Discovery Bridge

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The Discovery Bridge in downtown Columbus, Ohio, is a one-of-a-kind structure that provides unique solutions to historic, aesthetic, and technical issues. Because the bridge was a contributing element in the Civic Center Historic District and was federally funded, FHWA entered into a memorandum of agreement (MOA) with the State Historic Preservation Office. To comply with stipulations within the MOA, FHWA assembled a community interest task force, representing regional planning, Columbus development, historic preservation, and arts organizations. This task force identified architectural design parameters/criteria for the replacement bridge. To incorporate the input from the task force, public agencies, and private individuals, a unique and innovative bridge study process was developed. The new process included separate and intense engineering workshop sessions followed by presentations to the task force and general public. Within each session, the design team reviewed all input, developed ideas, evaluated alternatives, and prepared presentation sketches and renderings. The resulting structure is reminiscent of the previous bridge, respectful of the historic district, and a center for civic activities, and it was constructed using the latest in bridge design and construction technology.

Traditionally, federal, state, and local agencies have been responsible for maintaining the nation's transportation system at the highest level of service possible with limited resources. This has meant construction of new facilities and repair or replacement of existing facilities at a cost of billions of dollars annually. These expenditures, however, have not been sufficient to gain ground on the ever-increasing deterioration of the system. To stretch the budget as far as possible and provide a sufficient level of service, responsible agencies have had to provide a no-frills system. This can be seen in the Interstate system designed and constructed primarily in the 1950s and 1960s. This system was designed to meet the basic purpose of transporting goods and people across this nation. Many standard bridge types and details were developed to reduce design and construction time and minimize costs. Some of the details do incorporate aesthetic considerations; however, the primary purpose was to develop utilitarian structures that could be applied as frequently as possible without changes. Some very notable structures have been exceptions. These bridges, because of their location, history, or significance, have received special attention during design and construction.

In recent years, the utilitarian attitude has shifted. It is no longer enough to provide facilities that just get people from Point A to Point B. It has become apparent that these facilities will be around for many decades. At every level of government more consideration is being given to the impacts these facilities have on our living environment. New bridges, rehabilitations, and replacement bridges are being evaluated for their visual impact and, depending on the location and significance of each bridge, the aesthetics are given a much more significant role in the design. Not all bridges warrant more than just minimum aesthetic consideration, but in some situations it may be given a role equal to or greater than the technical design. One such bridge is the Discovery Bridge over the Scioto River in downtown Columbus, Ohio.

As the primary access across the Scioto River in downtown Columbus, the Discovery Bridge has always been a major structure. The current bridge, completed in June 1992, is the latest of six bridges to exist at this site. It replaces a bridge that stood for 60 years serving the public until time and deterioration took its toll. This fifth bridge was constructed between 1918 and 1921 at a cost of $659,000, replacing a truss bridge destroyed in the 1913 floods that devastated much of the Ohio River Valley.

The bridge constructed at that time was a concrete seven-span, barrel-arch structure with an overall length of 679 ft (Figure 1). The bridge carried six 10-foot traffic lanes on an earth fill supported by the arches and spandrel walls. On each side, 12-ft sidewalks spanned between the interior earth walls and the exterior fascia to form a vault used by utilities to get across the river. The fascia incorporated columns at each pier and at the abutments to highlight these locations and break up the large areas of concrete. A limestone balustrade was located along the bridge and was later extended along the top of the floodwall.

For many years, the bridge served the people of Columbus; however, in 1962 the sidewalks had to be overlayed, and in the early 1980s inspections reported significant deterioration. In 1983, the Franklin County Engineer's Office initiated a study to determine the structural condition of the bridge. This study included an in-depth inspection and destructive tests of core samples. In 1985, representatives from FHWA, the Ohio Department of Transportation (ODOT), the Franklin County engineer's office, the City of Columbus, and the inspection consultant met and decided that replacement

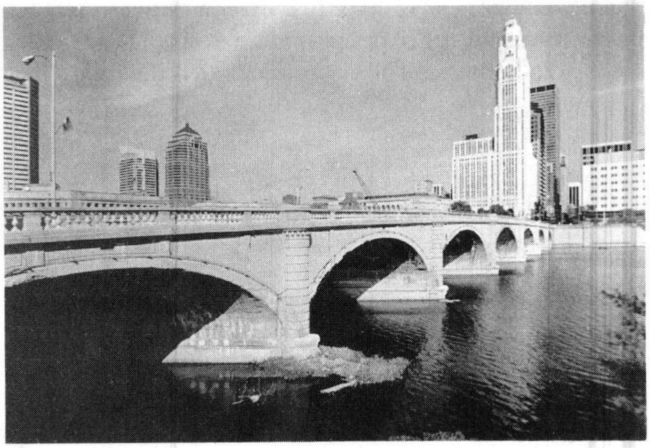

FIGURE 1 View of Broad Street Bridge in 1989.

of the bridge versus rehabilitation was the only feasible alternative.

