

AESTHETICS OF STEEL BRIDGES

Well designed bridges stir the imagination and create a sense of community excitement and identity

By Holger S. Svensson, P.E.



Unlike buildings, where the structure is often hidden by cladding and other finishes, bridges reveal to all the world their structural design. As a result, it is critical that designers and owners consider the impact that the appearance of a bridge will have on the surrounding landscape.

Some might argue that beauty is solely in the eyes of the beholder. Hogwash.

Fritz Leonhardt has stated in his book "Bridges" that the design of good looking bridges does not happen by chance, nor does it exclusively depend on some elusive "feel" which is only given to a chosen few. Constant examination of existing bridges - both beautiful and ugly - provides aesthetical awareness. When we analyze why one bridge is considered to be beautiful and the other one to be ugly, we find guidelines that are not only valid for bridges, but also for buildings. And these aesthetic guidelines are equally valid regardless of cultural influences.

AESTHETIC GUIDELINES

While it is difficult to establish general rules of thumb for such a complex issue, experience and examination of numerous attractive bridges around the world have provided some suggestions for consideration.

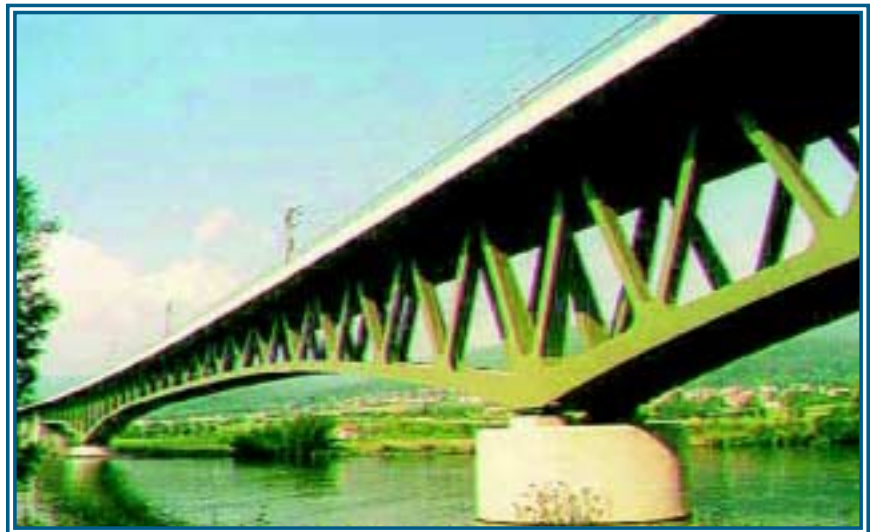
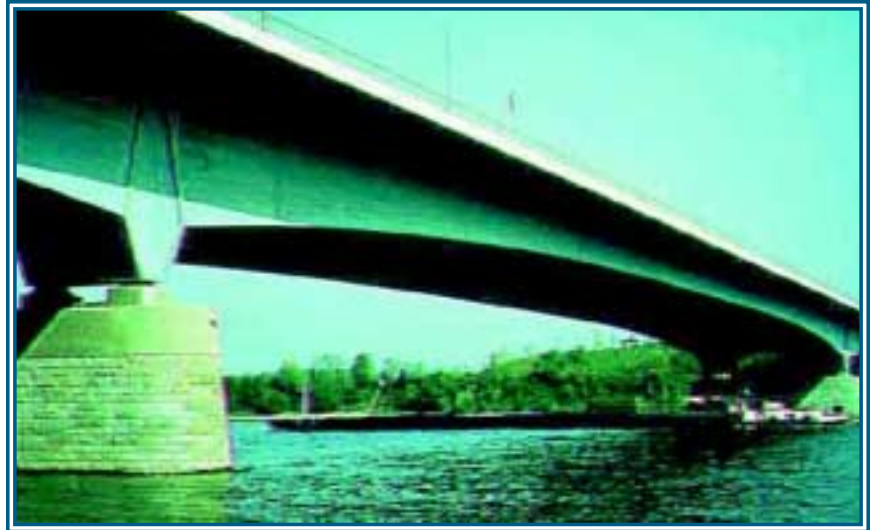
- 1. Give careful consideration to your structural system. There is beauty in a purity of form. In addition, the bridge must look trustworthy and stable.*



