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NOTABLE UNBUILT BRIDGES

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Described and discussed in this exposition are a number of unusual or notable bridges proposed in this century that for various reasons were not built. Emphasis is placed on bridges in the United States, although some bridges in other countries are also mentioned. Particular comments are made on their esthetic qualities. It is believed that much can be learned from these proposed bridges that could be used in future bridges.

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INTRODUCTION

Libraries are full of books and articles on all forms of bridges that have been built in locations around the world from ancient times to modern times. Little mention, however, is made of the notable bridges that have been proposed or designed but never built. The following exposition is therefore presented to fill this information gap by describing a number of these designs. Emphasis is placed on those that were intended for construction in the United States, but some unusual ones in other countries are also cited. Although none of the listed bridges has been built, many of the designs contain stimulating concepts that may in time spawn similar bridges that will be built. Others are interesting in themselves and for historical reasons.

To cast a research net as wide as possible, the writer contacted bridge engineers in all 50 states, including those in private practice as well as in government positions. Some published material on the subject was also found in miscellaneous journals. Information regarding others was obtained from personal sources. The accumulated list was narrowed down by applying a notability criterion which required that the bridge be especially large, incorporate significant technical innovations, or have an unusual configuration. Excluded from the list were numerous interesting unbuilt and sometimes even fully designed bridges that happen to be similar in nature and span length to other structures already built elsewhere. Examples of these include tied arch, suspension, cable-stayed, and box girder types. Some of these bridges were proposed as alternates to others that were built. In other cases, the same type of structure was built, but (e.g.) of steel instead of concrete. In still other cases, due to economics or politics, no bridge was built at all. For the most part, the bridges selected were proposed in the latter part of this century, although several from earlier periods are also included.

UNITED STATES BRIDGES

Two of the recent and better known unbuilt bridges were conceived by the structural engineer T. Y. Lin. These are the Inter-Continental Peace Bridge in Alaska and the Ruck-A-Chucky Bridge in California.

Long a dream of both American and Soviet engineers, a bridge across the Bering Strait linking Alaska and Siberia was proposed by T. Y. Lin in 1958, and it is in fact still being actively promoted. The 50-mile crossing would consist of two hundred and twenty 1200-ft-long cable-stayed spans and a main span of 180 ft. The girders would be made of hollow, precast, prestressed concrete boxes, approximately 40 ft square. The open upper deck would be for vehicles, the enclosed middle deck for trains, and the lower deck for pipelines. The piers would also be hollow, precast, prestressed concrete sections; round in form to resist ice pressure. As shown in Figure 1, a single stay cable scheme would be used for economy of construction and maintenance. The project is believed to be technically feasible and would cost about 4.2 billion dollars. Without a doubt, such a structure would rank with other monumental and historical construction projects, such as the Suez Canal and the Panama Canal. Moreover, it would symbolically as well as actually link the world's two superpowers and most of the earth. One could actually drive completely through the continents of South America, North America, Eurasia, and Africa--from Cape Horn to the Cape of Good Hope.

Another bridge designed by T. Y. Lin in association with the architect-engineer Myron Goldsmith of Skidmore, Owings, and Merrill is much smaller in scope but daringly different in another way. That bridge is the Ruck-A-Chucky Bridge designed in the late 70s for Auburn, California. It is unique in that it is a suspension bridge, spanning 1300 ft, but on a curve of 1500-ft radius. Since the proposed site is in a deep canyon by a dam, the design would make use of multiple steel cables attached to the deck structure and anchored back into the canyon walls in a broad sweeping pattern (see Figure 2). Alternate designs in both steel and prestressed concrete were prepared for the superstructure. Model studies at 1/200 of full scale conducted at the University of California, Berkeley, showed that the design stands up well for both static and dynamic forces. It was considered so attractive that it received first place as a piece of architecture in 1979 by Progressive Architecture magazine in its annual awards program.

Paolo Soleri, artist, architect, and city planner, has proposed since the late 1940s a number of highly imaginative bridge designs. Two of his better known structures are his tube bridge and his cantilever bridge. The tube bridge is illustrated in Figure 3. Made of reinforced concrete, it undulates over and under the deck following the general form of the bending moment diagram for a continuous beam. Where the bending moments are greatest, over the supports and at midspan, the tube is fully closed. Elsewhere, it is partially open; becoming flat at the points of inflection where the moments approach zero. Although novel in concept, the bridge is both elegant in form and potentially buildable. It would become a beautiful showpiece should it ever be constructed.

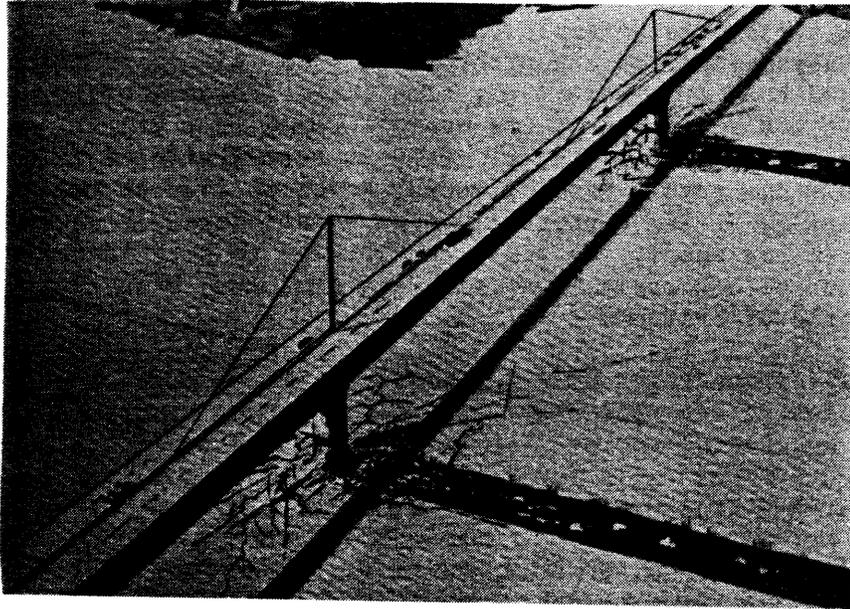


Figure 1. Peace Bridge

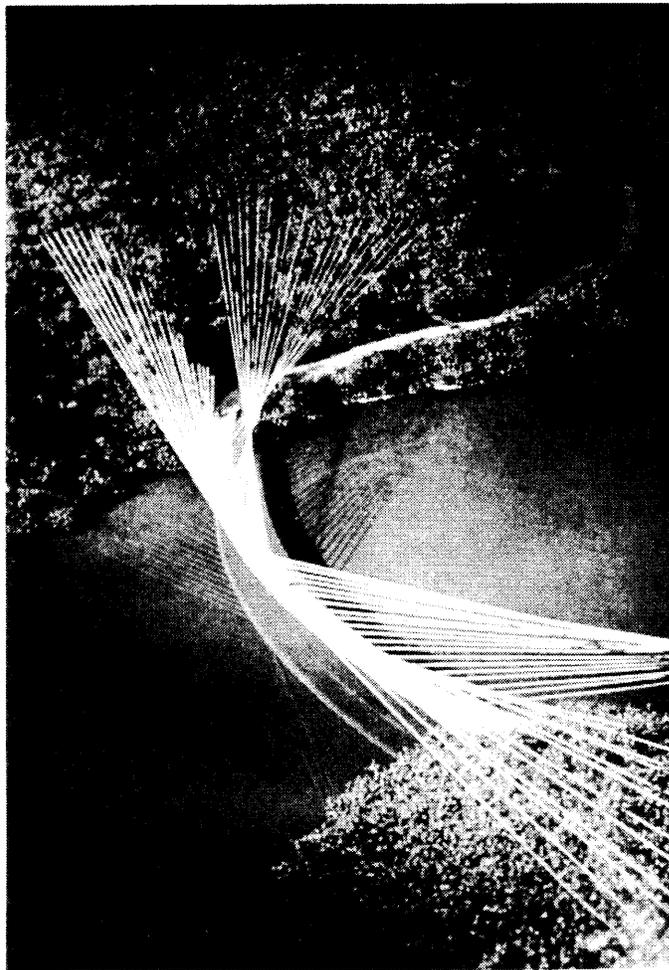


Figure 2. Ruck-A-Chucky Bridge

Figure 4 pictures Soleri's cantilever bridge. Very sinuous and organic in appearance, it can probably only be made of reinforced concrete, and then at a relatively high cost. Unfortunately, as shown, it functions (as suggested by its overall form) as a propped cantilever rather than as a pure cantilever. Were it to function as in Figure 5, it would have the proper bending moment envelope deep at the anchored ends and shallow at the center, although some thickening would be needed at the center for shear. To some, this bridge is pure fantasy and nonsense, but to others it is an exciting sculpture statement applied to the real world of bridges.

Figure 6 illustrates Soleri's proposed bridge made of magnesium alloy and plastic segments post-tensioned together by cables along the curved top and bottom chords. It has an advanced state-of-the-art image, which clearly calls for further research with regard to behavior, fabrication, and construction.

There are other Soleri bridges that are even more stylized (seen in Figures 7 and 8). Even so, their general configurations are more or less properly proportioned to resist the imposed bending moments, although probably inadequate to resist end shear. However, with some revision, they probably could be made to work, thereby producing bridges that would be classified as works of art. Judged as optimal engineering designs, they would not fare as well. But then, why not for special situations build a bridge more "art" than "technology"? Surely Frank Lloyd Wright's Falling Water House or the Taj Mahal could have been built more "rationally" and less "arty," but mankind would have been poorer for it.

A number of other bridges have been proposed by Soleri that combine basic vehicular functions as well as architectural space for such uses as restaurants, parking garages, and enclosed observation areas. Highly sculptural and generally of reinforced concrete, these tend to be more bulky and less graceful than those intended only for vehicles. More will be said of other proposed multi-use bridges later.

The illustrious architect Frank Lloyd Wright had an interest in bridge design as well as building design. One of his bridges was actually built, but several were not. One not constructed, his "Butterfly Bridge" was intended to span the Wisconsin River near Spring Green, Wisconsin. Figure 9 shows his 1947 drawing. Made of reinforced concrete, it arches gracefully from pier to pier across the river, flaring transversely in butterfly fashion to support the deck. While not as radical as Soleri's proposals, it anticipated many of today's designs using prestressed hollow box girders. A few years later, Wright proposed a similar type of bridge over San Francisco Bay of much longer span, which also was never built (see Figure 10).