That bridge was both graceful and elegant while conveying a feeling of strength and permanence. The bridge served for many years as the gateway to the city and as a focal point for city events. At the time of construction, the bridge was considered to be an outstanding structure. In spite of this and its importance to the area, the bridge was never considered to be historically significant in its own right. It was, however, a contributing structure in the Civic Center Historic District eligible for listing in the National Register of Historic Places. This district is composed of seven buildings and three bridges. To mitigate the impact of the bridge replacement on the historic district and the significance to the city, FHWA entered into a memorandum of agreement (MOA) with the State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation (Council). Within the MOA were four stipulations:

1. Recordation,
2. Plaque,
3. Coordination, and
4. Dispute resolution.

The third stipulation required that "FHWA continue to coordinate with the SHPO and other local agencies in the selection of the architectural design parameters for the replacement structure." To comply with this, FHWA created a community interest task force (CITF). This group included representatives from the following organizations:

- Mid-Ohio Regional Planning Commission,
- Downtown Columbus Community Improvement Corporation,
- Development Committee for Greater Columbus,
- Franklin County Commissioners,
- Columbus Historic Resources Commission,
- Columbus Landmarks Foundation,
- City of Columbus,
- Greater Columbus Arts Council, and
- Ohio Preservation Alliance.

CITF was charged with developing design parameters for design of the new Broad Street Bridge. In addition, CITF would review the preliminary bridge design and provide comments to the SHPO, which had review and approval authority of the preliminary design. In June and July of 1988, CITF met and developed 15 parameters. The following parameters were submitted to the Franklin County engineer for utilization by the design consultant.

1. Feeling of permanence/established/older,
2. Feeling of pedestrian friendliness/safety and security,
3. Articulated surfaces/sculptural form (molding, rustication) balustrades, railings,
4. Preference for curved arches (seven) (roundness)/ full vaults (solid barrelvault),
5. Graceful/uncluttered line/open,
6. Continuity between brides (Broad and Town) and railings and walkways,
7. Setting for Civil Center activities,
8. Well-defined entrance/exit,
9. View of bridge and district; view from bridge,
10. Connection between two sides of river,
11. Feeling of serenity/peaceful,
12. Use of concrete or masonry, color/texture/blend into district/warmth versus cold,
13. Use of bridge balustrades to blend into materials of district,
14. Unified classical design (irregular surface—shadow effect), and
15. Classical scale and proportion.

In August 1988 the "world class" team of Burgess & Niple, Limited; Leonhardt, Andrä und Partner; and H2L2 Architects/Planners was selected to design the replacement for the Broad Street Bridge. Burgess & Niple was the team leader assigned with overall coordination and management of the project, bridge design, and all plan preparation. Leonhardt, Andrä und Partner, from Stuttgart, Germany, was responsible for conceptual and final design of the bridge superstructure. H2L2 Architects, from Philadelphia, provided the bridge architectural expertise.

From the beginning of the project, the Franklin County engineer recognized that many people would be concerned about the design and aesthetics of the replacement structure. They were also aware of FHWA policies about alternate designs. To achieve the county's goal of obtaining approval for a single bridge design, a process that was sensitive to local concerns and that met FHWA and ODOT requirements, was critical. Burgess & Niple developed a process that included two separate design sessions followed by presentations to both CITF and general public. Each of the sessions was extremely intense and focused.

The first design session was held in early September 1988. Participants included representatives from the Franklin County engineer's office, the city of Columbus, and the design team. For 1 week, this design group met in an isolated conference room away from all outside distractions. This allowed full concentration on the session goal of developing approximately 12 preliminary alternatives.

The session was divided into five separate phases:

1. Information phase,
2. Creative phase,
3. Judgment phase,
4. Development phase, and
5. Analytical phase.

The objective of the information phase was to present the design group with all relevant data on the project firsthand. During this phase, all representatives of utilities affected by the project were invited into the session to discuss their on-site existing facilities, construction aspects, and future needs. Representatives from FHWA, the city of Columbus, and the Franklin County engineer's office were also invited to discuss the project from agencies' and communities' perspectives. All pertinent data and previous work were collected and reviewed by the design group.

Following the review of all data, concerns, and information concerning the project, the design group entered the creative phase. This phase was a brainstorming session to list all the possible alternatives that could serve as a solution to the Broad Street Bridge replacement. Judgment of the ideas was suspended to allow a free flow of ideas. The design group listed over 115 possible alternatives.

In the judgment phase, alternatives not worth further development were eliminated. The first step in this phase was to list all parameters that would affect the structure. Included were CITF's parameters, construction cost, safety, historic compatibility, ability to accommodate future riverfront development, and more. Advantages and disadvantages about the parameters were then listed for each alternative.

