffic barrier is really required; if it is minimal, then just extend the F-shape barrier of the pier until no barrier is required (Fig. 4.42). Look into eliminating the trail end on shoulder piers for dual highways.

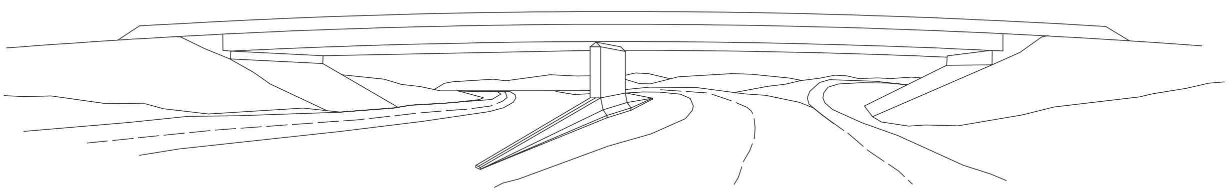


Fig. 4.42 Extending F-shape barrier of the pier

Similar approaches should be developed for protective devices at full height abutments, retaining walls and wing walls that are within the safety grading limits.

B. ABUTMENTS (Figs. 4.43 to 4.46)

The function of the abutment is to support the bridge at each end. Its visual job, as well as its structural job, is to mediate between earth and structure. The "correct" decision for an abutment depends on the designer's overall aesthetic concept for the structure. There is no single abutment which suits all structures. Therefore the following statements are made not as recommendations but as alternatives with their inherent consequences.

Fig. 4.43
The bridge ends abruptly at the wing wall, which also bends abruptly and ends suddenly. If the wing wall had followed the line of the parapet, both problems could have been avoided. The pier eliminates the pier cap problem. (Ramp over Owings Mills Boulevard, Baltimore County, MD)

Fig. 4.44
This example shows the effect of different lighting conditions on using a slanted parapet facet to carry the superstructure shadow line across the abutment. A sizeable recessed area or overhang is necessary to make this work over a wide variety of light conditions. (McDonogh Road over I-795, Baltimore County, MD)

Fig. 4.45
A large overhang carried across the abutment creates a strong shadow line and extends the apparent length of the bridge.

The possibilities vary from massive cantilever walls to minimal pedestal abutments perched on the edge of the embankment. The higher the placement of the abutment on the slope, the lighter and less prominent the bridge will appear; the greater the abutment height with its associated lower placement on the slope, the more anchored and heavy the bridge will appear, and views through short to medium length bridges will tend to be framed, or, at the extreme, enclosed.

For larger bridges, basic abutment placement and height will be a function of pier placement and span length throughout the structure, and thus will be a function primarily of structural and cost considerations, though visual concerns should play a role. However, for short bridges and highway overcrossings, the specific placement of the abutment is crucial to the appearance of the bridge. More detailed discussion of abutments for these types of bridges may be found in Chapter VII – Highway Bridges over Highways.

Some general guidelines for height are:

Minimum exposed abutment height (H) = 1/2 girder depth.

Otherwise the abutment will not look big enough for its function.

Maximum exposed abutment height (H) = 1/3 height of first pier and/or vertical clearance.

The point at which the abutment starts to be a dominant element is when H is greater than 1/3 the maximum clearance under the first span. Heights greater than that should be avoided unless a visual dominant abutment is a desired feature (Fig. 4.46).

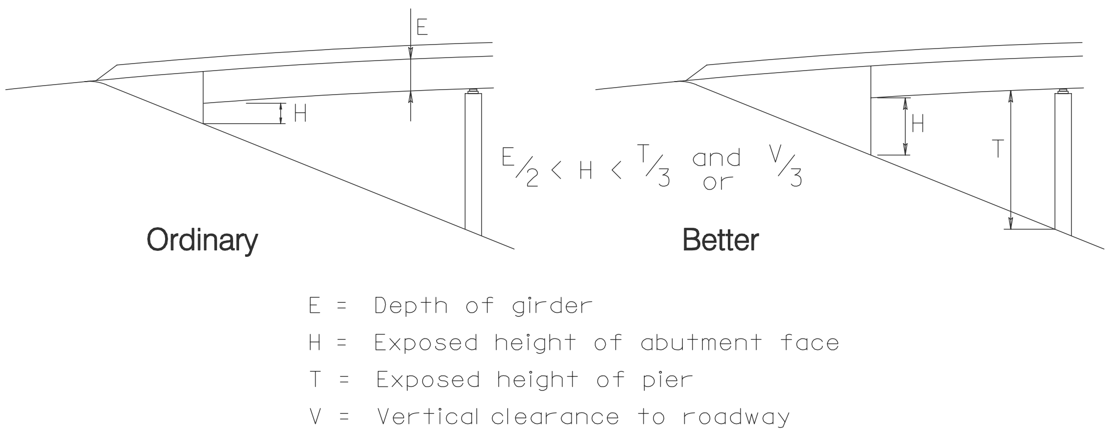


Fig. 4.46 Relation of abutment height to end span height

Carry the parapet profile across the abutment. Carry as much of the deck overhang as feasible across the abutment.

Landscaping at Abutments:

Landscaping at abutments can become a major determinant of the visual impact of the bridge, particularly for small abutments (H < 1/2D). Abutments of this size can be obscured by landscaping after a few years of growth. Whether this is good or not depends on the designer's overall concept for the bridge. In one- or two-span bridges, hidden abutments will leave the viewer with doubt about how the bridge is supported (Fig. 4.47). Bridges of three or more spans may give the impression that the end span is cantilevered, particularly if the end spans are also tapered, and thus make the apparent lack of an abutment more logical.

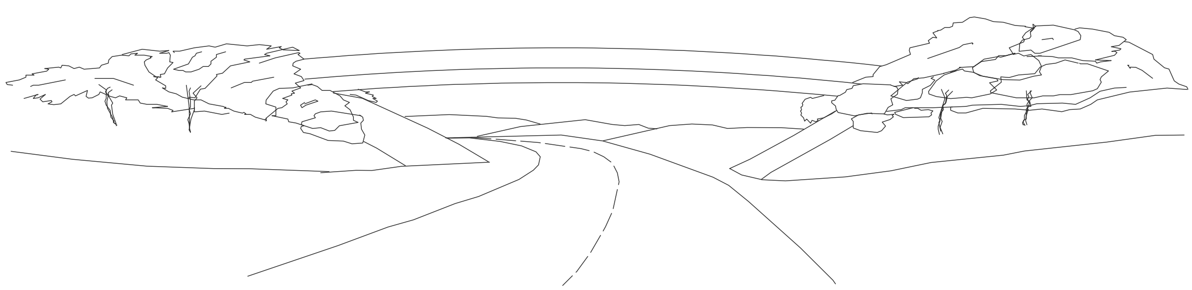


Fig. 4.47 The effect of abutments hidden by landscaping

As a first choice, align wing walls with the upper roadway (Fig 4.48).

Abutment wing walls should generally be aligned with the upper roadway. This makes the bridge seem longer and provides a logical place to tie in pedestrian screen and traffic barrier W beam. However, structures on extreme skews can generate wing walls which become quite long. One solution to this problem is to have the wing wall bisect the angle between the crossing features, which will shorten the walls. However, it also leaves narrow triangular areas top and bottom which are difficult to plant and maintain, and require additional traffic barrier W beam for the top roadway (Figs. 4.43, 4.49 and 4.50).

Align abutment wing walls with the parapet of the upper roadway where possible.

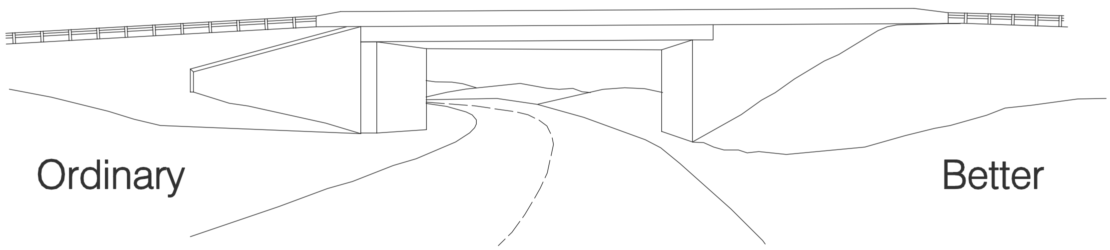


Fig. 4.48 The wing wall should usually follow the upper roadway.

Fig. 4.49
Too many unintegrated elements: The top of the wall is on a different line from the parapet/superstructure; there is a break in the wall height; the wall has a different pattern which confuses the viewer; the sign structure footing is different still; and the drain looks like an afterthought. (I-97 NB under MD 3 to join MD 3, Anne Arundel County, MD)

For extreme skews, align the wall with the lower roadway, then flare it to a logical end *with a graceful curve (Figs. 4.50 and 4.51).*

Fig. 4.50
Wall alignment is good. An illustration of how difficult it is to get patterns to "read" in the highway environment; this one fades away after the first few panels. (I-97 over MD 32, Anne Arundel County, MD)

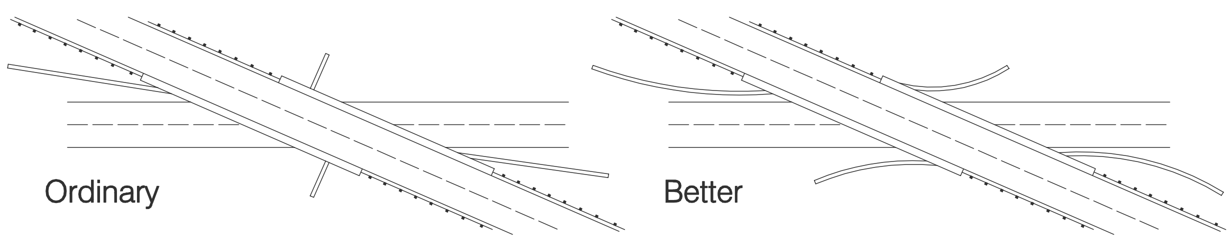


Fig 4.51 Wing walls on a heavily skewed structure should parallel the upper or lower roadway.

Although the most economical arrangement is to bisect the angles of skew, walls parallel to the roadways are more appealing.

The parapet, railing and/or pedestrian screen come to their ends at the abutment. By carrying the overhang and parapet detail across the abutment, the apparent length of the bridge can be increased (Fig. 4.45).

Use continuity of the parapet detail, deck overhang, recessed area and/or changes in texture to emphasize parapet continuity across the abutment.

This matter is discussed in more detail in Chapter VII. Details for ending the parapet and pedestrian screen are discussed in Chapter III, Section E.

On structures with substantial parapet overhang, set the face of the wing wall to hide the bearing area and provide as much of the overhang as possible. If bearings are major structural elements, you may consider leaving bearings exposed (Fig. 4.52). If exposed, the width of the beam seat should be at least one half the girder depth. In most cases where normal bearings are detailed, Maryland covers the bearings (See Chapter III, Section D).

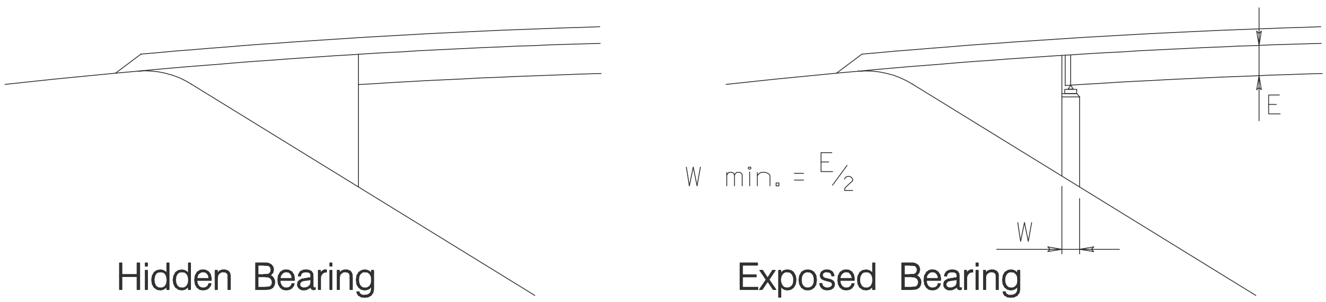


Fig. 4.52 Suggestions for exposed beam seats with significant bearings

Coordinate design with any adjoining retaining wall and/or noise wall (Figs. 4.49 and 4.50).

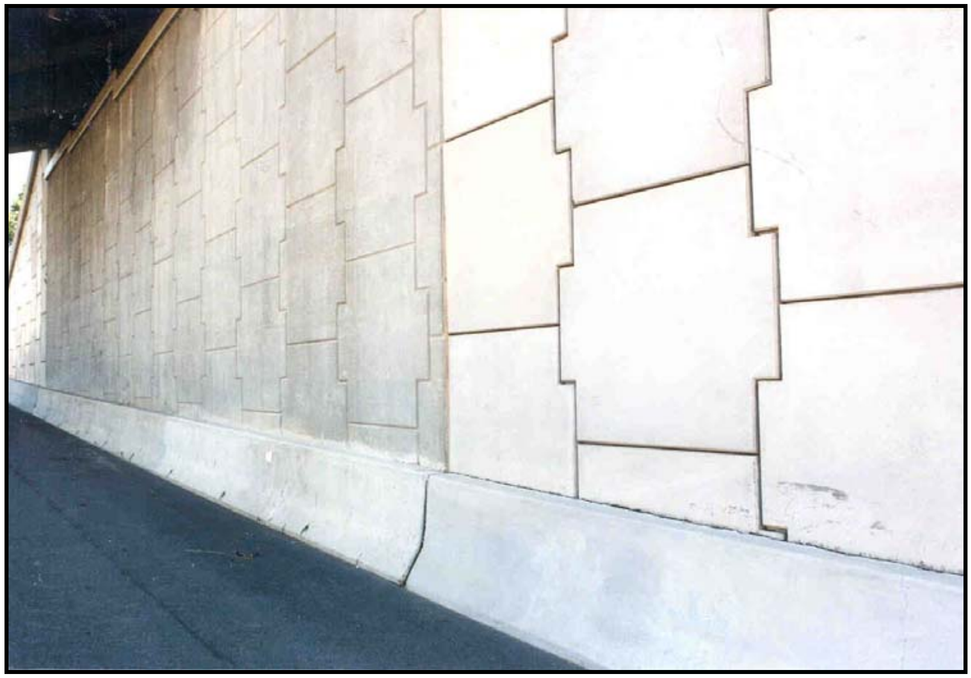
Structures often occur in proximity to retaining walls.

Abutments which adjoin retaining walls should be designed as a continuation of the retaining walls. The abutment should blend into the wall without abrupt changes in configuration.

Abutments constructed with proprietary wing wall retaining elements, which are a combination of precast and cast-in-place sections, present a special problem. The joint between the two prevents the wing wall from being seen as a simple continuation of the abutment. Unless the cast-in-place section is formed to mimic the precast section (a costly and probably unconvincing solution), a transition feature is necessary.

Trying to create the pattern of the proprietary wall in a poured element looks contrived (Fig. 4.53). The other alternative is to attach actual panels to the face of the poured abutment wall; though more costly, it will do the job. The transition should be at a logical location (perhaps at the expansion joint) and the joint detail should be a simple vertical feature, not a "toothed" reciprocal of the precast element (Fig. 4.54). See the discussion under Retaining Walls later in this chapter for more suggestions.

Fig. 4.53
(Ramp C over I-95, Prince Georges County, MD)



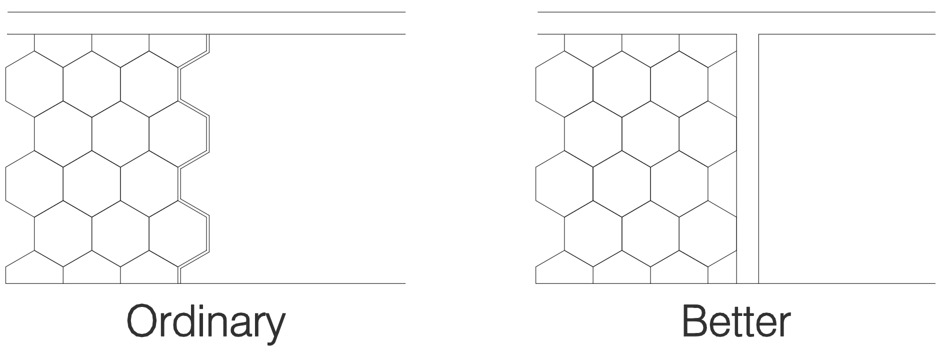


Fig 4.54 A clean joint between poured-in-place and proprietary precast sections of an abutment

Lay out the plan and elevation to scale of the entire abutment and any adjoining retaining walls all on one view. Do not break any elements in the vertical or horizontal direction.

Recognize and organize expansion, contraction and construction joints.

All lines should bear some obvious relation to the main lines of the structure. For instance, a vertical expansion joint in the abutment wing wall will show as a line in the wing wall face. Any pattern for the face should incorporate this line in the overall appearance. The most critical area is where the abutment face intersects wing walls and/or retaining walls. This can become a disjointed and unattractive element if it is not handled properly.

Keep surface treatment of abutments consistent with parapet details and pier design; any pattern should have an obvious relation to the main lines of the structure.

Surface treatment of abutments should be consistent with parapet treatments and pier design. For most structures the only abutment surfaces clearly visible will be the wing walls. Face walls are too foreshortened and usually too shadowed to be worth special treatment. Exceptions are unusually wide structures and bridges crossing city streets or pedestrian areas.

The first step is to recognize the basics.

For medium to high abutments an opportunity exists to draw attention to the abutment. One must decide whether to do that, and why. In most situations, it is better to keep the attention on the superstructure first and piers second. In any case, simple is usually better than complex.

More ideas on surface treatment can be found in Chapter V on surfaces. Abutments are discussed in detail in Chapter VII.

C. RETAINING WALLS

As a first order of work, a sincere effort should be made to eliminate or minimize the size of any proposed wall.

Changing grading slopes, altering over ambitious clearances, etc. can do wonders in wall eliminations and reductions.

Retaining walls are often major elements in the visual field, and thus can have significant aesthetic impacts. The key to success in designing retaining walls is in determining the overall shape and geometry of the wall. Surface treatment and color, while important, are secondary to the first two concerns.

Align walls parallel to the major adjoining roadway or place on a curved line in some clear and convincing relationship to the adjoining roadway.

The top of the wall should be a continuous smooth curve related to the topography (Fig. 4.55). However, in uneven situations that could cause many variations it may be preferable to carry walls of a constant height in longer sections.

The wall, when laid out, should be viewed in a natural scale, and slight changes in top profile should be eliminated. Letting the wall follow the need, based on existing ground locations, will result in a disaster (Fig. 4.56).

The profile of the top of the wall should be developed into a continuous straight line or smooth curve, and grading should be varied to fit to the top of the wall. Do not use sharp breaks or chorded curves. These can be eliminated by a smooth cap. Dips in walls should be avoided.

Where an elevation difference between adjacent roadways is accommodated by combining a slope and a retaining wall, the retaining wall should usually be located at the top of the slope, parallel to the upper roadway, in order to maximize the "space" of the lower roadway.

Fig. 4.55 The visual benefits of a smoothly curved alignment and profile

The endings of walls are very important. Abrupt turndowns with no effort made for a pleasing transition will be very evident (Fig. 4.57). Copings that look fine for the normal section of walls could look totally out of proportion at the ends of walls, where the height diminishes. This effect must be carefully addressed.

Fig. 4.56
The surface treatment is acceptable. A capping would have helped and a rounding of the break area at top would have been an improvement. (Dulaney Valley Road, Baltimore County, MD)

Fig. 4.57
Abrupt change in elevation with no effort made for a pleasing transition. (Ramp F over I-97, Anne Arundel County, MD)

Patterns for retaining walls seen primarily from a moving car must be large enough to be recognized at highway speeds; minimum element size is four inches.

The first step in surface treatment is to recognize and organize the expansion, contraction and construction joints. Beyond that, it is hard to generalize about the infinite number of possibilities. One point is clear: studying the pattern on elevation drawings is misleading if the wall will be seen primarily from a moving car. The wall will be seen as if it were on a vertical scroll unwinding in the peripheral vision. This leads to some specific observations.

Any line which is not parallel to the lower roadway, horizontal, or vertical, will be very prominent. Lines which are close to but not identical to the roadway geometry will be particularly noticeable.

Patterns which repeat abruptly and continuously at intervals of about 0.25 to 1 second at the prevailing speed--12 to 50 feet at 50 mph--will be annoying and quickly become monotonous. Patterns at shorter intervals will become a textural blur. Longer patterns such as every 200 feet will be viewed as adding variety, unless they are repeated too often without change.

Any pattern must consist of elements which are large enough to be seen at highway speeds (Figs. 4.56 and 4.58). Colors and textures are discussed in detail in Chapter V.

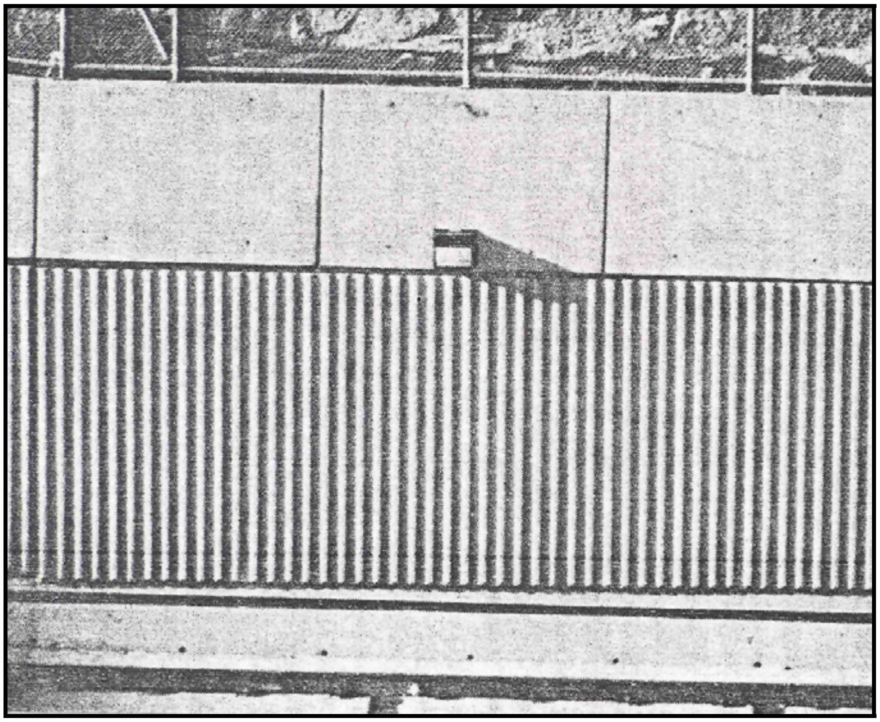


Fig. 4.58
Retaining wall texture bold enough to be seen at high speed or from a distance. (Boston, MA)

If you want a specific design to be recognized, it must be significantly elongated horizontally to compensate for perspective foreshortening. (This same principle is used in designing pavement numbers for traffic engineering.)

Copings and/or Capping:

Copings can do wonders to give a wall a finished look. The depth of copings is extremely sensitive to the height of the wall and may have to vary to obtain an attractive appearance, especially near the ends of walls (Figs. 4.59 and 4.60).

Fig. 4.59
A good example of coping which is in proportion to the size of the wall. However, the appearance would have been improved if the changes in height had not been so abrupt. (I-270 NB, Montgomery County, MD)

Fig. 4.60
An example of coping which is not in proportion to the size of the wall.

Drainage:

> *Drain holes at the base of the wall should be detailed in a consistent and logical relationship to the surface pattern and, if possible, be recessed in the wall pattern. It is quite possible to hide the drain in a grooved face. If the wall is to have alternating groove and flat areas, the pattern of drainage can be modified to satisfy the structural requirements and the appearance.*

Parapets, pedestrian screens and noise walls on retaining walls should follow the same rules as for bridges; if a bridge adjoins a wall, the parapets and screens should match in type and height.

When utilizing walls consisting of precast elements, a cast-in-place cap should be used to achieve a smooth, curved top profile.

Retaining walls constructed of proprietary repetitive precast elements offer special advantages and disadvantages. As before, the most important thing is to provide a smoothly curved alignment and minimally changing top profile. A cast-in-place cap can be utilized to achieve a finished look and a smooth curved alignment. The units themselves will create a unique pattern which will read as a texture in the highway environment. This can be made more noticeable by creating protrusions, recesses, exaggerated edges and/or exposed aggregate in the precast units.

A difficulty comes in having to provide for alternative bidding by manufacturers with different unit shapes. A design predicated on a hexagonal unit may be a different thing entirely if applied to a cruciform unit. If alternate bidders must be accommodated, the challenge will be to develop a design which applies equally well to all potential bidders. Alternatively, if a specific appearance is particularly important, bids should be restricted to manufacturers with compatible units.

If a series of walls will be seen on a section of road, the specifications should spell out that all the walls shall be supplied by the same proprietary firm. A real problem exists when a whole new route is to be advertised in separate contracts, where walls are required in each portion of the route, and where consistency for the entire route is desirable.

Where precast unit walls adjoin poured walls, care must be taken that the pattern and color of the poured wall is compatible with the precast wall. The joint should be a simple vertical element, not a reciprocal shape to the precast elements.

Precast concrete crib walls, derivatives using larger precast units which can become planting boxes, and gabion walls offer another type of alternative where space permits. A smoothly curved alignment (within the restrictions of the unit size) is again a requirement. However, the dimension of the units usually prevents a smoothly curved top profile. On the other hand, the open nature of the construction offers possibilities for plant growth that can convert one of these walls into a kind of hanging garden. In fact, these options should be used only where this kind of planting can be achieved. Then the top can be stepped back in a logical pattern related to the topography, and each step can be made a platform for further planting.

D. NOISE WALLS

It is always a challenge to locate noise walls in the highway environment while maintaining the aesthetic character of the roadside. By their very nature, noise walls are imposing structures which must be high and long enough to intercept traffic noise before reaching the adjacent receivers (residences). To achieve the optimum acoustic performance, walls are generally positioned close to the roadway in fill sections and near the right-of-way line in cut sections. The transition of noise walls between the cuts and fills is often visually awkward. Control of the horizontal alignment is particularly important. Designers find themselves with flexibility to follow the local drainage flow lines or property lines, since it is usually not necessary to parallel the highway alignment. This often results in a jagged alignment which seems to abruptly move into and away from the roadway and has an inconsistent relation to the topography. In addition, since the walls follow the terrain, they must be stepped. Care must be taken to avoid irregular stepping of panels or abrupt sumps in the top profile.

Layout:

Align noise walls in long smooth curves related to major topographical features and/or the roadway geometry, as a first choice.

In areas where a large amount of right-of-way exists, the use of a berm should be considered. A berm can help reduce both the costs and the dominating presence of a noise wall.

If the wall is a proprietary wall which depends on a zig-zag alignment for its stability, then the overall alignment of the wall should be established in smooth curves.

Profile the top of noise walls in long smooth curves or regular consistent steps with a minimum of height variation (Fig. 4.62).

The wall should be laid out with the proposed post spacing to determine the wall profile. In areas with large gradient changes, large post spacings can make for some unsightly panel stepping and thus may warrant a smaller spacing.

The overall profile of the wall should be reviewed after the acoustical profile is established. If at all possible, long runs of the same top element should be created, and when vertical changes are required, they should be stepped in uniform, small steps.

Care should also be taken when ending noise walls. Noise walls shouldn't end abruptly, but rather the height should be tapered down over several panels. Another option for ending the wall is to flare the end of the wall away from the roadway with a gentle curve.

If a stacked panel system is chosen, instead of a single panel system, the horizontal joint created between the stacked panels should be continuous. This may not be prominent if the wall is to be stained, or horizontal textures are introduced into the finish.