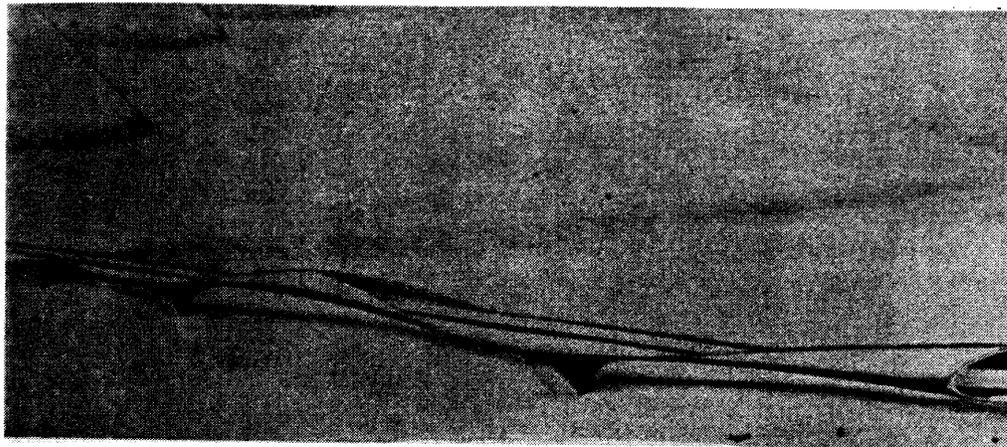


Figure 3. Tube Bridge

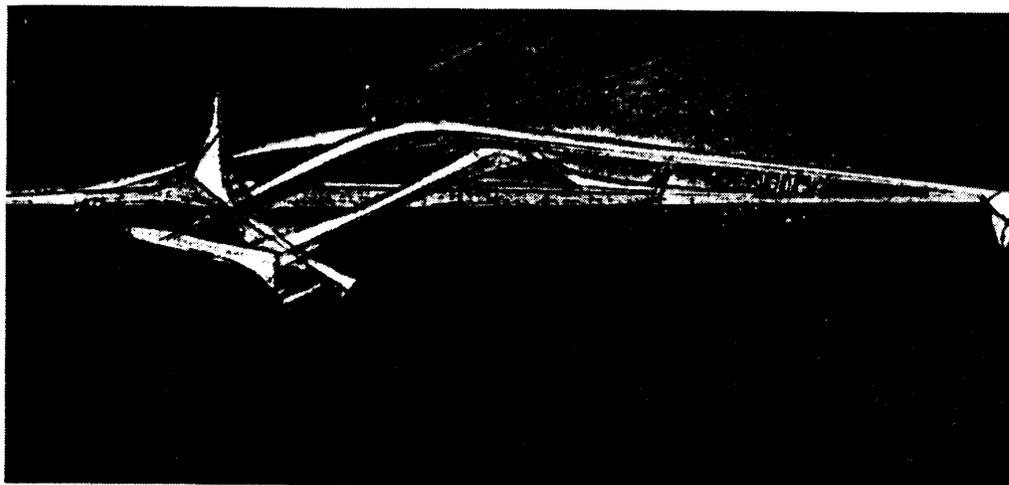


Figure 4. Cantilever Bridge

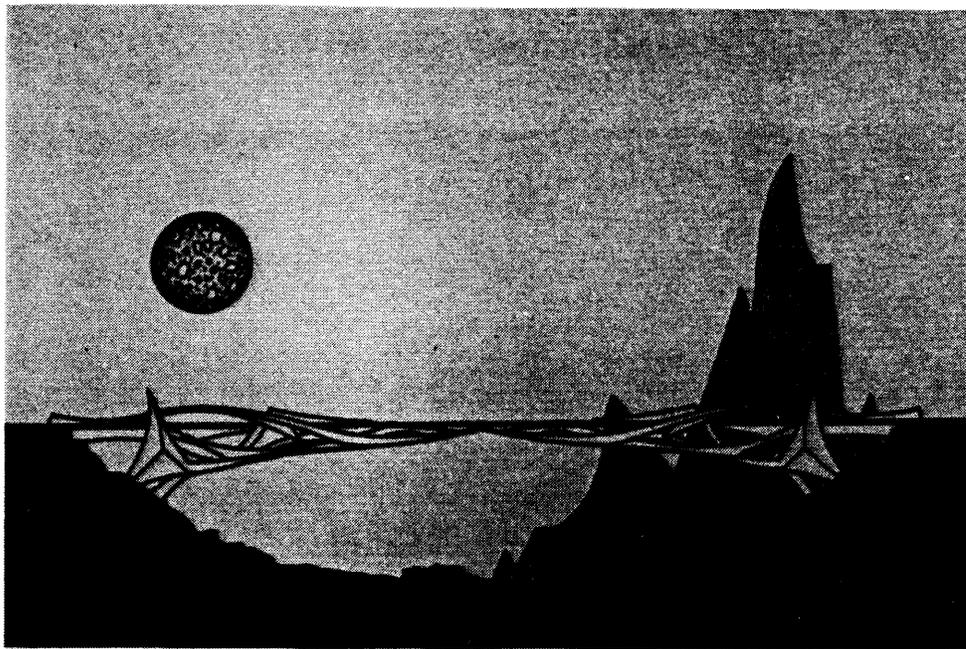


Figure 5. Double Cantilever Bridge

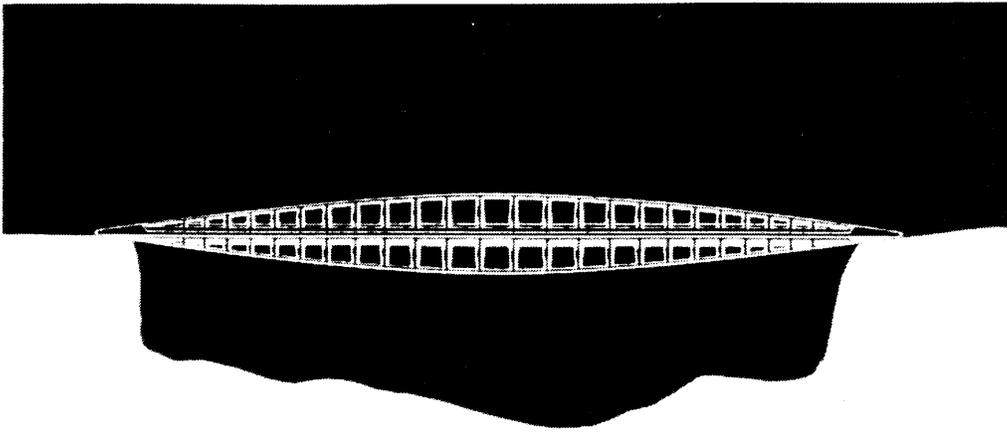


Figure 6. Segmental Bridge

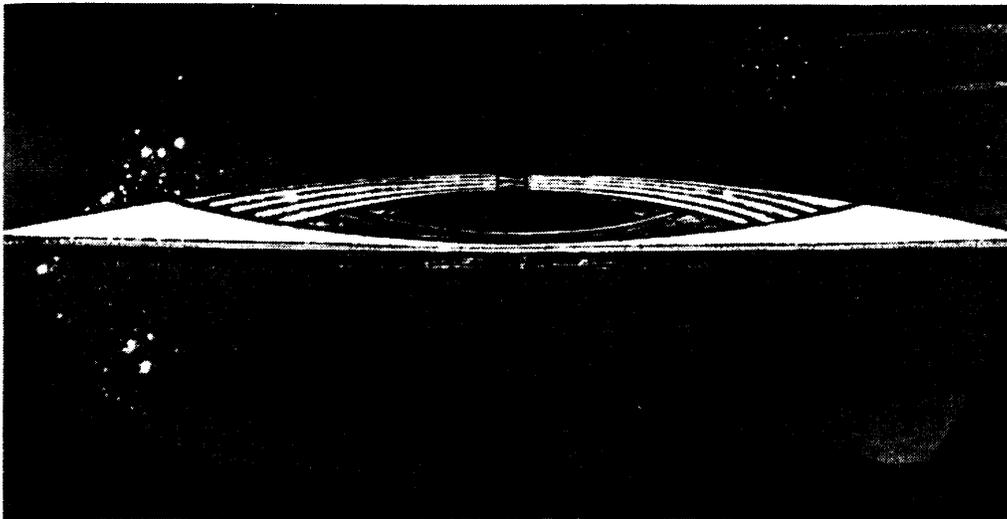


Figure 7. Lenticular Bridge

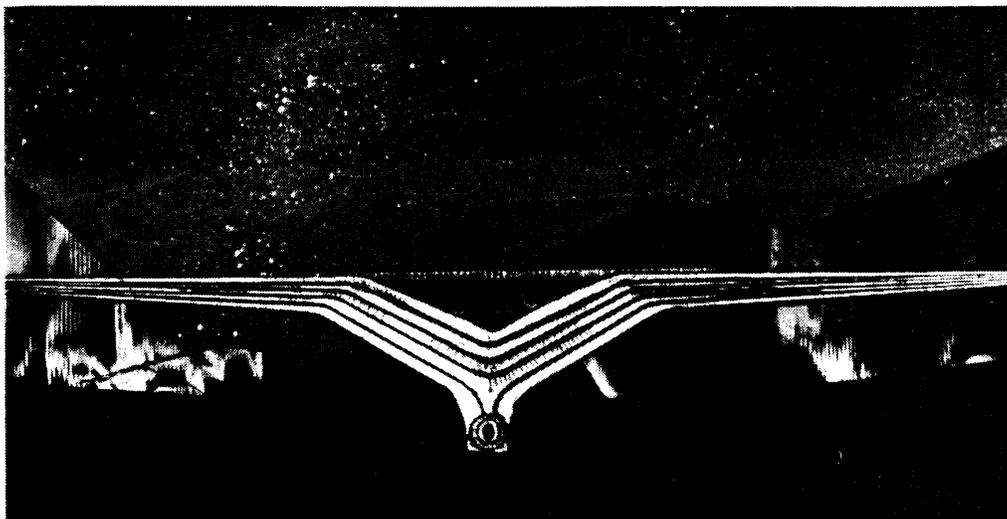


Figure 8. Gull Wing Bridge

In 1962, the Kaiser Steel Corporation commissioned structural engineer Pier Nervi to design a number of prototypical bridges using steel. The one shown in Figure 11 illustrates his use of a novel truss design for a viaduct for an urban area. Clearly a piece of solid engineering, it nevertheless incorporates a distinctive and esthetic arrangement of web members connecting the upper and lower deck, suggesting a tree-like columnar system coupled with a triangulated truss system. Also noteworthy are the piers, flowing upward and spreading outward continuously to sustain both the lower and upper levels.

Early in the 70s, the engineering firm of Johannessen and Girard of Phoenix, Arizona designed a novel and innovative elevated viaduct for Phoenix as part of the Papago Freeway. As illustrated in Figure 12, widely separated twin viaducts soar 100 ft over Central Park in downtown Phoenix. The virtues of this design are many:

- o Most older buildings could be left untouched along the right of way.
- o The oppressive psychological effects of an overhead bridge on people at ground level would be greatly reduced by virtue of the structure's great height.
- o Views from the ground would be generally preserved, and views from the bridge would be enhanced.
- o Vehicular noise and air pollution transmitted to the ground would be lessened.
- o Generally free development of the space below in the form of parks, buildings, and the like would be possible.

Helical ramps at the interchanges provide vehicular access to and from these elevated structures. The superstructure was designed as multi-cell hollow concrete box girders, spanning 170 feet. Tinted beige concrete with surface texturing was proposed for esthetics. Although seriously considered for construction, the project eventually was shelved because of its relatively high cost, as compared to a ground-based freeway. It would have been a noteworthy experiment, with possible application in numerous other urban communities.