While a mixture of different systems leads usually to difficulties for good shaping; there are, of course, exceptions. The Houston Ship Channel Crossing at Baytown in Texas requires eight traffic lanes with full shoulders. The most economical solution was found to comprise two independent beams, each supported by an A-tower and two inclined cable planes. Technical considerations and aesthetic shaping went together for the towers. Two cable planes improve the rotational resistance of the beam. By joining two legs at the top, the beam's torsional resistance is further improved. By joining two tower legs also at ground level, only one foundation is required for each diamond, which is economically advantageous. By using simple cross-sections, clean lines and good proportions, the diamond shaped towers were created. By connecting two diamond-shaped towers transversely, a frame is created which carries transverse wind loads not in bending, but in tension and compression. The tower legs can thus be very slender transversely. Although 150 meters high, they appear light. Technical requirements and good aesthetics do not contradict one another when applied judiciously.

2. Study the bridge's proportions in all three dimensions.

There must be good proportions between height, width and depth of a bridge in relation to the size of the bridge deck structure itself. There must also be good proportions between the spanned structure and the carrying piers, between the span-length and the depth of the beam, and between bright and dark surfaces due to light and shadow. Good proportions must also be created between the masses of the structural members, between abutments, piers and superstructure. The depth of an arch and the depth of the suspended beam must be clearly dif-



ferent for aesthetic reasons. If the arch and the beam have similar depths, the structure looks dull. For the Tangermünde arch, in Germany, a sturdy beam is required for the approaches already, so the arch can be very slender.

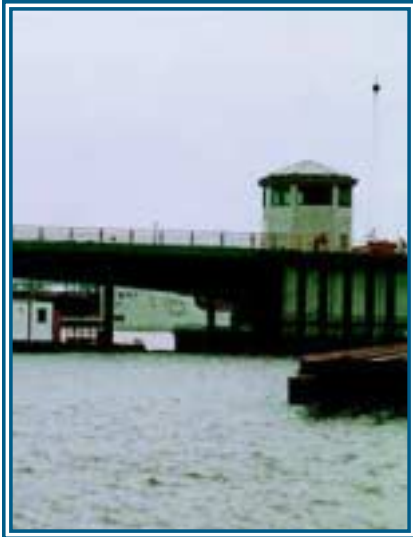
3. When approaching many bridges, the edge of the structure presents the dominant view. It is important to limit the number of directions of the edge plane. For the transition from a straight line to a curved dimension, the curvature should steadily increase, as in a second order parabola.

For the Nantenbach Railway

Bridge, in Würzburg, Germany, with a span of 216 meters, the number and direction of the diagonals is reduced to a minimum of 2 meters and no transverse bracing is used. Although the depth of the truss varies, these diagonals remain parallel for aesthetic reasons.

4. Try to integrate the structure into its environment—whether it's urban or rural. This is especially important with regard to the scale of the structure compared to the scale of the surroundings.

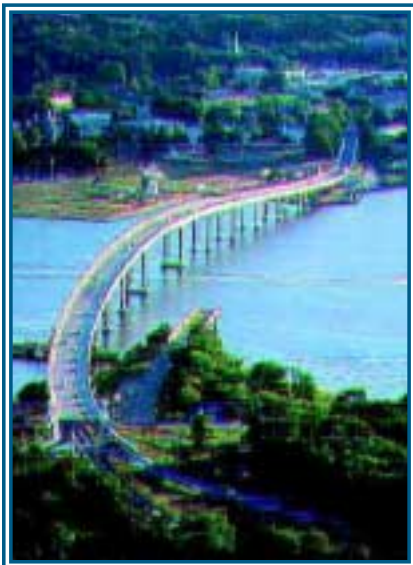
The Roosevelt Lake Arch in Arizona is in harmony with this partly technical, partly undisturbed landscape. Its 305-meter



span and great slenderness appears to belong naturally to these surroundings.

5. The choice of the materials has considerable influence on the aesthetic effects.

For heavy piers and abutments, stone masonry is often preferable to regular concrete. The heavy piers give a floating impression to the steel superstructure with its distinct support pedestals. For truss bridges, steel looks lighter than concrete. The same is true for pure tension members such as cablestays and hangers. The surface texture of the materials should be chosen depending on size and function. For large areas of abutments or piers, rough surfaces will be suitable. For slender steel beams, a smooth (but not glossy) texture will be appropriate.