Surface Treatment:

The guidelines for surface patterns and texture for retaining walls apply to noise walls too. (See Chapter III – Substructure and Chapter V – Colors and Textures.) However, unlike retaining walls, noise wall textures often serve an important purpose, noise reduction. There are two general categories of noise wall surface treatments: absorptive and reflective finishes. Absorptive surfaces are made with baffled faces or sound absorbing materials such as wood chips. When an absorptive face is needed, care must be given so that function and beauty are both achieved.

Noise wall surfaces also present an opportunity to be creative and innovative by utilizing formwork which creates scenes, logos, figures of wildlife and human figures in action.

When panelized systems are used with a prominent post every 12 to 20 feet an unfortunate repetition of closely spaced verticals is created. Systems which visually deemphasize the post are preferable (Fig. 4.61).

Landscaping:

Since these walls are difficult to make attractive, we should utilize elements to hide them, namely landscaping. Trees, shrubs and vines can turn a dull repetitive structural element into a pleasing, varying attraction. Care must be taken to select shrubbery, etc. that will give year-round beauty and not just in the growing seasons (Fig. 4.63).

Fig. 4.61
This panelized system features a prominent post. The top of the wall is stepped in an inconsistent manner. (Noise Wall along I-695, Baltimore County, MD)

Fig. 4.62
Noise wall with even stepping. (Noise Wall along I-695, Baltimore County, MD)

Fig. 4.63
This noise wall is placed with a zig-zag alignment for stability. Landscaping has been done in front of the wall to hide it in future years. (Noise Wall along I-695, Baltimore County, MD)

Special attention should be given to noise walls on structures as they present their own special problems.

> *Not only must the wall be noise-proof but it must now, if at all possible, be light in weight, compatible in appearance with the adjacent ground-mounted barriers at the bridge it is mounted on, and be easily mountable on structural elements that are supporting highway loadings. This combination of factors is especially difficult when modifying existing bridges (Figs. 4.64 and 4.65).*

If possible, every effort should be made to maintain a uniform height across the full length of the structure.

> *Care must be taken when ending the barrier on the bridge so that the transition area to the ground-mounted wall is pleasing in appearance and does not create a safety hazard for an errant vehicle that has come in contact with the approach guardrail. When placing a noise barrier on a structure be sure that its appearance is evaluated from both sides, one as the driver on the bridge and the other how it effects the "elevation view" of the entire bridge (Fig. 4.66).*

Fig. 4.64
Noise wall added to existing bridge structure. (I-695 over Edmondson Avenue, Baltimore County, MD)

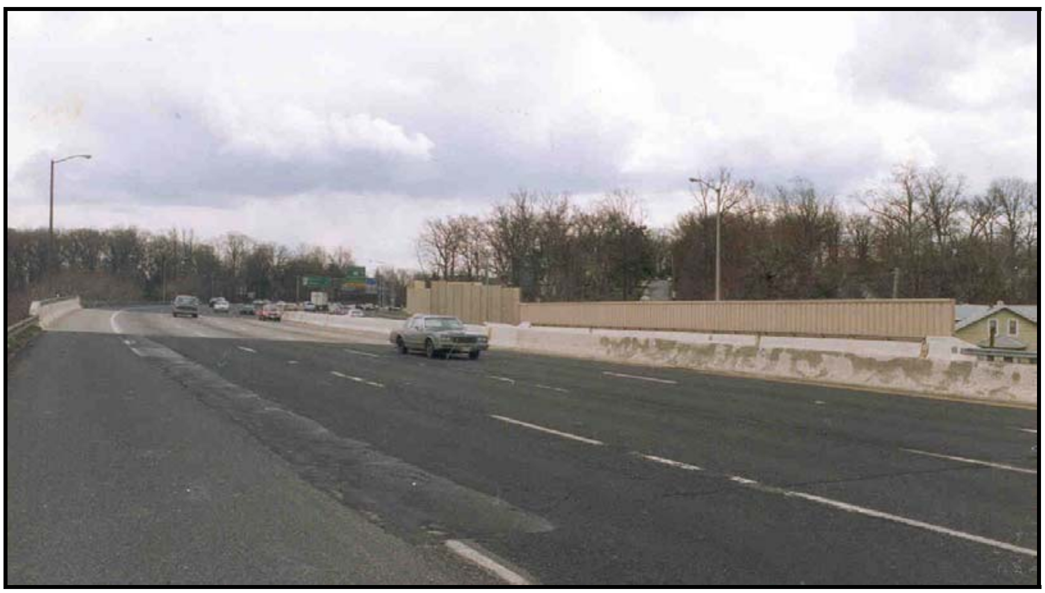


Fig. 4.65
Noise wall as part of the initial design. (I-795 over Gwynns Falls, Baltimore County, MD)

Fig. 4.66
Elevation view. (I-695 over Edmondson Avenue, Baltimore County, MD)

V. COLORS AND TEXTURES

The purpose of color and texture in the design of a structure is to further enhance the aesthetic impression of the structure's overall form and the shape of its major components.

While the strongest determinants of the visual impression of a bridge are the shapes of its major elements, the surfaces of those shapes can, through color or texture, alter our perceptions of them -- for both better and worse.

The application of special color or texture treatments is <u>not necessary</u> for the creation of a good-looking bridge.

Structural materials have their own characteristic color and surface finish. Appropriately shaped materials in their natural state can create an aesthetic bridge without the use of additional treatments. Color and texture are sources of enrichment and interest which can enhance a good structural design. The designer must decide whether to leave each structural material as is or to add some additional color, texture, or other surface treatments.

The techniques discussed in this chapter offer possibilities to enhance the form and appearance of the structure as long as the effects produced are consistent with the overall structural form. However, if the basic form is unattractive, attempts to correct it through applications of surface treatment, no matter how elaborate, are doomed to failure.

The two major goals of color, texture and other surfacing materials used for the enhancement of a bridge's aesthetics are:

- **To create a positive response from the viewer.**
- **To differentiate the various parts of the structure's lines so that the structural form and shape is clarified and enhanced.**

Creation of a Positive Response:

The selection of surface treatments should be influenced by surrounding environmental features, historical context and community traditions. The designer must consider who will view the bridge and how they will view it. The colors and textures may also be a component of a theme being developed for a community, route or group of structures. If the bridge is illuminated for effect as opposed to lighting for traffic, nighttime *conditions should be considered (Fig. 5.00). These can include the exaggeration of shadows and textures, depending on the location of the light source (or sources), and changes in apparent color caused by the color effect of different types of lighting. For example, mercury vapor and metal halide lighting will bring out blues and greens while other colors become dulled and grayish; high pressure sodium lighting will bring out reds and oranges, while blues and greens will become dulled and grayish.*

Highway elements are not generally intended to be the focus of a given area. As background structures, they are generally better kept simple with subdued colors. This does not mean that a surface should seek to be identical with surroundings, for example, a green bridge in a forest. Contrast is often the better choice, but the contrast should work well within the surroundings. (See Figs. 5.01, 5.02, and 5.03 for a comparison of the same bridge with colors which contrast with and blend with its environment.)

However, there are notable exceptions to this rule where the structure is meant to stand out in stark contradiction to its surroundings, such as when the bridge is in fact a dominant feature in the landscape, a gateway to an area or a landmark. Ridge Road over I-70 is such an exception (Fig. 8.01).

Fig. 5.00
The effect of lighting on the colors of a bridge and the viewpoint of observers of the lighting should be considered. (United States Naval Academy Bridge, Anne Arundel County, MD)

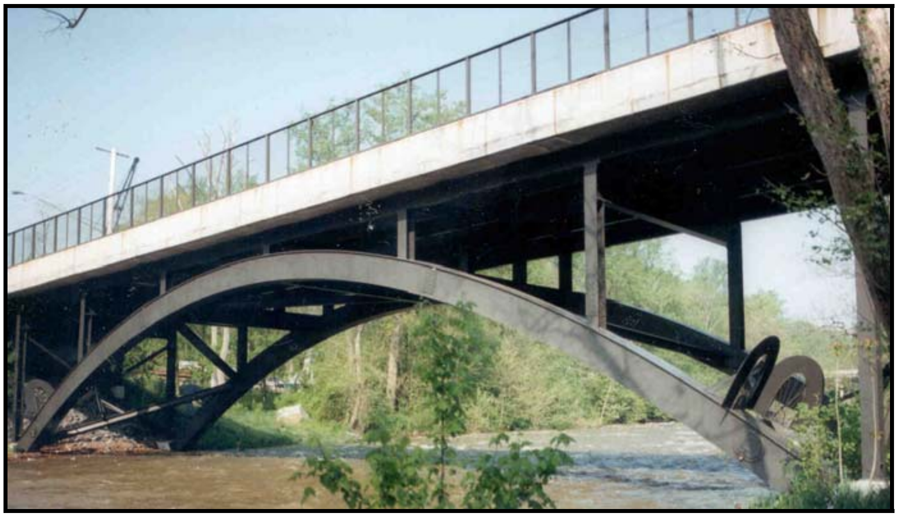


Fig. 5.01
Fig. 5.02
Fig. 5.03
Photos of the same bridge painted three different colors gives an unusual opportunity to make a judgement on color itself. Which version do you think looks better? The photos were taken at different seasons of the year and different times of the day, which complicates things a little. (MD 7 over Gunpowder River, Baltimore County, MD)

Differentiation of Components to Enhance Structural Form:

Color can be used in ways which go beyond surface protection. By using different colors for different parts of a structure, the structural form can be enhanced and underlined. The Victorians carried this to an effective extreme in their iron structures, right down to a different color for the bolt heads (Fig. 5.04).

Fig. 5.04
Different colors for different elements give this bridge a striking appearance. (Guilford Avenue over I-83, Baltimore City, MD)

The orientation of the bridge should also be considered. Features depending on the creation of shadows for their effect will work better on surfaces facing south, east, and west. Colors will appear brighter on south facing surfaces, and, for half the day, on east and west facing surfaces. They will also fade faster on these surfaces.

The degree of maintenance is another major consideration in the coloring of structural components. The designer can count on steel being repainted periodically, though perhaps not in an exotic color or pattern. It is unlikely that concrete will be recoated. Textured or colored concrete in locations subject to vehicular impact is a particular problem, as it is almost impossible to repair it to match the original.

A. COLOR

1. Differences in Materials - Concrete vs. Steel

There are significant differences in the application of color to steel as opposed to concrete.

Steel gives an opportunity to use colors in many ways, dramatic or conservative.

With steel bridges, a wide variety of colors are available in paint, quality control is relatively easy to achieve, and the need for periodic repainting for maintenance reasons means that the color will be periodically renewed.

None of these factors apply to concrete.

2. Coloring Concrete

There are three possible approaches to coloring concrete: 1) Integral coloring; 2) Staining, and; 3) External coatings. Integrally colored concrete is the most durable, but the colors available tend to be limited, and generally members of the earth-tone family. Quality control for integral coloring is crucial, and can be difficult to achieve from one batch of concrete to another. Staining concrete is another possibility, though the range of pigments is limited, and may produce a mottled effect. This technique is really only useful when the mottled effect is desirable. Both the integral coloring and staining techniques create color and texture matching problems if later maintenance patching becomes necessary. External coatings are also available and can be quite durable if correctly applied.

A problem with all concrete color techniques is that the basic pigments are not durable. Since it is not necessary to recoat concrete for maintenance reasons, that means that the material will continue to exist in its faded condition. The earth tones and blues tend to last the longest; reds go the quickest.

In addition, because of the variance in concrete production, sources of materials, etc. variations in the finished product are usually evident.

Basically, avoid coloring concrete; if color is strongly desired, consider a coating in an earth tone.

Where a special structure requires strong, permanent colors as part of a surface design in concrete, a better approach is inlays of material with permanent, characteristic colors. Examples are terracotta tile and glazed ceramic tile. These are available in a wide variety of colors, and have a successful centuries-old history of exterior use in architecture.

3. Protective Coatings of Concrete Portions of Structures

The final color of coatings must be evaluated with respect to the rest of the structure. Compatibility and not contrast should be the goal.

If only portions of an element are to be coated, i.e. bridge seat areas, etc. it should be reviewed to be sure that it does not create an unwanted conflict (Fig. 5.05). In this same vein, coating one element and not another, such as a pier under an expansion joint and not under a continuous slab, may be correct maintenance-wise but can create an unacceptable and unsymmetrical pattern of colors.

Fig. 5.05
Partial coating of piers. (I-270 under MD 28, Montgomery County, MD)

4. Weathering Steel

The choice of weathering steel is a color decision as well as a structural and maintenance decision. The material starts as a medium brown but over a ten year period reaches a permanent dark brown. This color strongly affects all other colors used in the structure, but may fit in with a rural, park-like setting.

Some of the unfortunate by-products of weathering steel are that it significantly reduces the visual contrast between shadow and non-shadow areas and it is very difficult to inspect because the color conflicts with rusting. Moreover, until the surface stabilizes, runoff from it may stain everything below it. By then concrete piers may be streaked almost as dark as the steel. Either the runoff must be caught and directed away from concrete surfaces, or the concrete must be coated to protect it from staining.

5. Choosing Colors

When groups of structures are closely spaced, colors for each should be picked in relation to each other. This does not mean that they all have to be the same, but that they all have some discernible relationship.

Bridges located in the same viewing area should typically be the same color, except when an accent or contrast is consciously sought.

Certain settings may require special colors. Examples of this are bridges located near a stadium, park or school where a color scheme is already established. Also, bridges near large bodies of water may look better with brighter colors.

More flexibility exists in the application of color accents, which are defined as specific decorative devices covering a small portion of the bridge. For example, one might work a decorative pattern built around the colors of the University of Maryland into a parapet of a bridge in College Park. If a color covers only a small portion of any one element of the bridge, and it is clearly incorporated into a decorative pattern independent of the structural form of the bridge, much more latitude is available in the choice of colors. This can be a tricky business, however. Large-scale full color drawings are necessary to judge the effect, and professional advice may be indicated.

Consider the background the bridge will be seen against. For example, colors in western Maryland, a rough mountainous area, are often seen against wooded backgrounds or rock outcrops, while colors on the Eastern Shore, a flat sandy coastal area, are often seen against fields or the sky. Backgrounds in urban areas can be very site-specific, depending, for example, on the brick of nearby buildings or the green of a park.

General Color Selection Guidelines:

- **First consider whether there is a reason to color the concrete or give special attention to the color of the steel.**

- **Consider the background against which the structure will be seen and the context in which components are used within a structure when choosing colors. A decision must be made as to whether the desired effect is one of contrast or complement.**

Where a bridge is composed of varying main superstructure elements, such as prestressed concrete approach spans and steel main spans, special attention should be given to the colors. In most instances the concrete will remain unpainted. The designer must then determine if the steel should be painted a color to match the concrete, to create a strong contrast, or to be compatible with the concrete. Each site must be evaluated as *to the length of the various elements and their locations. If a bridge is predominantly concrete, and only one span of steel exists (maybe because of curvature, etc.) it probably would be well to make the steel match the concrete. On the other hand, if the bridge is a low level structure over water with a movable steel span, the sudden change of character of the bridge at the bascule area allows the steel to use a contrasting color if so desired.*

- **Full-hued colors (forest green, royal blue) tend to attract attention to the bridge, particularly if they contrast sharply with the background.**
- **Bright pastels and reflective metallic colors attract attention in almost any circumstance. Avoid colors like Dayglo orange which go with nothing in the environment and will attract too much attention to the bridge.**
- **Browns tend to blend in to most backgrounds except sky.**
- **Lighter colors tend to attract less attention but still have some vitality. Light colors result in stronger shadows, making any design which depends on contrasting shadows more effective. Dark colors "swallow" shadows.**

6. Pedestrian Screens and Railing

A pedestrian screen is less obvious when its color is black (Fig. 5.06). Black tends to lose itself against most backgrounds. A light gray color is also acceptable.

Fig. 5.06
The black pedestrian screen blends nicely. (Brightview Drive over I-97, Anne Arundel County, MD)

Railings are usually made of aluminum which for most bridges is satisfactory.

7. Bridge Mounted Signs

Because signs have strong characteristic colors, the presence of a sign, and its size, on a bridge should be taken into account in the color selection of the bridge.

The best solution, especially if the signs are very large, is to place them on their own sign structures if possible. In many cases, it also will be the more economical solution.

The mounting structure should be painted a color compatible with the bridge itself.

Where there is a band of color along the length of a structure and another element intrudes, keep the band of color consistent across the structure and the element (Fig. 5.07).

Fig. 5.07
Notice how the color stays consistent around the base of the light pole. (Cold Spring Lane over I-83, Baltimore City, MD)

B. PATTERNS AND TEXTURE IN CONCRETE

Concrete offers many possibilities for using various types of patterns through the use of form liners, custom formwork, panels and other devices. To a certain extent, there is no choice but to create some level of pattern in large concrete surfaces. The form joints and construction joints of the concrete will create a pattern, whether you recognize it or not. The result is likely to be much improved if you do nothing more than control these patterns through design, rather then leave them to the vagaries of the construction process. It is important, therefore, on contract documents to show exactly where they will appear rather than referring to some general note, so that their effect can be analyzed and adjusted, if needed, in the design process. The specifications for the construction of the bridge should also alert the contractor to the types of forms he can use so that he does not inadvertently add more lines to the pattern through the creation of the forms.

The keys to successful use of patterns are:

- **Make sure that the pattern is subordinated to, and enhances, the overall design features and proportions of the structure itself.**

- **Make the pattern large enough to be distinguished from a distance when it will be seen primarily from a moving vehicle on the roadway.**

A pattern can be as simple as a pattern of incisions based around standard form panel dimensions and concrete lifts. Possibilities beyond that include raised or recessed panels, ribs and indentations. Surface treatments (e.g. bushhammering, acid wash) are not generally successful in highway environments, since they cannot be read at highway speeds. These treatments tend to break down the concrete surface so that it becomes more porous and more susceptible to dirt and deterioration.

- **Horizontal lines should be continuous, and should either be level or follow the major lines of the roadway. They must be carefully controlled, as any irregularities will be immediately obvious (Fig. 5.08).**

Fig. 5.08
A bad example of horizontal lines. (US 1 over MD 43, Baltimore County, MD)

- **Textural elements need to be large enough to be read at highway speeds; a dimension of about four inches is necessary in elements such as grooves and recesses, and the grooves should be deep enough to create defined shadows.**

Form liners which seek to imitate brick or other natural materials are another texturing option for concrete structures. However, they are sometimes unconvincing.

There has been some recent success on I-270 with a form liner created from actual stones. The contractors were careful to line up the joints between adjacent panels, and the result is attractive (Fig. 5.09).

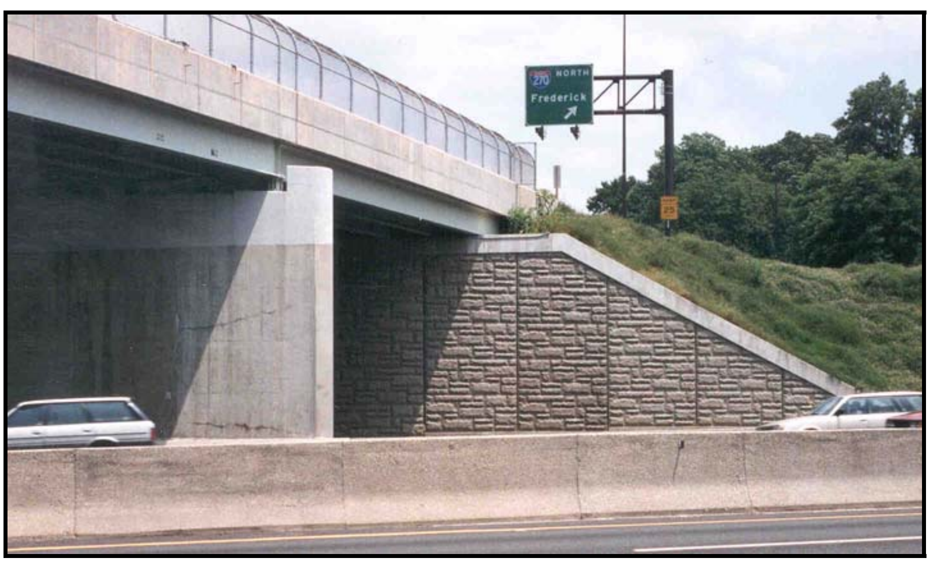


Fig. 5.09
Good use of form liners. (MD 28 over I-270, Montgomery County, MD)

Form liners which try to imitate small-scale detail, such as random wood boarding, are wasted at highway speeds, but may be applicable in areas where pedestrians circulate.

Surfaces in pedestrian environments, especially below the structure, have their own set of criteria, though they offer a wider set of possibilities. Decisions about them should be made based on the prior development of an aesthetic concept for the area. What is the predominant use of the area? Waiting for a bus? Walking to school? Sitting in the sun? How can the highway contribute to that use? For example, a surface created by fracturing protruding vertical concrete ribs produces many very sharp edges. It would be a bad choice adjacent to a tot lot, but might be a good choice to discourage graffiti artists.

What clues does the immediate area offer? Brick buildings? Fieldstone walls? Surfaces can be chosen which blend in or contrast, whichever fits the overall concept.

Finally, what will coordinate with other nearby highway structures? Once these overall criteria have been developed, it is time to approach the manufacturers' catalogues and other sources of information to review the possibilities available.

C. BRICK, STONE AND OTHER TYPES OF NON-STRUCTURAL FACING MATERIALS

Non-structural facing materials, such as brick, stone, and pre-cast panels, have been used to provide color or texture on surfaces. These find their most logical application for facings of abutments and retaining walls - circumstances which reflect their structural capabilities and historic use.

Of the various facing materials, random fieldstone appears to work best since its size and texture make it visible in the highway environment (Fig. 5.10). Precast concrete panels can work well. The major concerns are surface color and texture and the location of panel joints.

Fig. 5.10
Random fieldstone appears to work best since its size and texture make it visible in the highway environment. (M.V. Smith Rd. over US 48, Allegany County, MD)

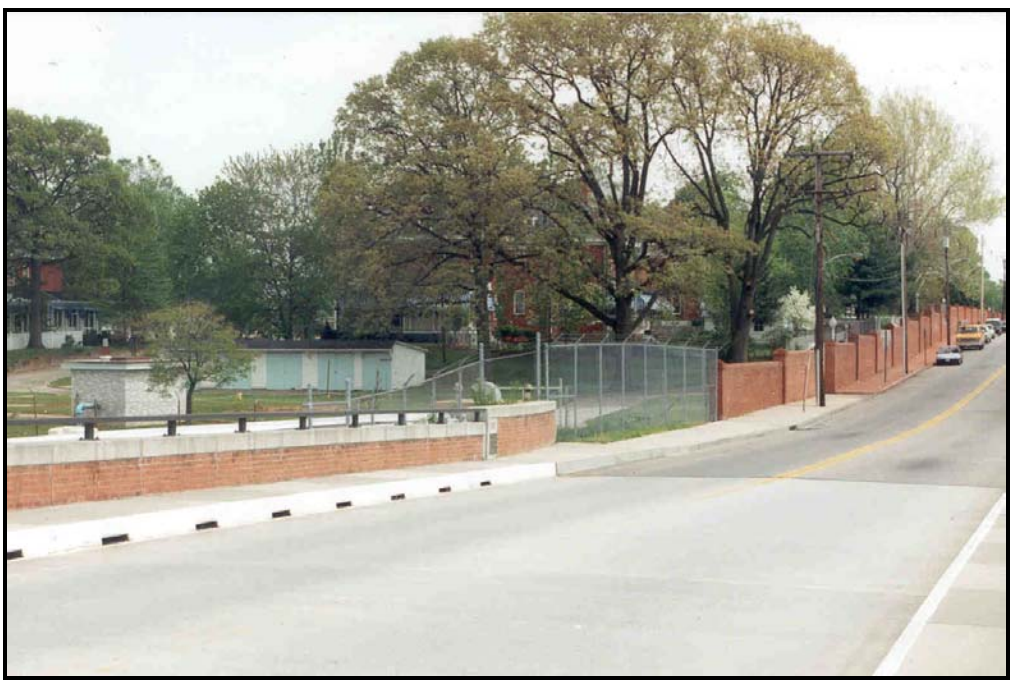


Fig. 5.11
Good example of tying into adjacent environment – U.S. Naval Academy in Annapolis. (MD 450 over College Creek, Anne Arundel County, MD)

Fig. 5.12
Brick-faced bridge in Annapolis. (Ridgely Avenue over US 50, Anne Arundel County, MD)

Brick with its mortar pattern is on the small side for highway uses, but can still add interest (Fig. 5.12). It is more appropriate to a pedestrian environment (Fig. 5.11). However, it may tend to bring the bridge structures in line with an historic area.

Color selection is even more critical with these materials, since the possibility of a future change is remote. Brick and concrete must be handled especially carefully, as the range of color choices is high, and the possibilities for an inappropriate choice multiply. With brick and stone, mortar color must also be considered. As insurance, sizable sample panels should be constructed on-site and viewed under various light conditions before a final decision is made. Seeking help from landscape architects is also a good idea.

D. ORNAMENTATION

Ornamentation created by add-ons should be kept to an absolute minimum unless the structure is in a very special location.

The goal of the engineer should be to develop strength from the shape of the structure and let that structural shape produce the aesthetic impact on its own.

However, ornaments can be used to articulate and emphasize the structural shape. Many of the classical systems of architectural ornamentation had their beginning in the elaboration of structural elements. However, ornamental and non-structural surface materials can disguise, detract from or destroy the structural form. Ornament can add additional levels of interest and richness (Fig. 5.13). It is best when restricted to those *locations with a high level of importance and exposure. Make sure that the ornamentation emphasizes, rather than camouflages, the structural form.*

If a bridge is a gateway to a special community, such as a state capital, pylons on the bridge may be appropriate to identify the importance of the structure as a gateway.

Fig. 5.13
Ornamental light posts add interest to this structure. (MD 675 over Pocomoke River, Worcester County, MD)

VI. SIGNING, LIGHTING AND LANDSCAPING

While signing, lighting and landscaping are not, strictly speaking, part of the bridge itself, they may have a major impact on the structure's appearance.

A. SIGNING

If possible, seek an alternative location for signs away from a structure. However, a primary function of signing must be public safety. It needs to be recognized that when there is a conflict between safety and bridge aesthetics, safety takes precedence.

The most desirable option is to keep signing off of bridges and far enough away that they don't hide the bridge. Unavoidably, this will mean specialized structures for the signs themselves. A sign on a simple, uncluttered sign structure even 300 feet before a bridge may be preferable to a sign on the bridge itself. However, there are situations where the highway layout is so constrained that the only reasonable location for a sign is within 300 feet of the bridge. In those cases, the driver's view through the sign structure should be checked. If the sign structure effectively blocks the view of the bridge, the sign might as well be on the bridge.

Where the location of a sign on a bridge is unavoidable, the sign or signs should be designed as part of the total bridge.

Frequently the argument for placing a sign on a bridge is that it is so close, and therefore it is more economical to place on a bridge than on a ground-mounted sign support. Be sure to check the economics, since quite often the individual support is less costly than placing the sign on a structure.

If at all possible, the limits for the sign depth shall be the top of the parapet, railing or pedestrian screen, and the bottom of the superstructure. Where more than one sign is on a bridge, all of the vertical dimensions of the signs should be the same, if possible.

Where the sign sizes and location become a problem, contact the traffic office to see if modifications and/or changes can be made.

Simplify the structural details necessary to mount signs on bridges.

The structural support system for the signs should match the color of the main bridge members.

Before any signs are erected on existing bridges, the bridge office should evaluate their size, location, support system, etc. just as signs would be evaluated for a new structure. Particular attention should be paid to items such as conduits.

Fig. 6.00
More attention to the signs may have improved this bridge's appearance. The sign could have been placed on its own support away from the bridge (MD 216 over I-95, Howard County, MD)

Fig. 6.00 shows how two signs, each a different size, shape and color, add clutter to this bridge. If this had not been an interchange area, a well-designed sign structure at the position of the photographer might have been a better choice. Even the solution shown above could have been better had the signs been created in a consistent relation with the bridge. Some suggestions: make the right-hand sign a complete rectangle; make the height of both signs with their lighting fixtures the same and consistent with one of the bridge dimensions—for example, the distance from the top of the parapet to the bottom of the girder. It is important that the bottom of the sign or its lighting fixtures not infringe on the underclearance of the bridge.