On the basis of the design team's judgment, each of the alternatives was rated on a scale of 1 to 10 (10 most desirable, 1 least desirable). All alternatives receiving a rating of less than 6 were dropped, reducing the number of alternatives to approximately 50. The parameters were then refined and consolidated into five encompassing categories. To avoid confusion between CITF's parameters and other design parameters, the categories were called criteria. The criteria included the following:

- Life cycle costs
  - Initial costs of construction,
  - Maintenance costs (including service life), and
  - Inspection costs;
- Compatibility
  - Ability to accommodate riverfront development,
  - Ability to accommodate festivals and special events;
- Constructibility
  - Construction time,
  - Simplicity, availability of local contractors,

- –Accommodation of utilities, and
- –Availability of materials and equipment;
- Fundability
  - –FHWA and ODOT participation in construction costs and
  - –Alternate sources of available funds;
- Historical/Aesthetics
  - –Visual impact,
  - –Historical compatibility,
  - –Proportions, continuity,
  - –Scale, and
  - –Obstructiveness/openness.

Criteria were then inserted into a scoring matrix with the purpose of comparing categories and assigning a measure of importance to each. The result was as follows:

Criterion	*Weight*
Life cycle cost	6
Compatibility	7
Constructibility	3
Fundability	4
Historic/aesthetic elements	10

The remaining alternatives (over 50) were then rated using the weighted criteria. The score for each alternative was totaled and a second list of alternatives was created. The highest scoring alternative from each bridge type above-deck support structures, arch structures, girder structures, etc.) made up the short list of 19.

These alternatives were then investigated in some depth in the development phase. The following material was prepared for each alternative to aid the design team in further evaluation:

- Sketches,
- Preliminary design calculations,
- Critique on aesthetic and historical impact, and
- Relative cost estimates.

On completion of the development phase, the design team began the analytical phase. Using the new material, the remaining alternatives (19) were again rated. Thirteen alternatives were short listed on the basis of the score. These 13 alternatives were the preliminary alternatives presented to FHWA, ODOT, CITF, and the general public.

On October 12, and 13, 1988, the 13 preliminary alternatives were presented to FHWA, ODOT, CITF, and the public, respectively. Preliminary alternatives were presented in soft-line, black-and-white sketch format illustrating basic shape and form (Figures 2 through 5). Aesthetic elements (i.e., texture, lighting, railing) had not been developed at this time and were not presented. The design group requested feedback on basic form of the preliminary alternatives. To facilitate

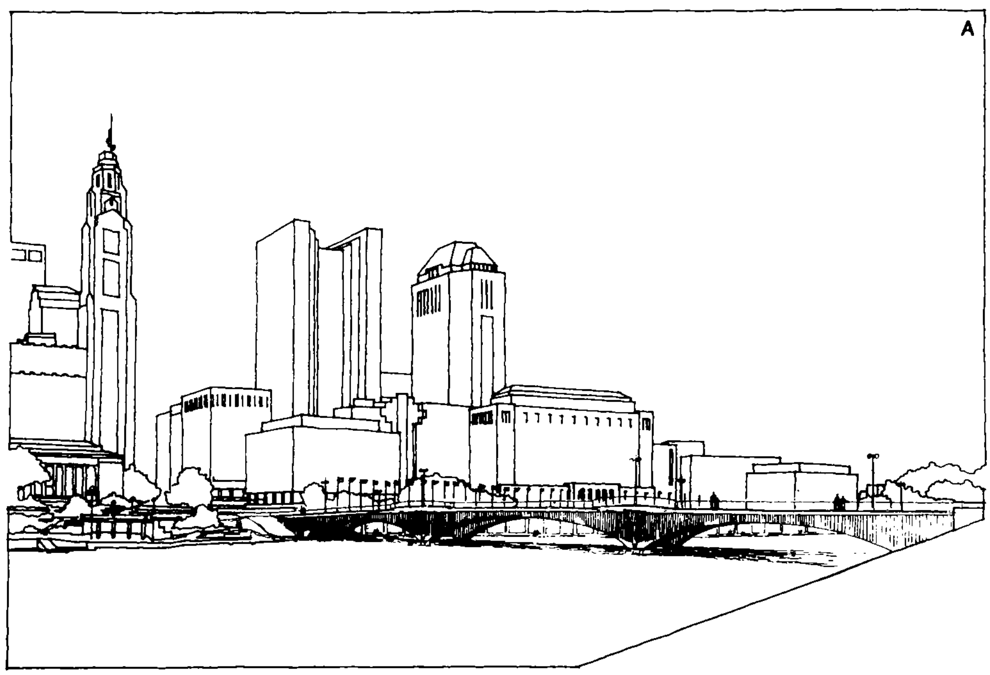

FIGURE 2 Preliminary Alternative A.

