



## Engineering elegant bridges – the process and the outcome

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### Summary

The appearance of our bridges and structures really matters. It is not good enough to build functional bridges that merely carry loads safely without also thinking about their appearance and how people will react to them. It is the appearance that usually dictates whether or not a bridge becomes popular with the public, and the appearance which will differentiate between the bridges that people love and those they hate. But elegant bridge design is about more than just the appearance, and this paper addresses the process of designing bridges elegantly as well as the elegance of the bridge itself.

**Keywords:** Bridges, elegance, appearance, elegant design, delight.

### 1. Introduction

Bridge design is not primarily about structural analysis and calculation, nor does it primarily involve checking material stresses and component sizes. Although these are among the tasks necessary to deliver a bridge design, the essence of bridge design, certainly any good bridge design, is much more about dealing with how people will experience the bridge. It is about understanding the particularities of a bridge location, the topography and surrounding environment, near and distant views, the approaches and destinations on both sides, social and cultural values, and many other factors. Only when these factors have been fully understood should the designer start to conceive a structural form and system that will satisfy the functional and economic necessities. Elegance, appearance, attractiveness and aesthetics are all the stuff of engineering design. They are not the sole province of architects and artists, but are as much an essential part of the engineer's domain. I welcome and enjoy the involvement of architects in bridge design. I find that the best designs usually evolve from a truly collaborative effort between engineer and architect, and a sign of this having worked well is when it is difficult to remember who first conceived the design ideas that led to the final solution. But problems occur when the engineer has not been trained or educated to appreciate the aesthetic and experiential aspects of design, and does not know how to select the materials and shape the forms in such a way to achieve elegance and delight in the finished bridge.

### 2. The importance of appearance

Beauty enriches life; ugliness impoverishes it. We would prefer to surround ourselves with beauty rather than ugliness, and this is because beauty feeds directly into the human soul and enhances a sense of wellbeing. Unfortunately, there are those for whom the need to design elegant structures seems to come a distant third to designing purely for function and economy. But there should be



economy in all three of Vitruvian attributes: structural systems and materials sufficient for carrying the loads and surviving the elements safely without excess waste, an arrangement that ensures all necessary functions can be satisfied and operations performed without undue complication, and a delightful form that gives pleasure without extravagant embellishment. This last factor get close to what we mean by elegance when applied to engineering structures.

### **3. Can elegance be prescribed by rules?**

Some try to show that for a bridge to look right there are certain prescribed numerical rules of proportion that had to be followed. In my view this cannot be done. There are too many variables and bridge design does not lend itself to strict regimented rules. They may find application in some building designs, because doors and windows tend to be rectangular and room heights occupy a narrow range, but even here such rules fall down. But proportions do matter, and considerable effort and perseverance is sometimes needed to get them just right in the search for elegance. The essence of beauty is, thankfully, much too mysterious to allow it to be defined and prescribed, and it involves many more dimensions than can be drawn on a piece of paper. The skilled designer will work at the proportions of the elements of the bridge, sometimes making very minor adjustments to make a significant difference, until it looks right with the rest of the structure and the surrounding context when viewed from all angles.

### **4. History and culture**

Another factor that strongly influences the perception of elegance is the cultural context; what looks right in one culture can sometimes seem clumsy in another. And these perceptions are also influenced by history with changing technologies, expectations and fashions; what appears out-of-date and old-fashioned in one culture may seem entirely appropriate and modern in another. The bridge designer needs to consider these factors in order to conceive a design that is appropriate to its time and place.

### **5. What do we mean by elegance in engineering design?**

Elegance, as a concept applied to bridges, implies notions of simplicity, slenderness, good taste, style, appropriateness, beauty and many other ideas which engender a sense of delight in the observer. But engineering elegance is more of an intellectual concept than mere physical beauty, and is perhaps appreciated best by engineers and others who possess an understanding of the technical challenges involved. It combines the purely visual experience of observing the form with an appreciation of the ingenuity in the technical solution necessary to arrive at it.

### **6. Conclusion**

The appearance of our bridges matters. Elegant designs which last the test of time and give universal pleasure are a source of great joy to many people and pride to those involved in their creation. As engineers, architects and designers we must strive to achieve such elegance, very often in spite of commercial pressures and contractual arrangements that seem bent on preventing it, because we are responsible for shaping the world we live in for future generations.

Elegance is not, however, just about the visible end result, The truly elegant solution is one that comes about through an elegant process in design and construction towards an elegant solution which combines imagination, innovation, careful assessment and detailed analysis. The truly delightful bridge is one that both appears elegant to all viewers and also hints at the true elegance of the processes involved in its creation.