Note features off the bridge.

Quite often we take the time and effort to develop a structure that is pleasing in appearance, yet, when the structure is viewed in its completed state, the attractiveness is significantly diminished by a myriad of other highway elements--light standards, traffic lights, ground mounted signs, etc. (Fig. 6.01).

The bridge designer should make himself aware of all of these features during the design phase and, where possible, work with the other disciplines in minimizing the impacts of these items on the structure's appearance.

Fig. 6.01
The large sign detracts from the view of the structure. (I-595 over Rowe Boulevard, Anne Arundel County, MD)

B. LIGHTING

1. Lighting of Roadway

The three areas of concern are: type of light standard, location of light supports, and location of conduits.

Wherever possible, avoid placing roadway lighting on bridges.

If lighting on a bridge can't be avoided, place roadway lighting poles in some logical relationship to the structure itself, such as at supports or placed symmetrically around the supports (Figs. 6.02 and 6.03).

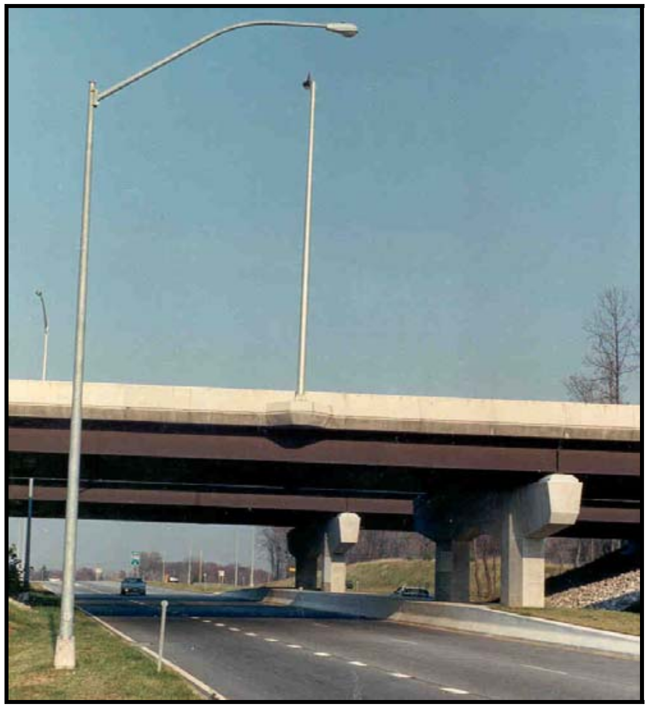


Fig. 6.02 Should the pole have gone over the pier?

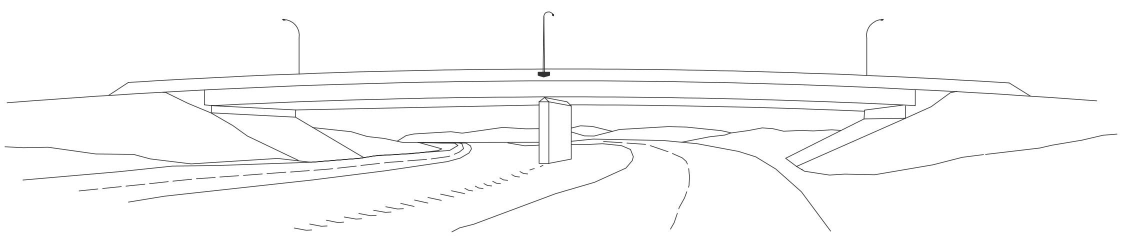


Fig. 6.03 Lighting supports organized around structural features

Mount medium-height lighting poles on a projected area of the deck behind the parapet (Fig. 6.02). The projected area should be as continuous as possible with the parapet itself and consistent with any pedestrian screen posts, grooves or recesses and construction joints of the parapet. The design goal is to maintain the horizontal line of the parapet with as little interruption as possible. The location of the poles should be coordinated with rail and/or screen post spacings.

When a bridge has lighting standards, then the light fixture on the bridge must match those on the approach roadway. Where lighting is for a specific bridge, then lower, more personalized lighting standards should be selected for that bridge (See Ornamentation Section, Chapter V.)

Lights mounted under a bridge to light the underside of the superstructure offer a special opportunity to make the bridge a nighttime feature. In this case, the area beneath the bridge usually becomes the brightest part of the night visual field, creating a "lighted portal" effect (Fig 6.04).

Fig. 6.04
Lighting adds a special effect. (The United States Naval Academy Bridge - MD 450 over the Severn River, Anne Arundel County, MD)

Mount lights under structures in some consistent relationship to the structural features, so that they emphasize the structural form itself. For example, placing lights between every third stringer of a girder bridge would not only light the roadway below, but light the space between the girders, creating a rhythmic interval of light across the "ceiling" of the space underneath the bridge.

Conduit for lighting can become a distracting feature. Place conduit for lighting in parapet walls wherever possible. For lighting below the bridge, mount exposed conduit between girders or place in front face of abutments. Conduit should be installed parallel to or at right angles to main structural members.

Placing of galvanized conduits on a weathering steel fascia girder is a prime example of what not to do. Every effort should be made to have all conduits, etc. behind the fascia girders. Where lighting is required under the bridge to light the roadway, the fixtures should be above the bottom of the stringers and all the suggestions for camouflaging the conduits, listed above, should be followed.

2. Accent Lighting

There are specific bridges that, because of their size, their location in the community, the environment or their symbolic importance, deserve to be lit. There are two basic approaches in this situation:

- **Floodlight the bridge. This will not replicate the daytime appearance, since the shadow areas and the color effects will be unavoidably different. However, it does come closest to giving a complete picture of the bridge (Fig. 5.00).**

- **Outline significant features of the bridge in lights, or otherwise light only significant portions of the bridge. This probably works best when the lighting is designed to create a pattern of the basic structural form. Such an approach can be used to enhance nighttime safety for boaters.**

Both of these techniques require a great deal of specialized expertise and experience. It is also very important to evaluate the effect of this lighting on nearby properties, and nearby residences in particular.

C. LANDSCAPING

The bridge engineer should coordinate with landscape architects and designers.

Landscaping should be an enhancement of an already attractive structure. It should not be relied on to cover up an embarrassment or hide some unfortunate detail. Conversely, it should not be allowed to grow up to hide some important feature which is crucial to the structural form of the bridge. Landscaping can be a more economical and effective way to add richness and interest to a design than special surface finishes or materials. For example, a large, plain concrete abutment can be effectively enhanced by well-chosen landscaping around it.

It is important, in the selection of landscape material, to be sure to picture the ultimate size of landscaping--height of trees, etc.--in making decisions. Summer and winter appearance also should be considered.

1. Concept Development

The application of landscape concerns, such as environmental suitability, topography, and existing vegetation, is part of the site analysis and conceptual development process *for the bridge as a whole. This process will produce a consistent design intention for adjacent landscaping and the entire route (Figs. 6.05 and 6.06).*

It is important again to look at a theme for an entire route where appropriate.

For example, in more rural areas, where the design intention is to ensure an unobstructed view by providing a maximum open space under the bridge, landscaping can be used to emphasize the continuity of the space through the bridge. One way this could be achieved would be to establish a repetitive pattern of planting which starts before the bridge and continues beyond the bridge (with a minimal interruption directly underneath).

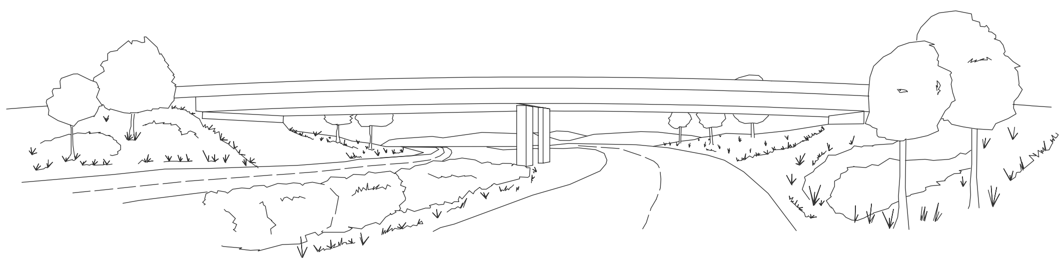


Fig. 6.05 Continuity of landscaping patterns enhances the continuity of the scene.

Fig. 6.06
Landscaping can be a continuation of the overall landscaping pattern of the highway, as it is here, or it can focus attention on the bridge. (I-83 at I-695, Baltimore County, MD)

In more urban areas the buildup of many different structures (bridges, retaining walls, noise walls, buildings) often becomes overwhelming. Landscaping can then become a vital contrast for all of these hard-edged elements. For example, small auxiliary walls or barriers can be placed in front of major walls or abutments to create level planting areas, or planting vines, etc. to cover large expanses such as noise walls (Figs. 4.60, 4.61 and 4.62).

Landscaping creates its own shape and colors. These must be considered in relation to the colors and shapes of the bridge itself. This means that the landscape architect should be part of the design team as the bridge concept is developed, so that he can lay out planting patterns and plant material which will enhance the overall structural concept.

Landscaped mounds can be used to protect bridge piers in median areas (Fig. 0.01). (Also refer to Chapter IV-Substructure.)

In locations where a bridge adjoins a community or group of buildings, landscaping can be an indispensable element in mediating the differences in material and scale. Here, the goal is probably best served by intensifying planting patterns and species already existing in the community, in order to emphasize the continuity of the community environment.

Generally, highway landscaping works best, and is most easily maintained, when the materials and patterns replicate the existing natural vegetation in the immediate area. This rule applies to landscaping around bridges as well. However, there always will be locations where contrasting plantings are desired in order to accentuate or emphasize a particular bridge location or structural form. These can be very legitimate, in the same way that it is legitimate to paint a bridge a contrasting color in a forest, as long as it is consistent with the design intention of the structure itself and the design theme of the highway or group of structures involved.

2. Slope Protection

Slope protection is both a landscaping feature and a structural component. However, it should be comprised of a landscaping material, such as riprap, and placed so that it looks like part of the landscape. Riprap has the advantage of having plants growing in it and blurring the edge with the landscape.

For bridges over highways, use only enough slope protection to cover the area beneath the bridge where plants cannot grow. Drainage channels from the bridge should be accommodated with separate riprap channels, stabilized planting or buried piping (Figs. 6.07 and 6.08).

Fig. 6.07
Concrete slope protection may lack the flexibility to deal with drainage and soil problems, such as undermining. Stone riprap has the flexibility to respond to soil settlement, which is why it has been used for this repair. (MD 175 EB over I-95, Howard County, MD)

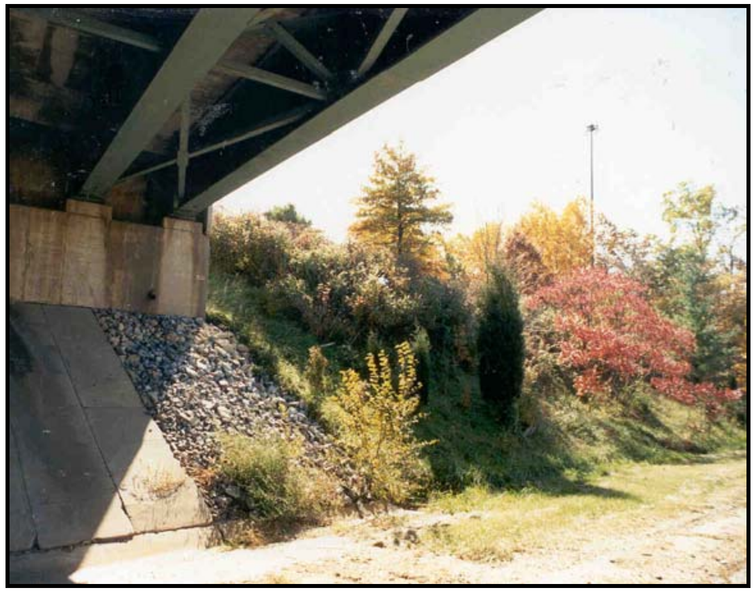


Fig 6.08
Here a reasonable amount of stone slope protection has been provided. Its edges will soon blend into the landscape, reinforcing the sense that the landscape continues easily through the bridge. (Millersville Road over I-97, Anne Arundel County, MD)

Use riprap for most roadside applications. Although dark-colored stone will attract less attention, strive to use local stone sources so that the color of the riprap is in character with the local environment.

When a more finished appearance is desired, use concrete, brick or stone under a structure. This is especially true in an urban area surrounded by roadways, sidewalks, buildings, etc. Patterns pressed into newly placed concrete can give a good appearance at minimum cost and break up the flat surface of conventional concrete.

Light riprap should not be used close to bridge areas where it would provide a ready supply for vandals to bombard highway traffic.

TYPICAL BRIDGES

"...Beauty will not unconsciously arise out of a search for economy. Rather, there are personal choices for the engineer to make, and he is to be judged on them."

David P. Billington
Professor of Civil Engineering
Princeton University

The first six chapters of these guidelines deal with the aesthetics of separate bridge components. The chapters that follow bring the components together.

The bridges are organized into groups based on the types of situations which occur frequently. There are often times where these intermix or overlap. The designer should find the guidelines given in each category consistent enough with the others that they can be combined.

VII. HIGHWAY BRIDGES OVER HIGHWAYS

A. DETERMINANTS OF APPEARANCE

Bridges should show not only our skill, but our respect for the public and the environment. A properly designed bridge can blend with its surroundings, offer visual pleasure, and may stimulate an otherwise bored observer.

Most highway overcrossings are relatively short, except for complex interchange ramp structures, and are easily encompassed at one glance. It is important that they be kept simple, with simple lines and shapes, few different materials, and with all parts in clear relationship to one another. They are seen by people who are moving along predictable paths at predictable speeds, which makes it easier to predict what people will see at each point, and to control what their perception will be.

Highway overcrossings often come in groups--for example, all of the bridges on a section of freeway, or all of the bridges in an interchange. Since multiple bridges may be seen in quick succession, it is necessary to consider their relation to each other, so that the result is not a visual hodgepodge. (See the discussion of design themes in Chapter II, Section C.)

Highway overcrossings of freeways and high-speed arterials are seen best when they are still distant. The closest point at which such a bridge will "register" to a motorist is 300 to 500 feet. At any point closer the motorist is focusing beyond the structure and the bridge itself is a blur in his peripheral vision.

An important ingredient in every successful, aesthetically pleasing design is how well the elements of the structure are sized in proportion to the overall scale of the structure. At 300 to 500 feet the only parts clearly visible are the features of the elevation view. This means that the following elevation features will determine the visual impression created by the structure:

- *the parapet and girder fascias*
- *the wing walls of the abutments*
- *the end elevation of the pier (height and shape)*
- *the number of spans and their proportion*
- *the bearings and bearing pads, when dominant*

Exceptions exist for bridges on a severe skew, very wide bridges or bridges crossing a sharply curved roadway. In these cases, portions of the abutment face or the pier which are not in shadow may become important components of the visual field. These situations need to be analyzed on a case-by-case basis, using perspective views taken from viewer locations on the undercrossing roadway.

B. SINGLE SPAN STRUCTURES

The design of a highway overcrossing starts with the required clearance envelope of the under roadway. In the early days of highway bridge building, that was the limit of the bridge (Figs. 7.00 and 7.01).

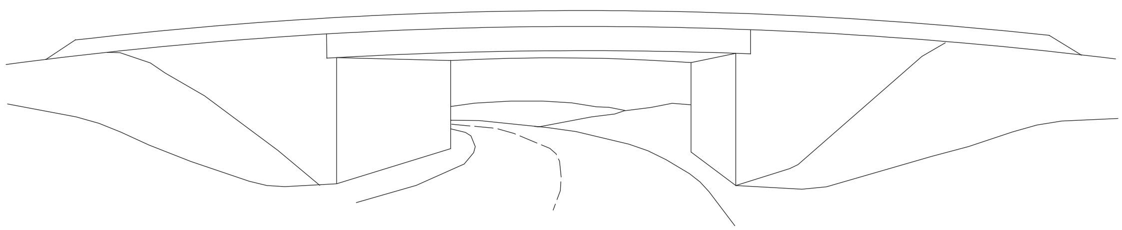


Fig. 7.00 Safety problems and visual limits of a bridge with high abutments at the minimum horizontal clearance lines

Fig. 7.01 *Minimal clearance, high abutments from the early days of highway bridge building. (Germany)*

Designers soon realized that high walls create an uncomfortable degree of enclosure for motorists as well as cut off the view through the structure, thus creating a safety hazard (Fig. 7.03). So they added piers at the shoulder edges and moved the abutment to the top of the slope (Figs. 7.02 and 7.04).

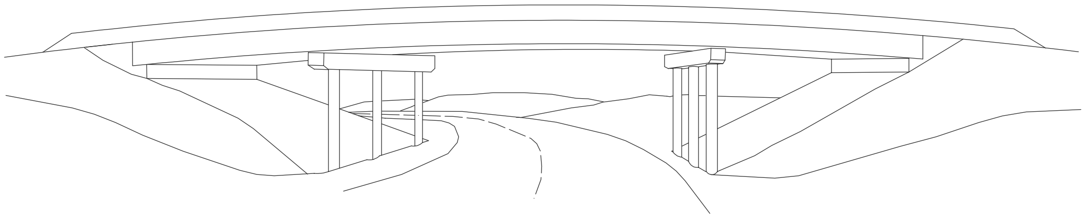


Fig. 7.02 Opening up the view somewhat

Fig. 7.03
High walls with minimum side clearance. (I-270 over MD 85, Frederick County, MD)

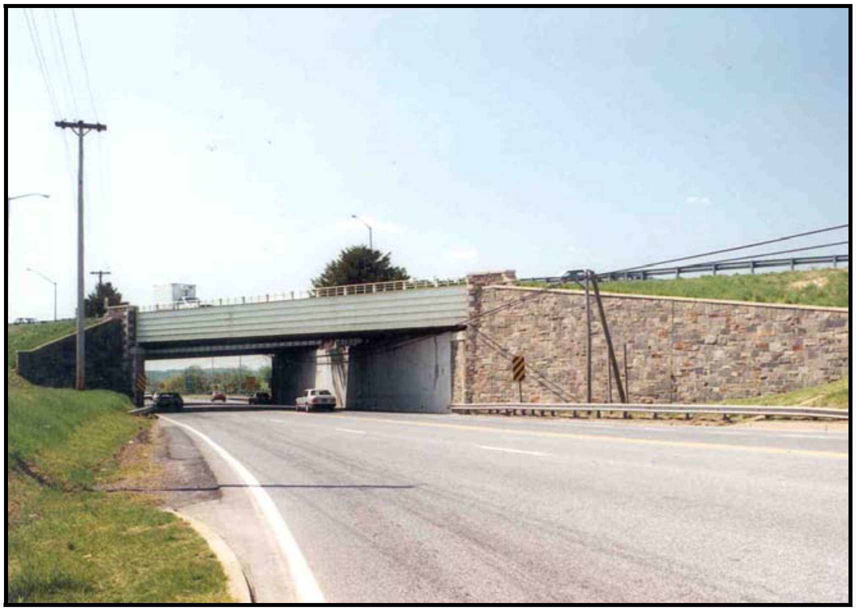


Fig. 7.04
This three-span bridge has shoulder piers and opened side areas; however, the piers are still a hazard. (US 48 over MD 42, Garrett County, MD)

While this was a big improvement, the added void areas on either side are relatively small and cut off from the major space by the piers, while the piers themselves are safety hazards. Each of the above methods also restricted the possibility of widening the under roadway. More recent structures eliminate the side piers and move the abutments back down the slope to a point set by safety clearances, structural economy, and appearance. (See discussion of Abutments in Chapter IV - Substructure.) Structures began to look as shown in Figs. 7.05 and 7.06.

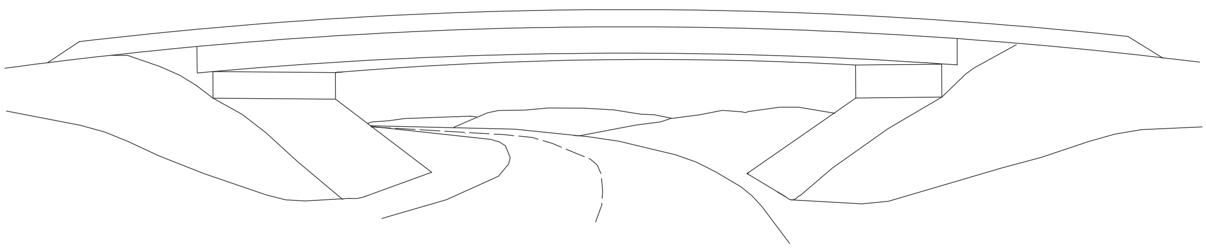


Fig. 7.05 More view and more safety

Fig. 7.06
This represents current thinking: medium height abutments well outside the clearance zone for improved safety and aesthetics. Note also: this is the relevant viewpoint for highway overcrossings. (US 15 over MD 806A, Frederick County, MD)

With the safety problems minimized, the view through the structure is much more extensive and the under roadway can easily be widened.

This whole process is an excellent example of the incorporation of safety and function in structure design, while getting the benefit of added aesthetic appeal. Each step was made for a functional reason as well as an aesthetic reason. At each step the superstructure cost more, but there were offsetting savings in the substructure. In some cases, these savings totally offset the additional cost; but even where they did not, the new designs were accepted because designers felt that the improved safety and improved appearance were worth the additional cost.

One span bridges are the simplest highway overcrossings. Abutment placement is the key element. The determining visual variable is abutment height, more specifically the ratio of its height to the clearance under the structure and the girder depth. For abutment height the possible range is from H = 0 to H = the full under clearance (V) of the bridge at the edge of roadway (Fig. 7.07).

Relate abutment height to vertical clearance at the roadway edge.

At H = V the sense of enclosure and the ability of the bridge to create a portal (usually undesirable) is at a maximum. At H = V/2 the portal effect begins to disappear.
H = 1/2 E (the exposed girder depth) represents the minimum height that should be attempted, unless the designer wants the landscaping to cover the abutment.

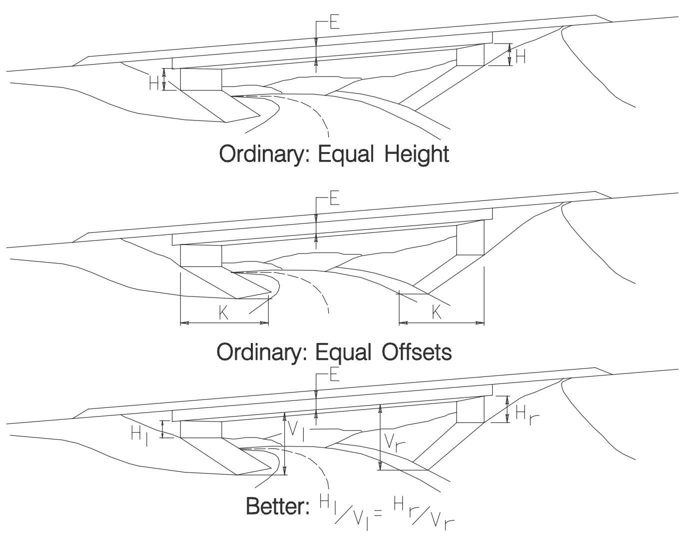


Fig. 7.07 Abutment height should be proportional to the vertical clearance at the nearest roadway edge.

For most single span structures, the general abutment location will depend heavily on required span length, structural economy and safety, though the aesthetic effect of the variations should be kept in mind. One must be especially careful on single-span, severely skewed bridges in establishing the height of the abutment. As the bridge is lengthened the depth of the structure is drastically affected, sometimes defeating the goal of creating a slender structure, so that structure depth becomes more offensive than abutment height. Severely skewed structures will sometimes require unusually long wing walls. See Section E (Severely Skewed Structures) for more discussion.

Once the general location is decided, however, the exact location of the abutments should be based on aesthetic analyses which consider the specific geometry of the structure.

The most common problem is a structure on a vertical grade, so that one side is higher than the other. Using either a common abutment height (H) or a common clear distance from the roadway edge (K) results in an unbalanced appearance.

Consider sloping the face of the abutment inward to decrease the apparent length and slenderness of the girder and create a sense of transition into the abutment (Figs. 7.08 and 7.09).

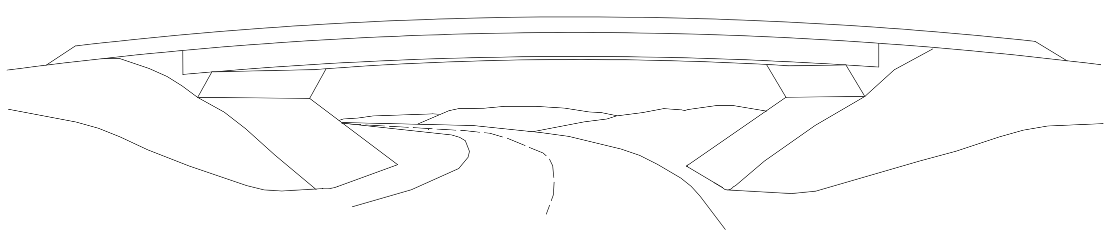


Fig. 7.08 Sloping abutments inward will make the bridge appear shorter.

Fig. 7.09 *Sloped abutments make the bridge seem shorter. (Bay Dale Road over US 50/301, Anne Arundel County, MD)*

Consider sloping the face of the abutment outward to emphasize the separation between abutment and girder and to reduce the apparent height of the abutment (Fig. 7.10).

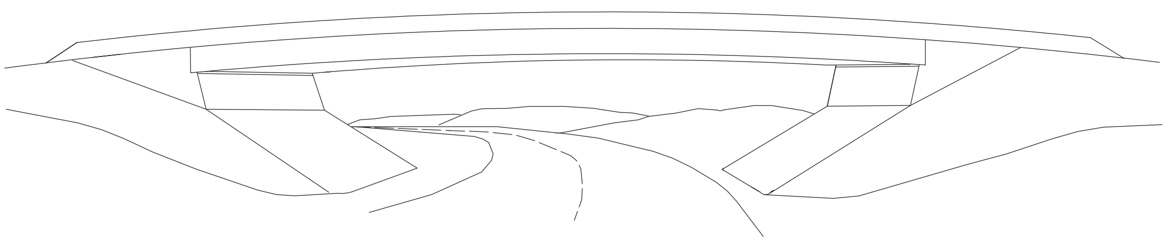
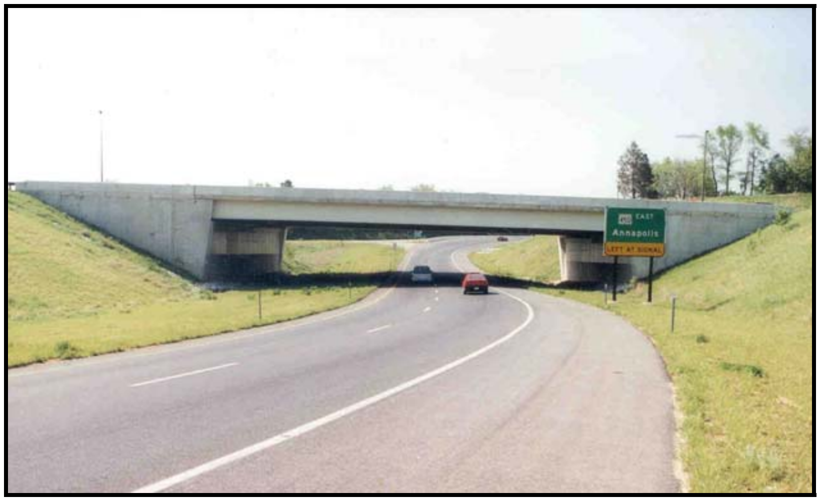


Fig. 7.10 Sloping abutments outward may make the bridge appear longer and also serve to deemphasize the abutment height.

