

THE ARCHITECTURE OF BRIDGES

by

Arnold H. Vollmer
Senior Partner
Vollmer Associates

Some capricious muse must have let me - or misled me - into designating the topic of my intended remarks today as the "Architecture of Bridges". I am going to discuss not architecture but engineering and the complete highway rather than just bridges. It is probably true that a rose by any other name would smell as sweet, but in the interest of lucid communication, it's wise to use words in their commonly accepted sense. Although architecture and engineering have much in common, so do males and females - but, by all means, long live those minor differences!

Architecture is the art, craft or skill of creating, designing or arranging space, generally enclosed by walls, floors and roofs, for human need and use, always of very complex nature. Civil engineering is the art or skill of designing structures or structural complexes of very different types from those which occupy the architects' attention. The highway, with which we are immediately concerned, does not represent, except in such special elements as tunnels or covered viaducts, enclosed space; and the use to which the highway is put is of a far simpler and, at the same time, less flexible nature than that of a building. In architecture, structural concepts may be of major significance but rarely dominate the design process; in the engineer's work, they are usually the controlling influence.

A building of even the most specialized type serves a multitude of basic human functions. A hospital, for example, serves people not only engaged in an undergoing therapy, but also the acts of sleeping and walking, sitting and exercising, research, education, birth and death, to cite only the most obvious.

The sole function of a highway is transportation of people or goods. It should serve this function safely, efficiently and agreeably - but then so should any of man's creations, from bicycle to a building, serve its intended functions.

When a policeman delivers a baby in the back of a patrol wagon he is acting as a midwife, not as a policeman, even though he has been thrown into the role of midwife by virtue of his responsibilities as a protector of the public welfare. When an engineer cooks a meal, he is, I hope, acting as a cook, not as an engineer. When he designs a building

as engineers often do, he is acting as an architect; and when architects design highways, as they seem to be doing more and more frequently these days, they are acting as engineers, not as architects.

If I seem to labor this point it is for what I consider a good reason; I want to see engineers continue to design highways and to avoid having our fellow professionals, the architects, take over our job because we have defaulted on certain of our responsibilities. If we are to avoid this, we must design excellent highways. And this excellence must include not only safety, structural integrity, economy and efficiency but also that difficult to define quality to which I referred obliquely earlier when I said a highway must be agreeable - that is, the quality of beauty. It would be beating a dead horse to try to analyze and probe for reasons for the universal human tendency to demand more than just functional effectiveness in man's works. We may not always achieve success but we try to shape our environment and the objects within it in such a way that they serve not only physical function but also satisfy some indefinable spiritual need. Anthropologists argue at length as to precisely what distinguishes man from his other close animal relations, but I have always felt that it is this aesthetic impulse which more than any other separates the men from the beasts.

It's always tempting on an occasion like this to attempt to spread oneself thin and, in 45 minutes or an hour, lay down all the rules for accomplishing whatever the stated objective of one's talk may be - in this case, that of producing aesthetically exciting highways. Even if I were capable of such feats of condensation and summarization, I am not quite sure that I'd know where to start, let alone finish up. Beauty is not susceptible of easy definition. Each creative mind works in a slightly different way. Analysts have attempted to grapple with the establishment of rules since time immemorial. Because a work of art is expressive of certain mathematical or geometrical relationships and rules does not mean that the cold application of those rules to a design problem will result in a work of equal greatness; great poetry has been written within the sonnet form but it does not follow that adherence to the sonnet form results in great poetry. One can receive inspiration from the work of another, write a new symphonic variation on an old theme, but ultimately each has to find his own method of expression. We use words like proportion, balance, relationship, symmetry and asymmetry, detail, and texture, and speak of them as good or bad, successful or unsuccessful, but we do not really know precisely what the quality is that makes a complex grouping of materials, whether they be paints, brick and mortar, fabrics or concrete and steel, a satisfying entity. What is one man's meat frequently turns out to be another's poison. It's a far cry from the Parthenon in Athens to the Gateway Arch in St. Louis, but both are undeniably beautiful. In each case, a creative mind assisted by others has produced a rational and emphatic statement which causes our spirits to soar beyond the confines of our earthbound condition.

Perhaps it is the elusive, indefinable and mystic nature of beauty which has resulted in its being so often evidenced in works concerned with service to religion and God - from a Bach Cantata to an Aztec pyramid. Metaphysics, however, is not my field of specialization and at best I can hope to offer a few very personal observations which may provide helpful, if minor, guideposts along an admittedly tortuous road.