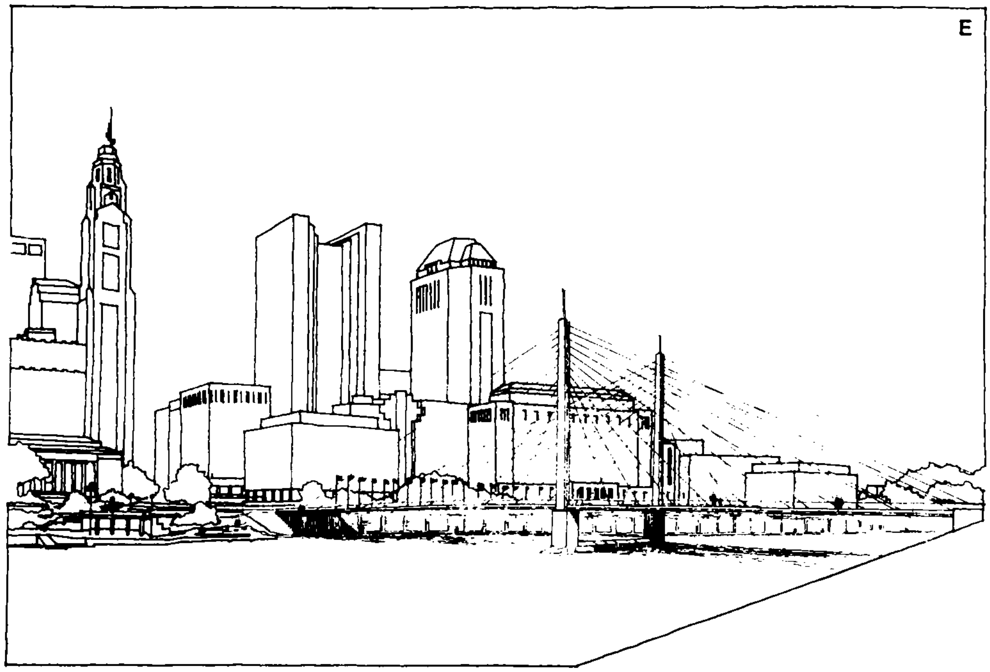

FIGURE 3 Preliminary Alternative E.

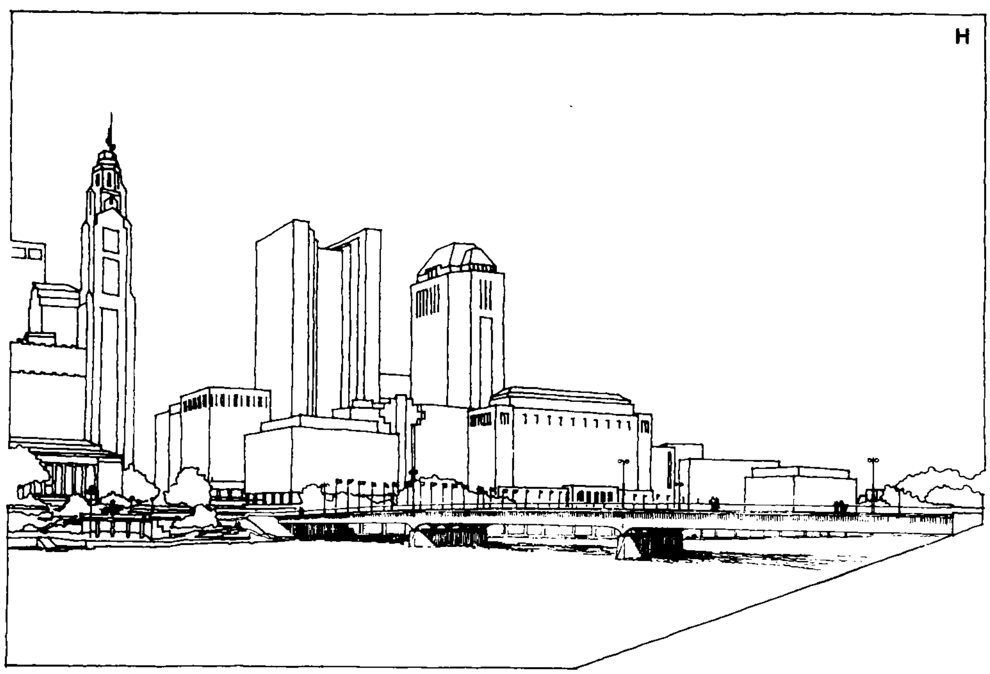

FIGURE 4 Preliminary Alternative H.

this process, a handout with survey was presented and distributed.

