

AESTHETIC APPROACH on BRIDGE PIER DESIGN

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Abstract: Bridges are significant examples of human intervention in the landscape and have been around in human history and culture for a long time. Bridges are considered to be more than an element of the transportation system by creating a unique sense of identity for a city, town, or region. Thus, we designers play an important role in the design of bridges. Bridge design is an art, an art that uses science and mathematics to support many of its judgments. But other judgments are made during the design process which science cannot help, such as decisions about appearance. Through this study on the aesthetic element of bridge pier design, design teams produce bridges of aesthetic value can analogize the whole bases to support aesthetic judgments out of a part. Bridge piers can be a major element in forming people's impression of a bridge. Basically bridge piers are part of the substructure which support the superstructure at the end of the span and transfer loads from the superstructure to the foundation. Piers are visually the vital part of bridge design especially for the vertical factor. Pier design is a sensitive matter to bridge users since people take advantage of all parts of bridge such as passing or taking a rest under a bridge, etc. Thus, it is important and valuable to investigate the aesthetic characteristics of bridge piers based on the aspects of visual and formative languages. These are classified under two heads, visual aspects and visual qualities. Visual aspects mean outward or visible aspect of a thing. To analyze the visual aspects of bridge pier design, the elements categorized under three items; basic elements (line,

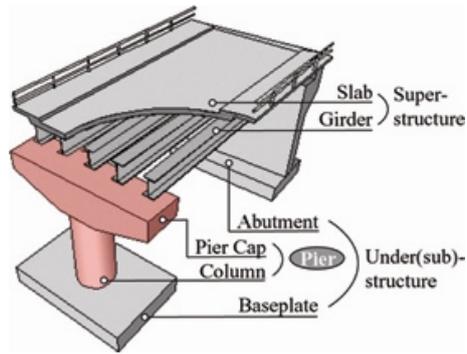
shape, form), color, and detail elements (texture, shade & shadow, reflection) must be studied. Visual qualities are discussed from the viewpoint of pier group. Those are composed of harmony, unity, order, proportion, balance, scale, contrast, rhythm, and illusion. The design of aesthetically pleasing bridge piers is a difficult task, and there are no correct answers. However, there are basic rules that arouse sympathy. The design process is a decision making. During the process of design piers, aesthetic standards of judgment will be of great assistance to designers.

Key words: Bridge Pier Design, Aesthetic Approach, Visual Aspects, Visual Qualities

1. Introduction

Bridges are powerful examples of human intervention in the landscape [1] and have been around in human history and culture for a long time. Bridges are considered to be more than an element of the transportation system by creating a unique sense of identity for a city, town, or region. Thus, we designers play an important role in the design of bridges. Bridges are ordinary concerned only for engineering problems especially in the period of the industrial revolution. However, a bridge designed without consideration of aesthetics can be unattractive and a visual barrier. Bridge design is an art, an art that uses science and mathematics to support many of its judgments. But other judgments are made during the design process which science cannot help, such as decisions about appearance.

Basically bridge piers are part of the substructure which support the superstructure at the end of the span and transfer loads from the superstructure to the foundation [2]. Piers are visually the vital part of bridge design especially for the vertical factor (Figure 1). Pier design is a sensitive matter to bridge users since people take advantage of all parts of bridge such as passing or taking a rest under a bridge, etc. It also decides a whole bridge image and makes a good or bad environment. The most important principle in bridge pier design is to achieve a clean and well-defined anatomical construction, devoid of deception and unnecessary detail, and with a directness of line both pleasing to the eye and responsive to senses.