A few months ago I was a member of a jury which judged last year's crop of steel bridges for the AISC. Since all of the entries were still standing at the time of judging, we assumed that they were structurally sound. Most of them having passed the eagle-eyed scrutiny of State highway departments and the Bureau of Public Roads, it seemed probably that they met reasonable standards of safety and economy. The judges, therefore, were largely concerned with their aesthetic qualities. The debates we engaged in over their merits and over the deficiencies we found most glaring were all very subjective and none of us had magic formulae to apply to measure what proportion of span to depth or height had produced instant beauty. However, there was so little disagreement as to the winners - and the members of the jury ranged from bridge engineers to an art museum director - and, more important, there was such general agreement on those characteristics which the winners displayed and the losers lacked, that for better or worse I shall share those observations with you.

The first quality which invariably seems to characterize the successful highway structure is what I term articulateness. The word "articulate" is defined: "perceived, expressed or formulated in clearly distinguished parts . . . systematically interrelated . . ." Keats said that "Beauty is truth; truth, beauty. . . ." Today we might put it "Tell it like it is!" Let each part of the structure express its function simply and clearly and make the interrelationship of each part to the others as simple and clear as possible. To explain what I mean by this, let me go back for a moment to the distinction I drew between the roles of the architect and the engineer. Disregarding for a moment the exceptions which apply to any rule, as I noted earlier the architect is concerned with complex human functions which are rarely controlled or dominated by structural considerations. Space, not structure, is the major design element. The structural system employed to support the physical environment for these functions is most often a secondary consideration. The parts of the building of which we are most conscious, the enclosing walls, are often in effect curtains, independent of the structure which supports them. Occasionally and sometimes with success, the architect exploits the structural system as an aesthetic device. Historically, of course, this was most evident in the architecture of the Gothic Church. The vast spans of sports arenas and the externalized windbracing of some skyscrapers are contemporary examples of this device. But it is the very virtuosity of our structural designers and of our modern technology which, to a great extent, frees the architect from subservience to structural considerations.

Quite the contrary with the highway and particularly the urban highway, which is likely to be largely a viaduct or tunnel or combinations of both, here structure is it! No walls, windows, doors, partitions, furniture or fixtures distract or detract from the main consideration.

As Elizabeth Mock in her fine work, "The Architecture of Bridges," put it: ". . . a bridge is at once the most tangible and most abstract of architectural problems . . . capable of extraordinary purity, though it may perhaps never achieve the richness and depth of expression that are possible in buildings of more complex human motivation."

It is the essential purity of the problem which demands a simple, clearly stated, articulate solution. One of the reasons for the almost universal appeal of the suspension bridge, other than its usually dramatic situation, is probably the fact that it's hard to disguise the way it works. The function of each element and its relation to every other element - anchorage, cable, tower, hanger and deck members - is unequivocally clear. Economy alone generally precludes unnecessary and confusing embellishment. Not so the simple highway grade separation structure. There seems to be fair game for what must be interior decorators who've been locked out. Boldly rusticated stone masonry, all of six inches thick, makes a thin pretense at monumentality, effectively disguising the basic structural concept; frames pretend to be built-up arches; the end bearings of beams are concealed behind a structural fig-leaf. Simplicity and directness is eschewed and a premium is put on tricky innovation for the sake of being different.

But then no one is so self-righteous as the reformed sinner; often they become evangelists. Twenty-five years ago I designed a modest underpass for an Adirondack Mountain beach park. The structure was a reinforced box. I faced the spandrel member with rough-hewn timber and the walls with native masonry. The timber "beam" which appeared to rest firmly on the stone walls was actually supported by bolts in the concrete structure behind. I remember being very proud of my use of indigenous materials. The result was quite pretty and totally without engineering validity. Mark Antony may have had some bridge designers in mind when he said that the evil that men do live after them. The evidence of my shame still stands firm and unfortunately will certainly survive me. Not for a moment do I mean to suggest that all surfaces must present a dull monotony and that varied materials - including stone and brick - and surface treatment cannot be perfectly valid, so long as the essential nature of the structure and the materials of construction are enhanced and exploited rather than concealed.

The other characteristic of the well designed highway or structure that I want to emphasize might be termed continuity, consistency, coherence or integrity, the quality which makes it appear that the whole has been designed under the guidance and control of one individual. When I began, I noted, without further excuse or explanation, that I intended discussing