The effect of sloping the abutment face inward can be achieved economically by allowing the corners of the abutments (curtain walls) to be sloped while the main portion of the abutment face is vertical (Fig 7.11). However, if curtain walls are used they should be of substantial width (i.e. two feet) so that they simulate a structural element as opposed to an aesthetic add-on. Preferably, the entire face of the abutment should be sloped in the same plane, if the cost is not prohibitive.

Fig. 7.11
Economical solution to sloping abutments. (I-595 over MD 2 Ramp, Anne Arundel County, MD)



The abutments will usually look best if the wing walls parallel the upper roadway.

C. TWO-SPAN STRUCTURES

One of the most effective measures that can be taken to achieve a pleasing appearance and, at the same time, provide structural economy and durability, is to provide a continuous superstructure as free of joints as possible.

The use of a continuous design results in a more harmonious, flowing structure with uninterrupted lines. To economically utilize materials, the designer is led to proportion the structure, balance the span arrangement, and smoothly transition girder depth changes (i.e. haunches). The absence of joints will greatly reduce the staining and deterioration of the substructure due to leakage.

An important ingredient in every successful, aesthetically pleasing design is how well the elements of the structure are sized in proportion to the overall scale of the structure.

Span-to-depth ratios determine whether a bridge appears to flow gracefully or appears heavy upon the landscape. In general, a span to depth ratio of 25:1 to 30:1 will produce a well-proportioned continuous superstructure.

For two-span structures, the principles of abutment placement are the same as for the single-span structure. Fig. 7.12 shows the unbalancing effects created by abutments of different heights. However, many times this is unavoidable since dual highways may have different numbers of lanes for each roadway and the bridge can be on a significant grade. Pier placement is generally determined by the centerline of the under-roadway median. That leaves pier shape and superstructure shape as additional elements to deal with.

Fig. 7.12
This bridge illustrates the unbalancing effects of two different abutment heights, not a pleasing situation. (MD 3 over I-97, Anne Arundel County, MD)

Application of the guidelines from Chapter III - Superstructure will result in a girder/parapet combination with a thin appearance. The pier should not distract or detract from this appearance, but should do its job of support as simply as possible. The most likely distraction is the end elevation of the pier cap (Fig. 7.13).

Fig. 7.13
The horizontal bottom of the stepped pier cap has resulted in a very heavy pier cap end on the high side. This is undesirable. (Bridge over I-70, Frederick County, MD)

Use a pier which eliminates the pier cap as a distracting element (Figs. 7.14 and 7.15).

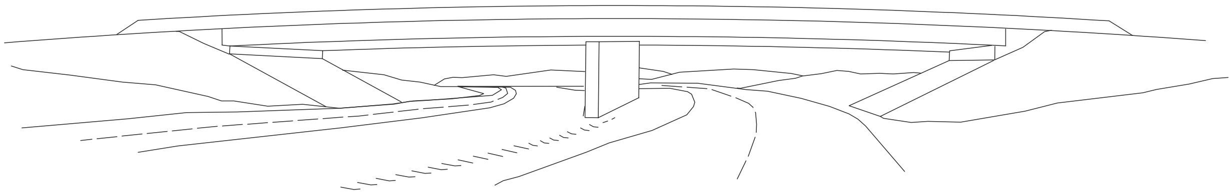


Fig. 7.14 A simple wall pier, a good solution, means no pier cap or pier cap end.

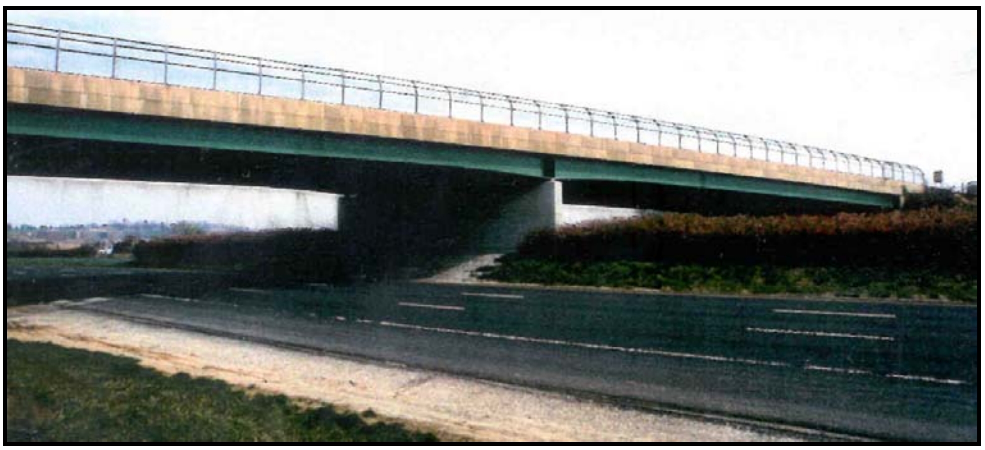


Fig. 7.15
This shows the simplest way to deal with the pier cap end. (Beaverdam Road over I-83 in Baltimore County, MD)

Recess the pier cap behind the columns to minimize the pier cap as a separate element (Fig. 7.16).

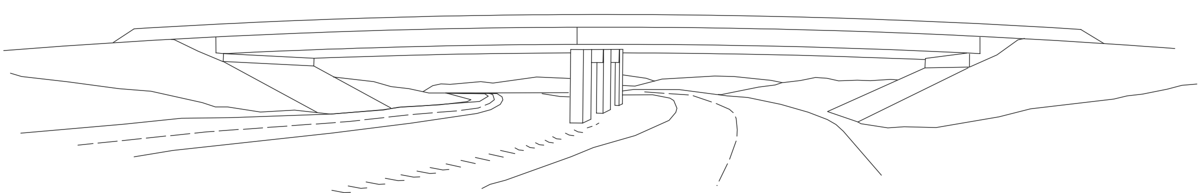


Fig. 7.16 Pier cap recessed behind front column

Minimize the end elevation of the pier cap by keeping the vertical dimension significantly smaller than the horizontal, by using a keystone shape, or both. The effect is to make the cap seem more a part of the girder (Fig. 7.17).

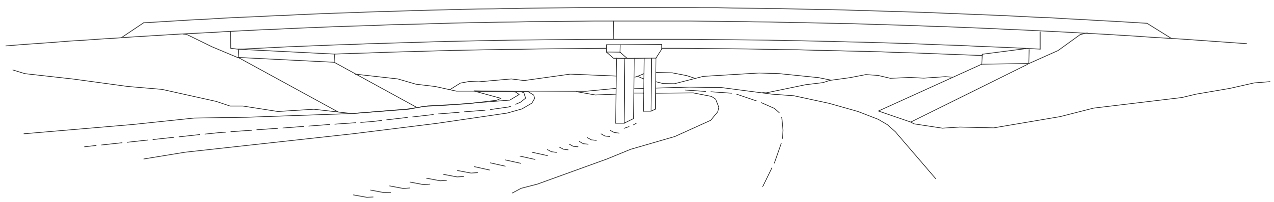


Fig. 7.17 A minimal pier cap; dominant end dimension is horizontal

Consider tapering the pier and/or chamfering the top (Fig. 7.18).

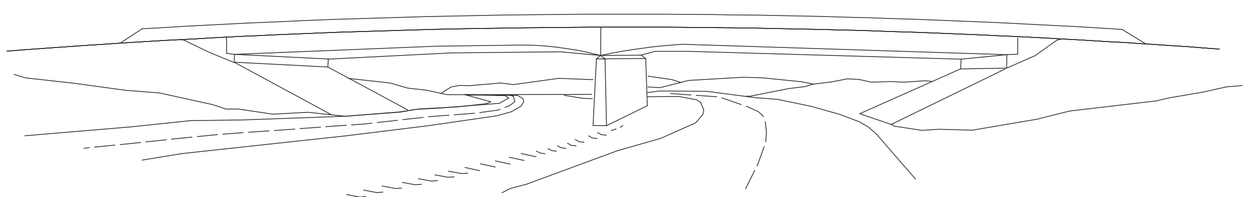


Fig. 7.18 Chamfering the pier top accentuates the point of bearing.

D. STRUCTURES WITH THREE OR MORE SPANS

Maryland's policy is to eliminate shoulder piers wherever possible. However, situations occasionally require them (Fig. 7.19). When shoulder piers are added, as when a stream parallels the road under, the structure becomes a bridge of three or more spans. In order to achieve reasonable end spans, the abutments are usually pushed to the top of the slopes.

The previous guidelines for single-span and two-span situations continue to apply. However, complications caused by additional spans need to be dealt with.

Fig. 7.19
A situation requiring shoulder piers. (Montrose Road over I-270, Montgomery County, MD)

Keep the structure depth constant or smoothly varied over the entire bridge. (For economic reasons this is sometimes done only on the exterior girders, where simple end spans are utilized.) Certainly, haunching of girders over some of the piers is an option to be evaluated. Structural continuity is a big help here, since it keeps everything visually continuous as well.

> *Abutment height should be minimal in order to keep the side span to a visually (and structurally) reasonable length. If the side spans are tapered and structurally continuous, the bridge is read as acting as a cantilever, and a minimum abutment height (H < D) will make sense.*

Usually, use pedestal abutments with H = minimum height with bridges of three or more spans.

> *The side view of the far-side pier is more visible than the side of the center pier of a two-span bridge, so that the overall appearance of the pier becomes more important, rather than just its end view. Guidelines from the substructure configuration section on minimizing the pier cap (Chapter IV) should still be followed.*

Try to avoid the use of solid (wall) piers as side piers, as they tend to cut off the view. This is especially true of long piers that are relatively close to the traveled way.

Recess the pier cap behind the front column or otherwise unify the pier cap and columns so as to minimize the pier cap as a separate element.

Structures of five or more spans sometimes occur as highway overcrossings, but they are more properly considered as ramp or viaduct structures, which are covered in a later section.

E. SEVERELY SKEWED STRUCTURES

Severely skewed structures are difficult visually because they usually require side piers, and quite often taller abutments, to minimize span lengths. At the same time they make the side piers more obvious because of the skew and the length of the piers. The result is a multiplication of objects in the visible field. Each column of the pier and the pier cap becomes more visible. Another contributing factor is that because of the skew, the span lengths become greater, necessitating deeper girders, which quite often present problems with underclearance. Here are some ideas for severely skewed structures.

Maximize the overhang (the amount of slab cantilevered beyond the fascia girder), which should reduce the overall length of the piers.

Maximize the girder spacing, which may reduce the number of columns, with the same result as above (the girder spacing should be evaluated for maintenance of traffic for future deck replacement).

Where possible, use one column per girder or girder pair, which may eliminate the pier cap as an element.

Move the abutment down the side slope if this allows the elimination of the side pier altogether.

In extreme cases, integrate the pier cap in the superstructure, which eliminates the pier cap as a visual element as well as all but two of the columns. However, this may create other functional problems.

With severely skewed bridges, the wing walls can get quite long. It is usually best, from an aesthetic viewpoint, to keep them parallel to the upper roadway (Fig. 7.20). Straight walls which simply bisect the angle between upper and lower roadway, although the most economical solution, should be avoided, if possible, because they create a major object unrelated to either roadway and they create triangular areas of landscaping top and bottom which are hard to plant and maintain.

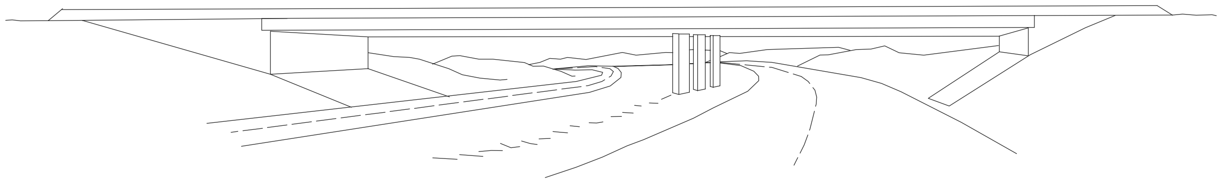


Fig. 7.20 Using one pier column for each girder or pair of girders and placing the wing walls parallel to the upper roadway are good techniques to simplify a severely skewed structure.

An exception to the suggestion about keeping the wing wall parallel to the upper roadway may exist for the high abutments (H = 2/3 V to V) which are often required at very extreme skews. In some cases it may be better to place the wing walls along the lower roadway to provide the driver on the lower roadway with a sense of transition to the high abutment. The wing wall should be placed to create a gradual smooth inward curve, losing side clearance as it gains height (Fig. 7.21). (Refer to Chapter V – Colors and Textures for a discussion on the vertical grooves shown in Fig. 7.21.) Walls of this type may require fencing, depending on the surrounding community.

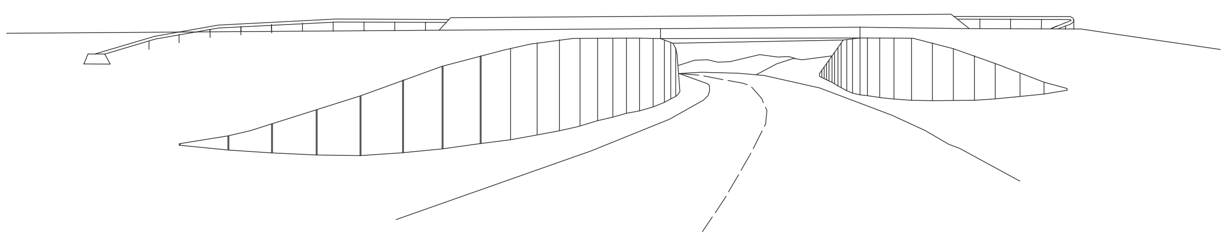


Fig. 7.21 Transition of wing walls to a high abutment wall

F. STEEL RIGID FRAMES

With steel rigid frames, give the legs enough slant to maximize their length and to give full play to the visual illusion of an additional span and an open feeling (Figs. 7.22, 7.23 and 7.24).

Fig. 7.22
This rigid frame highway overcrossing is very appealing, though the legs might have been slanted a little more. (Gorman Road over I-95 in Howard County, MD)

Fig. 7.23
Note the importance of proportions in rigid frames. The legs are light and graceful. (Gorman Road over I-95 in Howard County, MD)

Fig. 7.24
The legs are heavier and strongly delineate the triangular void—the effect is a little too massive. (MD 216 over I-95 in Howard County, MD)

G. ENDING THE PARAPETS

Since the abutment and parapets are such major elements, and since both ends of the bridge can usually be seen at once, the decision about how to end the parapet profile and railing or pedestrian screen has a major impact on the appearance of highway over-crossings. The four basic alternatives are shown in Figs. 7.25, 7.26, 7.27 and 7.28.

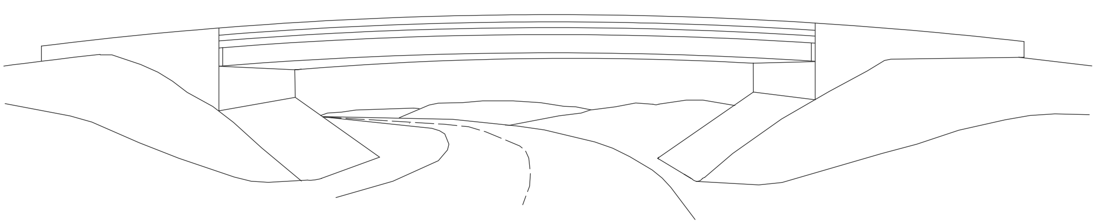


Fig. 7.25 Alternate 1: Ending the superstructure features at the abutment will make the bridge seem shorter and deeper.

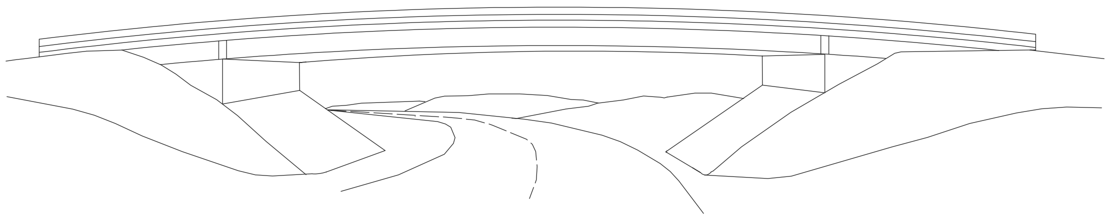


Fig. 7.26 Alternate 2: Extending the superstructure features over the abutment will make the bridge seem longer and will emphasize the horizontal continuity of the bridge. However, this is difficult to make convincing over tall abutments unless significant physical features (such as continuing the same slab overhang) are employed.

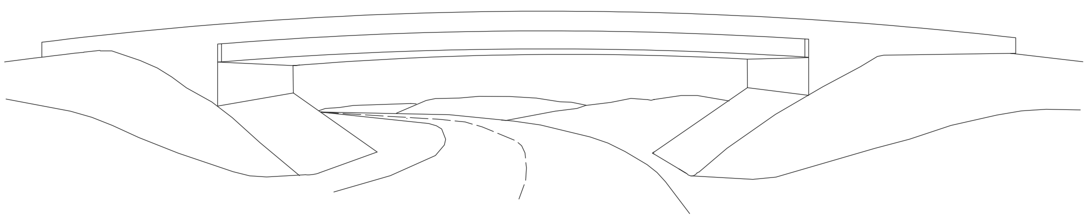


Fig. 7.27 Alternate 3: If the parapet is solid and of the same material as the abutment, the abutment can be made to appear continuous with the parapet by keeping the abutment side wall and parapet face in one plane. This and Alternate 4 frame the view through the bridge and create a portal effect.

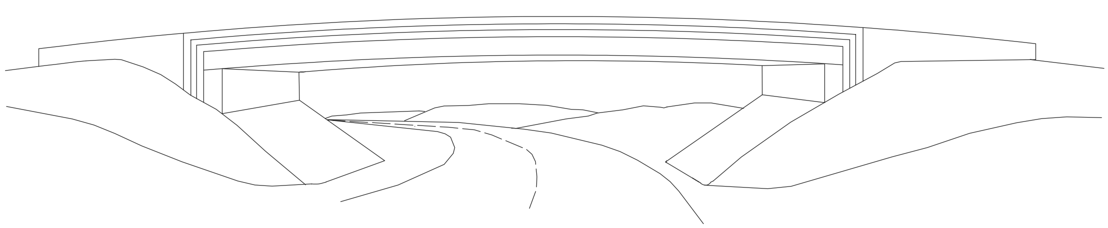
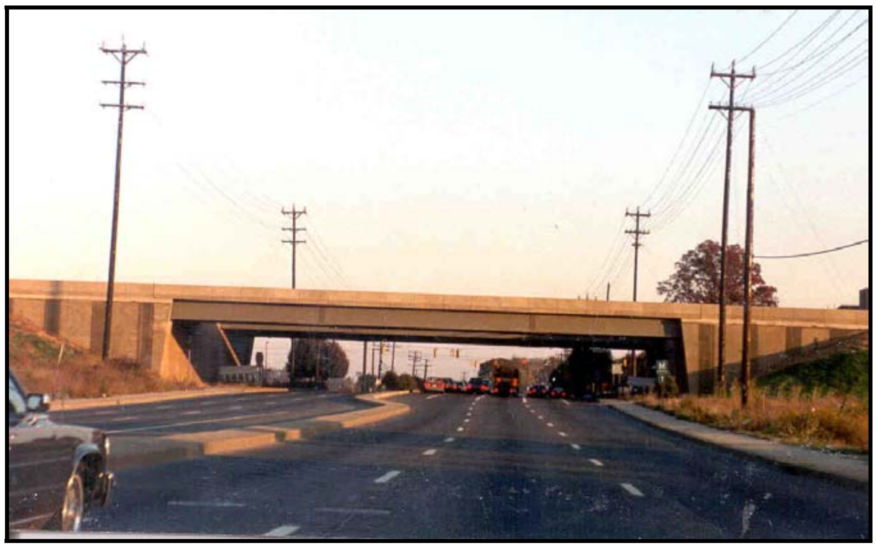


Fig. 7.28 Alternate 4: A variation of this approach is to form the parapet features into the corners of the abutment, emphasizing the portal effect. This works well for medium to high abutments.

The choice between alternatives should be based on the designer's overall concept for the structure and should be influenced by the amount of slab overhang on the superstructure, the presence of a solid fascia on the superstructure (necessary for Alternate 3) and, most important, the height of the abutment face. Alternate 2 works best for small to medium height abutments. It is difficult to accomplish at the higher abutment heights because the designer is trying to deemphasize by visual technique two objects which make up 2/3 of the structure. It only works if a large deck overhang is carried across the abutment (Fig. 7.29).

Fig. 7.29
Sloped abutments and a parapet continuous across the abutments make this bridge seem thinner and more dynamic: the band across the abutment below the parapet would be more effective if it were recessed and a bit thinner. (I-370 over MD 355 in Montgomery County, MD)



Keep abutment features consistent with the structure as a whole.

Creating patterns on the abutment which bear no relation to superstructure features usually divides the structure into visually separate but physically connected objects; it should usually be avoided. However, if some correlation exists between pier treatment and abutment treatment, then, if done properly, this can be an enhancement (Figs. 7.30, 7.31 and 7.32).

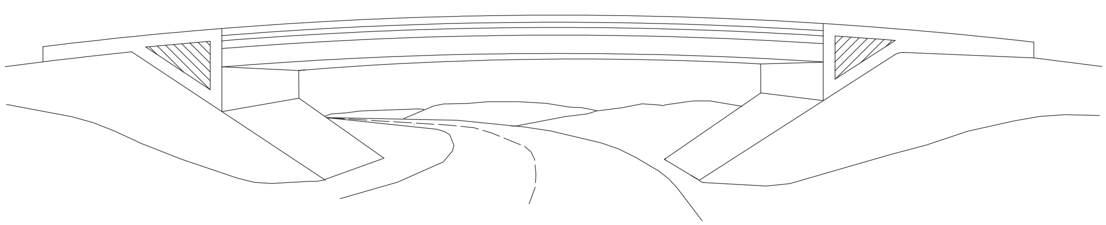
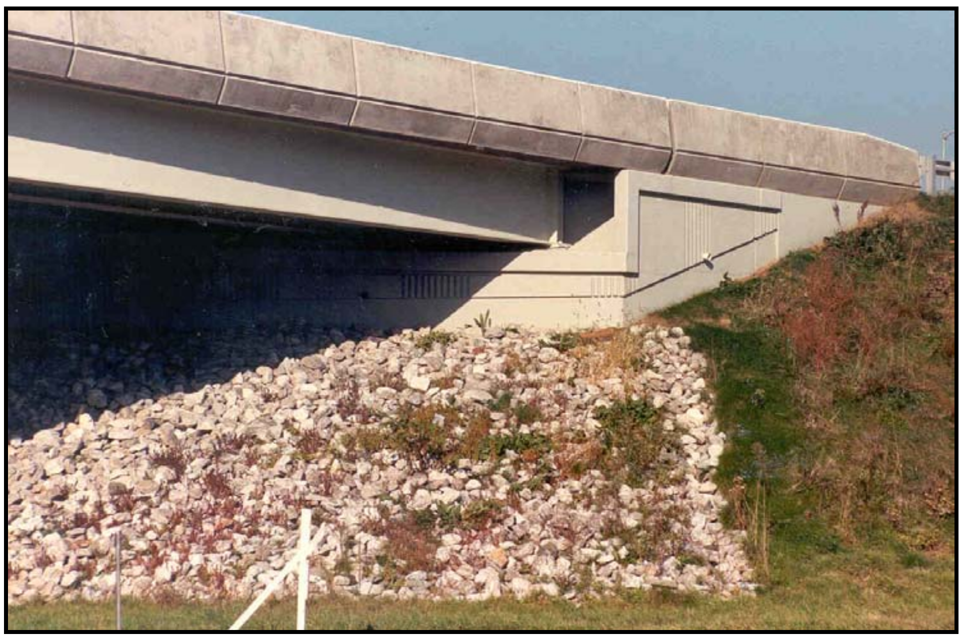


Fig. 7.30 An abutment with a pattern which is visually inconsistent with the balance of the structure

Fig. 7.31
Striations of pier and striations on abutment. (Benfield Boulevard over I-97 in Anne Arundel County, MD)

Fig. 7.32
The abutment features end too soon to reinforce the horizontal nature of the bridge. (I-795 in Baltimore County, MD)



H. THE OVERALL COMPOSITION

When putting it all together, it is important to give the bridge an overall appearance of unity.

Choose shapes from the same family. Faceted piers should be used with faceted parapet design; rounded pier designs with rounded parapets.

Use a minimum number of different materials, different colors, and different textures.

Always use a given material, color or texture the same way within a structure.

Most importantly, proportion the span lengths and abutment heights to achieve the most aesthetic balance in the structure.

> *Be sure when making your decisions that all elements in the completed setting are shown--lighting, signing, adjacent walls, fencing, railing. An abutment may look fine with the bridge but may not be compatible with a wall tying into it.*

VIII. BRIDGES OVER VALLEYS AND/OR DEEP HIGHWAY CUTS

A. DETERMINANTS OF APPEARANCE

Bridges over valleys and deep highway cuts offer many aesthetic opportunities. Consider the possible points of observation:

- **Roadways, trails, dwellings, etc. provide viewing locations underneath.**
- **Important viewpoints may be miles away.**
- **The overall layout of the approach roadways shall be carefully considered, as quite often the approach roadway parallels the ravine and presents the driver and passengers with an exceptional view of the entire crossing. If this occurs, the view from this location must be evaluated.**

The first consideration is the position of likely observers. In the event that the bridge is also spanning a roadway, particularly a bridge spanning a major highway cut, many of the observers will be in cars on the roadway underneath. However, there are significant differences between an ordinary highway overcrossing of relative short length and low rise and the extended length and much greater height that usually occurs in deep cuts or valleys.

For this type of bridge, typically there will be a number of important observer locations, some of which may be a mile or more away. While all these cannot be covered, the designer should at least be aware of the most important observer locations and consider these viewpoints when making decisions. Any pictures, drawings or sketches made should be taken from at least two or three of the most important viewpoints.

Major features of the bridge will determine aesthetics:

From any viewpoint, the following major features of the bridge are likely to determine the visual impression:

- **The shape of the basic horizontal and vertical geometry**

- **Superstructure type**

- **Pier placement, which relates also to the number and shape of the span openings**

- **Shape of piers**

If the area under the bridge is used by pedestrians or if the underside is exposed to motorists below because of height and/or superelevation, the appearance of the underside will also be important, more so than the normal highway-over-highway structure.

Parapet shape, superstructure depth and abutments are generally not as important due to the height and length of this type of bridge.

On bridges over valleys or ravines, the depth of the superstructure is generally not as critical, since the overall length is so great. Also, details of the parapet and abutments will not be as critical, because these elements are a relatively smaller portion of the total bridge. However, general rules of simplicity and continuity of materials still apply.

Surface treatment will also have very little impact except for substructure units that may be near or adjacent to trails, etc.

1. Basic geometry

Keep the bridge on vertical and horizontal tangents, or on long continuous curves if possible.

The horizontal and vertical geometry are important because they set the overall shape of the bridge. The bridge will look best if it is straight or composed of a few long continuous curves. Curves on bridges, both horizontal and vertical, if required, should be for the majority of the length of the bridge (except for the very long bridges). Every effort should be made to develop symmetry of the geometry.

Any consideration of geometry needs to take into account the driver's view from the overcrossing roadway. This will generally be best if the curves are long and continuous. In particular, placing two short vertical curves on either end of a bridge, with a tangent on the bridge in between, will produce a very uncomfortable view for the driver, and is unnecessary if the only goal is to avoid a vertical curve on the bridge. The vertical curves on bridges are fine if they are long enough, and if the sump point is off the bridge. These criteria require early coordination with the highway designer.

2. Superstructure type

Decisions concerning the type of superstructure should always have economics and maintenance as prime considerations. An economic bridge can still be visually exciting (Fig. 8.00).