[Fig.1] Girder-bridge Construction

2. Previous studies of aesthetic approach on bridge pier design

In the field of aesthetic approach on bridge design, various studies including Frederick Gottemoeller (2004), 'BRIDGESCAPE: The Art of Design Bridge,' Kazuo Sugiyama(2006), 'Formative study of Bridges' and so on, have been made based on Fritz Leonhardt (1982), 'Bridges: Aesthetics and Design.' However, there is few or no aesthetic study on bridge piers. By as of May 2009, S. L. Billington (2000), 'Improving Standard Bridges with Attention to Cast-in-Place substructure' is uniquely regarded as an article having a close relation with aesthetic study on bridge piers, however, it is distinguished from the subject study in that it does not study bridge piers in design aspect systematically.

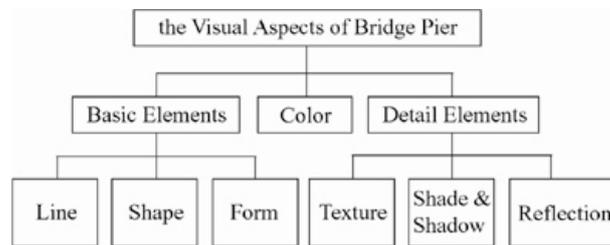
3. To classify aesthetic approach on bridge pier design

The main purpose of this study is to investigate the aesthetic characteristics of bridge piers based on the aspects of visual and formative languages. These are classified under two heads, visual aspects and visual qualities. The former focuses on pier design itself, and the later concentrates on the relation between bridge piers and other elements of a bridge, nearby piers or surroundings. Subsidized items are classified based on design elements which should be basically studied considering 'Design Principle,' 'Design Morphologic' and so on.

4. The visual aspects of bridge pier design

Visual aspects mean outward or visible aspect of a person or thing. To analyze the visual aspects of bridge pier design, the elements categorized under three items; basic elements (line, shape, form), color, and detail elements

(texture, shade & shadow, reflection) must be studied (Figure 2).

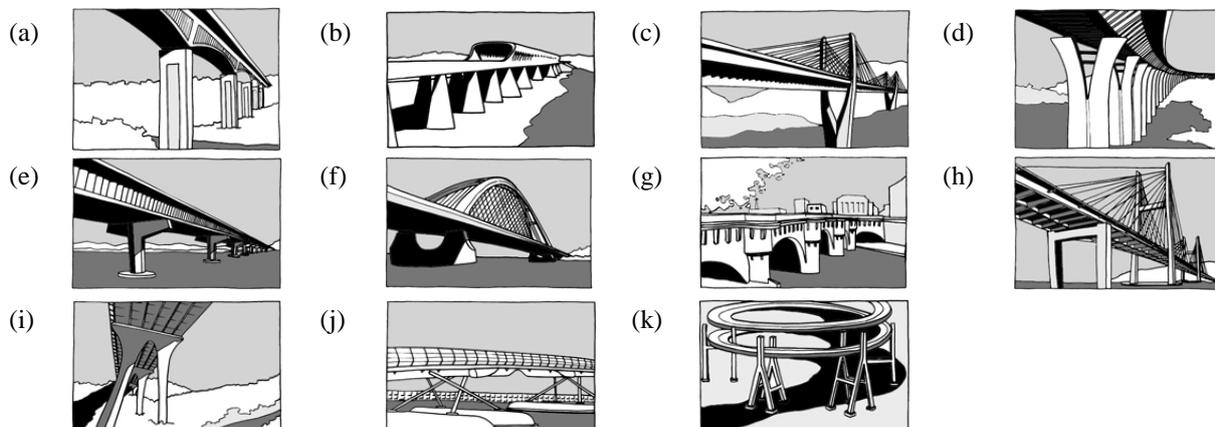


[Fig.2] A classification of the visual aspects of Bridge Pier design

4.1. Basic Elements: Line, Shape, Form

- **Line:** A line in geometry is an effective means to measure space by two distinct end points. However, a line in bridge pier design is a living and moving creature with full of expression, direction, and orientation. In other words, it is possible to make dynamic bridge piers by using straight or curved, fixed or atypical lines. Moreover, making repetition of lines or managing thickness of lines can also give us various impressions.