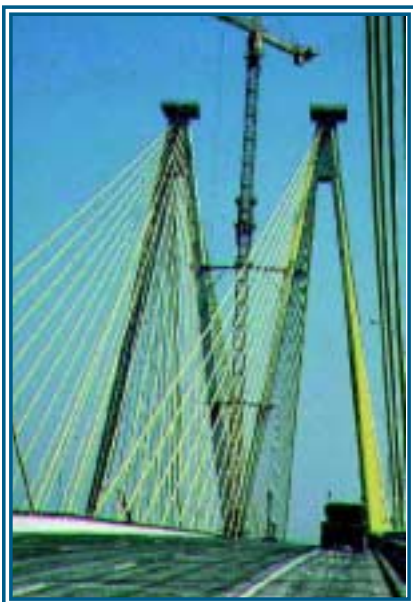


6. Simplicity and restriction to the pure structural shape is important. All additions, such as ornaments, decorations or architectural extras, should be avoided. The shape of a bridge is mature if nothing can be left out.

In 1989, the State of Maryland sponsored a nationwide design competition for a replacement bridge across the Severn River at the very end of Chesapeake Bay, in front of the famous Annapolis Naval Academy. We participated with the proposal as one of five entrants. Our basic idea was to design the bridge as simple as possible in order to respect the historic naval academy.

7. Pleasing appearance can be enhanced by color.

Natural colors of masonry or painting the bridge structure--in harmony with the surroundings--can enhance a bridge. Glaring loud colors over large areas--especially in the shape of abstract ornaments - are disturbing and spoil the bridge's appearance. However, exceptions are possible such as a slim, brightly



colored red steel truss and tower against the gray concrete beam of a pedestrian bridge.

8. The space above the bridge should be shaped in such a way that the driver experiences the bridge and gets a comfortable feeling.

Old bridges were often decorated with columns or statues of saints. In this sense, piers may extend upwards above the roadway on both sides of a bridge, or the ends of a bridge can be marked by classical column fitting the colonial style of the surroundings. The two A-shaped towers and inclined cable planes of the Houston Ship Channel Crossing at Baytown give a feeling of security to the bridge users.

9. A structure should be designed so that the flow of forces is evident to the casual observer.

For example, at the ends of a cable stayed bridge the highest concentration of forces takes place because the backstay forces have to be tied back to the anchor piers. This is made understandable by concentrating several cables at the bridge ends.

10. Moderate aesthetic lighting can enhance the appearance of a bridge at night.

With traditional bridge lighting, the individual lights follow the bridge contours. Modern bridge lighting tends to floodlight large bridge areas continuously. The light is then reflected back from the structure itself. Differently colored lights, (e.g., yellow for the vertical faces and blue light for the underside of the arches) have to be used with discretion. The tower legs of the Burlington Bridge across the Mississippi are very attractively floodlighted with blue and yellow light.

SUMMARY

These 10 suggestions should not be considered as strict rules for designing. Design shall



always begin within individual freedom for intuition and imagination.

Good designs still depend on the gifts and talents of the designer, on their sensitiveness towards aesthetics and on their training in visual appearance. The suggestions can serve as self-analysis, or as a critical faculty for checking the design, especially with models or visualizations, which can help to detect aesthetic mistakes. A pleasing appearance is often the result of critical analysis, which leads to step-by-step improvements, until harmony is obtained.

Designing a bridge is a task that requires special knowledge and experience. Not every civil engineer is, therefore, qualified to design a major bridge, but specialized Bridge Engineers are given the task. The same is true for architects: specialized Bridge Architects are capable of improving a design. Experience shows that the collaboration on bridges between engineers and architects often fails if both do not have the required special knowledge and experience.

The collaboration between bridge design engineers and architects can show good results if both are prepared to listen to one another. The architect has to be aware of the special requirements for bridge design. The

engineer must be the lead designer because the design of a bridge is more governed by technical than aesthetical requirements. A well-designed bridge will, however, satisfy both requirements.

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