

Principles and Its Application of Bridge Aesthetic Design

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Abstract: This paper introduces the three levels of bridge aesthetic design, the main and secondary factors of bridge aesthetic design, and the proportion, rhythm, and order principles of bridge aesthetic design. The article is based on a S-shaped bridge as an application case. It describes its design ideas: the proportional principle is used in the overall styling arrangement of the bridge, and the principle of order and rhythm is used in the design of the bridge railings. In addition, the knowledge of traffic psychology is used in the design of the stairs. It proves the importance of bridge aesthetic design principles, and the positive role of each principle on bridge landscape.

Keywords: Bridge design; Aesthetic

1. Introduction

Aesthetics, the study of the mind and emotions as they relate to the sense of beauty, is concerned with visual appearance and quality. In bridge design, as in architecture, excellence is achieved by integrating science, technology, and aesthetics. The bridge designer must strive to understand the creative artistic process, as well as scientific and technical principles, and merge the most fundamental concepts into a unified theme for an expressed purpose.

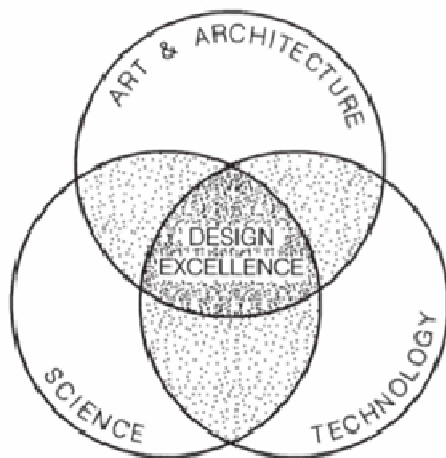


Figure 1. Three components of design excellence
(M.P.Burke & J.Montoney)

Early in the design development the Preliminary Bridge Plans Engineer will initiate the aesthetic design process. At this point in the design, preliminary concepts are re-

viewed, and a level of aesthetic attention is determined. The level of aesthetic attention determines the number and type of participants in the aesthetic design process, the depth of the process, and, to some extent, the resources to be devoted for aesthetic considerations. Three levels of aesthetic design have been established: Levels A, B, and C.

Level A aesthetic process is intended for bridges with major cultural or aesthetic significance.

Level B aesthetic process is used for mid-level structures. Level C aesthetic process is implemented for a low level of aesthetic consideration.

Level A is used for projects of major aesthetic importance. Characteristics of structures in this category are highly visible bridges, bridge projects that generate substantial citizen interest, bridges located in environmentally sensitive and historic locations, and bridges that are historic themselves. Aesthetics may be a significant factor in determining the structure type for Level A projects.

2. Aesthetic Design Factors

The principles of aesthetics that stimulate the senses in most viewers are proportion, order, simplicity, balance, color, and texture. Design excellence requires designers to orchestrate these aesthetic principles with the physical and geometric components of a structure. The appropriate application and integration of these principles, together with sound structural and functional design, can result in bridge forms that exhibit strong visual character and quality, structure into its environment is also an important aesthetic consideration. Once a roadway corridor, bridge, or interchange is established, it becomes a prominent landscape feature, immediately changing the character of the environment. Compatibility with natural

settings or developed areas is essential. It is vital that designers consider these influences and incorporate aesthetic values into the design of bridges and highway corridors so the structures enhance the beauty and character of the immediate environment and community.

As one might expect, there is no single design parameter that controls the general physical characteristics of a bridge. An attractive bridge is the orchestration of design parameters employed simultaneously to complement each other. Designers can interpret these design parameters to constitute principal aesthetic design factors.

The principal aesthetic design factors fashion the visual basis upon which the balance of the appearance is built. Designers should concentrate on developing the best design solutions for these design parameters prior to considering other visual treatments. To find the best design solution, designers must consider the aesthetic objectives outlined previously when making decisions regarding these design parameters.

Principal aesthetic design factors:

1. Superstructure type and shape
2. Vertical and horizontal geometry and their relationship to the surrounding environment
3. Pier placement and shape
4. Abutment placement and shape
5. Interaction between the bridge and its surroundings/environment

Secondary aesthetic design factors can be used to accentuate the positive qualities that have been treated with the principle aesthetic design factors. The texture, color, and shape can be engaged to draw attention to, or to detract from, the role of structural elements. When considering the secondary aesthetic design factors, designers should consider the aesthetic qualities defined previously.

Secondary Aesthetic Design Factors:

1. Railing details
2. Surface colors and textures
3. Architectural embellishments
4. Lighting

3. Principles of Bridge Aesthetic Design

3.1. Proportion

Proportion exists in geometry and in musical frequencies, or tones. The correlation between harmonic proportions in music, geometry, and color evolved in antiquity from a philosophical basis. This correlation between harmonic proportions in music and architecture is strongly suggested in classical architecture. Balanced and harmonious geometric proportions are fundamental characteristics in the development of graceful buildings and bridges alike.

The concept of proportion may be thought of as a mathematical relationship. A graphical example of such a relationship is the Golden Rectangle. The Golden Rectangle is a logarithmic spiral constructed from the convergence of a mathematical series of proportions referred to as the Fibonacci series. This series is based on the proportion of $a:b$, $b:(a+b)$, etc.

In design, the most obvious proportional relationships are based on relative size and shape of the elements. There can also be proportional degrees of surface texture and color. Proportion may become a system of planned order that contributes to the unity of a design. Appropriate proportion must exist between the various parts of a structure: between its height, width, and depth; between solids and voids; between surfaces and openings; and between areas of sunlight and shadow.