Professor Robert LeRicolais, formerly of the University of Pennsylvania, experimented with a number of unique bridge structures during the 60s. One of his proposals, shown in Figure 13, is called "Skyrail" because it was intended for railed vehicles traveling in the sky high above a city. Approximately 300 ft above ground, these bridges were to be supported by towers every 1600 ft. The bridge would have contained cable tendons coiled in a double helix around circular diaphragms to form a "stiff hollow rope." A number of these Skyrail structures carrying rapid-rail vehicles within this hollow rope were to be interconnected in a geometric network LeRicolais called "Trihex." However,

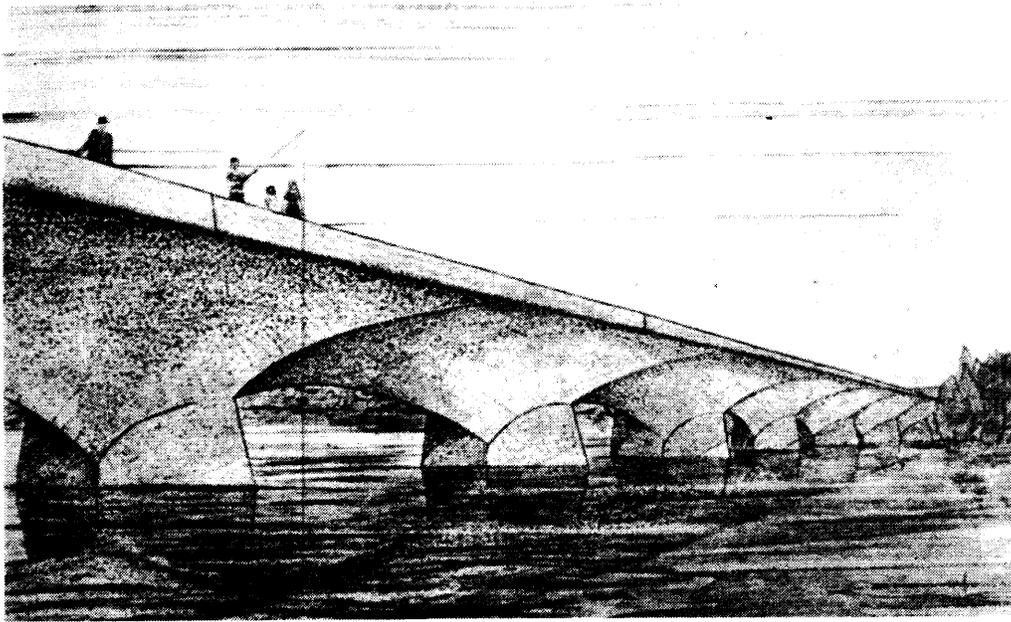


Figure 9. Butterfly Bridge, Wisconsin



Figure 10. Butterfly Bridge, California

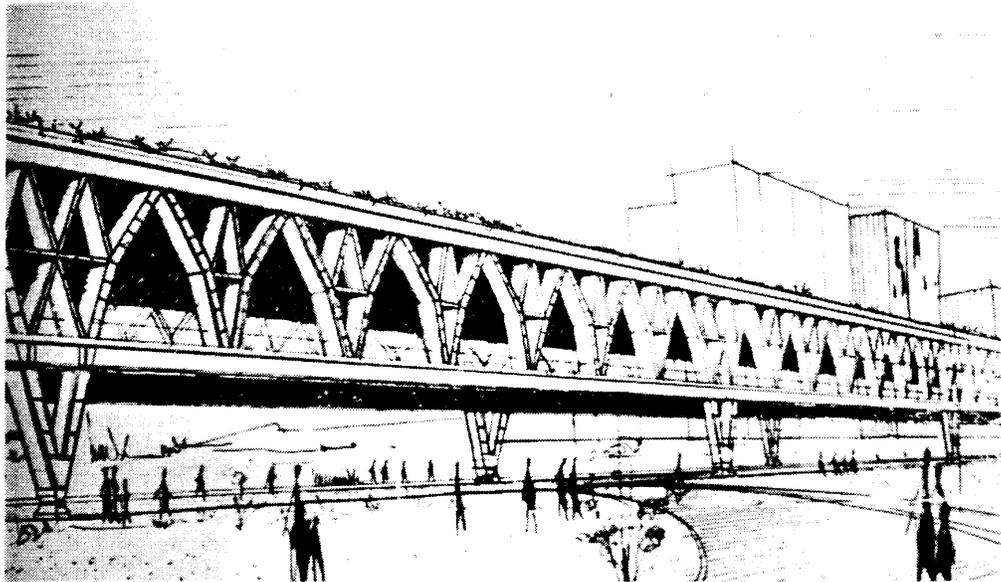


Figure 11. Viaduct

there is some doubt in engineering circles if such a system of bridges meeting all the criteria of strength, deformation, cost, and the like is at all possible in the foreseeable future.

A specific example of a "Trihex" pattern can be seen in his "Fish" bridge (see Figure 14). Note that this truss basically consists of two triangulated Warren trusses, chord to chord using the adjacent chords to support the deck. Then, at some of the joints, there are braces that subdivide the triangles into hexagons and provide rigidity, thus the name, "Trihex."

Little Rock, Arkansas is the site of an unusual compound arch bridge. Designed in 1975 by the engineering firm of Garver and Garver, this bridge was to carry four separated traffic lanes over a complex interchange (see Figures 15 and 16). To be made of weathering steel, the arches would span 360 ft in each direction. In plan, the arches resemble a Maltese cross, beautifully compatible with the four curved ramps they support by means of tension hangers. Unfortunately, cost dictated that a more conventional interchange be built.

In 1966, the structural engineer Lev Zetlin was asked to design a bridge across the inner harbor of Baltimore, Maryland. His solution is ingenious in concept and most striking in form (see Figure 17). Spanning 840 ft between the tips of the towers, the multiple decks carrying 14 lanes of traffic are supported by an innovative "cat's cradle" system of force and counterforce cables. This basketwork of tensile members resists lateral as well as vertical forces. Furthermore, the system provides damping against flutter with no need for stiffening trusses as commonly found in conventional suspension bridges. Unfortunately, this dramatic structure was never built because of a decision to traverse the harbor with a tunnel rather than a bridge. Yet, in the future, many of its valuable concepts may well be incorporated in another bridge at another location.

A different kind of suspension bridge was proposed by the engineering firm of Weidlinger Associates in 1965 (see Figure 18). Intended for windy sites, this suspension bridge features a large diameter tube through which vehicles would travel. This prestressed concrete tube is equally resistant to vertical, horizontal, and torsional forces. At the same time, users would be shielded from any sort of dangerous wind gusts. Esthetically, the heavy mass of the tube appears to conflict with the relative lightness of the cables. It is believed that the construction of such a bridge would not particularly advance the esthetics of suspension bridges.