Fig. 8.00
This design cut the span lengths in half, reducing girder depth and cost. It also created a bridge with great visual appeal. (I-64, Virginia)

B. ARCHES AND FRAMES

Dynamic visual impressions of arches and frames at prominent locations may offset additional economic costs (if any).

Valleys and highway cuts present most of the few opportunities for steel arch or rigid frame type bridges in Maryland. The choice of structural type should depend first of all on the structural economics of the required bridge. However, arch and frame forms offer a dynamic visual impression which may weigh in the balance at particularly prominent or important locations (Fig. 8.01).

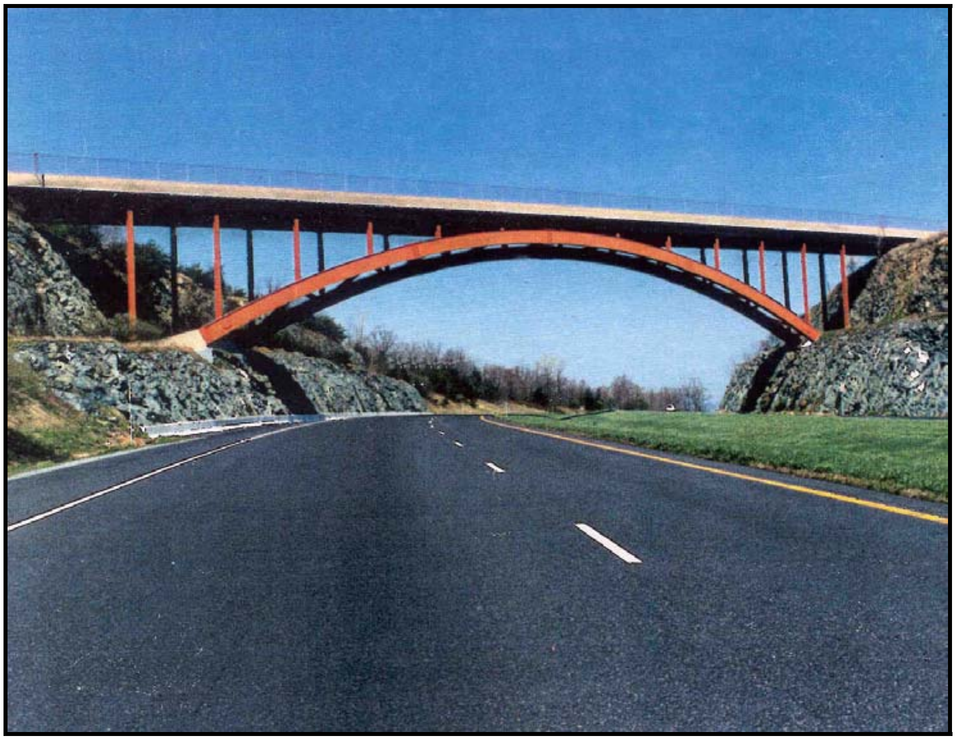


Fig. 8.01
The striking appearance of an arch or frame should be considered along with its economic cost. This arch bridge has become known as the gateway to Western Maryland just because of its appearance. (Ridge Road over I-70, Frederick County, MD)

Arches and rigid frames look best where there are strong forms at their ends to "contain" the visual thrust of the arch/frame, such as hillsides, or retaining walls (Figs. 8.01, 8.02 and 8.03).

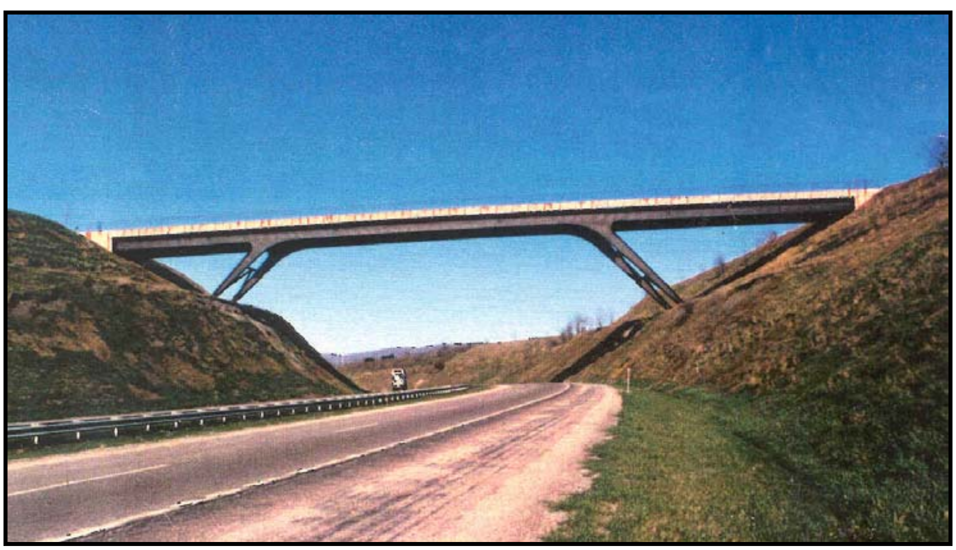


Fig. 8.02
The dynamism of an arch or rigid frame in this situation speaks for itself. This could have been even more graceful if the side spans were similar. (Blooming Rose Road over I-68, Garrett County, MD)

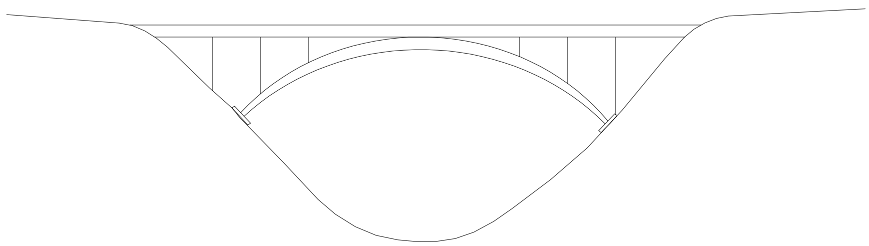


Fig. 8.03 Appropriate situation for an arch

Sufficient height is required to develop these bridge types visually and structurally.

Arches and rigid frames look better (and also are more efficient structurally) where there is sufficient height to develop their overall form (Fig. 8.04).

Fig. 8.04 The importance of height to a rigid frame

For arches:

At the crown, the arch rib should just touch the floor system.

Keep deck supports similar over the whole length of the bridge.

A heavier support at the springing is structurally unnecessary. Visually, it interrupts the lines of the bridge.

Try to keep symmetry.

For frames:

Get enough slant on the legs to take full advantage of the visual (and structural) potential of this form.

Carefully study the proportions of the frame legs versus horizontal and ratio of span lengths to ensure a pleasing shape.

These structures can become heavy-looking if not carefully shaped (Fig. 8.05).

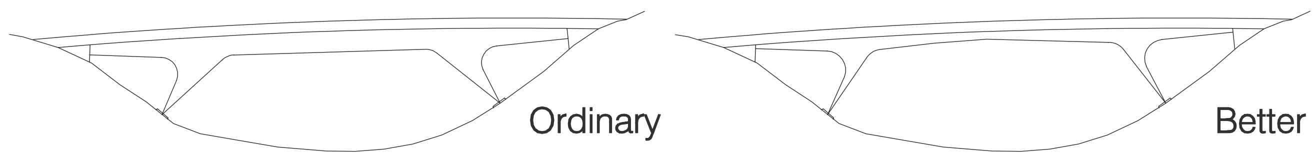


Fig. 8.05 Proportions are critical to the design of a rigid frame.

For both arches and rigid frames:

Try to find natural locations on the valley walls (such as a rock outcropping) or cut side walls (as on a bench) to place the springing.

Keep sway bracing and floor system to a minimum number of members that are simply arranged and in a clear and consistent relationship to the main members.

Take advantage of structural needs (stiffeners, bearing plates, etc.) to develop attractive details which accentuate the points of stress concentration and transfer.

When combining arch or frame with additional girder side spans, look for ways to make the total structure seem as continuous and compatible as possible. For example, the stringers of an arch floor system could be made the same depth as the approach girders.

C. MULTI-GIRDER BRIDGES

Use haunched girders where appropriate.

Transition to different girder depths using tapered webs (Fig. 3.07).

Steel girder superstructures are frequently used for bridges over valley and highway cuts. Since the spans will often vary in length over the bridge, it may be necessary to change girder depth, provide haunches, or both in a single bridge (Figs. 8.06 and 8.07).

Fig. 8.06
A superstructure which rests lightly on its piers and flows as a continuous ribbon. (I-68 over MD 144 and Elk Lick Run, Allegany County, MD)

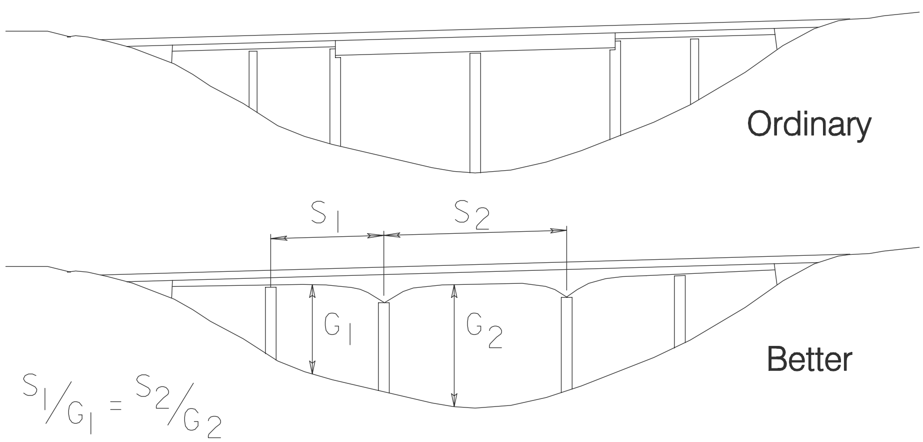


Fig. 8.07 Pier Placement for Multi-span Girder Bridges

D. PIER PLACEMENT

Pier placement can make or break the appearance.

The proportions of each opening (ratio of height to span length) should be roughly similar.

For all valley and highway cut bridges, developing pier locations requires consideration of the overall shape of the valley or cut, the clearance requirements of obstacles being spanned, utilities, construction access and the height of the bridge.

Piers should not be placed at the deepest part of the ravine.

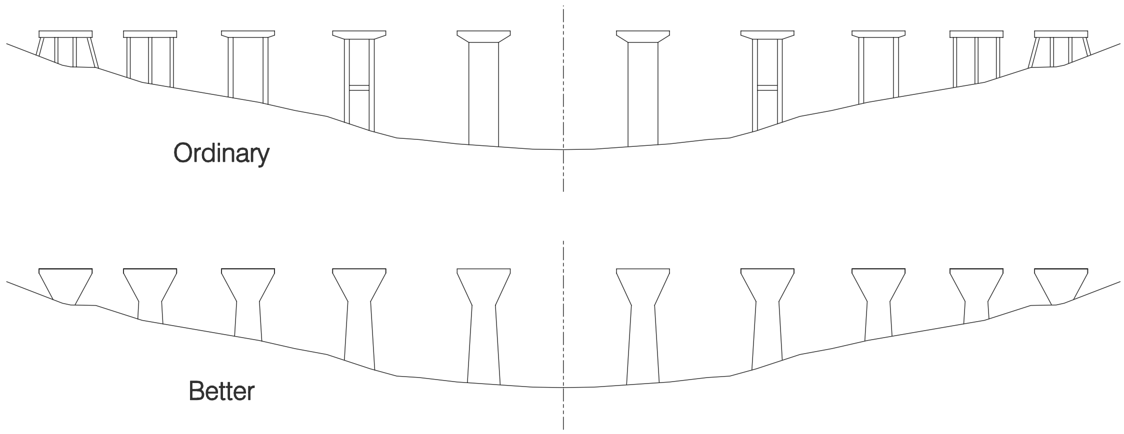
Generally, the main span should be centered over the deepest part of the ravine. The flanking spans should be symmetric with a best fit span to height ratio. This ratio should be followed for subsequent sets of flanking spans (Fig 8.07).

Consider oblique views and varying pier heights in developing a family of piers.

Oblique views from the underside and nearby communities are usually important, and several piers are often visible from a given location. In order to prevent the view from degenerating into a forest of columns, the characteristics of groups of piers, as well as columns within the piers, need to be considered. Chapter II, Section B gives guidelines for this situation.

Piers must look pleasing when viewed as a group or individually.

Since the piers will more than likely vary drastically in height over the bridge length, the key is to develop a family of pier shapes which relate well to each other when viewed as a group (Figs. 8.08 and 8.09). The goal is to portray a smooth flow of forces along the girders, and from the girders into the piers and then down to the valley floor. See the discussions of tall piers and families of piers in Chapter IV for some ideas.



Under Construction (Woodrow Wilson Bridge Project Interchanges)

Fig. 8.08 Families of piers varying by height

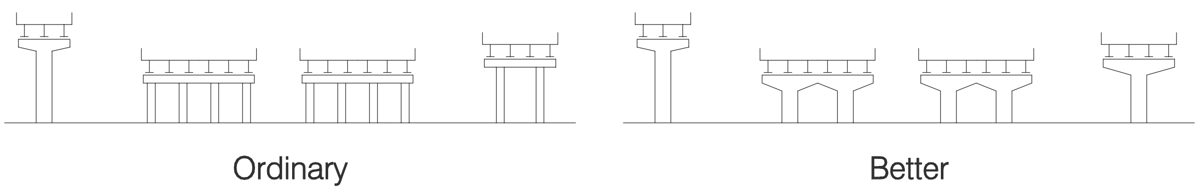


Fig. 8.09 Families of piers varying by length

E. THE VIEW FROM THE UNDERSIDE

Consider view from the underside if appropriate.

The appearance of the underside may be important if the bridge is viewed from below. The confusion of lateral bracing and diaphragm bracing may be a real distraction because of the number of members, the number of different angles at which they are installed and the competition they offer to the main lines of the structure.

Paint steel a light color to help reflect light to the bridge underside.

Concrete or steel box structures, where the underside is completely enclosed, solve this problem, particularly if the steel is a light color to reflect light. However, as noted in the superstructure section, the State of Maryland does not prefer this type of construction because of its lack of redundancy, inspection problems, etc. Girder-type bridges can be very satisfactory as long as the details of diaphragms and wind bracing are kept simple and consistent along the bridge, and, if steel, they are painted a light color matching the girders.

Keep bracing to a minimum using fewer, larger members rather than many smaller members (Fig. 8.10).

Simplify bracing elements. Make use of vertical stiffeners as connection plates for cross bracing, etc.

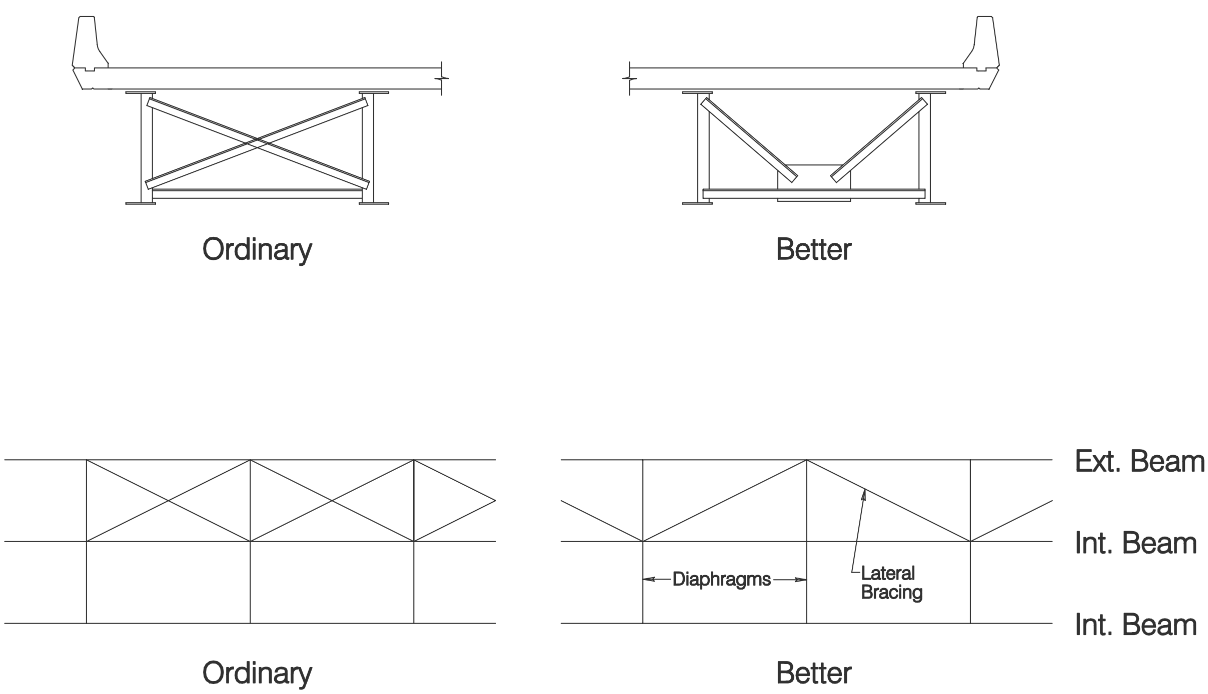


Fig. 8.10 Keep bracing to a minimum and at a consistent angle to the girders, if possible.

IX. BRIDGES OVER WATERWAYS

A. DETERMINANTS OF APPEARANCE

Generally, the most important view of bridges over wide waterways is the oblique view from the shore. It is often possible to identify particular locations which are likely to be the most favored viewing points.

For example, people are likely to congregate in areas along the shore dedicated to public docks, fishing platforms or parks. If there is a curve in the roadway approaching the bridge, drivers may also get a view of the bridge prior to crossing it. On waterways with a significant amount of recreational boat traffic, the view from the water should also be considered.

At the most likely (oblique) viewpoint the following major features of the bridge are likely to determine the visual impression:

- *The shape of the basic horizontal and vertical geometry*
- *Superstructure type or types*
- *Pier shape, number and spacing of piers*
- *Parapet and railing design*
- *Navigational requirements of the waterway*

B. BRIDGES OVER WIDE WATERWAYS

The visual goal of bridges of this type should be to display the basic geometry of the bridge as a sweep of structural ribbon from shore to shore (Fig. 9.00).

Fig. 9.00
This bridge blends in with the area.
(MD 450 over Severn River, Anne Arundel County, MD)

The waterway being crossed often requires spans of different lengths within the structure. This could result in different superstructure types, materials (concrete and steel), sizes or shapes. The designer must make clear and simple transitions between them for the bridge to be a visual success. Accommodating the spans of various lengths and depths is an aesthetic challenge of this type structure.

The navigation requirements of the waterway being spanned will set the vertical geometry of the bridge. If the navigation channel is near the middle of the bridge, gradual vertical curves with gentle grades can be used to get the highway traffic across the bridge (Fig. 9.01).

Fig. 9.01
This is a good example of gentle vertical curves with the navigation channel near the middle of the bridge. (US. 50 over the Nanticoke River Bridge, Dorchester County, MD)

It may be necessary to use a movable bridge if the navigation channel is near the shore or occurs in a moderate length bridge, and the channel is a major shipping channel (vertical clearance of 50 feet or more). Every effort should be made to avoid this type of bridge because of their high construction, maintenance and operational costs. When this type bridge is used, the vertical profile is generally very close (10 to 15 feet) to the water surface and flat.

The bridge should be the same form and material throughout its length; variations in depth to accommodate span changes, such as haunches, should be accomplished gradually with smooth curves or slight tapers (Fig. 9.02).

Fig. 9.02
(Germany)

Where steel and concrete girders are used together, the steel paint color should be selected to match the concrete (Fig. 9.03).

Fig. 9.03
Steel spans over channel and prestressed concrete for remainder. (US 50 over Nanticoke River, Dorchester County, MD)

Large overhangs on the superstructure accentuate the continuity of the superstructure and permit narrow and less obtrusive piers with fewer columns (Fig. 9.04).

They should be continuous throughout the length of the structure.

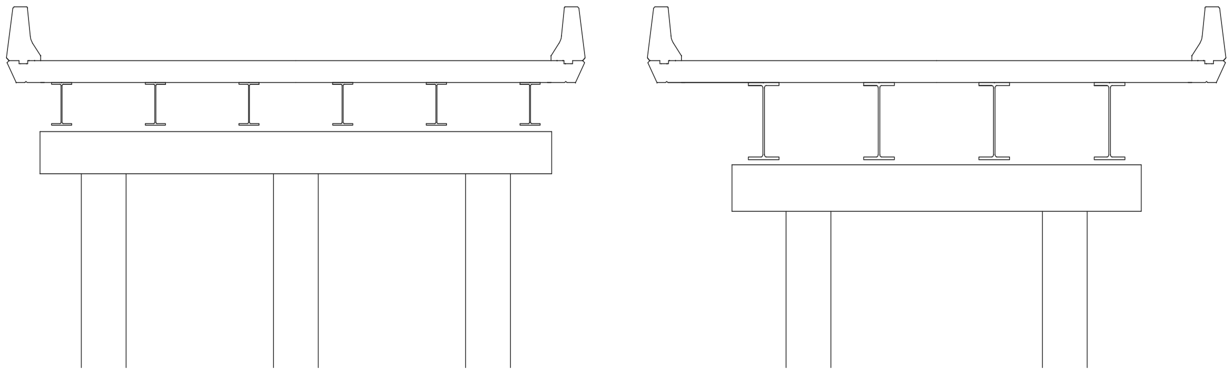


Fig. 9.04 Large overhangs permit piers with fewer columns.

Parapets and railing designs are generally important in establishing the horizontal continuity of bridges of this size. Because of the length of these bridges, these features should be addressed for the users of the bridge. The designer is encouraged to use rails which are open and permit the users' views up and down the waterway. The designer is cautioned that on high traffic routes it may be wise to limit the view up and down the waterway so the driver concentrates on the roadway.

C. BRIDGES OVER WETLANDS AND NARROW WATERWAYS

The visual goal of this type of bridge is to provide sufficient detail and interest based upon its location. These bridges, for the most part, should follow the guidelines described in Chapter VII – Highway Bridges over Highways. A structure located in a park setting that is a multi-use facility including recreation such as boating or a hiking trail would be treated differently from a bridge that is inaccessible except to the bridge inspector.

In the case of the bridge located in a park and viewed closely by park users, care should be taken to make the bridge fit into its surroundings to encourage its use (Fig. 9.05).

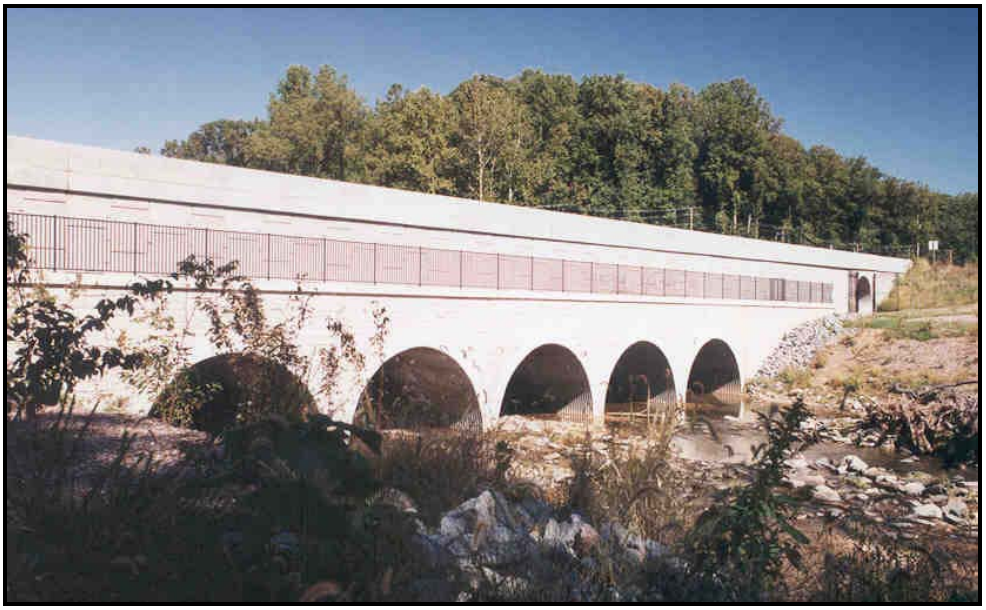
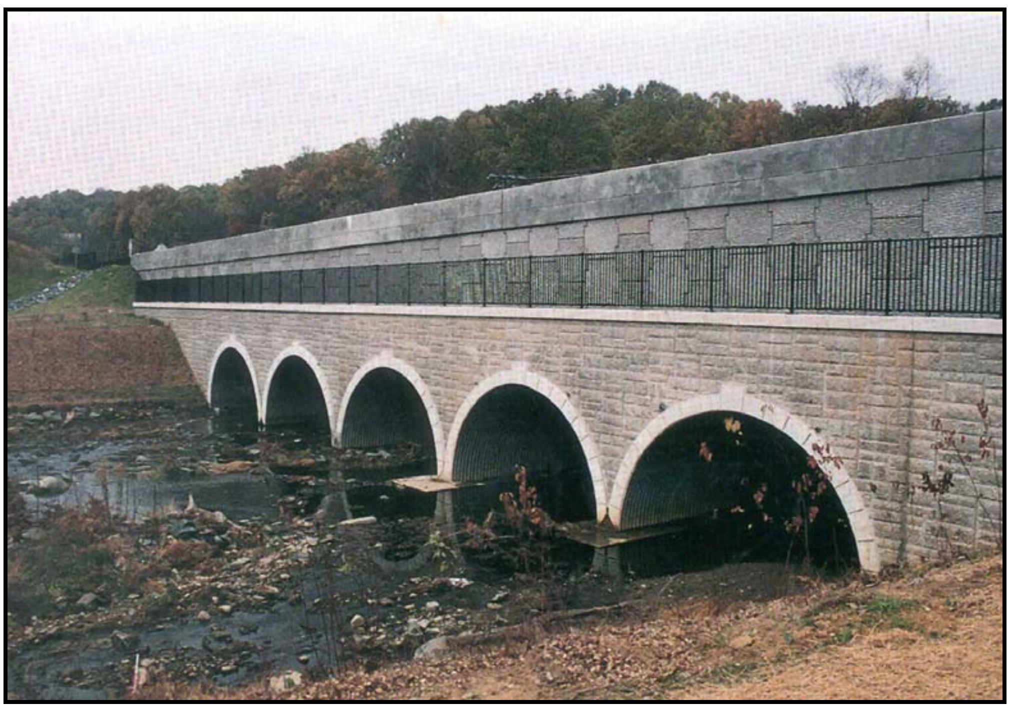


Fig. 9.05
The structure has been modified to accommodate equestrian trails (above) to provide safe access under the highway. The stone-like finish on the walls (below) fits well into the park setting. (US 1 over the Gunpowder Falls, Baltimore County, MD)



Native materials may be incorporated into the structure, such as stone work (Fig. 9.06).

Fig. 9.06
The stone work on the parapets and the pier matches the nearby mill. (MD 161 over Deer Creek, Harford County, MD)

In the case of the bridge located in a remote area that is not visible to the traveling public and will only be visible from the area surrounding the bridge, the land use will determine how many will view it (Fig. 9.07).

Fig. 9.07
Only those traveling on the water will view this bridge. (MD 333 over Trippe Creek, Talbot County, MD)

Structures that span over sensitive wetlands have become more common due to environmental requirements. Many of these structures provide minimal vertical clearances.

The designer should avoid placing piers in the waterway, as they become debris collectors during flood stage.

This creates an unsightly maintenance problem when the water returns to its normal level. Unless the debris is removed, it blocks the waterway opening during flooding, worsening the situation.

Construction access and environmental disturbance both during construction and subsequent maintenance activities must be evaluated very closely.

Pile bent type piers offer the least environmental disturbance since excavation is kept to an absolute minimum.

A solid shaft overpour of the piles down to the wetlands or below the normal water surface may be considered (Fig. 9.08).