Each participant was urged to fill out all of the survey forms. The following was concluded from responses:

1. The majority of those responses ranked criteria the same way as the design team.
2. Constant depth structures were not well received.
3. The public either hated or loved the cable-stayed structure.
4. Steel structures were not well received.
5. Arch-shaped structures were well received, with the plate arch family receiving the most acceptance.
6. There was concern regarding the length of deck cantilevers and the resulting shadow effect.
7. A five-span arch-shaped structure should be developed for further consideration.
8. Significant visual elements should be included, such as railing lighting.

During the week of October 24, 1988, the second design session was held. The first order of business was to review responses from the task force public meetings. On the basis of responses and engineering judgment, the following preliminary alternatives were eliminated from further development:

- Constant-depth bridges,
- Cable-stayed bridge, and
- Steel bridges.

This reduced the preliminary alternative list from 13 to the following:

- Three-span concrete plate arch,
- Three- and four-span concrete twin frame,
- Three- and four-span concrete continuous haunched girder, and
- Three- and four-span concrete continuous deep haunched girder.

The list of alternatives was also expanded to include five 5-span structures. This created a new list of alternatives for further study during the design session.

Before the design session, a model of the site (scale: 1 in. = 30 ft) had been prepared. Study models of each of the alternatives on the new list were developed for review and evaluation while the design team proceeded to its next task of the design session.

On the basis of input received from the meetings, the criteria used to arrive at the preliminary alternatives were modified as follows:

- Life cycle costs,
- Compatibility,
- Constructibility,
- Fundability,
- Aesthetics, and
- Historic elements.

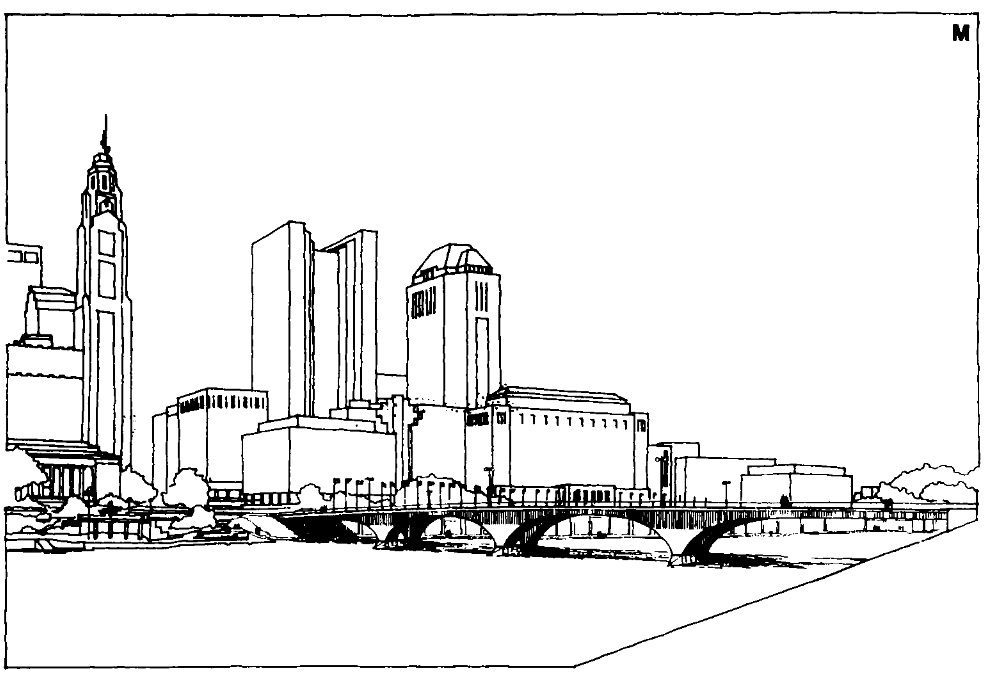

FIGURE 5 Preliminary Alternative M.

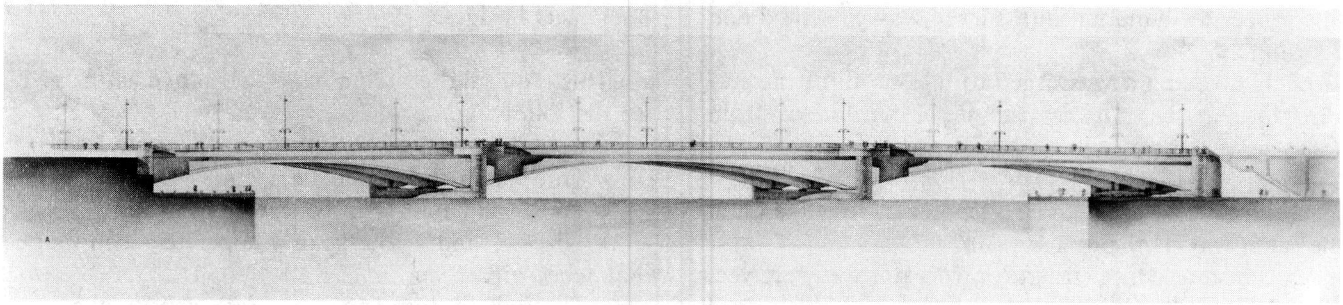

FIGURE 6 Rendering of Feasible Alternative A (7 ft long).