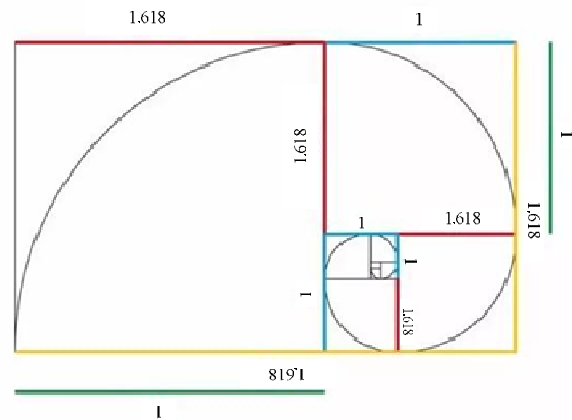


Figure 2. Golden rectangle

3.2. Rhythm

Rhythm is the regular recurrence of any like elements in, on, or around a structure. It requires that the elements have some similarity of visual characteristics in addition to a modulated placement. In bridges, for example, major rhythms are created by the repetition of similar pier shapes. Minor rhythms may be created by the spacing of light poles, post spacing within a railing, or even the horizontal rustication on a pier. Modulating the placement of these elements can create visual flow or movement across the scene. A good example of this is when pier spacing gradually increases near the main span when a bridge crosses a wide river or lake.

3.3. Order

Order refers to arrangement. It is the arrangement of size, direction, and color design elements so that they work together as a unit without visual confusion. The whole arrangement works as a unit with each element having a proper place and function. The selection of a constant girder depth throughout the structure is an element of

good order. Order is also achieved by limiting the lines and edges of a structure to only a few directions. Under the rule of order, the regular recurrence of similar elements in a composition creates a natural flow, known as rhythm, that is satisfying to the eye.

4. Application of Principles

In the design of a pedestrian bridge, the designer anti-symmetrically sets the human viewing stairways on both sides of the s-shaped bridge. The stairways use different paving colors than the bridge deck. The golden ratio is adopted, and the length of one side walk is about 0.618 of the total length of the bridge. The golden ratio is also adopted in the arrangement of bridge piers, the ratio of the side span to the main span of the bridge is also about 0.618: 1. In this way, a proportional harmony is formed in the arrangement of the bridge beams and piers.

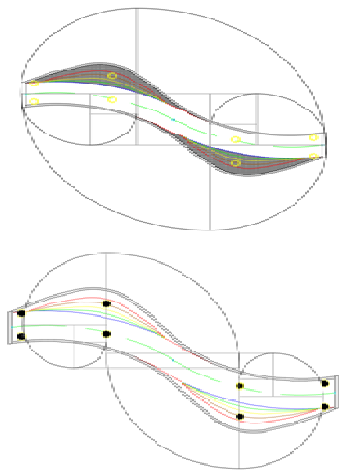


Figure 3. Golden rectangle in design of deck and piers

In actual design work, rhythm is usually considered comprehensively, and the two play a role on the basis of proportion, which is also an enhancement of the beauty formed by proportion. The three organically combine and influence each other. If the overall proportions are not harmonious, then rhythm and order cannot form a beautiful effect. In the above pedestrian bridge, the principles of rhythm and order are applied to the design of bridge railings. Bridge railings have many and dense members, which is the most suitable place to apply this principle, because if it is too sparse, it will not produce a visual rhythmic relationship. The railings that made of tempered glass are all vertical, and no cross bars are provided to destroy this rhythmic relationship. Due to the overall row required by the order relationship, the columns of the railing are all vertically upward, rather than perpendicular to the deck, and the large longitudinal slope change of the bridge viewing stairway brings

certain difficulties to the design and installation of the root of the railing.

In the consideration of the main aesthetic design factors, because the viewing ladder is arranged at the S-turn of the bridge, due to the pedestrian's cognition of natural laws, there will be a sense of "centrifugal force" out of control at this position. The design of the road adopts the "superelevation" treatment similar to the corner of the racing track, giving people a supported safety psychology when turning, forming a pedestrian's cognitive harmony.

Humans have a sense of freshness about unknown things, but at the same time there is a sense of fear. The main purpose of this bridge is to create a friendly atmosphere for pedestrians, so it is familiar, warm and safe. The bridge deck uses warm colors. The colors of the viewing stairs are red, orange, yellow, green and blue, which are taken from the colors of the rainbow in nature, and gives a familiar feeling and makes people feel unobtrusive. It creates a psychological pleasure for pedestrians.

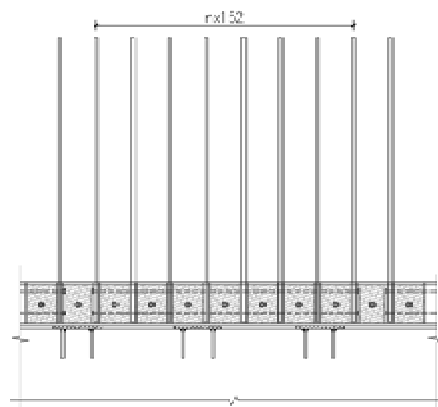


Figure 4. Rhythm and order in railing



Figure 5. Aerial view of bridge

5. Conclusion

To ensure that bridge designs exhibit a strong sense of visual quality and beauty, aesthetics must be an integral part of the bridge design. This application of aesthetic considerations must encompass all aspects of the design from bridge type selection to the application of each detail of the structure.

The applicability of aesthetic architectural principles in bridge design is verified through specific engineering applications. According to the characteristics of the bridge, some bridge architectural design principles can be selected as a guide in the process of bridge modeling

design, which can quickly realize the optimization of bridge modeling.

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