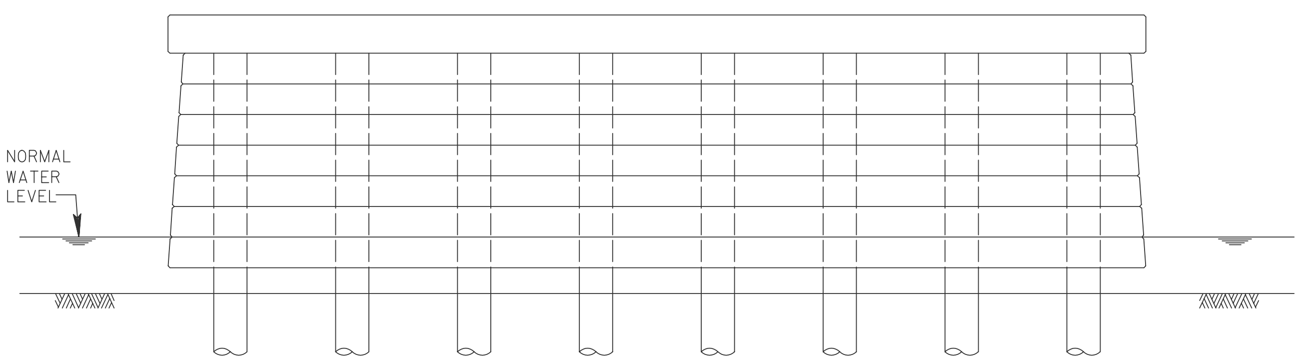


Fig. 9.08 Solid Shaft Overpour

This will eliminate the turbulence problem and also introduce an element of protection to the exposed piles. Another option is to provide a protective fiberglass wrap around each of the piles. Precast concrete beams should be considered to eliminate the routine painting required by steel superstructures.

D. PIER CONFIGURATION

Pier configuration plays a critical role in the aesthetic design of the bridge and, if not done properly, can undermine the original intent. Piers should be kept to a minimum, since they will tend to line up in the oblique view. The more elements in each pier (columns, pier cap), and the more angles at which they are placed, the more confusing the whole effect will be. Some ways to avoid these problems are listed below.

Use as few columns as possible at each pier (Fig. 9.09). Two is much better than three; three is much better than four. (For structures which stay low to the water, solid shafts may be the best solution.)

Fig. 9.09
Minimum use of columns makes this a more attractive structure.
(US 50 over Severn River, Anne Arundel County, MD)

If bridges are relatively narrow and high above the water, carefully shaped single shaft piers can be very effective (Fig. 9.10).

Fig. 9.10
This a good example of the use of single shaft piers. (Thomas Johnson-Lower Patuxent River Bridge, St.Mary's and Calvert Counties, MD)

The designer can take advantage of the economy of large diameter piles by giving thought to their placement and layout (Figs. 9.11 and 9.12).

Fig 9.11
This is a good example of properly spaced large diameter piles. (MD 213 over Bohemia River, Cecil County, MD)

Fig 9.12
This bridge might have looked better with less batter on the columns and with more space between the columns at the cap. (MD 313 over Nanticoke River, Wicomico County, MD)

Avoid mixing battered columns and vertical columns. Don't batter the outside columns on piers with three or more columns unless structurally necessary (Fig. 9.11).

The pier cap is a prominent element in the oblique view and will interrupt the visual lines of the structure unless it is minimized.

This is particularly true if the end of the cap is near or in the same plane as the face of the parapet.

The chapters on substructure and highway overcrossings suggest several ways to minimize the pier cap which also work for cast-in-place piers over water. However, in marine construction, piers utilizing individually driven precast concrete cylinder piles with precast caps have become very economical. The challenge is to find a way to meet the visual goals with this economical technology.

Pier heights for bridges over navigable water usually vary dramatically as the bridge rises to meet marine clearance requirements. Since most or all of the piers are visible at once in the oblique view, it is important that there be a continuity of form and shape (Fig. 9.13).

Fig. 9.13
These piers provide a good example of proportion in the substructure as well as the entirety of the bridge. (US 50 over Nanticoke River, Dorchester County, MD)

Use the same basic form for all piers (Figs. 9.14 and 9.15).

Fig 9.14
Too many columns on too many piers give the appearance of a forest of columns when seen from certain angles. (US 50 over Choptank River, Dorchester County, MD)

Fig. 9.15
A view seldom seen but worth noting. (US 50 over Nanticoke River, Dorchester County, MD)

Adapt changes in height in ways which preserve the main lines of the basic pier.

The main channel spans often call for a change in structural type and/or material.

Keep visible lines, overhangs and colors as consistent and continuous as possible when the structural type changes.

X. VIADUCTS AND LONG INTERCHANGE RAMPS

Simple diamond and cloverleaf interchanges usually have one structure which should be treated as a highway-over-highway crossing (See Chapter VII). More complex interchanges usually require multi-span ramp structures with many features in common with viaducts. Therefore, the multi-span interchange ramp bridges and viaducts will be treated as one subject.

A. DETERMINANTS OF APPEARANCE

The viewpoints in complex interchanges and viaducts are usually at multiple locations along the intersecting roadways.

The most important views can usually be identified based on traffic volumes or length of time a particular structure is in sight. Viaducts, particularly in urban areas, may have an almost infinite number of viewpoints, many of which may involve pedestrian traffic in close proximity to the bridge. With this range of possibilities, it is hard to identify specific features of the bridge as being more important.

Any and all features could be important depending on the circumstances, however, the following features will probably be most important.

- **The shape of the basic horizontal and vertical geometry**
- **Pier placement and shape**
- **Structure type**
- **The appearance of the underside of the superstructure**

B. SUPERSTRUCTURE DECISIONS

Keep the horizontal and vertical geometry as smooth as possible.

Regretfully, most of the time the bridge engineers have very little control over the geometry, but they should make their feelings known in the formative stages of the interchange layout. At least a set of preferred do's and don'ts should be developed and brought to the attention of the highway designers as the interchange layout is created.

Use horizontal and vertical curves of generous length and radii (Fig. 10.00).

Fig. 10.00
Smooth horizontal curve with a generous radius. (I-83 over I-695, Baltimore County, MD)

Use long continuous spans and curved girders (if roadway is curved).

Keep the form and depth of the structure as continuous as possible.

Make girder depth transitions with smooth curves and/or long tapers (Fig. 10.01).

Fig 10.01
Notice the girder depth transition. (41st Street over I-83, Baltimore City, MD)

Use large overhangs to emphasize horizontal continuity and minimize pier width.

C. SUBSTRUCTURE DECISIONS

Where possible, use pedestal abutments to minimize the transition from roadway to bridge.

Use as few piers and columns per pier as possible.

Because there will be so many piers, and they will be visible from so many different viewpoints, it is important to minimize the number of elements, and keep the shape simple.

Single shafts are better than paired columns, and paired columns are better than multicolumn piers (Figs. 10.02 and 10.03).

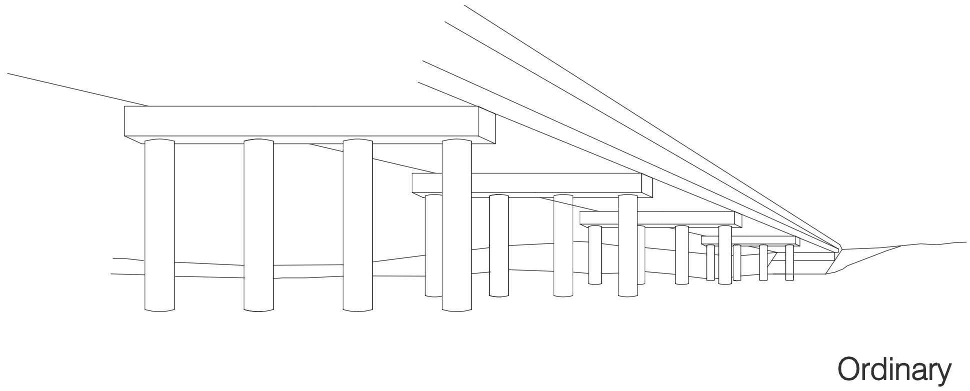


Fig. 10.02 Multi-column piers complicate the problem of skewed crossings and create a confused appearance.

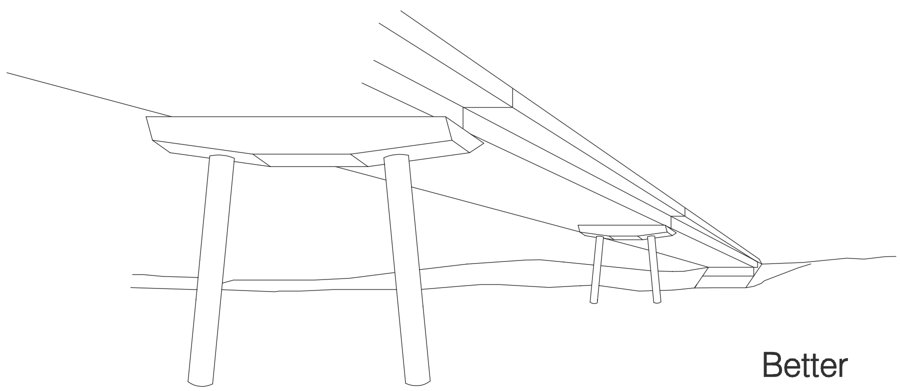


Fig. 10.03 The benefits of simplification. Two column piers and long spans create more options for convenient pier placement.

Where different lengths of piers occur, make an effort to have their shapes compatible.

Evaluate a pier shape for all heights of piers to be used.

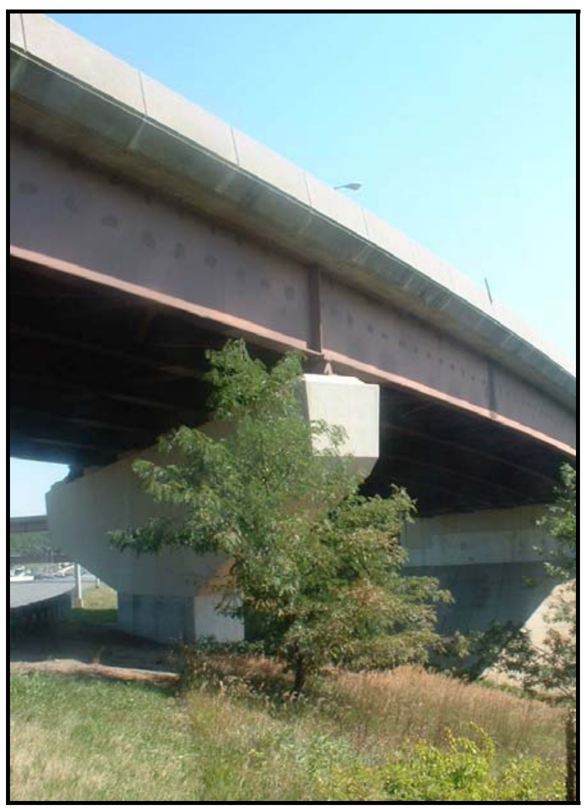
> *A hammerhead pier cap of a specific depth will look good on a tall pier, but as the pier height diminishes, as is usually the case for a ramp bridge, that same pier cap may lose its aesthetic relationship with a short stem.*

Keep all piers the same material and consistent in shape, where possible (Fig. 10.04).

Fig. 10.04
Piers with a simple but consistent shape provide continuity across a structure. (US 50 over I-95, Prince Georges County, MD)

Chamfered pier tops attenuate the substructure/superstructure joint and emphasize superstructure continuity and lightness (Fig. 10.05).

Fig. 10.05
Wide chamfered pedestals attenuate the substructure/ superstructure joint. (I-795 over I-695, Baltimore County, MD)



Place piers so that they are radial to bridge curvature. Where radial piers are not possible, try to keep adjacent piers or series of piers as close to parallel as possible to avoid having an oddly placed pier.

Place piers so that they are parallel to others in a series or radial to the over roadway. The best approach is to place all of the restrictions on the plan view--roadways, pedestrian areas, utility crossings and streams--then develop pier placements that satisfy the restrictions, satisfy the span relationships and still preserve the basic concepts of good layout.

If a situation is particularly complex, consider integral pier caps.

Integral pier caps can be utilized in both steel and concrete superstructures. They have been used in high exposure locations because they minimize the size of the pier, provide for more flexible pier location, and emphasize the continuity of the superstructure. However, these elements are non-redundant integrally framed cross members. Integral pier caps should be used only in situations where the physical requirements or importance of the location are so extreme that they can be accommodated in no other way. In such cases the burden is on the designer to develop ways to reduce the problem of selecting these structure types, such as providing a "fail safe" mechanism. (See discussion of fracture-critical members in Chapter IV - Substructure.)

D. BRIDGES OF VARYING WIDTH

Use curved continuous girders, especially on the exterior.

Keep the exterior overhang constant so that the fascia girder line looks continuous.

Add or subtract girders, as necessary, in a simple, logical fashion.

Keep the framing simple.

Ramps and viaducts often vary in width and continuity to accommodate ramps and acceleration lanes. Any structure involving adding or deleting individual girders requires the layout of these girders in such a way as to logically accommodate the gradual change in width. Flaring of beam spacing is preferred to framing in with short girders into other girders (Fig. 10.06).

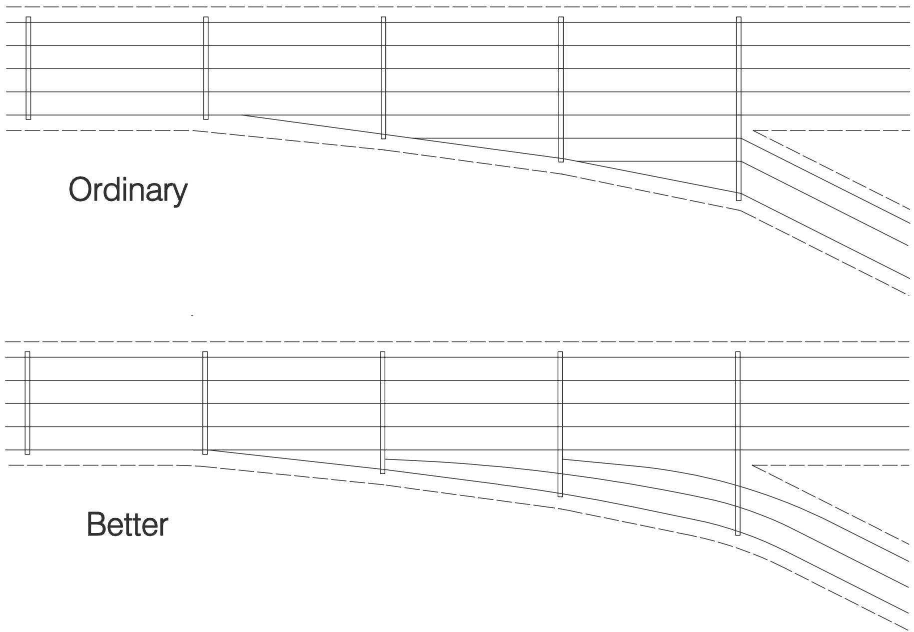


Fig. 10.06 A logical and simple method of adding girders will improve the appearance of the underside.

E. DESIGN OF THE UNDERSIDE

Consider whether significant pedestrian or vehicular traffic will be able to view the underside of the bridge for sustained periods.

Due to the height and locations of these bridges, their undersides will often be prominent, particularly to pedestrians. The designer should approach the features of the underside with the knowledge that they will be important factors in forming visual impressions of the bridge. Concrete slab structures are the best solution and provide a light-reflecting surface (Fig. 10.07). Steel plate girders present more of a challenge, but they can be made acceptable with attention to details, and with a light paint color. (See Chapter III - Superstructure for discussion of details.)

Interchanges in urbanized areas represent a special challenge since they often require the integration of bridges and retaining walls, along with requiring placement of lighting, signing and even traffic signals on the bridge. It is important, therefore, to lay out all the structures that connect with one another on one work sheet, rather than planning each viaduct and wall as a separate entity. It is also mandatory to show the placement of all light standards to their full height as well as signs that may be bridge-mounted. Where many lights are required, special lighting standards on bridges should be considered.

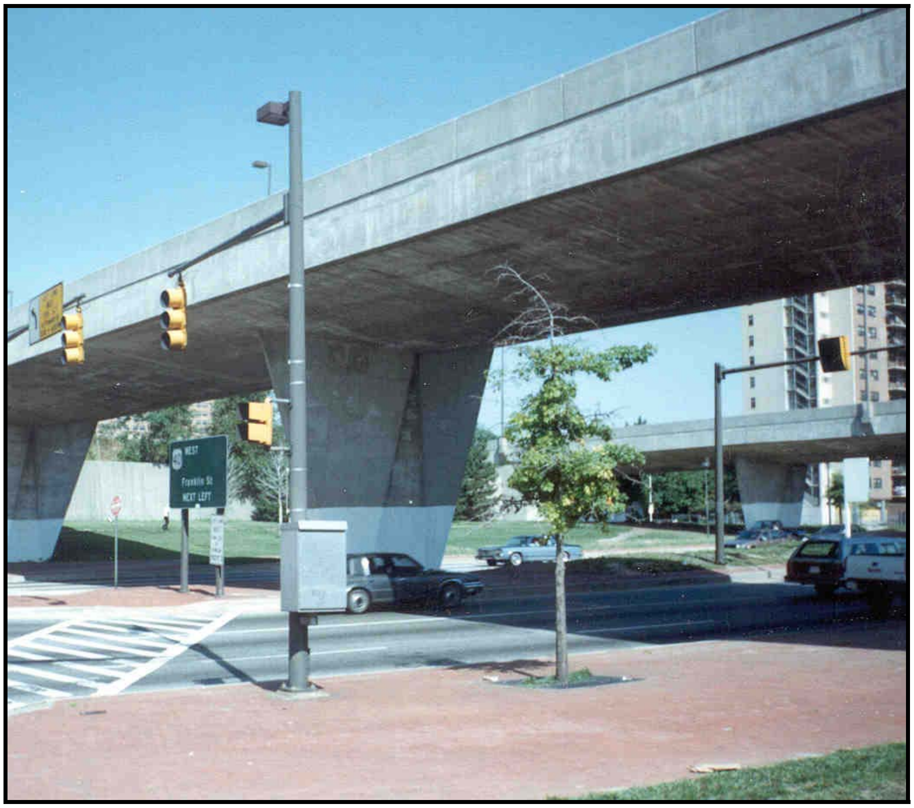


Fig. 10.07
A concrete slab bridge provides an attractive surface to view from under the bridge. (US 40 over Martin Luther King Boulevard, Baltimore City, MD)

Simplify and organize the bracing, lighting, drainage details, etc. into clear patterns.

Since an urban interchange is inherently confusing, the visual design goal should be to make the structure and appurtenances as simple as possible. Consistently used materials and shapes and continuous surfaces all contribute to improving the sense of visual order.

The design of the underside becomes even more important because of the need to focus attention on traffic signals and signs and the frequent presence of pedestrians. Once again, simple details and shapes consistent with the overall structure, aligned along the outlines of the major structural elements, all help to create the impression of visual order.

Painting the steel a light color will tend to brighten the underside.

Lighting of the underside of urban interchange structures is often important for reasons of function as well as appearance. By coordinating the placement of the lights with the major structural elements and the traffic patterns below, the lighting can make a positive contribution to the visual impression over and above merely providing light.

XI. HIGHWAY BRIDGES OVER RAILROADS

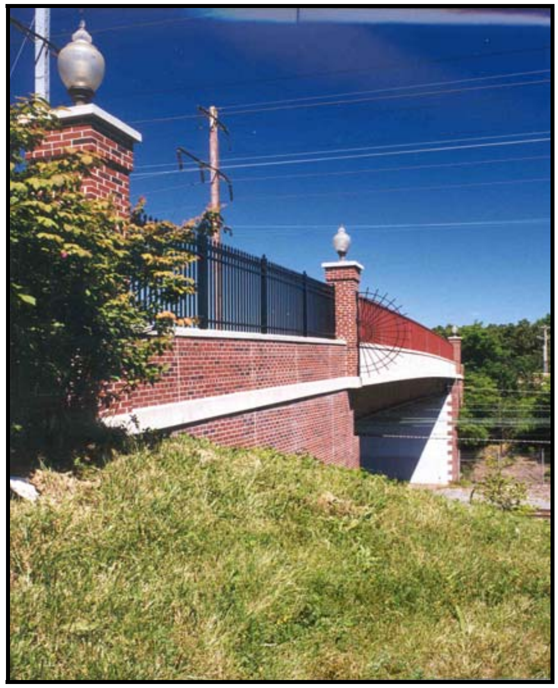
A. DETERMINANTS OF APPEARANCE

Bridges carrying highways over railroads are similar in many respects to highway overcrossings. Additional ideas for these situations can be derived from those sections of this guide.

One major difference is that the point of view may be less important. If the only people likely to see the bridge are occasional railroad employees, or those in trains moving at high speed, then less emphasis need be made, especially if additional money is required. In some instances, the structure may span a scenic railroad. Even though passengers are primarily looking out to the sides of the train, a structure may be seen in the distance on a curve. In this case, the designer may want to give more attention to the appearance of the structure from the rail. Also, there are often adjoining communities which have significant oblique views of the structure. In that case, these are the viewpoints which should be of most concern (Figs. 11.00 and 11.01).

Fig. 11.00
This bridge is located in the downtown area of a small town. The designer did a great job of matching the architectural details of the bridge to the architecture of the locale. (MD 39 over CSX Transportation, Garrett County, MD)

Fig. 11.01
Brick details were added to this structure to match the surrounding community.
(MD 564 over AMTRAK, Prince Georges County, MD)



Span lengths should be as long as feasible.

Multiple short spans should be avoided (Fig. 11.02). The multiple spans will usually provide a cluttered view. In evaluating costs, be sure to include the costs of special sheeting required to construct a pier next to the railroad as well as railroad communication systems, which are usually present in these areas. It may mean that the overall structure cost is more economical without the piers (Fig. 11.03).

Fig. 11.02
An ordinary example of multiple short spans with piers adjacent to railroad tracks.
(County Bridge over CSX Transportation, Montgomery County, MD)

Piers located adjacent to tracks should be avoided.

Piers should be located as far from the tracks as possible or eliminated entirely (Figs. 11.03, 11.04 and 11.05). This will result in a two-fold benefit. First, from an operational standpoint, the pier will not be a safety hazard and will not require a railroad crash wall. Second, from an aesthetic standpoint, the tunnel-like effect of the pier closing in on the tracks will be eliminated.

Fig. 11.03
Single-span crossing with slender superstructure. (MD 27 over Maryland Midland Railroad, Carroll County, MD)

Fig. 11.04
Single-span crossing with slender superstructure and cantilever abutments. (MD 213 over CSX Transportation, Cecil County, MD)

Fig. 11.05
The solid shaft piers on this structure were an excellent choice. Multiple column piers would have created a "busy" look. The long slender spans and wide spaced piers provide an open feeling. (Alternate US 1 over CSX Transportation, Prince Georges County, MD)

Electrified Railroads present their own special problems providing for the electrified facilities.

> *Location of catenary poles and wires must be considered to avoid the cluttered appearance. In most cases there is not much that can be done, but, if possible, the placement of catenary poles near the structure should be avoided. The poles often appear as add-ons and will visually disrupt the appearance of the bridge. An alternative to consider is placing the poles outside the view of the bridge.*

B. DESIGN SUGGESTIONS

Place wing walls parallel to roadway to emphasize the length of the structure.

Taper protective barriers at the end of the wing wall to visually increase the bridge's length and give a finished appearance. If the railroad only makes up a portion of the crossing, then taper down or round the barrier at the ends to give a finished appearance (Fig. 3.45).

The protective barrier or pedestrian screen should be tapered down at the end posts (Fig. 11.06). Abrupt full height endings tend to make the bridge appear shorter and visually disrupt the continuity of the bridge. Tapered endings emphasize the length of the structure.

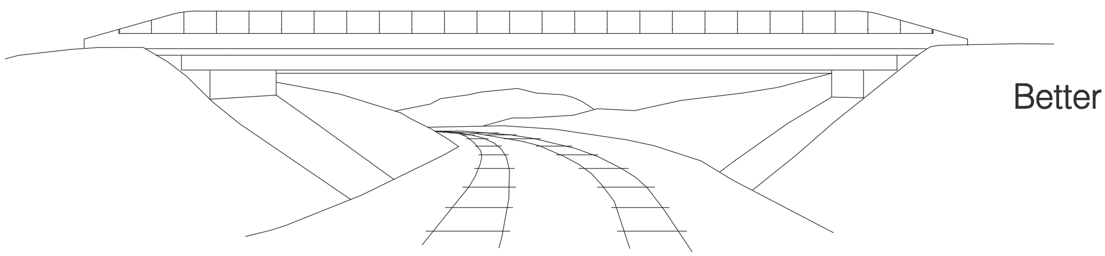


Fig. 11.06 Tapering of pedestrian screen

XII. RAILROAD BRIDGES OVER HIGHWAYS

A. DETERMINANTS OF APPEARANCE

The design of aesthetic railroad bridges over highways provides a unique challenge to the engineer. The bridge must project a sense of strength and the ability to carry its load to the observer. At the same time, the bridge must be proportioned in such a way that it doesn't overpower and dominate the landscape. There are limitations on what the designer can do to improve its appearance. The heavy concentration of loads that these bridges are required to carry result in deep girders and massive substructure elements. This problem is further compounded by the railroad's reluctance to use continuous structures. Despite these limitations, the same concepts that are used to produce aesthetically pleasing highway bridges can also be applied to improve the appearance of railroad bridges.

B. SUPERSTRUCTURE DECISIONS

The visual goal is to display the strength of the superstructure while maximizing its apparent length.

A railroad bridge is similar to a highway bridge in that visual continuity is one of the most important factors in creating an aesthetically pleasing design. The goal is to design a structure that results in apparent slenderness and lightness that also blends in well with the substructure and its surroundings. Although railroad bridges use simple spans, the designer can achieve a continuous effect by following a few guidelines.

Where possible, keep the fascia girder depths in all spans the same.

If the situation allows, equal spans are preferred. Avoid mixing short end spans and long center spans which serve to emphasize the breaks in the simple spans (Figs. 12.00 and 12.01). Unequal spans with varying girder depths give the effect of making longer girders look unreasonably heavy. The impression of the bridge's strength must be carried throughout the structure.

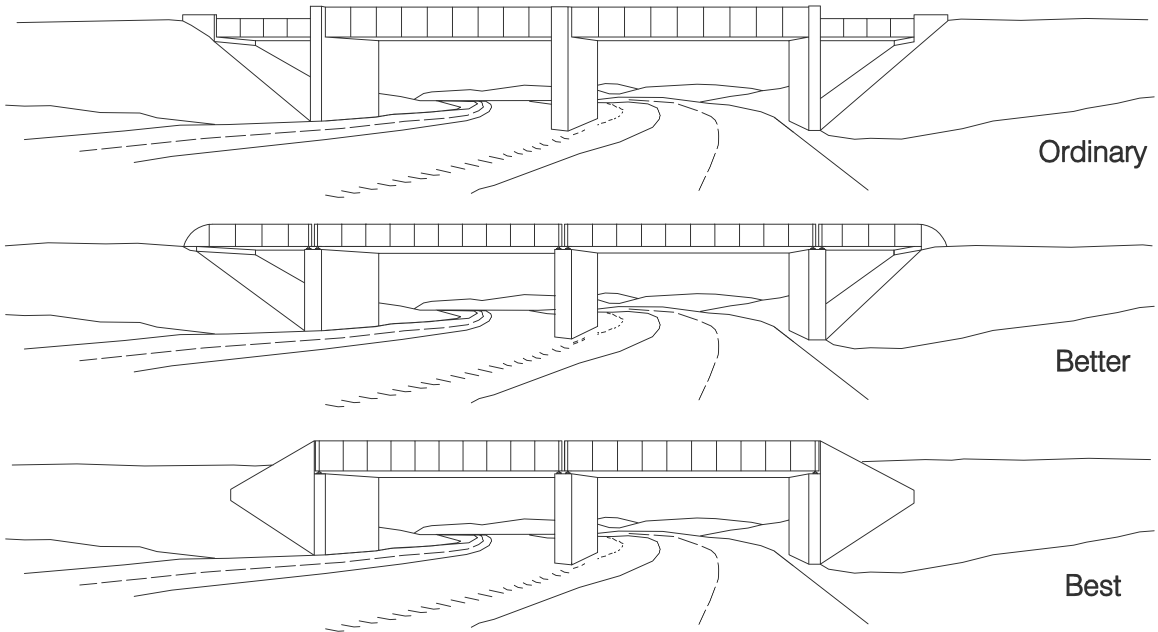


Fig. 12.00 Avoid girders of different depths.