In a manner similar to Design Session 1, the criteria were inserted into a scoring matrix and the following measures of importance were determined:

Criterion	*Weight*
Life cycle cost	4
Compatibility	6
Constructibility	2
Fundability	3
Historic elements	6
Aesthetics	10

Using all available information and the model, each of the alternatives was rated. The three highest scoring alternatives became the proposed feasible alternatives.

Feasible alternatives included two 5-span and one 3-span plate-arched bridges. The difference between the five- and the 3-span alternatives was the termination location of the end arches, either high or low. All three were scaled and proportioned along lines appropriate for geometric limitations of the site. They also retained key visual elements of the existing bridge and surrounding architecture.

On December 8 and 15, the feasible alternatives were presented to FHWA, ODOT, SHPO, CITF, and the public, respectively. At those meetings the design team presented color renderings of each feasible alternative (Figures 6 through 8) and presented ideas on lighting, texture, color, railing, and shadows, emphasizing that the elements shown were only ideas illustrating possibilities and not finalized items (Figures 9 and 10).

Participants were asked to focus primarily on shape. Survey forms given to CITF requested that they rank their parameters in order of importance and evaluate each alternative on the parameters. The public was requested to comment on preference. Both CITF and the general public were also requested to provide input on architectural elements presented.

After the presentations, the design team again evaluated the responses. These were in general a statement of which of the three alternatives was preferred. As could be expected, there was no single alternative that stood out clearly as the preferred, although the five-span alternatives were preferred over the three-span. Since no clear preferred alternative came out of the presentations, it was decided to carry all three for further development. Responses about the architectural elements were also reviewed and applied to each of the three feasible alternatives.

Responses received on the proposed alternatives did not indicate a need for further refinement of the evaluation criteria. Therefore, each alternative was further developed and evaluated on the basis of life cycle cost, compatibility, constructibility, fundability, and historic elements/aesthetics. In addition, the design team evaluated the feasible alternative on the basis of the CITF

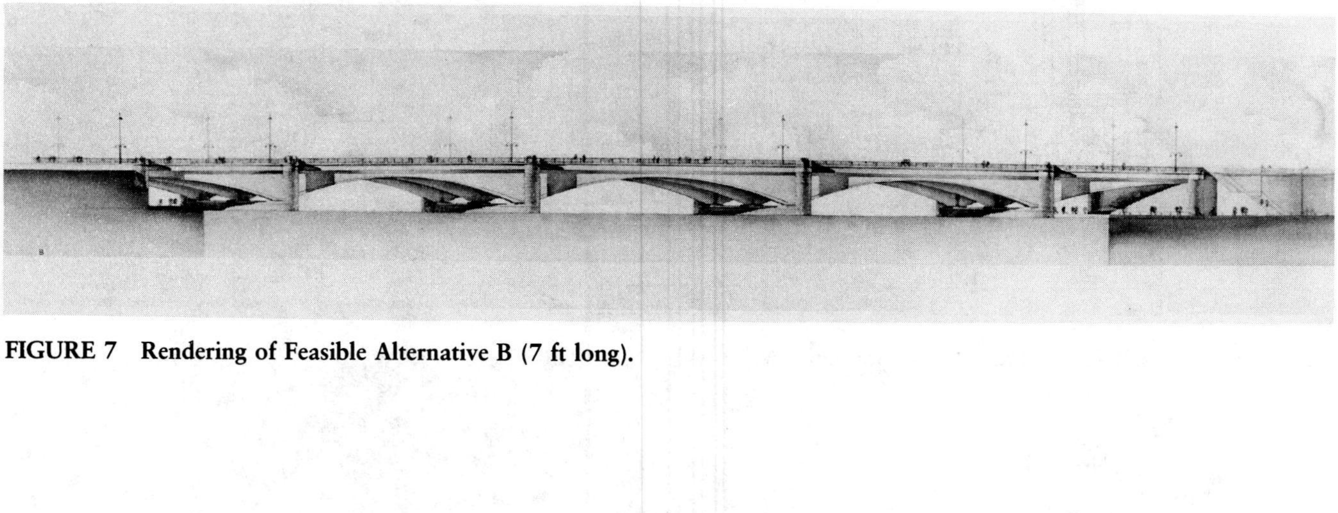

FIGURE 7 Rendering of Feasible Alternative B (7 ft long).