- **Shape:** The shape interface provides definitions for objects that represent some form of geometric shape. There are various ways to categorize shape and form. In this study, shape and form are thought of as either two-dimensional or three-dimensional. A two-dimensional shape has only width and height by closed-line. Nevertheless, a three-dimensional form has depth as well as width and height. During the pier design, we should keep an eye on the characteristics of the pier shape type (Figure 3).



[Fig.3] Vertical shapes of piers: (a) I -type, (b) U -type, (c) V -type, (d) Y -type, (e) T -type, (f) U -type, (g) Arch -type, (h) Square -type, (i) PI(II) -type, (j) X -type, (k) Mixed -type

- **Form:** Functional forms can increase the aesthetic qualities of bridge design. On the contrary, sometimes, piers can be designed sculpturally without violating the functional design objectives. Design of pier forms should be responsive to materials and technologies. For example, concrete easily provides various forms through control of formwork, while steel is usually lighter and more dynamic in appearance. Generally bridge piers seem aesthetically more pleasing if they are simple in form, the lines of the structures are continuous. Moreover the use of large and solid piers should be avoided. To make a good pier form, we must check the appearance of all possible viewpoints.

4.2. Color

If bridge piers are to be painted, colors will affect their image. Both functional and aesthetic impact of piers can be added by colors. Piers with vivid and complementary colors tend to stand out too strongly, especially on a large surface. For this reason, low chroma and neuter-just as gray- colors are easy to apply to anywhere. Warm colored piers (e.g., red, yellow, brown) emphasize the presence and size of forms, whereas cool colored piers (e.g., blue, green, purple) diminish the visual aspects when there are no visual obstacles. Color should be carefully selected to blend with surroundings. Ideally, bridge pier color should incorporate the local color in order to maintain harmony with the local environment. And we have to consider the direction and sort of light, moreover it is also depended on the season of the year.

4.3. Detail Elements: Texture, Shade & Shadow, Reflection

- **Texture:** Texture refers to the properties held and sensations caused by the external surface of objects received through the sense of touch. It helps improve the appearance of the pier. All materials have those own textural characteristics (Table 1). A variety of textured finishes can be obtained by use of manufactured form liners, especially, on concrete piers. In general, very rough texture on bridge piers will give unpleasant feelings to people who use it closely. Decoration is also part of texture and should be managed carefully.

[Table.1] Sorts and texture characteristics of materials on bridge piers

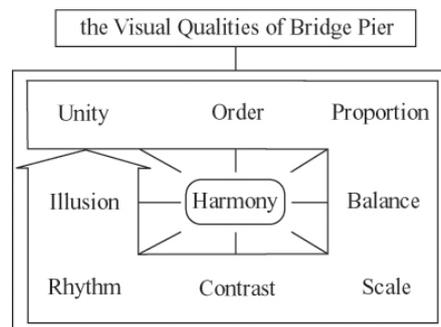
Materials on bridge piers		Characteristics
a. Construction Materials	Wood	- Wood has soft and warm surface. - An annual ring gives dynamic patterns.
	Stone	- All stones have unique color & texture characteristics. - Surface can be changed by processing stones.
	Steel	- Usually steel has slender and hard surface.
	Concrete	- Concrete is easy to make various textures by using pre-cast concrete molds.
b. Decoration Materials	Tile	- Tiles are easy to make various patterns and usually shine on surface.
	Stone Block	- Stone blocks also make various patterns and textures by processing stones.
	Sculpture	- Sculpture on bridge piers is an art rather than texture.
	Painting	- The most liberal patterns and textures can be designed.
	Planting	- Planting on piers gives more natural texture.