Fig. 12.01
Equal spans and constant girder depth increase apparent length and slenderness. (CSX Transportation over I-695, Baltimore County, MD)

Superstructure depth-to-span ratio should be kept as small as possible.

Minimizing the depth-to-span ratio is one of the most important considerations for producing an aesthetically pleasing bridge (Fig 12.02). This is especially crucial for railroad bridges. Limiting the depth-to-span ratio will help to offset the massive size associated with railroad bridge girders.

Using varying spans and depths can also create a large jump in the girder profile (Fig. 12.02). Once again, this breaks the flow of the lines across the structure and emphasizes the use of simple spans. By keeping the fascia girders the same depth, the appearance of continuity is presented to the observer.

Fig. 12.02 *Varying girder depths emphasize the use of simple spans. This makes the bridge look short and heavy. (CSX Transportation over I-270, Montgomery County, MD)*

Eliminating at-grade crossings in flat terrain presents its own special challenge.

Because railroad grades must be very flat it creates the need for long approach ramps on either side of the bridge structure. If the tracks are located in an area that is confined by buildings on either side, the ramp approach must be created by the use of long and expensive retaining walls (Fig. 12.03) or a long extension of the bridge structure.

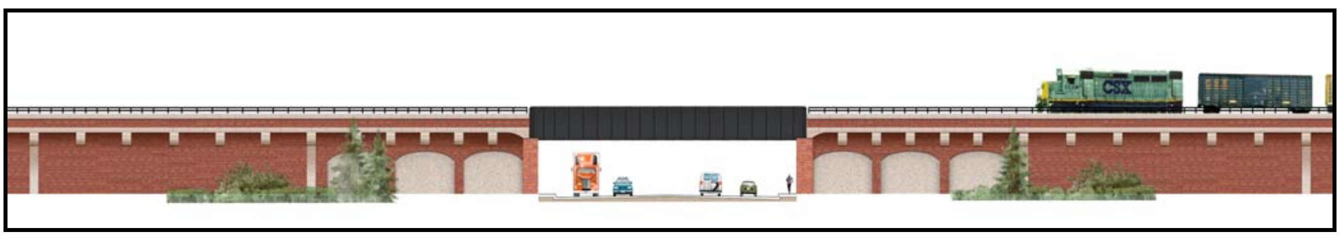


Fig. 12.03 *Confined flat area necessitated construction of long ramps with walls. Aesthetic treatment is utilized to soften the intrusion of the long structure into the community. Rendered Elevation of Grade Separation of CSXT Railroad at MD 450 (Rendering by Whitman, Requardt and Associates, LLP - Baltimore, Maryland)*

Superstructure details such as bearings should be exposed, as they will complement the structure appearance.

Curtain walls and pilasters which hide bearings should be added only if they give the appearance of being an integral part of the structure. They should not give the look of being added on as an afterthought. When bearings are exposed, higher rocker type bearings should be used. This type of bearing separates the superstructure from the substructure and gives the superstructure its own identity. The goal is to have the interface between the substructure and the superstructure emphasize the continuity of the structure.

Use stiffener details to emphasize the horizontal nature of the girder, if possible.

Vertical stiffeners are a necessary element of railroad bridges. They should not be hidden, but emphasized. The railroads require the use of vertical stiffeners on their bridges. If possible, the stiffeners should be placed on the inside face of the girder. Stiffeners placed on the outside face emphasize the large depth of the girder and give the appearance of dividing the superstructure into shorter spans. If the vertical stiffeners are to be placed on the outside face of the girder, they should be placed according to the imposed shear stresses. This creates a denser pattern at the supports offsetting some of the effect caused by the stiffeners being placed externally.

The choice of color should be based on the surroundings and location of the bridge. The color should blend the bridge in with its environment and help minimize the size of the girders. Painting the superstructure a dark color hides the stiffeners and from certain vantage points minimizes its size (Fig. 12.01).

C. SUBSTRUCTURE DECISIONS

The substructure of a railroad bridge over a highway has an important part in producing an aesthetically pleasing structure. The design of the substructure can help minimize the size and appearance of the superstructure and stress continuity in the bridge. As with highway bridges, the substructure should be proportioned to reflect the scale of the superstructure. The pier and abutment design should help emphasize the slenderness and continuity of the bridge. The goal is to achieve a balance between the two elements. Keeping the design of the piers and abutments simple is key to achieving this balance.

Pier and abutment design should work to emphasize the slenderness of the superstructure.

The same heavy loads that cause railroad bridges to have deep girders also result in massive abutments to support those girders. The combination of these two massive elements results in an imposing structure. The placement of the abutment can help offset this problem. By moving the abutments back away from the edge of the roadway, the slenderness and length of the superstructure are enhanced. The cost of moving the abutments back must be taken into consideration. The added cost of increasing the length of the girders may cause this option to be prohibitive.

Use large simple shapes for the pier and abutments.

The pier design for railroad bridges should be kept simple. The pier must give the impression that it can support the large superstructure. For most railroad bridges over highways, solid shaft piers give the best impression of strength while at the same time maximizing the appearance of height in the structure (Fig. 12.04). This arrangement produces a smooth substructure/superstructure interface. A cap and column type pier may make the bridge appear like it is made up of numerous short heavy elements.

Fig. 12.04
The use of solid shaft piers gives the impression of strength. (CSX Transportation over I-495 Montgomery County, MD)

A pronounced chamfer at the top of the pier will highlight the substructure/superstructure interface.

Skew wing walls with abutment.

> *Abutment wing walls placed parallel to the railroad alignment may add something to the appearance. This configuration is not as efficient as walls placed at a bisecting angle, yet it may help increase the apparent length of the bridge. This is very expensive because of heavy railroad loads. In most cases, because of the massiveness of the abutment, the flared wing walls are not necessarily a detraction.*

Consider architectural treatments such as heavy grooving only for very expansive abutments, wing walls and piers. (Fig. 12.03)

XIII. PEDESTRIAN BRIDGES

A. DETERMINANTS OF APPEARANCE

Pedestrian bridges provide a unique opportunity to let the imagination run free. They look best when the superstructures are kept slender and graceful (Fig. 13.00), and flow continuously over the supports and into the ramp or stair sections. Since stairs are inherently discontinuous features, real design ingenuity is required to integrate them smoothly into the balance of the structure. Ramps are more easily incorporated into the structure and provide for the needs of those with disabilities.

Pedestrian screens are the most prominent element and should be treated as such.

Depth-to-span ratio should be minimized to avoid heavy appearance.

Support element should be simple and light, if possible.

Fig. 13.00
A good example of long graceful spans on a sharp skew angle. (Hiker/Biker Trail over MD 100, Anne Arundel County, MD)

Ramp configuration should relate to the bridge or roadways below (Figs. 13.01 and 13.02).

Fig. 13.01
Long arching superstructure with ramps and stairs located parallel to roadway main line. (Pedestrian Bridge over MD 702, Baltimore County, MD)

Fig. 13.02
Another view. (Pedestrian Bridge over MD 702, Baltimore County, MD)

B. DESIGN SUGGESTIONS

Keep the bridge as long and slender as practical.

The bridge should be as long as practical (Figs. 13.00 and 13.05). The superstructure should be proportionately slender in relation to the span length.

The bridge and ramps should provide for a smooth and continuous geometric flow. Sharp breaks and odd angles should be avoided.

Stairs and ramps must be integrated into the structural and aesthetic continuity of the bridge (Figs. 13.04, 13.07, 13.08 and 13.09). Ramps and stairs that are located on odd angles provide a confusing and disrupted appearance (Fig. 13.03). Curving or long graceful ramps provide a more pleasing appearance.

Fig. 13.03
A poor example-- pedestrian bridge with ramps located on odd and random angles. (Pedestrian Bridge over AMTRAK, Harford County, MD)

Design graceful, generous curves into the bridge profile instead of straight grades. This allows for the bridge to have a lighter appearance (Fig. 13.05).

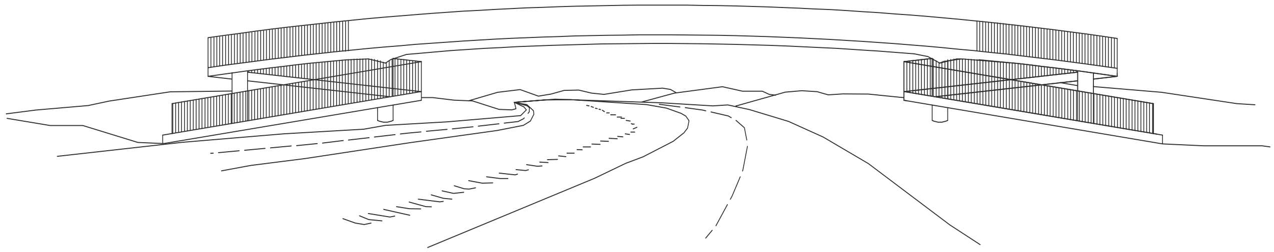


Fig. 13.04 Spiraling ramps look more graceful than random angles.

Provide as low a parapet as is possible. The structure is more slender and opportunities for graffiti are reduced.

The use of concrete parapets should be avoided. The pedestrian screen should extend down to the walkway level (Figs. 13.00, 13.05 and 13.06). This will emphasize the slenderness of the superstructure.

Fig. 13.05
Long graceful arching spans with simple abutments. (Pedestrian Bridge over MD 295, Baltimore County, MD)

Fig. 13.06
Simple spans with flat grade. (Pedestrian Bridge over MD 295, Baltimore City, MD)

Fig. 13.07
Integrating stairs and superstructure. (Pedestrian Bridge over US 15, Frederick County, MD)

Fig. 13.08
Another view. (Pedestrian Bridge over US 15, Frederick County, MD)

Keep the design of the pedestrian screen simple to offer a more open appearance.

> *Careful attention should be given to the pedestrian screen on the bridge. The design should be simple and open. The spacing of fence posts should be close enough to cover the required specifications, but spaced out to eliminate a busy appearance.*

Lighting should be provided at the walkway level to eliminate the light standards and to accent the bridge.

Fig. 13.09
Integrating ramps and superstructure leads to a pleasing structure. (Australia)

Consideration should be given to using existing structures that are to be removed, as pedestrian structures if a suitable location can be found, such as a park. (Fig. 13.10).

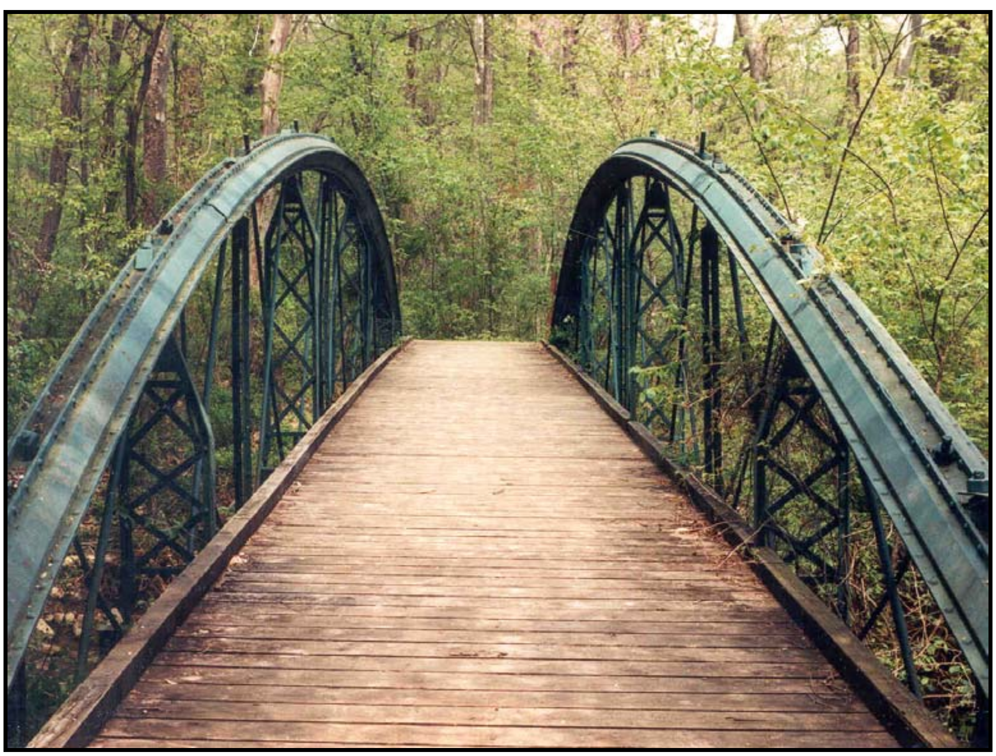


Fig. 13.10
This bow string arch from MD 77 was relocated near Catoctin Furnace. (Pedestrian Bridge over Little Hunting Creek, Frederick County, MD)

Here are two other examples of pedestrian bridges blending with the area (Figs. 13.11 and 13.12).

Fig. 13.11
This bridge contains the same railing details as a nearby gazebo. (Pedestrian Bridge over Water, Quiet Waters Park, Anne Arundel County, MD)

Fig. 13.12
This bridge blends nicely with the environment. (BWI Hiker Biker Trail Bridge over Sawmill Creek, Anne Arundel County, MD)

Consider using prefabricated pedestrian bridges.

Several companies offer a variety of prefabricated bridge superstructures made of steel or wood. Most companies have standard designs that can be modified to match the aesthetics of the area. The company generally has design criteria that need to be followed. These bridges can be used on large projects such as over highways or smaller recreational bridges. Some designs can be shipped up to 120 feet in one piece and set onto the constructed or existing substructure. Overall, prefabricated bridges not only add to the aesthetics of their surroundings, they save time and money.

XIV. REHABILITATION AND RECONSTRUCTION, MIXING OLD AND NEW STRUCTURES AND STRUCTURAL ELEMENTS

Rehabilitation and reconstruction will become more and more prevalent as our existing highways are expanded and rebuilt and we try to get more life out of existing structures. It is usually not possible or desirable to reconstruct or reproduce an older structure. New structural techniques, safety requirements (elimination of shoulder piers, etc.), new materials and new functional requirements all will make that the wrong solution. However, it is possible to construct new bridges alongside old so that the ensemble is visually consistent and attractive. Usually, the existing structure has significant age, and will, sometime in the near future, be replaced. Therefore, the new structure should take into account that the sister bridge will not be there for the full life of the new structure. It is also possible to reconstruct old bridges to incorporate new requirements and techniques while still respecting the original design intent and appearance.

The introduction of a new crossing on an existing route, such as an expressway, creates a real challenge to blend and not clash with other existing crossings along the route. This requires a thorough evaluation of the location--noting existing structures near the new, their pier placement and shapes, their color, pedestrian screening, etc. This does not mean that it must match the existing, but that it should blend in or fit in to some overall future plan. For example, it is acceptable to have a two-span continuous crossing in an area with four-span bridges as long as the two different types complement each other, as by a similar pier design or parapet appearance. Often this is not possible, but the emphasis should be to see if it can be done while meeting the goals for the new structure.

The mixing of old and new is a situation where hard and fast guidelines cannot be given. The best solution depends very heavily on the situation as it exists in the field.

A thorough field review and documentation, including color photographs of the old structure from various viewpoints, should be undertaken in order to assist in developing the new. The review should use the guidelines outlined in the previous sections as criteria. Often, this kind of careful study and analysis will produce its own ideas.

If the old bridges have very few features which are consistent with these guidelines, or if the old bridge stands alone rather than as part of a group of similar structures, then it may be better to make the new bridge completely independent. However, if the old bridge has very good qualities, these should be carried over to the new bridge and preserved on the old bridge. Features which are not consistent with these guidelines

should be minimized.
The desirable features can be made the basis of common details, proportions and structural systems that are used in both new and old structures. The new features need not be literal reproductions of the old. For example, it may not be necessary to construct new fieldstone abutments to match old abutments. However, the new abutments could be made similar in size, shape, color, and/or proportion to achieve the desired consistency. The worst solution would be to attempt to reproduce the fieldstone in cast concrete. The sham will be quickly apparent and will make both new and old look tawdry.

Color offers a quick and obvious way to blend old and new. If a new steel bridge is to be built next to an old one, it is a simple matter to paint them the same color or a related color. Concrete may offer similar possibilities. For example, if the older pier cap is to be given an epoxy finish for maintenance purposes, the same finish can be applied to a similarly shaped new adjacent pier cap.

Quite often a major portion of an existing structure, that is in sound condition, is incorporated within a newer enlarged structure. The designer should make every effort to make the total structure look as though the new and old belong together (Fig. 14.00). Certainly the designer should try to preserve the types of construction. Multi-circular column piers should be extended with like construction. However, care should be taken in the layout of old and new together that column spacing, cap shapes, etc. tie in with one another. Little things such as bottom of caps of existing piers and widened portions being at the same elevation, same surface treatments, etc., can make a world of difference.

Fig. 14.00
The existing stone faced arch bridge has been extended without sufficient consideration of how its appearance fits in with the existing bridge.

When rehabilitating or performing required maintenance, careful consideration should be given not to alter the appearance or historical value of the structure. The repairs should be made to match the existing structure as close as possible (Fig. 14.01). Whether it is scupper modifications or pneumatically applied mortar repairs, a little attention to the details of the structure can save the looks of the structure and it usually does not significantly add to the cost of the project.

Fig 14.01
Extraordinary efforts were utilized to maintain the historically accurate appearance of the Booth's Mill Bridge. (MD 68 over Antietam Creek, Washington County, MD)

XV. PRIZE WINNING BRIDGES: RECOGNITION HALL

The Maryland State Highway Administration is responsible for approximately 2800 bridges. The Cassleman River Bridge located in Western Maryland, our oldest bridge, was the longest single span stone arch bridge in the United States when it was opened in 1813. In 1963 it was designated a registered national historic landmark by the United States Department of the Interior's National Park Service. The bridge was designed with a high arch to accommodate boats for the extension of the C & O Canal (which never materialized due to the building of the railroads). Now a portion of the Cassleman River State Park, the bridge is no longer open to vehicular traffic, but stands as a beautiful monument to the early bridge builders.

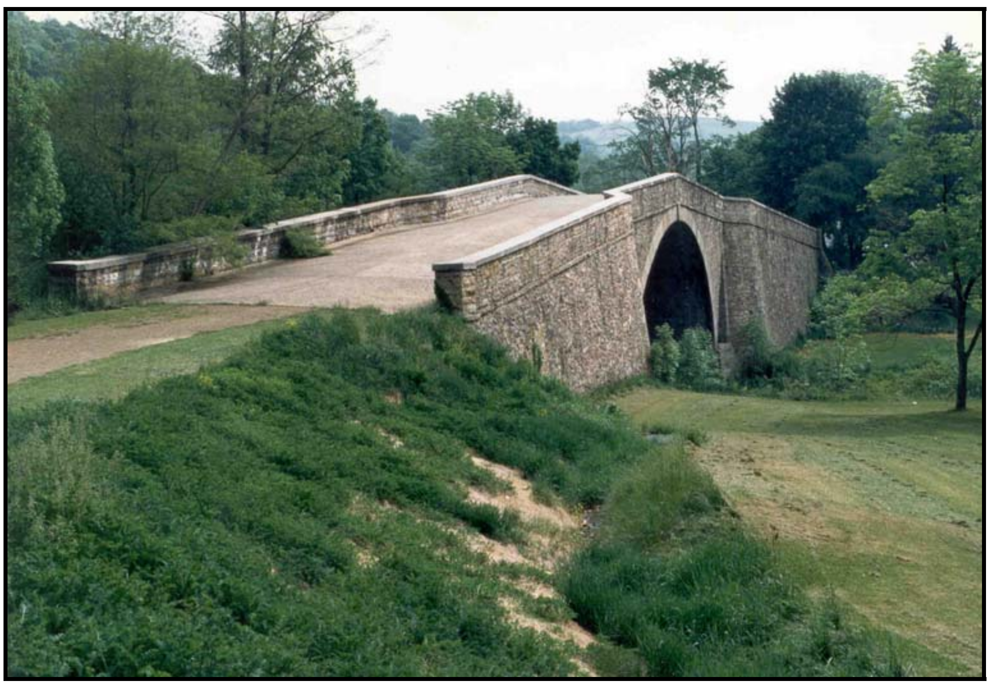


Fig. 15.00 Cassleman River Bridge

In keeping with this tradition, Maryland has been fortunate to receive its share of bridge awards throughout the years. It was therefore decided in the fall of 1990, that a bridge "Recognition Hall" be created to provide a suitable display for them. Recognition Hall presently consists of over 50 panels, each of which has the actual award mounted on it, a photograph of the structure and a plate containing the names of the Administration's Design Engineer, the Consultant Engineering firm (when applicable) and the Contractor.

In addition to these panels, there is a large display of the seven awards (many on a national scale) received for the United States Naval Academy Bridge which carries MD 450 across the Severn River into our State Capital, Annapolis.

The awards range from top national recognition to regional and local levels, and acknowledge excellence in Engineering, Construction, Aesthetics and Service to the citizens of Maryland. Although the panels are only large enough to acknowledge the above-cited individuals, an arch bridge placed above the entrance to Recognition Hall is inscribed "Dedicated to those who made this hall possible." This inscription acknowledges that award-winning bridges are not just created by design, but require competence of the men and women throughout all modals within the Administration as well as the Consulting Engineering firms and Contractors.

A partial listing of the awards displayed in our Recognition Hall follows.

Fig. 15.01 MD 7 over the Gunpowder Falls

The American Institute of Steel Construction presented the Administration with its top 1989 "Prize Bridge Award" for best Short Span Steel Bridge of 1987 - 1989. The steel arch bridge is located on MD 7 over the Gunpowder Falls. The beauty of the structure is best appreciated by the freshwater fishermen and naturalists strolling along the banks. SHA Design Engineer: James T. Aguirre, P.E.; Consultant Engineering Firm: Envirodyne Engineering, Inc.; Contractor: Central Atlantic Contractors.

Fig. 15.02 Vienna Bridge - US 50 over Nanticoke River

The American Society of Civil Engineers presented the Administration with an Award for Outstanding Civil Engineering Achievement in 1990 for the Vienna Bridge and Bypass. The bridge is located on US 50 over the Nanticoke River. The entire roadway embankment and bridge were constructed through marshes. The area is the breeding grounds for rockfish, an endangered species, and required considerable planning and careful implementation to avoid an adverse environmental impact. SHA Design Engineer: Robert J. Healy, P.E.; Consultant Engineering Firm: STV/Lyon Associates/T.Y. Lin; Contractor: The Hardaway Company.

Fig. 15.03 Woodrow Wilson Bridge

The American Consulting Engineers Council presented the Administration with its "Grand Conceptor" Award in 1984 for Engineering Excellence for widening and deck replacement on the Woodrow Wilson Bridge. This high traffic volume bridge carries the I-95 portion of the Capital Beltway (Washington, D.C.) over the Potomac River between Maryland and Virginia. The deck replacement was performed at night utilizing precast deck sections and quick-set polymer concrete bearings. The bridge was reopened to full traffic each morning. SHA Design Engineer: Mervat Younan, P.E.; Consultant Engineering Firm: Greiner Engineering, Inc.; Contractor: Cianbro Corporation.

Fig. 15.04 Pocomoke River Bridge

The Pocomoke River Bridge carrying MD 675 over the Pocomoke River received a Consulting Engineers Council award in 1990. The bascule bridge was built in 1920, and rehabilitated in 1989, preserving the original appearance by recreating the flanking spans to match the original configuration. The project required total replacement of the approach spans, renovating the bascule counterweights and underpinning the bascule piers and pilothouse. The bridge was closed to vehicular traffic during construction, but pedestrian traffic was maintained throughout the project. SHA Design Engineer: Douglas M. Hutcheson, P.E.; Consultant Engineering Firm: Greiner Engineering, Inc.; Contractors: The Empire Construction Company and National Foundation Company.

Fig 15.05 I-97 and I-595 Connector Route

The I-97 & I-595 Connector Route received an award from the Consulting Engineers Council for Innovative Excellence in Engineering in 1988, and the Shield of Masonry award from the Brick Masonry Institute in 1991. All bridges in the Connector Route include precast brick veneer and exposed aggregate concrete facing panels on the parapets and steel girders. This interchange is located in the historic Annapolis area, where concern was raised by civic groups about the appearance of the bridges during the project development stage. Although the concept has been used in building construction for many years, the placement of facing panels on a bridge with traffic producing live loads and vibration required innovation for tying each brick to the panel in a way that would prohibit its dislodgement if the mortar failed. The bolted panels are removable for inspections and future renovations. Design and construction were performed under several phases by multiple firms. SHA Design Engineer: John W. Narer, P.E.; Consultant Engineering Firm: Whitney, Bailey, Cox & Magnani; Kidde; Johnson, Mirmiran and Thompson; Contractor: Danis; Williams; Driggs.

Fig. 15.06 US 50 over Severn River

The Severn River Bridge carrying US 50 over the Severn River near Annapolis received the American Society of Civil Engineering's Outstanding Civil Engineering Achievement award in 1987, and the Federal Highway Administration's first place award for Cost Savings Innovation in 1988. Both awards were for the outstanding design for widening the superstructure without widening the piers, which was accomplished by expanding the length of the pier caps with steel saddles and steel girders, sandwiching the existing concrete pier cap. The entire project was performed while traffic on the bridge was maintained. SHA Design Engineer: Mervat Younan, P.E.; Consultant Engineering Firm: Envirodyne Engineering, Inc.; Contractor: Whiting-Turner.

Fig. 15.07 Chester River Bridge

The Administration received a 1990 award from the Precast/Prestressed Concrete Institute for Excellence in Architectural and Engineering Design Using Precast/Prestressed Concrete for the Chester River Bridge. This bridge carries MD 213 over the Chester River in Chestertown. The project consisted of encasing existing piles, lifting out one superstructure span at a time, repairing portions of the substructure and lifting a wider, complete full-span precast section into place. The removal and replacement of the superstructure spans were performed at night and the bridge reopened to full traffic in the morning. SHA Design Engineer: Randolph P. Brown, P.E.; Consultant Engineering Firm: Century Engineering, Inc.; Contractor: McLean Contracting Company.

Fig. 15.08 Canal Parkway

The Maryland Section of the American Society of Civil Engineers recognized the Canal Parkway Grade Separation at the C&O Canal in 1998, as an Outstanding Civil Engineering Achievement. Considerable thought was given to this project as it carried traffic on Ford Avenue across the C&O Canal/Towpath and ties into the Potomac River Bridge into West Virginia. Working with the National Park Service, a Warren Truss with a grid deck was selected as it facilitated crossing the C&O Canal/Towpath while maintaining the required underclearance. The traffic barrier is an open rail system developed to afford the desired level of protection with the greatest degree of openness for views off the sides of the bridge. Vertical posts were lined up with vertical truss members to reduce visual clutter when looking off the side of the bridge or viewing the bridge from the towpath. Detail studies were conducted on the aesthetic treatment of the abutments, as everyone along the towpath would view them at very close range. It was decided to incorporate stone work into them to resemble the old structures around Cumberland. Native stones were selected in an ashlar pattern to create a structure that serves the highway users and fits well with the park setting. SHA Design Engineer: Glenn C. Vaughan, P.E.; Consultant Engineering Firm: Wilson T. Ballard Company; Contractor: Carl Belt, Inc.