Figure 12. Papago Bridge

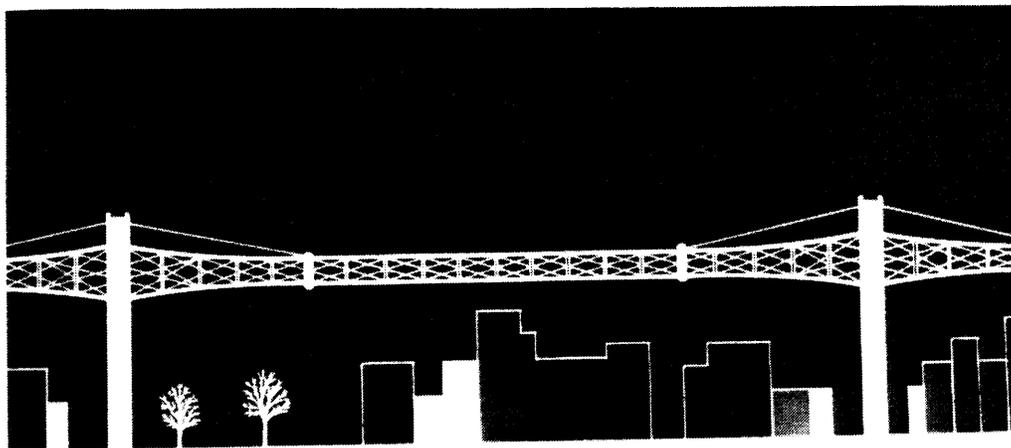


Figure 13. Skyrail Bridge

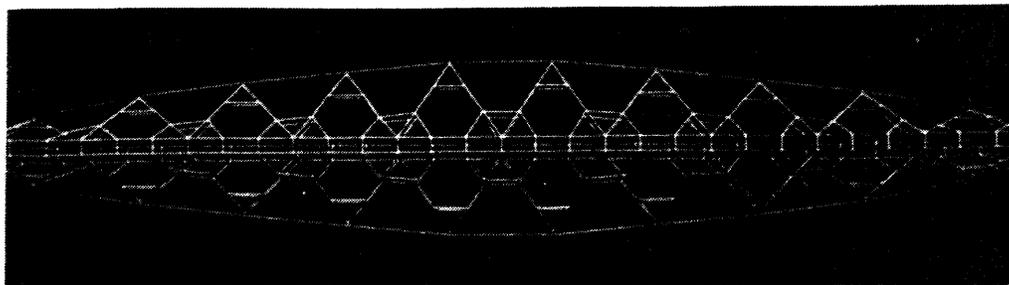


Figure 14. Fish Bridge

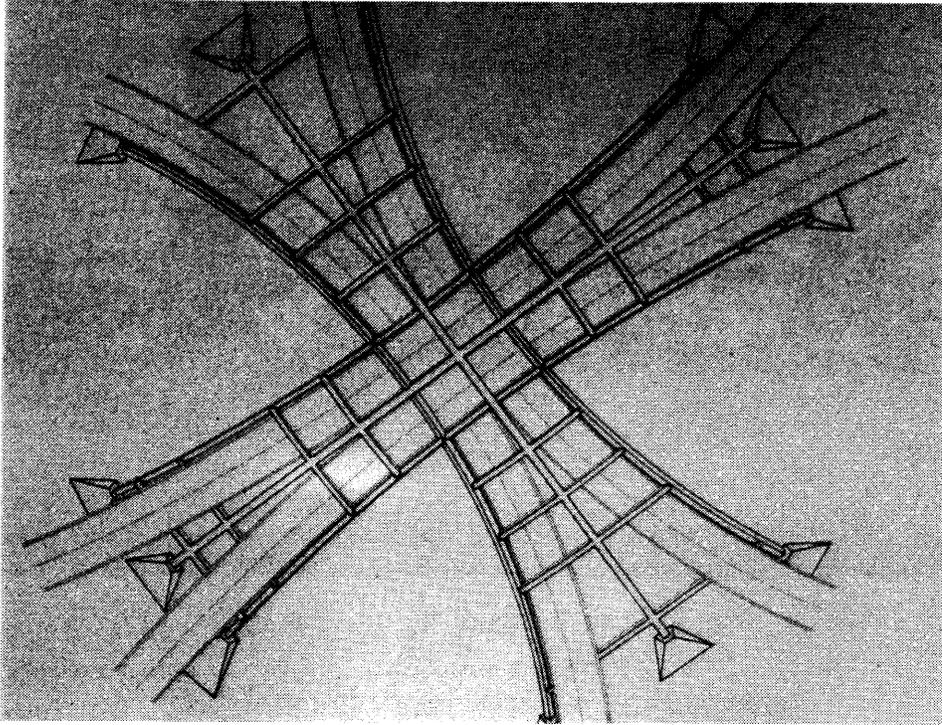


Figure 15. Little Rock Bridge, plan

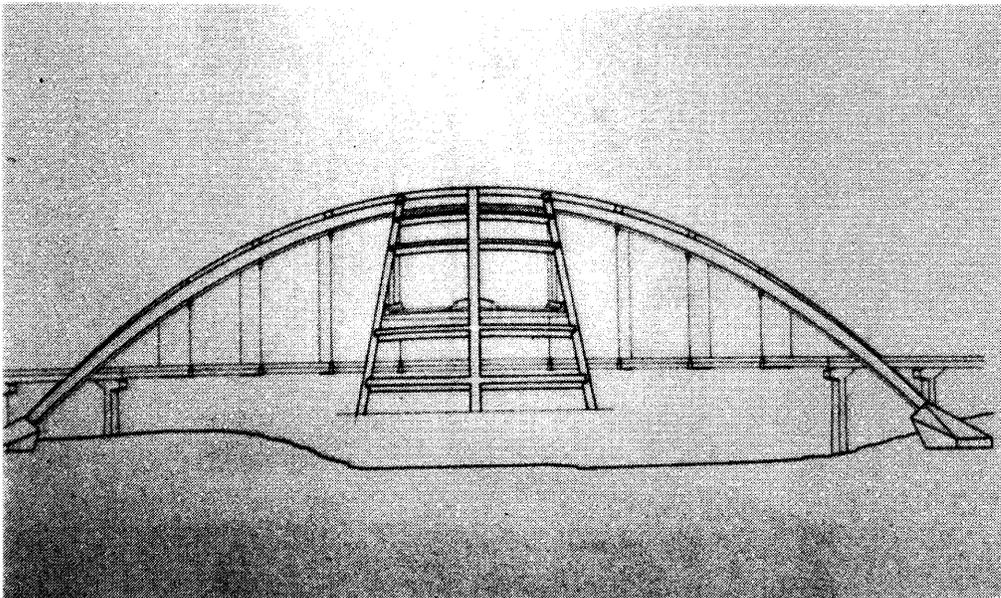


Figure 16. Little Rock Bridge, elevation

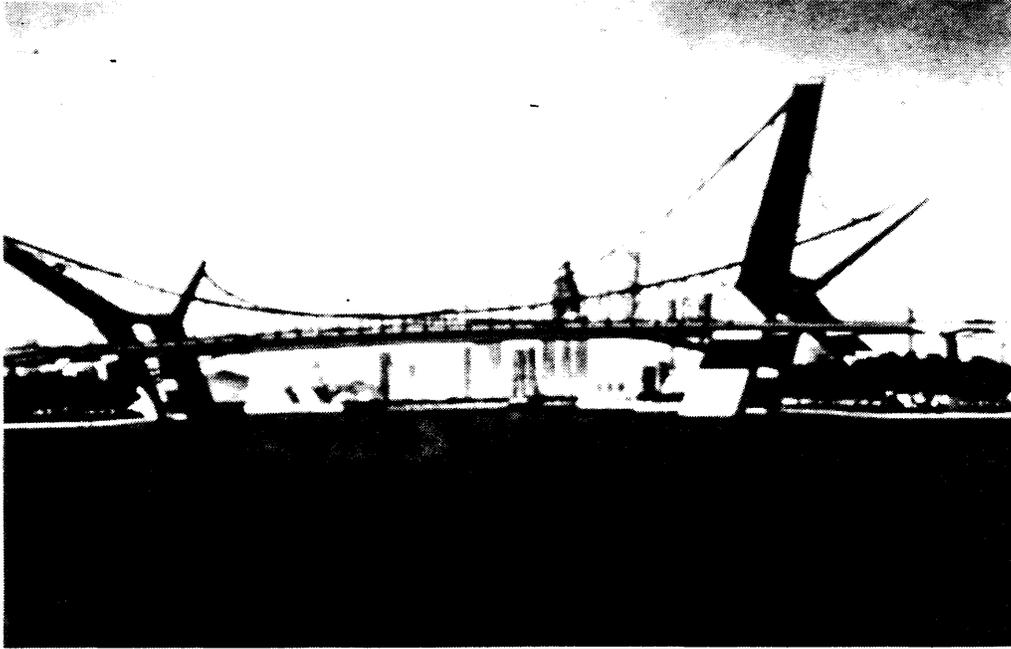


Figure 17. Inner Harbor Bridge



Figure 18. Tubular Bridge

In the 1960s, two talented aspiring architects at the University of Virginia, James Chapman and George McClure, in association with the author, designed a multi-use bridge to span the East River in New York City. This bridge not only carries vehicular traffic, it also contains residential units, shops, restaurants, and parking garages (see Figure 19). Through traffic travels on the center lanes and local traffic on the outside lanes. Down ramps are provided inside the piers for multi-level parking. The structure is all steel. Suspension cables hang from the tubular towers, and rigid arches below add the needed stiffness. Apartments, stores, and the like are within the superstructure above the deck. Additional open and recreational spaces are created by bridging over portions of the roadway. Although somewhat massive, the bridge has a dramatic sweep offsetting its bulk. The flat arch below the deck serves to stiffen the suspension span above the deck.

It is interesting that such multi-use bridges have often been proposed, but none have been built in recent times. By way of example, the architect Hugh Ferriss in 1929 proposed the suspension bridge seen in Figure 20. It was to cross the East River and to contain offices or apartments within the vertical space between the suspension cables and the roadway. In the same year, the architect Raymond Hood also proposed a bridge for the same location, which would contain offices, apartments, stores, hotels, and theaters carried on heavy concrete girders between the piers (see Figure 21). A few years earlier in 1924, the architect Louis Mullgardt designed a multi-use bridge to span the bay between San Francisco and Oakland in California. Steel trusses between the massive piers would support the deck, and the huge hollow piers would contain offices, apartments, and even small factories (see Figure 22).

As an aside, a somewhat more conventional steel truss bridge connecting San Francisco and Oakland was proposed as early as 1914 by the engineer Charles Fowler. Using a combination of cantilever and suspended trusses, the clear spans reached 2000 ft. Five such large spans were needed. Although daring for its day, its engineering was believed quite sound. However, it was ponderous and ungainly esthetically despite some effort to create an archlike appearance.

Several other long-span bridges of questionable esthetics were proposed in that early twentieth century era. These were to span the Hudson River in New York City. The engineer Gustav Lindenthal drew plans in 1920 for a bridge at 59th Street using a suspended span in which the suspension cables were stiffened (by trusses) rather than the deck. Esthetically distressing, however, was a massive tall masonry office building set high up on a tunnel-pedestal that was to serve as a gateway on the eastern end.

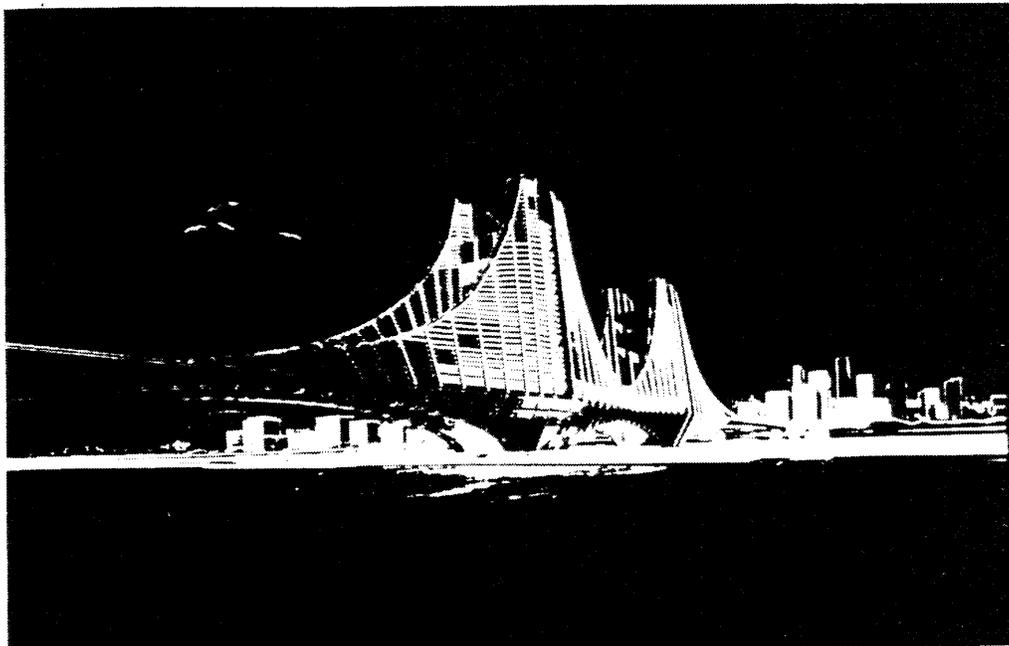


Figure 19. East River Bridge, suspen/arch

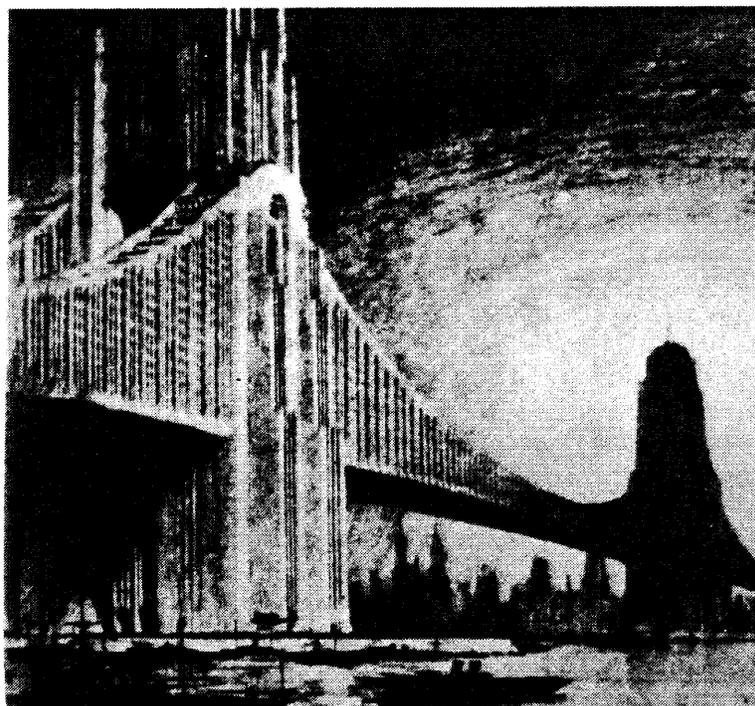


Figure 20. East River Bridge, suspension

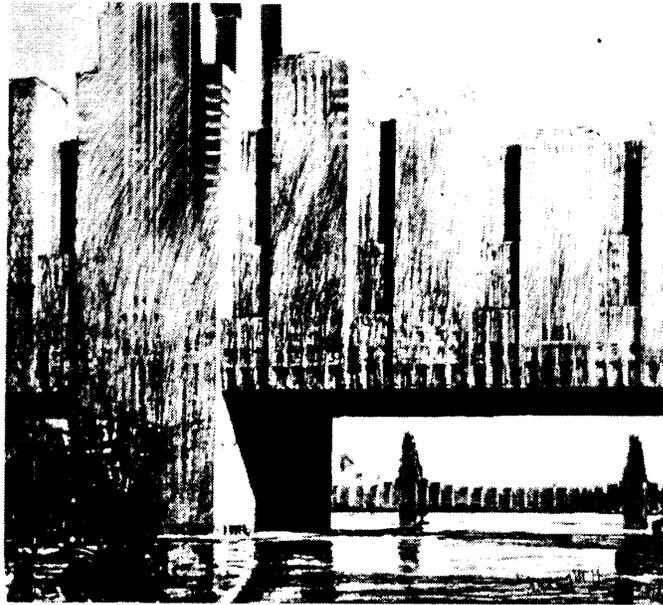


Figure 21. East River Bridge, girder



Figure 22. Oakland Bay Bridge

Professor Kroveshehn's design in 1927 at 179th Street was somewhat less ponderous, but still esthetically disturbing in that it overlaid a steel trussed arch bridge on a lightly stiffened suspension bridge so that one was quite confused as to what was going on. Fortunately, engineer Othmar Ammann came to the rescue later and built the more graceful deck-stiffened George Washington Bridge. Fortunately, he left off the heavy stone facing on the towers, as first proposed.