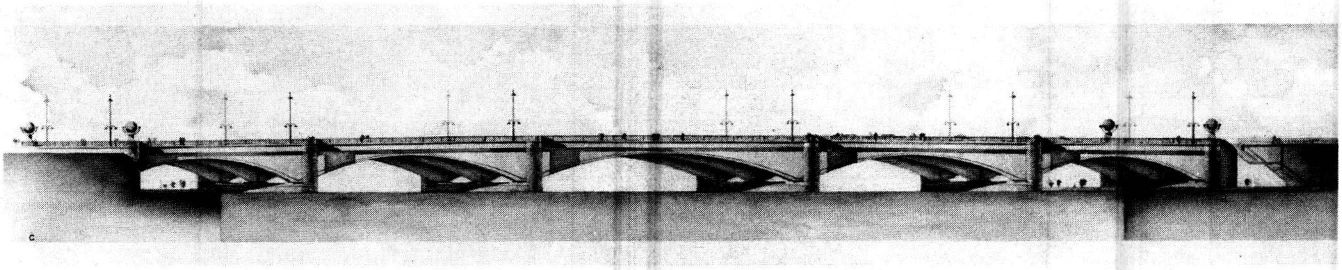

FIGURE 8 Rendering of Feasible Alternative C (7 ft long).

parameters. Each of the alternatives met the parameters to various extents.

In February 1989, all three feasible alternatives were submitted to ODOT for review and approval. The design group recommended the five-span alternative having end arches ending high. This recommendation was based on the input received from all organizations and the public and on basic engineering judgment. In August 1989, the recommended alternative was approved by ODOT and FHWA, and the design team was authorized to begin final design.

Incorporation of historic and aesthetic elements into the final bridge design required a unique design concept. All elements were integrated into the structural design

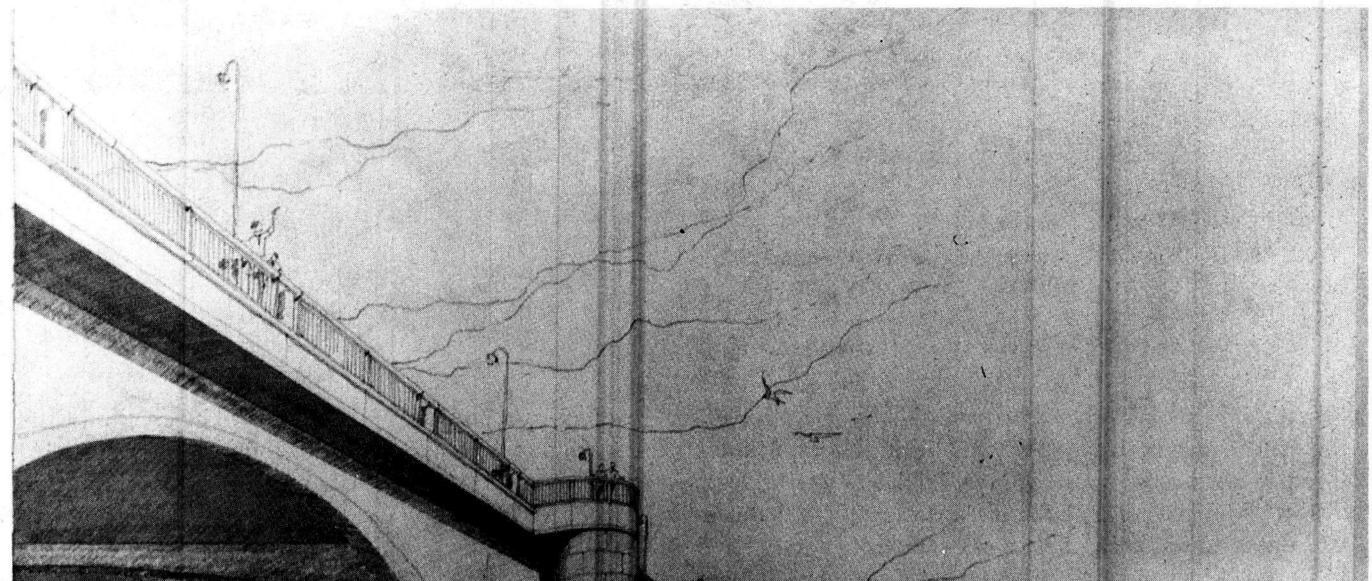

FIGURE 9 Feasible Alternative A: perspective view.