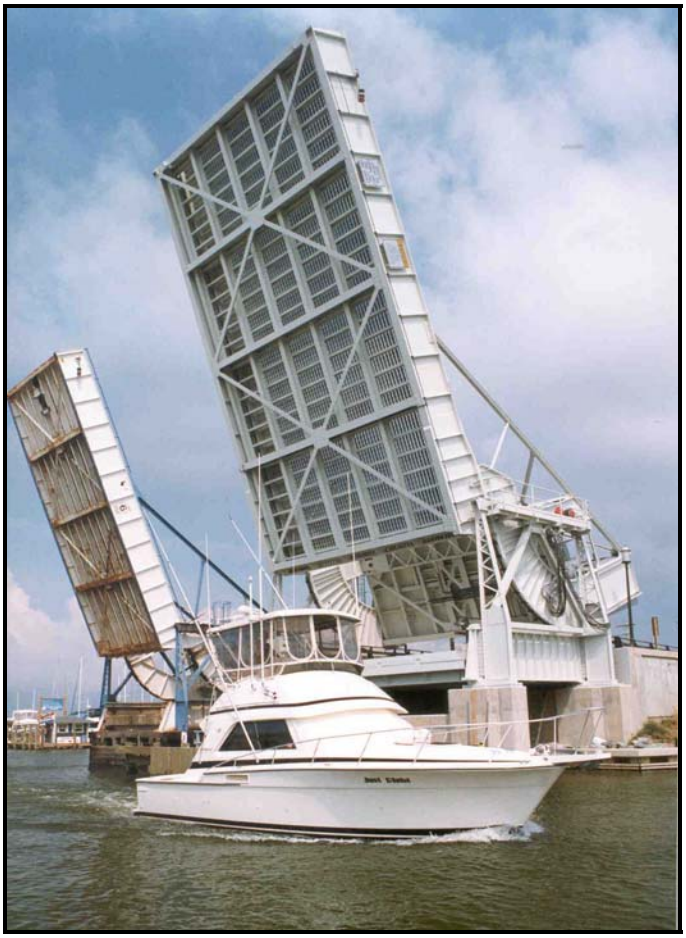


Fig. 15.09 Knapps Narrows

The Knapps Narrows Bridge at Tilghman Island on our eastern shore has been recognized by the Consulting Engineers Council for innovative excellence in engineering design, and the American Society of Civil Engineers, Maryland Section, as the Outstanding Civil Engineering Achievement Award for 1999. The original overhead counterbalanced bridge, an historic landmark at Tilghman, opened on demand approximately 23,000 times a year, making it one of the busiest drawbridges on the East Coast. This was due to the enormous amount of boat traffic and the low profile of the bridge. When the existing bridge was determined to be beyond repair, the citizens of Tilghman wanted it replaced in kind. The new structure resembles the old bridge but on a larger scale with a longer single leaf span and a higher profile to permit passage of small boats without opening. The original structure was removed and re-erected several miles away, as part of the Chesapeake Bay Maritime Museum in St. Michaels. SHA Design Engineer: Ralph Manna, P.E.; Consultant Engineering Firm: Modjeski & Masters/Whitney, Bailey, Cox & Magnani/Gipe Associates; Contractor: Archer-Western Contractors, Ltd.

Fig. 15.10 Booth's Mill Bridge

The Historic Booth's Mill Bridge over Antietam Creek in scenic Washington County, Maryland was originally constructed in 1883 and in 1995 was fully restored. This restoration has been recognized by the American Society of Civil Engineers with their 1996 Award for Outstanding Civil Engineering Award for Aesthetic and Functional Design and the 1995 American Concrete Institute Excellence in Concrete Award. SHA Design Engineer: James T. Aguirre, P.E.; Consultant Engineering Firm: Diver Brothers Consulting Engineers; Contractor: Kiewit Construction and Espina Stone Company.

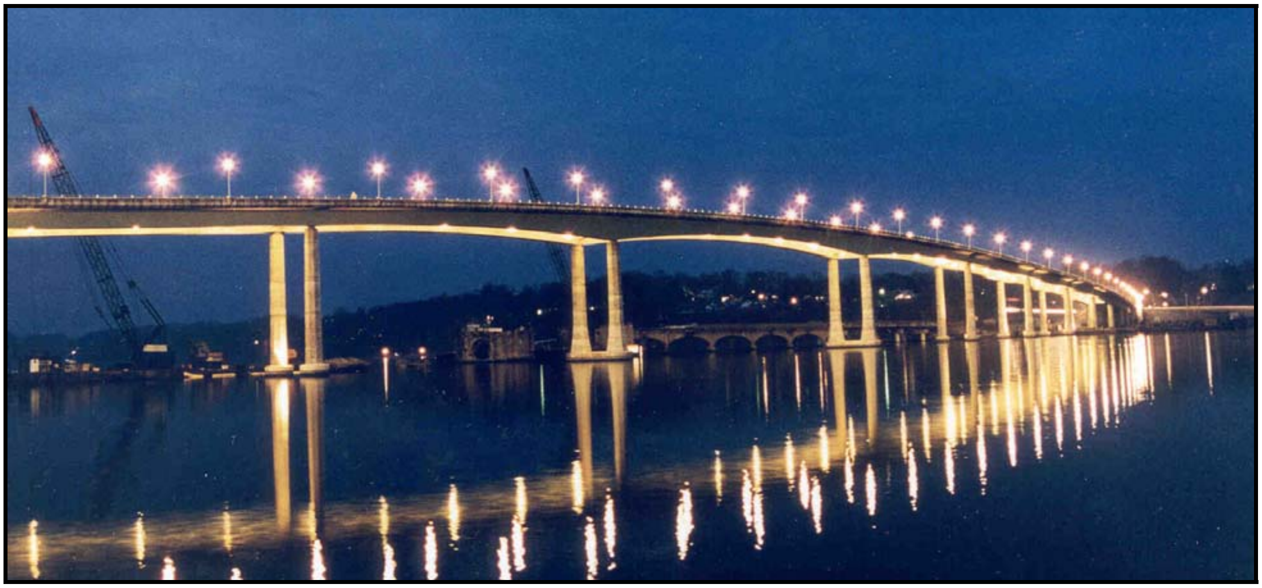


Fig. 15.11 United States Naval Academy Bridge

The United States Naval Academy Bridge received seven awards from 1995 to 1997. The bridge site is the eastern gateway to Maryland's historic capital, Annapolis, which contains many fine examples of Georgian and Victorian architecture. The western end of the bridge and approaches lie within the grounds of the historic United States Naval Academy. The eastern approach includes a scenic overlook providing a panoramic view of the Severn River, the U.S. Naval Academy, the U.S. Naval Academy Bridge, and Jonas Green Park. The Severn River is one of the premier sites for recreational sailing on the East Coast, and Jonas Green Park is a center for fishing, boating and picnicking.

This bridge replaced an existing two-lane, low-level, concrete girder structure containing a double bascule span. It was not economically feasible to do the required extensive repairs. There was also constant interruption to vehicular traffic during the warmer months with the vast amount of sailing on the scenic Severn River.

The United States Naval Academy Bridge was setting records in its very conception. It was the first successful major bridge design competition completed in the United States in the past 100 years that was designed and constructed. The Maryland State Highway Administration and the Governor's Office of Art and Culture cosponsored a unique and innovative international bridge competition. The goal was to involve leaders in the bridge engineering field; and challenge them to think in technical, economic and aesthetic terms to design a structural work of art. All entries were coded so that none of the panelists or jurors knew which firm submitted them. A diverse blue ribbon jury representing the numerous aspects and concerns of this important site selected the winning entry.

The bridge is a 17-span, continuous, double trapezoidal steel box girder bridge, 2835 feet long.

Each pier is comprised of two individual tapering octagonal columns without a pier cap; the girders are placed directly on them. Details include granite work at the abutments and bases of piers, brickwork inlaid into the parapets, nautical theme bridge lighting for the roadway, substructure accent lighting, selection of the color for the bridge lighting and railing to blend with the patina of the copper roofs in the U.S. Naval Academy, adding an overlook to the northern portion of the west abutment, and the bridge pylons were well thought out without adding excessive ornamentation. SHA Design Engineer: Paul E. Matys, P.E.; Consultant Engineering Firm: Greiner, Inc./Leonhart, Andra & Partner; Contractor: Cianbro Corporation.

The United States Naval Academy Bridge received:

- *The Presidential Design Award, Federal Design Achievement Award in Recognition of Your Contribution in Design for the Government of the Untied States of America*
- *American Institute of Steel Construction/National Steel Bridge Alliance in Recognition of Outstanding Design in Structural Steel – Medium Span Category*
- *Federal Highway Administration – Biennial Award for Major Structures over $10 Million*
- *American Consulting Engineers Council in Recognition of Achieving National Final Status in the Engineering Excellence Awards Competition*
- *NQI Achievement Award – 1997 National Finalist – Partners for Quality Construction*
- *Consulting Engineers Council of Maryland – Award of Merit for Innovation Excellence in Engineering Design*
- *American Society of Civil Engineers, Maryland Section – For Outstanding Civil Engineering Achievement in Serving the Transportation Needs of the State of Maryland*

Fig 15.12 MD 436 over Weems Creek

One of the few remaining swing span bridges in the State of Maryland, the new bridge on MD 436 (Ridgely Avenue) over Weems Creek was selected as a Merit Winner in the 1998 National Steel Bridge Alliance Prize Bridge Competition. The bridge was designed to fit into the community and accommodate the high mast sail boats that use Weems Creek. The swing span is operated by a hydraulic system located in a room in the center pivot pier. Heat prevents the hydraulic oil from becoming too viscous during the winter months. The center pivot and both rest piers are surrounded by a timber fender system with decking to facilitate inspection and maintenance of the hydraulic system. The hydraulic jacking system raises the bridge before withdrawing or driving the wedges thus minimizing frictional resistance and lubrication maintenance. The bridge deck provides a pedestrian sidewalk and bicycle compatible travel lanes. The bridge includes an open rail system on both sides to preserve the view up and down Weems Creek while crossing the bridge. Special shielded light fixtures were selected to light up the sidewalk area after dark and minimize the amount of light dispersed into the neighborhood. A tender's house emulates the architectural character of the neighborhood and the new bridge. Since the house is only operated full time during the boating season, features include a fire resistant exterior and rolling shutters to cover the windows and doors that allow the operators house to be secured during while untendeds. Features such as a walkway around the entire octagonally shaped tender's house and raised seam metal roof add character to the site. SHA Design Project Manager: Glenn C Vaughan, P.E.; Designer: Greiner Engineering, Inc.; Contractor: Cianbro Corp.

Fig 15.13 Dulaney Valley Road Bridge

The Dulaney Valley Road Bridge over I-695 (MD 146 over Baltimore Beltway) received a 2001 Excellence in Concrete Award from the American Concrete Institute and an Honorable Mention for Excellence In Highway Design from the Federal Highway Administration 2002 Biennial Awards. Located on a major route leading into Towson (County Seat of Baltimore County), a "gateway" concept was developed giving aesthetics a major significance. Designers worked in conjunction with the local government, business associations, and the community to develop a structure that would compliment the existing buildings and the newly constructed "Towson Roundabout" in the heart of the business district. Many of the buildings in Towson and the surrounding interchange are built from "Butler Stone" commonly found in this area. A form liner matching this stone was applied to the parapets, wing walls, and the arched pier. Multicolor concrete stain was applied to achieve the realistic stone finish. Architectural pilasters adorned with the town's logos, ornamental picket fencing, and ornamental streetlights complete the "gateway" theme. The completed bridge now distinguishes the interchange as the "Gateway to Towson" and has become a source of community pride. SHA Design Project Manager: Danelle M. Bernard, P.E.; Designer: State Highway Administration; Contractor: The Six-M Company, Inc.

Fig 15.14 MD 140 Interchange Improvements at I-695

The MD 140 bridge (Reisterstown Road) over I-695 (Baltimore Beltway) was selected by the American Society Of Civil Engineers, Maryland Section as the Outstanding Civil Engineering Achievement in 2004. This bridge is only the third single point urban interchange (SPUI) used in the State of Maryland and the first SPUI used on I-695. The original bridge that was built in the 1960's had outgrown its average daily traffic (ADT) volume in the 1990's when the ADT reached over 44 000 vehicles with the projected ADT volume for 2020 being greater than 60 000 vehicles. The bottlenecks created extended back on the corridors of MD 140 and I-695. An SPUI was selected to alleviate traffic within the limited right-of-way. The new traffic patterns, business accesses, maintenance of traffic throughout construction, and aesthetics were all results of a continuous team effort with the contractors, consultant engineering firms, residents, businesses, and the Administration.

Almost every day, visitors to our area can be seen browsing through the corridors observing and enjoying our structures that have achieved special recognition. The very existence of Recognition Hall conveys to all Administration employees, as well as Contractors and Consultant Engineering firms working with the Administration, that we take pride in our bridges and strive for and recognize not only excellence in design but excellence in appearance as well.

The Administration is proud of Recognition Hall and encourages its Engineers to participate in the various competitions. Now that we have created Recognition Hall, the "RH Factor" will hopefully be in mind as each project is designed and constructed.

Fig. 15.15 Lobby of Recognition Hall

XVI. COMPETITIONS

Structures usually fall into three basic categories: long special bridges which are usually few in number, bridges with locations which are extremely sensitive or controversial regardless of the size of the bridge, and many smaller structures which Maryland has informally designated as "workhorse bridges". The larger special bridge is usually given considerable time and effort in determining not only its location but its appearance. Many different types of superstructure designs are usually evaluated with various substructure configurations, including the number of piers, the spacing of piers, and the shape of piers. A team approach, comprising engineers and other interested parties, including the public, is often used in the development of bridge alternatives and the ultimate selection.

Maryland has had several experiences with major bridges where the selection of the structure was taken through the design competition process. One in particular was the old Severn River Bridge replacement near Annapolis. The competition was advertised internationally for consultants with a background of successful major bridges who would be interested in developing the structure solution for this location. The list of interested consultants was reduced to a workable number (six) by the Competition Screening Committee. These consultants were provided with a fixed fee to compensate their effort in producing their submittal. A Competition Program and Rules document was provided to all contestants listing the criteria governing the competition, including the required documents to be submitted.

A jury to evaluate the solutions was selected. Special care was taken in the makeup of the jury to ensure proper representation and expertise in the various areas of concern. It was composed of engineers (private and State), an architect, a landscape architect, citizens from the area where the structure would be constructed, a representative from the county or local jurisdiction, representatives from agencies that would be involved (Water Resources Administration, Department of Natural Resources, Scenic Rivers, etc.), historians, and individuals from the art world. This jury made an extensive field reconnaissance of the site on foot, by water, and by bus, and then was allowed to view each of the presentations of the contestants. Each entry included conceptual plans, supporting computations, an estimate, artist renderings from different vantage points and a report as to why a particular solution was selected for the site. The jury was assisted in the decision-making process by two teams. One team reviewed each of the entries for its constructability while the other team reviewed them from a technical viewpoint. From this process a deliberation took place and the jury selected the winning entry. The project then moved into the formal design stage with the winning entry being designed by the successful contestant.

Another example of the successful use of a design competition in Maryland was the Woodrow Wilson Bridge over the Potomac River, near Washington DC. This was considered to be an extremely important and highly sensitive structure, worthy of the time and effort necessary to conduct a world-class design competition. The previous competition model used for the Annapolis bridge was utilized again, with refinements to address this particular application. A winning entry was selected unanimously by the jury and the successful team designed the bridge, which is currently under construction.

Naturally, for "workhorse bridges" or small structures in sensitive locations, these kinds of procedures, which are time consuming and expensive, are not practical. However, Maryland has found that there are other mini-type competitions that can be performed. The design of a "workhorse bridge" is assigned to either an in-house design team, or a consultant working for the State. The development of the proposed bridge is usually the result of the input of only a few individuals. One of the techniques that can be used with "workhorse bridges" is to allow various design teams within an office to develop the structure that they feel best suits that location. We have tried this at several sites and it works well. It would be desirable for one particular entry to be selected in its entirety, as this would give the designer a sense of ownership. However, frequently the final design combines elements from several of the alternatives. This can be acceptable in a design competition since good ideas can come from many sources and should not be lost in the process.

This kind of approach does several things: it stimulates the design team to put extra effort into the conceptual stage of development, as they know their offering will be compared to others, and it develops a spirit of competitiveness to a point where several of the design teams, on their own, may develop models, renderings or perspective views of pier shapes, etc. to reinforce their submission.

In summary, the use of a competition has merit in cases of major, significant structures. It can be considered whenever the situation dictates that something unique needs to be developed for a particular location and it gives all the parties interested in the structure a feeling of ownership. The use of a "scaled down" design competition may also be considered for bridges of a lesser, though still significant, nature, where spurring the creative process may be desirable.

XVII. MARYLAND'S AESTHETIC BRIDGES

This chapter includes pictures of some of Maryland's most attractive structures:

MD 146 (Dulaney Valley Road) over I-695, Baltimore County, Maryland

MD 140 (Reisterstown Road) over I-695, Baltimore County, Maryland

MD 623 over Broad Creek, Harford County, Maryland

MD 272 over Northeast Creek, Cecil County, Maryland

MD 390 over CSX, Montgomery County, Maryland

US 113 over MD 589, Worcester County, Maryland

MD 450 over the Severn River, Anne Arundel County, Maryland

Rendering of I-95 over the Potomac River
(Woodrow Wilson Bridge), Prince Georges County, Maryland

Paper Mill Road over Loch Raven Reservoir, Baltimore County, Maryland

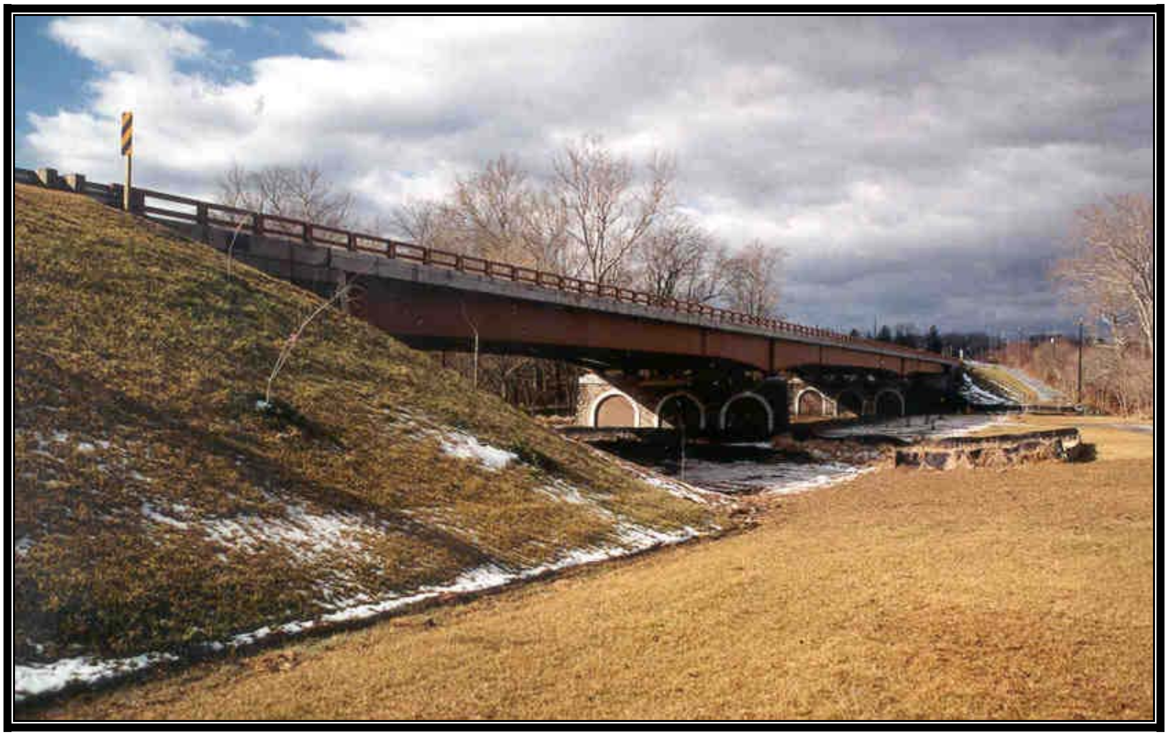
Providence Road over I-695, Baltimore County, Maryland

MD 436 (Ridgely Avenue) over I-97, Anne Arundel County, Maryland

MD 103 over US 29, Howard County, Maryland

MD 392 over Marshyhope Creek, Dorchester County, Maryland

MD 242 over St. Clement Creek, St. Mary's County, Maryland



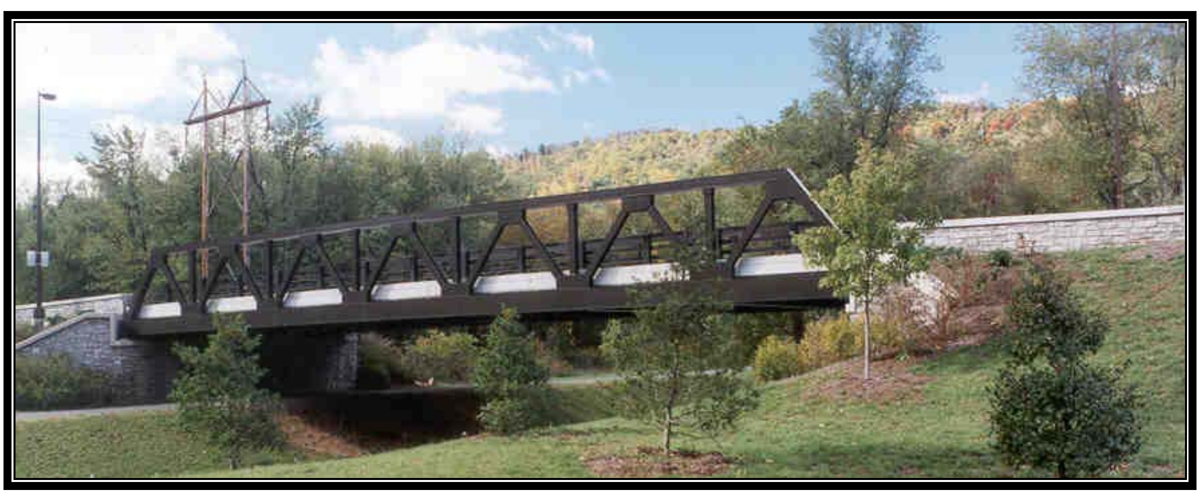
MD 28 over Seneca Creek, Montgomery County, Maryland

New Design Road over I-70, Frederick County, Maryland

MD 109 over Branch of Monocacy River, Montgomery County, Maryland

Halfway Blvd. over I-81, Washington County, Maryland

Samford Road over MD 32, Anne Arundel County, Maryland



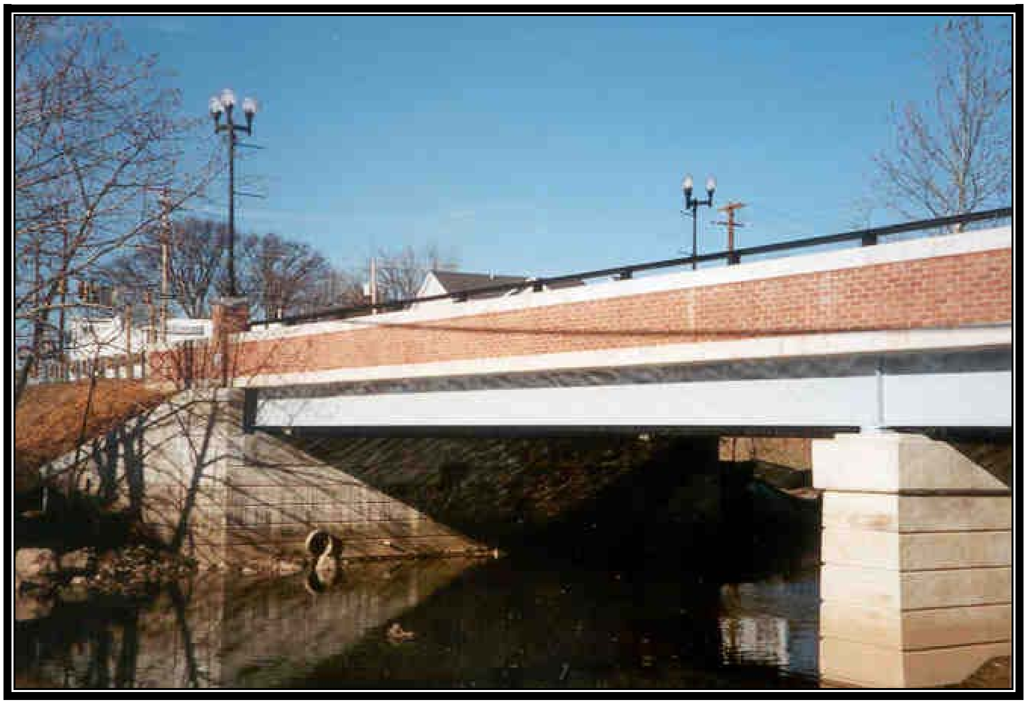
Ford Ave. (Canal Parkway) over the C & O Canal, Allegany County, Maryland

Ramp A over MD 4, Calvert County, Maryland

MD 45 (York Road) over I-83, Baltimore County, Maryland

Old York Road over I-83, Baltimore County, Maryland

Arundel Mills Blvd. over MD 295, Anne Arundel County, Maryland



MD 213 over Big Elk Creek, Cecil County, Maryland

MD 33 over Knapps Narrows, Talbot County, Maryland

MD 304 over German Branch, Queen Annes County, Maryland

MD 314 over the Choptank River, Caroline County, Maryland

MD 436 (Ridgely Avenue) over Weems Creek, Anne Arundel County, Maryland

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XIX. APPENDIX

Estimating Additional Costs for Aesthetic Features

We often have to estimate the costs of improvements made for aesthetic reasons. It is easy to fall into some traps which can give a false reading.

All of the pluses and minuses of a change have to be added up before a true picture is realized. For example, reducing girder depth may increase the cost of the girders in themselves, but save an offsetting amount in approach roadway costs.

Often costs are compared on the basis of unit costs of material: so many dollars per cubic yard of concrete or pound of steel. This tends to give a misleading picture if there are significant differences in the alternatives beyond the amount of material involved. For example, a decision to use a two-column pier in place of a three-column pier might involve more concrete, but it may also produce offsetting savings in forms, footings and fabrication of reinforcement.

Contractors have accumulated habits, tools and equipment suitable for current standard designs and details. Thus, the old standards will often be bid for less, regardless of the estimated cost savings of a new proposal. However, should a new proposal with an estimated cost advantage be instituted and perpetuated, within a year or two the contracting industry will have adapted and the cost advantages will be realized.

Construction estimating is an imperfect art. It is unusual for the engineer's estimate to come within 5% of the contractor's bid. Any feature or combination of features which costs less than 5% of the total cost of the bridge is essentially outside of the range of precision of cost estimating. It might as well be treated as cost-neutral, given the inability of the designer to predict its eventual effect on the total price of the bridge.

We encourage your input. We envision our guide as an ever changing document which we will refine, update and continue to redistribute. All of us are always brighter than any one of us. We are anxious for your input; together we can learn and develop. Your input should not be limited by anything - comments on format, concepts, emphasis, whatever - are welcome.

Jock Freedman
Bridge Engineer, Maryland

MARYLAND STATE HIGHWAY ADMINISTRATION
QUESTIONS AND / OR COMMENTS

AESTHETIC BRIDGES USERS GUIDE

DATA: DATE: ____________________

NAME: ____________________

PLEASE TITLE (IF APPROPRIATE): ____________________

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ADDRESS: ____________________

CITY/TOWN: ______________ STATE: _____ ZIP CODE: ________ PHONE #: (   ) ____________

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or you can email us at **Mpats@sha.state.md.us**
or you can mail your comments to
Maryland State Highway Administration
Office of Bridge Development
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