In 1966, the architect Chloethiel Smith designed a new "Ponte Vecchio" for Washington, D.C. (see Figures 23 and 24). Spanning approximately 900 ft across the Washington Channel and anchored at five "islands," the bridge was intended to have a number of uses. It would serve as a pedestrian mall, a limited-use vehicular link, and a leisure time activity center. Contained on the "islands" at several levels would be shops, restaurants, cafes, art galleries, and roof terraces. The basic structure was to be of precast, prestressed concrete. Although this bridge was believed to fill a need and appeared to be economically feasible, the project never materialized because of inadequate private financing.

Another combined bridge and shopping center was proposed by the architect Tinsley Galyean to span the Kanawha River in Charleston, West Virginia. Since the business district of the city is squeezed in by the river valley, normal expansion is difficult. So in the early 60s, a new bridge was suggested to carry vehicles and pedestrians and to contain seven stories of shopping space (see Figure 25). Structurally, the entire system was to be hung from a three-story-deep girder, which in turn would be supported at the ends by large, tall, hollow piers. Parking was to be within these piers. The roadway would be located at the lowest level, somewhat above the elevation of the river banks.

The author too has long studied multi-use bridges and has even designed one for the 21st century (see Figure 26). Still haunted by the East River bridge project of Chapman and McClure developed over 20 years ago, the author sharpened and stylized the form to read as both a bridge and a super-scale polished steel and glass sculpture. The use of crisp curved edges is an attempt to incorporate a sense of lightness in an otherwise overwhelming mass. Smooth reflective glass surfacing over the residential units further enhances the feeling of lightness. For similar reasons, a skin of stainless steel covers the lower arch forms. Residential units, shops, and cafes would be housed vertically between the two main suspension cables and the deck. Parking facilities for vehicles are located below the deck. The roadway to accommodate both through and local traffic is positioned between the habitational zones. At intervals, enclosed pedestrian bridges would span the roadway, linking both sides of the residential zones.



Figure 23. Washington Channel Bridge, overview

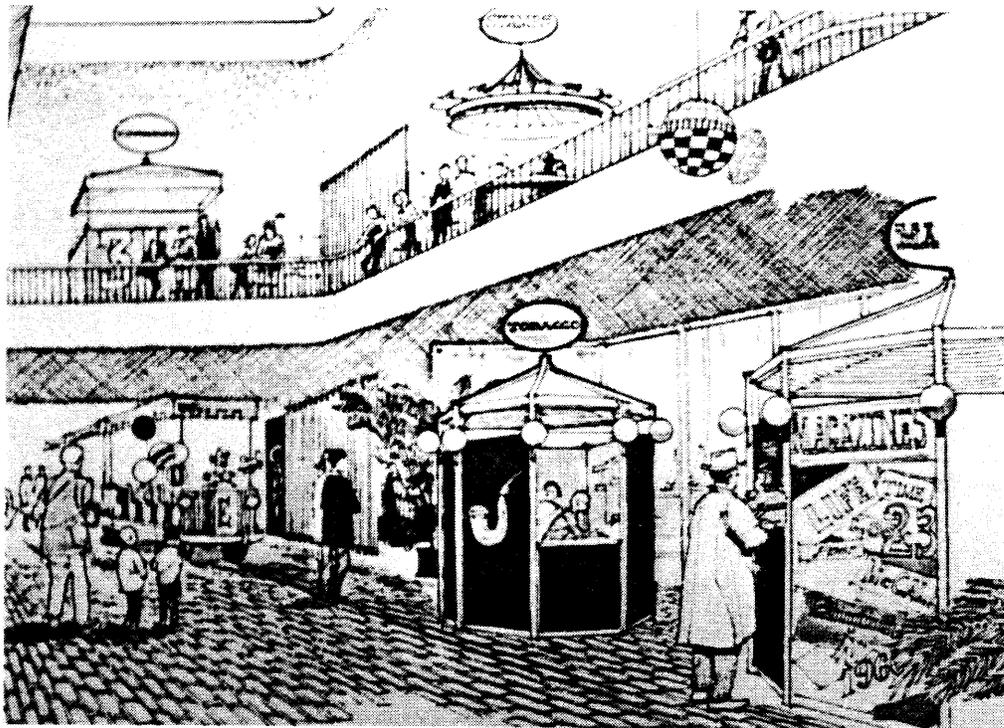


Figure 24. Washington Channel Bridge, detail

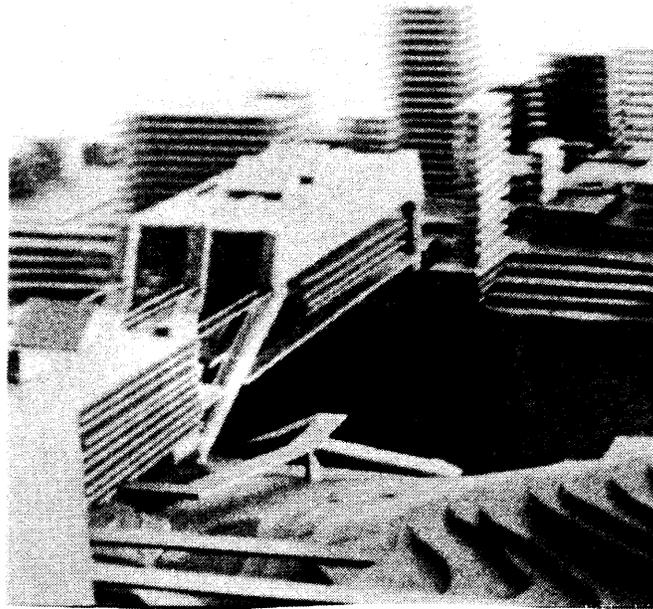


Figure 25. Charleston Bridge



Figure 26. Skin-covered Bridge

A rather different category of unbuilt bridges includes those that have been built but have been redesigned for an entirely different use. From time to time, obsolete or abandoned bridges have been considered for conversion to such facilities as restaurants, shopping malls, and fishing piers. One of the largest such projects involved the abandoned Big Four railway bridge across the Ohio River in Louisville, Kentucky. In the mid 70s the engineering firm of Schimpler-Corrandino Associates in association with the designer Leonito Lanceta redesigned this large four-span steel through truss bridge into a mixed-use commercial complex (see Figures 27 and 28). The deep trusses would have been used to support two levels of floors, with added cantilever platforms outside the trusses also supporting two levels of floors. At the land approach to the bridge, there would have been additional built space. Restaurants, hotels, condominiums, apartments, offices, retail shops, exhibition halls, and parking garages were planned for all of this space. A marina would have been constructed beneath the bridge.

It is curious that despite the attractiveness of the idea and the apparent financial viability of this and similar projects, only a very few such adaptive-use bridge projects have ever been carried through to completion.

Other proposed bridges could be mentioned that do not fit into conventional categories. One of these has been put forward by the author and would look much like a cable-stayed bridge. However, the cables are actively controlled by means of sensors, computers, and force actuators. Their purpose would be to control both static and dynamic deformations almost to the point of total negation. By this means, even very long bridges in the span range of a mile or more could be constructed with considerably less material and mass than is required for conventional bridges because much less passive rigidity would need to be built in.

Alaska takes credit for another unconventional bridge. This structure over Glen Highway was intended as a moose crossing, enabling the animals to migrate without having to cross this busy thoroughfare. The concept was to extensively landscape the bridge with vegetation so that it would resemble the surrounding terrain, thus inducing the moose to cross safely and unafraid. An ordinary underpass was built instead for economy.

Still another unorthodox structure is a cable-stayed replacement bridge for the Williamsburg Bridge in New York City. Although the proposed bridge clear spans an impressive 1700 feet, its uniqueness is due not to its length but to its manner of construction. As proposed by the firm of Hardesty and Hanover in 1987, the split bridge decks and towers would be constructed adjacent to the existing bridge. Then when the old bridge was demolished, the new towers would be pivoted inward toward each other bringing together the twin bridge decks (see Figure 29). It is estimated that this closure could be done in only nine hours. The speculation is that because it is an unprecedented concept, it is likely to remain unbuilt.

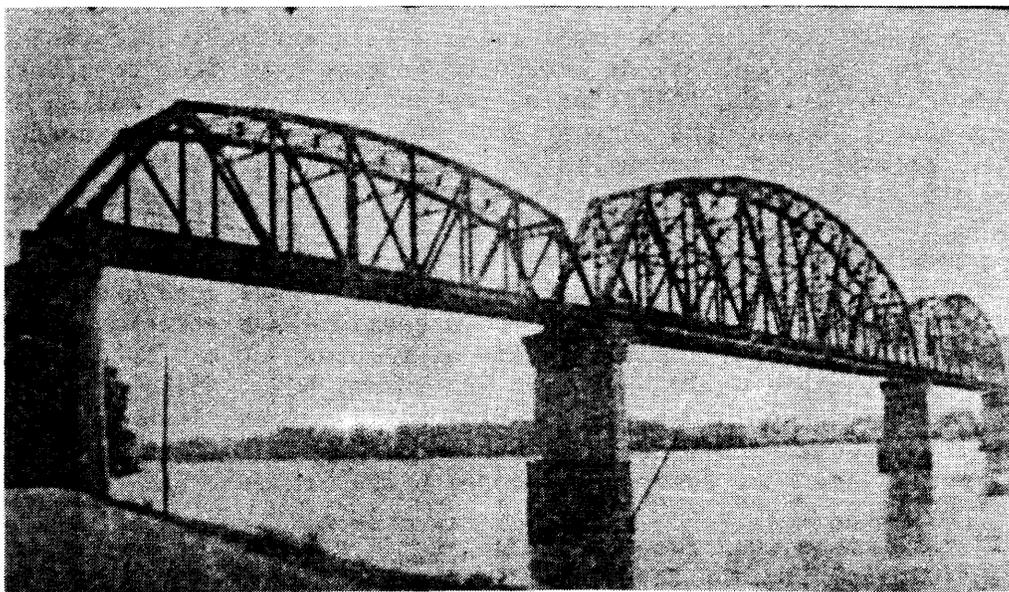


Figure 27. Big Four Bridge, overview

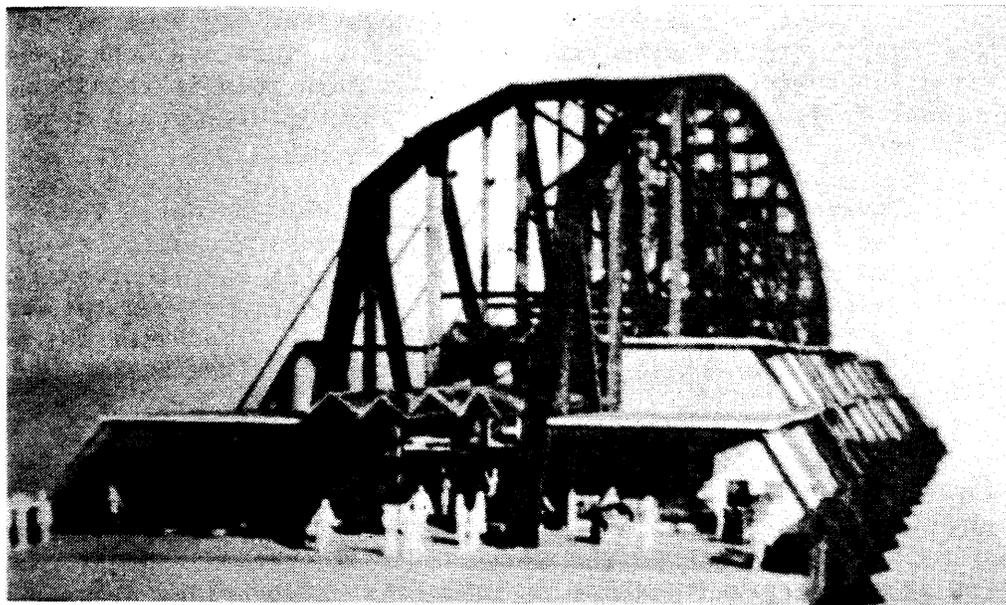


Figure 28. Big Four Bridge, detail

EUROPEAN BRIDGES

In Europe there have been a number of notable bridges proposed but not built. A recent project that created considerable interest was the bridging of the two-mile link between Italy and Sicily at the Messina Strait. An international competition held in the mid 70s for the purpose of finding a suitable design brought forth a number of innovative solutions. The boldest design was submitted by Pier Nervi (see Figure 30). Free spanning almost the whole distance across the water, the suspension portion is 9,900 ft long, approximately double that of any existing bridge. The towers would rise almost 1500 ft above the water. Were the structure not proposed by an eminent, nergy engineer named Nervi, it would have been dismissed out of hand. The bridge is even more impressive in that it was designed to resist seismic forces in addition to all other static and dynamic ones.