highways not bridges. We've come a long way, I think, from the days when the bridge or tunnel was the only highway element considered worthy of engineering design and the rest of the road was left to the surveyor. Perhaps as purely structural problems those elements can be isolated; but in every other aspect - function, safety, aesthetics - highways are indivisible. Each part relates directly or indirectly to every other part. The alignment and profile, signs and structures, guide rails and side slopes, planting and light posts are part of a total concept proclaiming clear intent on the part of the designer rather than accident or inadvertence. Scattered throughout the countryside there are all too many examples of the violation of the concept, but each was the work of someone of whom I am fond and more important whom I want to remain fond of me. Otherwise the easy approach to illustrating what I am driving at would be to show you some of these examples. One, for instance, is a bridge across a major river. That bridge should last not less than 100 years and each day of its existence it will blight the natural beauty of the river it crosses. The main span is a truss which in itself was very competently designed. The adjacent approach spans are also trusses, again well-conceived, but surely designed by somebody who was not on speaking terms with the designer of the main spans. The minor approach spans are plate girders which appear to relate to the adjacent spans only in that they presumably carry the same load. The camel, whose appearance has been described as resembling that of a horse designed by a committee, has the beauty and grace of the winged Pegasus compared with this conglomerate. Perhaps it was designed by a computer which spelled out the most economical solution to each span without regard to the whole. Granted that the design of a highway presents some special problems which the architect is not faced with: Interstate 64 is hundreds of miles long and goes through many partially sovereign States. Even if our friends from the Bureau decided to take over our design work completely, no one man or one team would be capable of the total design. Nor for that matter would it be desirable to have one concept dominate such an enormous undertaking. One can, after all, get too much of a good thing. I think that even the standardization of bridge types within a single State has gone too far. Limits must be placed on where one concept stops and another starts and a graceful transition from one to the other must be achieved. This is not easy, but it is by no means an insurmountable problem. After all, pavement widths, continuity of alignment and grade and other design controls automatically ease the problem of transition. We walk through an Italian hill town where hundreds of master builders and artisans worked on different structures and find a wholeness and integrity which delights the viewer. The same is true in some of our New England towns such as Nantucket, Salem or Marblehead. Closer to home your green grass and white fencing provide a unifying influence which results in a whole which pleases the eye and raises the spirits.

Emerson said that ". . . A foolish consistency is the hobgoblin of little minds. . . ." One of our design problems stems directly from the enormous variety of options available and the virtuosity of our designers. These riches of material and method should not be wasted but they cannot be

allowed to spoil us and our work. The highway must not be allowed to become a mere showcase for our versatility and virtuosity. In designing any segment of our highway system, we must not start at one end and work our way through solving each problem as it comes along without regard for how the adjacent or previous problem was solved, any more than we would narrow a road from three lanes to two simply because at one point it cost a little bit more to carry through with the original and valid requirements. Many structural concepts may be required to solve all of the problems but each must be considered in the total context.

There is a school of art which is known as "Found". Elements as disparate as an old shoe and an automobile carburetor are assembled to form sculpture. The examples which I have seen don't make me relegate Michelangelo's David to the realm of old hat but some of the work of this school is at least amusing and interesting and there is a great difference between such work and a junkyard. The mind and hands of creative thinkers have been at work, at least, attempting to combine these different elements into a semblance of congruity.

Finally, I would like to touch on an aspect of highway design that is very much on my mind these days. That the highway is not something sufficient unto itself but rather just one element of a complex has suddenly been discovered by some eloquent but Johnny-come-lately members of the planning professions. The game is given a new name - "multiple-use" or the "Baltimore concept" - and lo! we're told it's a new idea. Then, when integration of the highway with the rest of the landscape or the urban scene is not achieved, it's blamed on that popular scapegoat, that insensitive Philistine, the highway designer. I remember sadly ten years ago, when we started the preliminary design of the Interstate System in Louisville and Jefferson County, how desparately we tried to find other responsible people to integrate with. Redevelopment along our routes was planned but the plans were either undeveloped or kept concealed. Where were they then, our present noisy critics? We worked on our own and prayed for guidance. Now that the planners have discovered the highway, the story is different but there is one important theme that has not changed. The highway by virtue of its very scale, by virtue of the characteristics of the functions it serves, must continue to be a dominant if not the controlling element in the urban design effort.

What are the physical characteristics of what we call a school? It can be a skyscraper or it can be a campus-like cluster of individual classrooms. The designer has infinite flexibility limited only by the abilities and capacities of that infinitely versatile animal, the human being. The highway, on the other hand, no matter how much we may attempt to modify the characteristics of vehicular travel by speed reduction and so forth, is still a complex of monumental and relatively inflexible components. The building blocks of the highway designer are Brobdingnagian. Highways are truly the main arteries of the urban body and the highway designer cannot be subordinated. This puts upon our shoulders an awesome responsibility.

Let's rise to the challenge and show them what we are capable of achieving.

To quote Elizabeth Mock again ". . . . A great engineer is not a slave to his formulas. He is an artist who uses his calculations as tools to create working shapes as inevitable and harmonious in their appearance as the natural laws behind them. He handles his material with poetic insight, revealing its inmost nature while extracting its ultimate strength through structure appropriate to its unique powers."

falls like the challenge and then from what we are expected to do
 and what we are not expected to do. A great deal of it is not
 state for his journal. He is an artist who sees his audience as
 to state for his journal. He is an artist who sees his audience as
 as the artist who sees his audience as to state for his journal.
 through situations appropriate to the paper.