• Shade & Shadow: Shade is an area of darkness under or next to an object where sunlight does not reach. A shadow is a dark shape on a surface that is made when something stands between a light and the surface. All pier colors, textures and forms respond instinctively to the light that falls upon them. These shade and shadow enhance the structure, and we must try to minimize the areas where lighting produces undesirable effects by carefully chosen detail. Square formed piers usually look thinner than round ones by shade and shadow effects. And then image of piers is related to the angle, strength, distance and color of light.

• Reflection: The reflection of bridge piers is an image that we can see in water or glass and the process by which light and heat are sent back from a surface and do not pass through it. As a rule, pier surfaces should be matte rather than glossy [4]. A smooth glossy surface will reflect and can distort its figure. Moreover it will reflect light and can dazzle the image reflected. In some cases, when design concept or designers' attentions are somewhat unique, glossy one can be adapted without any obstacles. A reflection gives visual play, so designers can make full use of this characteristic.

5. The visual qualities of bridge pier design

Artistic sensitivity of bridge piers does not only come from visual aspects (Figure 2) but also from visual qualities which include harmony, unity, order, proportion, balance, scale, contrast, rhythm and illusion (Figure 4). However, it is not easy to classify these factors clearly because these are combined systematically and simultaneously.



[Fig.4] A classification of the visual qualities of Bridge Pier design

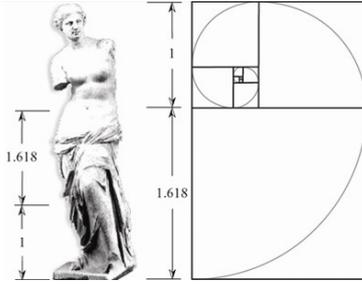
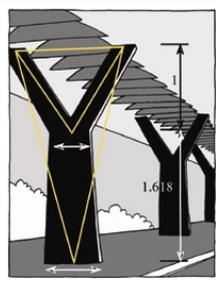
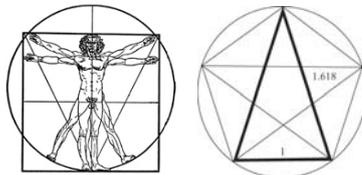
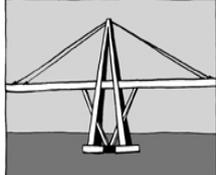
- Harmony: Pythagoras, one of the most famous and controversial ancient Greek philosophers, defined aesthetics as harmony. The Italian Renaissance architect Alberti said, “I shall define beauty to be a harmony of all the parts, in whatsoever subject it appears, fitted together with such proportion and connection, that nothing could be added, diminished or altered, but not worse.” The ultimate end of aesthetics is to make harmony with others. In bridge pier design, harmony with nature, bridge, and man-made environment must be considered. The surrounding environment must also be recognized and identified beforehand as neutral, passive, active, stable or evolutive, which to a certain degree restricts the selection of forms and colors.

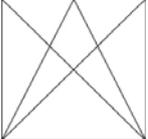
- Unity: We get aesthetic satisfaction from unity of variety. Unification of the bridge piers into a single continuous one will be helpful in identifying the bridge image strongly. Therefore it is necessary to design a group of piers of varying heights as variations of the same basic shape. Unity of piers can be taken to adopt a similar form for repetition, proximity, and continuity of piers. In some cases, curved lines can connect different factors easily. For example, the smooth connection of pier cap and column makes two parts as one pier.

- Order: An order requires the organization or arrangement of the members of bridge piers. Good order of pier design can be considered as one of the means of attaining wholeness, not recognizing each piers. The order of bridge piers is achieved by limiting the directions of lines and edges to only a few and avoiding unnecessary accessories. It means shaping, portioning, and aligning design elements of the simplest forms and avoiding any haphazard appearances.