The most unique solution was proposed by the engineer Alan Grant. This bridge is entirely underwater and is held down rather than held up using adjustable anchor cables attached to the sea bottom (see Figure 31). Inside the streamlined tube there would be three smaller tubes: two for vehicles and one for trains. Appropriate concrete ballast would neutralize the buoyancy forces. Neither a true bridge, nor a tunnel, such a structure clearly is unique in that none like it has ever been constructed anywhere. However, it should be noted that Robert LeRicolais also had suggested a similar type of underwater bridge at the same location.

Years after the Messina Strait competition, bridge engineers were continuing to design possible structures for this site. A 1982 solution by the noted German engineer Fritz Leonhardt, in association with Gruppo Lambertini, designed an all-steel cable-stayed bridge with a main span of 5900 ft (see Figure 32). Its basic form is not greatly different from other recent long-span suspension bridges, but it is considerably longer.

Figure 33 shows a 1985 model of a suspension bridge, also for the Messina Strait. Designed by engineers at the University of Rome, Italy, the span between towers is almost 10,000 ft. The towers rise over 1,300 ft above sea level. Incorporated into this bridge are several innovative features, advancing Nervi's earlier design for this site. The deck is of light orthotropic steel construction and is supported underneath by large tubular trusses in a novel triangular configuration. Of even greater interest are its suspension cables, which are to be graphite composite strands. Still highly experimental, graphite cables have the potential of providing exceptionally high strength-to-weight ratios. As is well known, dead loads are the main adversaries of long-span structures, and such a bridge would be considerably lighter than one with steel cables.

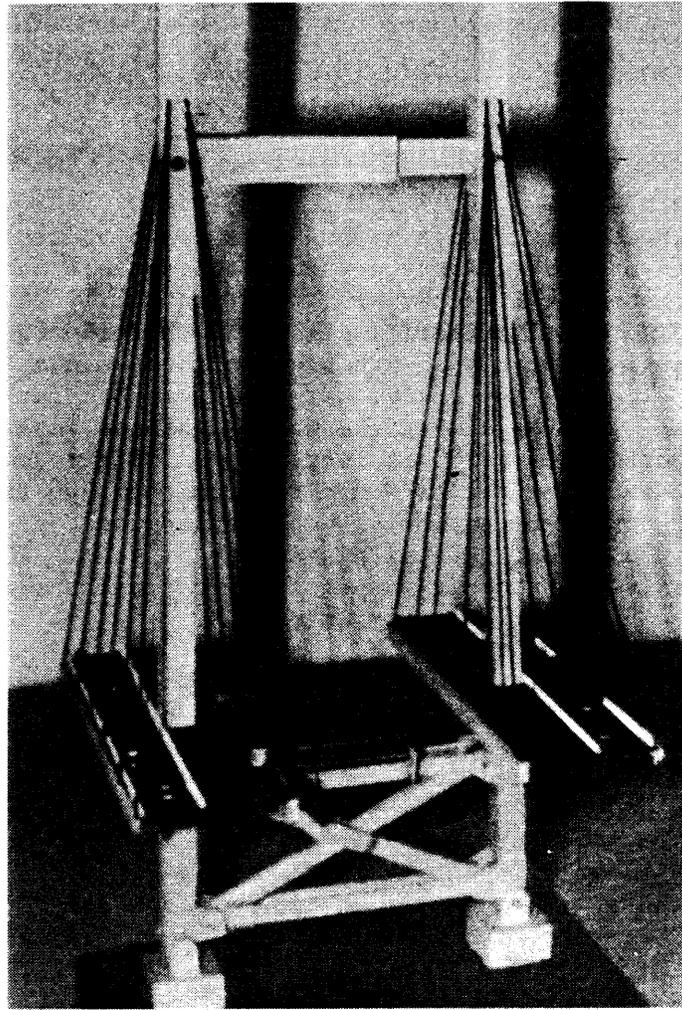


Figure 29. Williamsburg Bridge

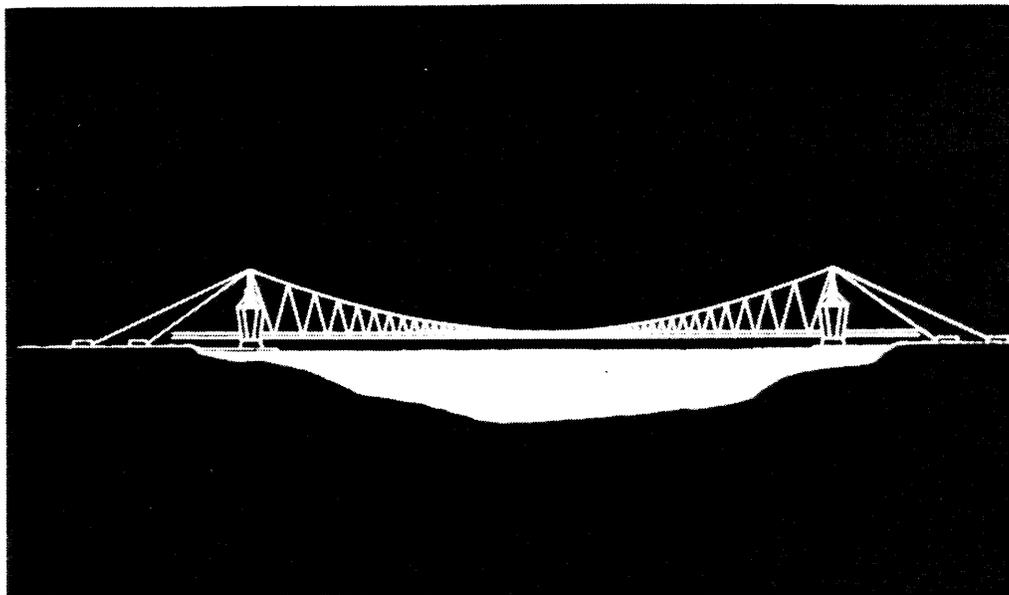


Figure 30. Messina Strait Bridge, suspension

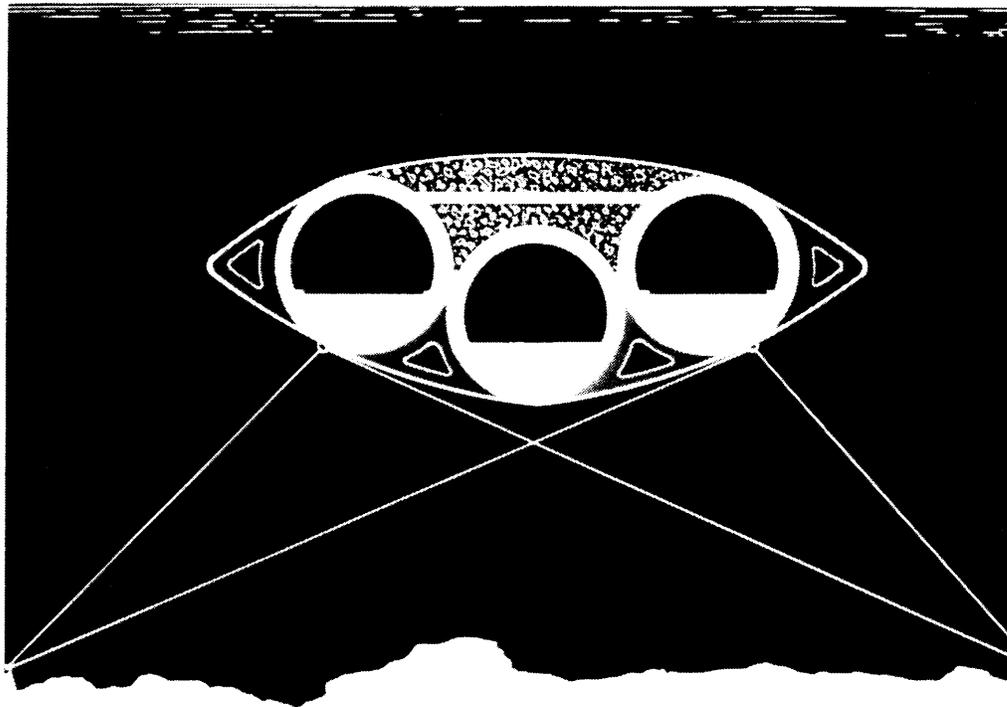


Figure 31. Messina Strait Bridge, underwater

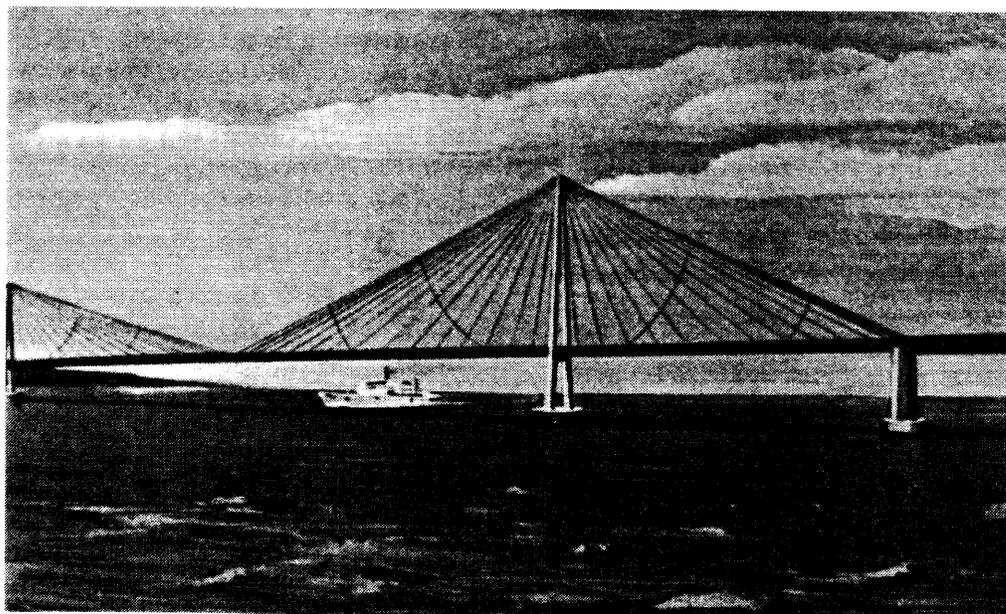


Figure 32. Messina Strait Bridge, cable stayed

Fritz Leonhardt has proposed a more novel design for other bridges, employing a monocable suspension system using one above-deck suspension cable instead of the two normally used. Figure 34 shows his unbuilt Tagus River bridge for Lisbon, Portugal, proposed in 1960, with A-shaped towers. A similar monocable design was also suggested for the Rhine River at Emmerich, West Germany in 1961 but it was rejected as being too innovative. In both cases, conventional suspension bridges were erected instead. The esthetics of the monocable design is clearly cleaner, simpler, and lighter than twin cable design. It could be the next step in suspension bridge construction.

An entirely different kind of bridge, put forward by the noted engineer Ulrich Finsterwalder to cross the Bosphorus in Turkey, must be given praise for its daring concept (see Figure 35). The main span of 1,346 ft is essentially a thin prestressed concrete ribbon draped in the configuration of a flat catenary. Note that at the cantilever arms over the piers, the deck gently curves concave downward, whereas the actual stress ribbon between the arms curves concave upward. Substantial anchors at the land ends (not shown) would be needed to secure the prestressing tendons within the ribbon.

To date, a number of stress ribbon bridges have been built, most of them in Czechoslovakia. These are, however, of much shorter span and are only for pedestrians. It is questionable that the deck undulations in a bridge for vehicles would be acceptable by the public since vehicles passing over the bridge would appear to be driving across a series of hills and valleys. In addition, it is expected that the thinness of the ribbon would cause an unacceptable amount of vibration.

Still other water crossings in Europe have received attention by bridge designers. T. Y. Lin and his associates are studying the feasibility of a suspension bridge at the Strait of Gibraltar, which would connect the nine miles between Gibraltar and Morocco. A possible design is shown in Figure 36. There would be two main spans each an astounding 16,400 ft long along with several shorter ones. The towers for these super-spans would rise 2250 ft above the water and plunge 1500 ft below the water. A bridge in this region must resist winds of 140 miles per hour as well as periodic seismic shocks. For wind resistance, the main suspension cables are slanted inward toward the deck at midspan and braced by means of cross-latticed prestressed hanger cables. Despite the awesome scale of this structure, its appearance is deceptively simple, having none of the cluttered bracing systems so common in bridges of much less span.

Also, in recent years, prior to making the decision to construct a tunnel under the English Channel, various schemes for constructing a series of essentially conventional suspension bridges across the 23 miles between England and France were investigated. The danger of ship collisions with the bridge piers in this heavily used often foggy sea, however, have ruled against such bridges in favor of a tunnel.

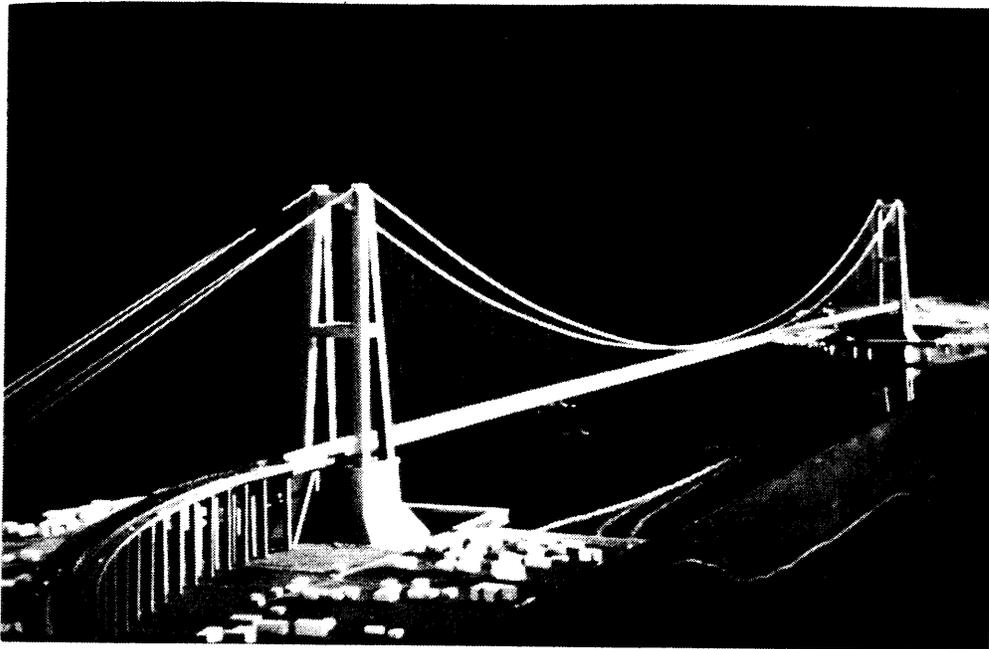


Figure 33. Messina Strait Bridge, graphite cable

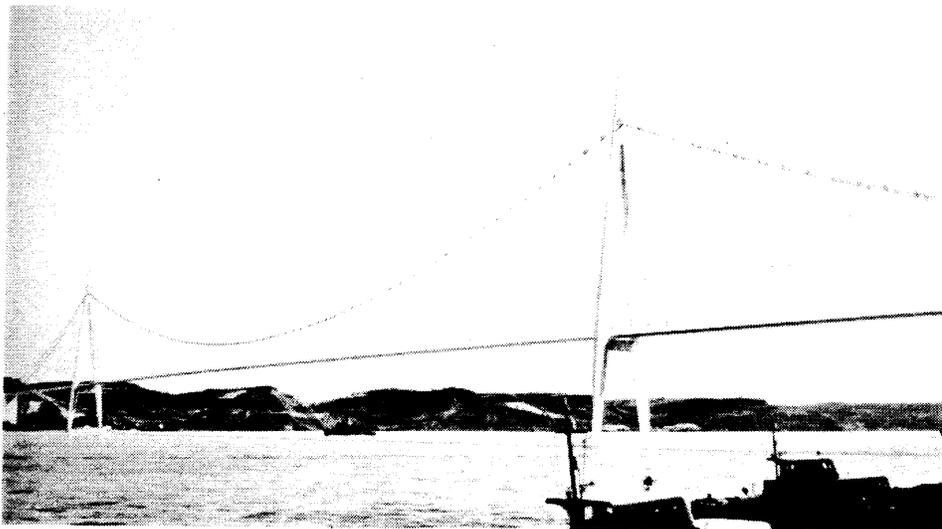


Figure 34. Tagus River Bridge

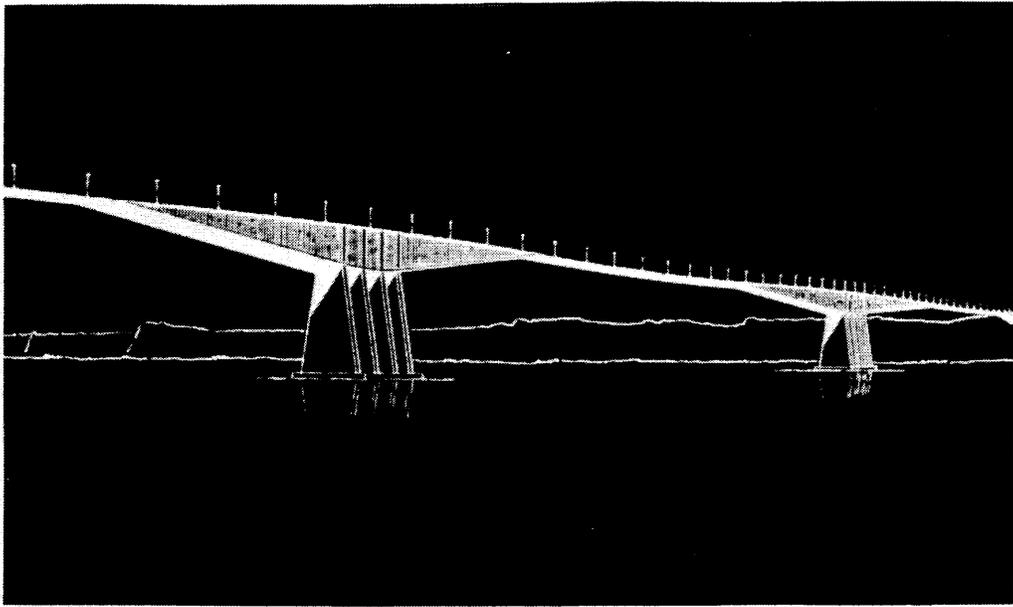


Figure 35. Bosphorus Bridge

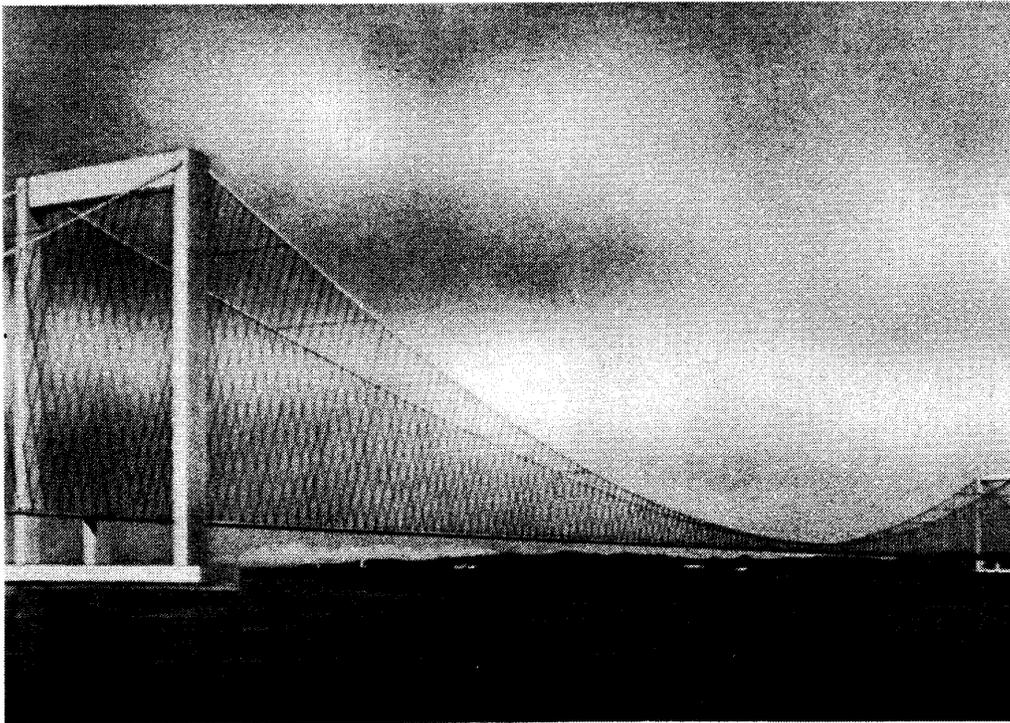


Figure 36. Gibraltar Bridge

A number of more modest but graceful bridges have been proposed in this decade by the Spanish architect, engineer, and sculptor, Santiago Calatrava. The one shown in Figure 37 is a pedestrian bridge intended for Florence, Italy. The form's smooth flowing lines make it as much a piece of sculpture as a bridge. It can be questioned whether the aerodynamic curves have any functional use, such as to minimize stress concentrations at the junctures. However, the overall concept of using a deck suspended from an arch is reasonable. Of particular interest is the structure of the deck itself, which suggests a surface supported organically by a delicate pattern of ribs.

Still another very graceful and sculptural bridge was designed by the architectural and engineering team of Goldsmith, Zevi, Cestelli-Guidi, and Ferris for the 1954 Garibaldi Bridge competition. The proposed bridge in Figure 38 was to span the Tiber River in Rome, utilizing portions of the foundations of the old bridge at the site. In this structure, the curves are not arbitrary but are shaped to reflect and optimize the forces in the structure. It is a beautiful fusion of technology and art, with one not violating the other.