- Proportion: Proportion is a function of the visual relationships of the components of structure, each to the other, and of the structure to its setting. The proportioning of bridge piers pertains to harmonious ratios of lengths to widths to heights of structural members and of openings they may frame. The proportioning of details requires great care, but it is the total effect achieved by combining members of various proportions that are most important. Great matters that require attention is that proportion can be influenced by improved materials and methods of construction. Good proportions must exist among the relative sizes of the various parts of a structure; among its height, width, and breadth; among its masses and voids, closed surfaces, and openings; and between the light and dark caused by sunlight and shadow [4]. Some of the proportion rules-such as the Golden Section-do give pleasure to many people from the ancient Greece to these days (Table 2). These all are means good visual harmony and balance. In general, long piers look beautiful. On the other hand, the key to improve the appearance of a short pier is to eliminate or minimize the pier cap, or incorporate it into the superstructure.

[Table.2] Various golden sections

Proportion	Masterpieces		Bridge Piers
Golden Ratio $X^2 = X + 1$ that is 1:1.618		La Venus De Millo	
		Vitruvian man by Leonardo da Vinci (1492)	

Gradation Ratio		 <p data-bbox="890 286 1075 412">The birth of Venus, Botticelli Sandro (1485)</p>		
Geometry Ratio			<p data-bbox="890 479 1043 555">Annunciation (1425-28)</p>	

- Balance: Balance is the ability to remain steady without falling. It is important that bridge piers appear stable when viewed from all possible locations. It has the same visual strength although in a different size. Visual stability on bridge piers divides into symmetrical balance and asymmetric balance. Symmetrical balance is achieved by placing elements in a very even pier form. Asymmetrically balanced piers are not stable but they do not fall down. The later one will be more challenging to design. In general, large, dense elements appear to be heavier while smaller elements appear to be lighter. However, balance can be managed by materials of being colored or textured, too.

- Scale: Scale is concerned with size relationships, but in terms of visual effect. On bridge pier design, scale is related to human activity and distance within surroundings. Viewers first see the generally large bridge piers first from a considerable distance and later in motion where all elements are strong with no small-scale or fussy details.

- Contrast: Contrast occurs when two elements are different. Big and small elements, black and white color, and squares and circles can all create contrast on bridge pier design. Some features providing contrast sometimes improve the design quality. Hence, without basic sense or rule, confusion or disordered figures can be designed. One of the noticeable theory related to contrast in design is “The principle of figure & ground (Gestalt principle of visual organization).” It means the figure(object)-ground(surroundings) relationship is ambiguous. We can apply this principle to design piers during making form or controlling day and night volume into surroundings.

- Rhythm: Rhythm is an ordered recurrent alternation of strong and weak elements in design. It requires closely related repetitive forms that shall be compatible. Good rhythm in pier design shall as far as possible be both uniform and simple. It can be also achieved through skillful detailing in varying span lengths of bridge. A long

series of similar piers can seem monotonous, but making the piers with interesting shape or adding visual points take away from the monotony of repetition.

- Illusion: Illusion can interfere with visual perception. The designer shall be aware of illusion, either to exploit or counteract its effects in the interests of good design. Illusion is perhaps the greatest obstacle to the formation of precise rules of proportion, and is one of the main considerations dictating the need to examine scale models of intended structures. Generally speaking, piers with vertical lines look long and thin while piers with horizontal lines look short and thick. Even though these are the same sized square columns, they look so different from one another by controlling the hollowing out a groove.

6. Conclusions

Bridge aesthetics has a vast effect on the public, and every opportunity should be used to provide attractive structures. Among them, bridge piers can be a major element in forming people's impression of a bridge and the beauty of pier-design helps to maintain man's mental and psychic health. However, the design of aesthetically pleasing bridge piers is a difficult task. Moreover there are no correct answers. In spite of this characteristic, there are basic rules that arouse sympathy. Through this study, we can confirm aesthetic characteristics of bridge piers, and it will give us aesthetic standards to make the most effective decision whenever decision making is needed. To help make our world beautiful, it is important to evaluate ways to improve the appearance of our bridge pier designs. Finally, I expect this study will make a contribution to in-depth studies about bridge design.

7. References

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