As an indication that the concept of multiple-use bridges appears to be an international idea, Figure 39 shows a proposed multi-use bridge for the Thames River in England. Proposed in the 60s, it is a kind of new "Olde London Bridge" combining retail shops, a pedestrian mall, and a vehicular roadway.

The subject of unbuilt bridges would not be complete without discussion of several really "far out" ones. Among the several entries that received an award in the 1987 Bridge of the Future competition, the one shown in Figure 40 has an unusual twist. Designed by Shuichi Kobari of Japan, the structure is essentially symbolic in nature with the twist of midspan representing a transition from old to new. Such would be the case if the bridge spanned a river connecting an existing old town to a new city of the future. Realistically, the structure is far from being practical, but it is thought provoking. With some structural reworking, the concept of fusing two structural forms in this manner could be made to work and may even make sense in connecting two dissimilar cultures or countries, such as East Germany and West Germany or Israel and Egypt.

Another, perhaps even more mind-blowing bridge, was conceived in the early 70s by the noted sculptor Claus Oldenburg (see Figure 41).

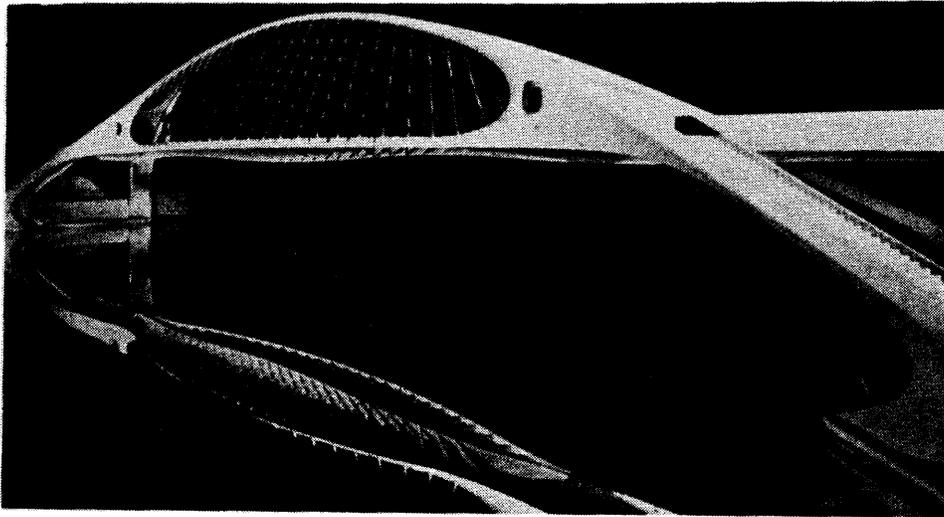


Figure 37. Florence Bridge

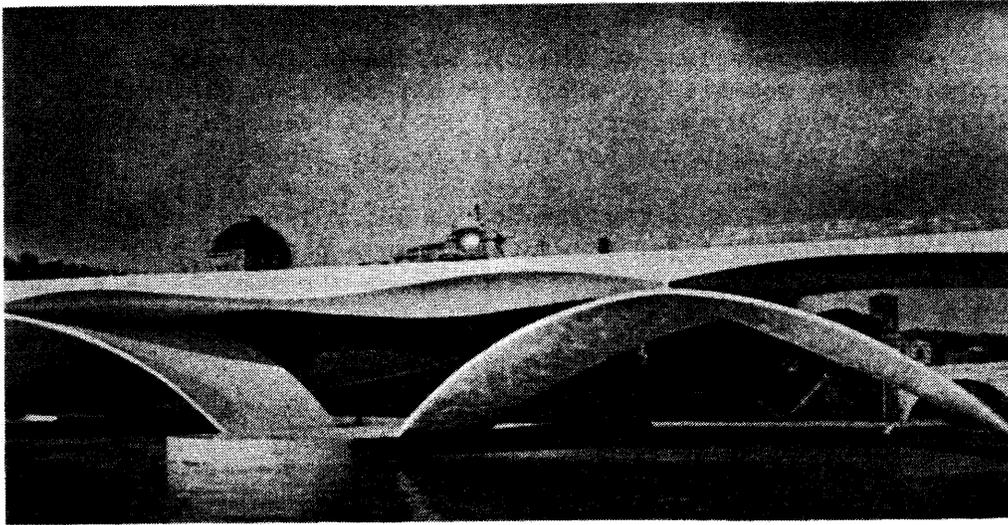


Figure 38. Garibaldi Bridge

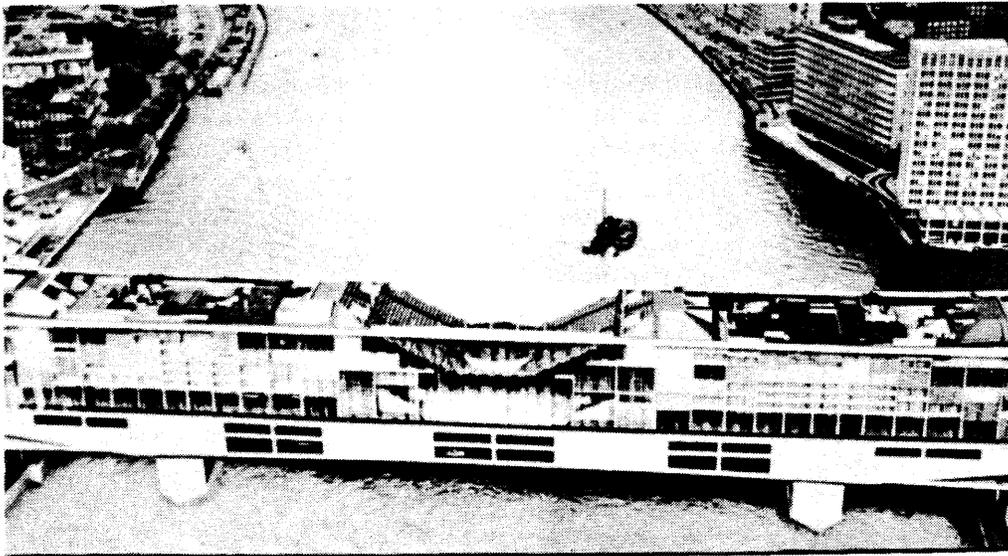


Figure 39. Thames Bridge

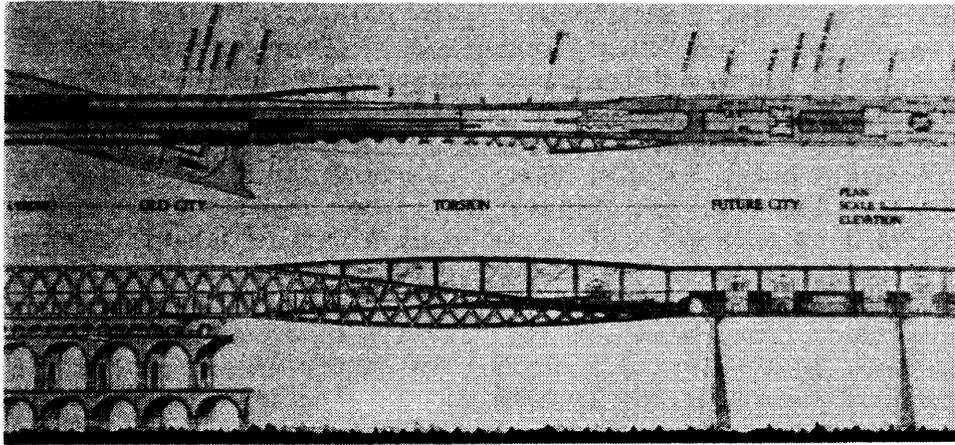


Figure 40. Twisted Bridge

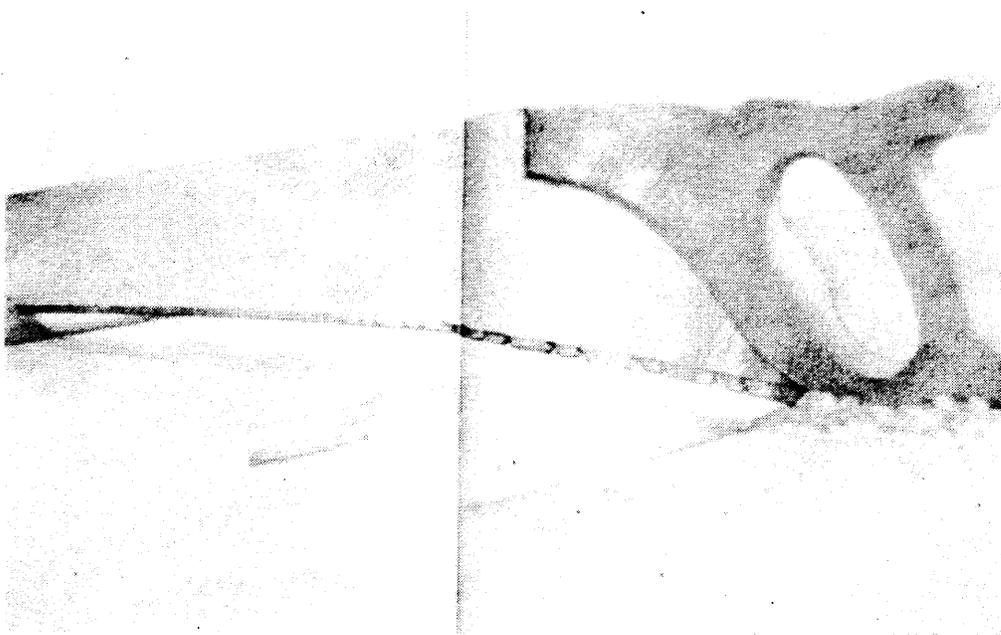


Figure 41. Rhine Bridge

This colossal carpenter's saw is in reality a steel bridge for the Rhine River. At the lowest edge by the teeth there is a glassed-in pedestrian passageway. Above the passageway would be a roadway for vehicles. A proposal for a bridge such as this again raises the question whether a bridge can be more "art" than "technology." Whereas this writer can in some situations justify Soleri's or Calatrava's designs as legitimate bridges, Oldenburg's cannot be so justified. His heavy tilt toward a purely sculptural statement grossly overpowers the form as having any rational relationship to that needed to carry loads and forces normally on a bridge. Ideally, all bridges should be visually pleasing; however, this can be done in ways that do not deny a bridge's basic reason for being. Within the last half century, esthetic principles of gracefulness, simplicity, lightness, clarity, and honesty of form have set the guidelines. Ornamentation and "style," so common in earlier bridges, have been rejected. It is this author's opinion that "style" and ornamentation, if properly handled, have their place and should not be totally excluded. Surely many "arty" old bridges are considered to be just as beautiful as the best of today's "clean" bridges. One has only to look at old bridges in all parts of the world, dating as far back as the early Roman Empire, to see the truth of that.

CONCLUSION

In the examples of unbuilt bridges discussed, many different ideas and concepts have been proposed. Most appear to be basically sound in nature, although rather innovative and daring. Those that take a quantum leap in concept or span would need further research with regard to materials and behavior. Some could be built with existing technology, although at a premium cost. Some would project a whole new and exciting vision of bridge esthetics. Generally, these structures were not constructed because they were either too innovative or too expensive or both. In any case, much can be learned from these proposed structures that could have application in future bridges. Without such imaginative proposals, bridge design would of course continue to evolve but in a slower and less exciting manner.

ACKNOWLEDGEMENT

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