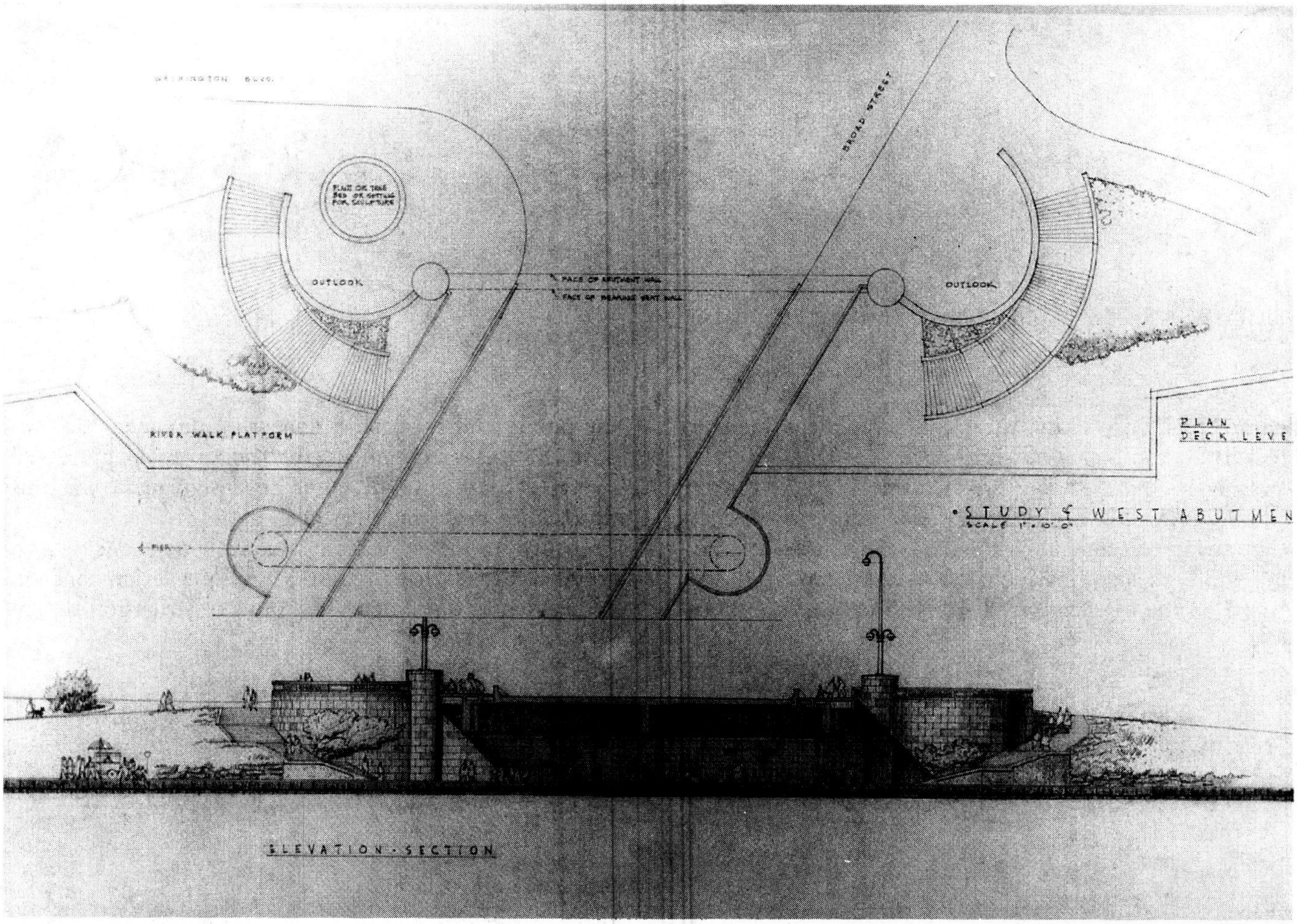

FIGURE 10 Plan and elevation views of west abutment.

instead of being add-ons or afterthoughts. For example, the balconies provide pedestrians with a comfortable location to view the river, the riverwalks, and the bridge. The preliminary concept for the balconies placed them on large columns separated from the bridge. These were to be reminiscent of the pilasters that existed at each pier of the previous bridge. From a structural perspective, the separated columns created several problems. But placing them back into the arched girders as on the old bridge allowed enough area at the bottom of the pilaster to carry the extreme bridge loads to the bearings. These extreme loads required design of the largest known bearings of this type in the United States. At the top of the pilaster, a transition to the 8-ft balcony projection was achieved with a trumpeted cap (Figure 11).

Another example of integrating historic and aesthetic elements within the structural design is seen in the bridge rail and plaza balustrade. The rail is designed to meet current federal standards for static loads and is reminiscent of the previous bridge rail by creating a similar rhythm and openness. Rectangular concrete posts evenly spaced between balconies frame structural rail segments. Each segment incorporates slender vertical pickets between vertical and horizontal structural members, a brass handrail, and cast bronze medallions (Figure 12). Each medallion located at the center of each segment depicts either the Columbus coat of arms or three sailing ships on the ocean. The plaza balustrade is also designed to current standards and replicates the previous balustrade.

Plazas, like the balconies, provide areas for pedestrians to relax and enjoy the surroundings. At the west end, circular plazas include landscaping at the center, walkways to other attractions, and circular stairways down to the river (Figure 13). At the east end, the plazas provide a comfortable transition from the hectic downtown streets to the relaxed atmosphere found down the stairways, along the riverwalk.

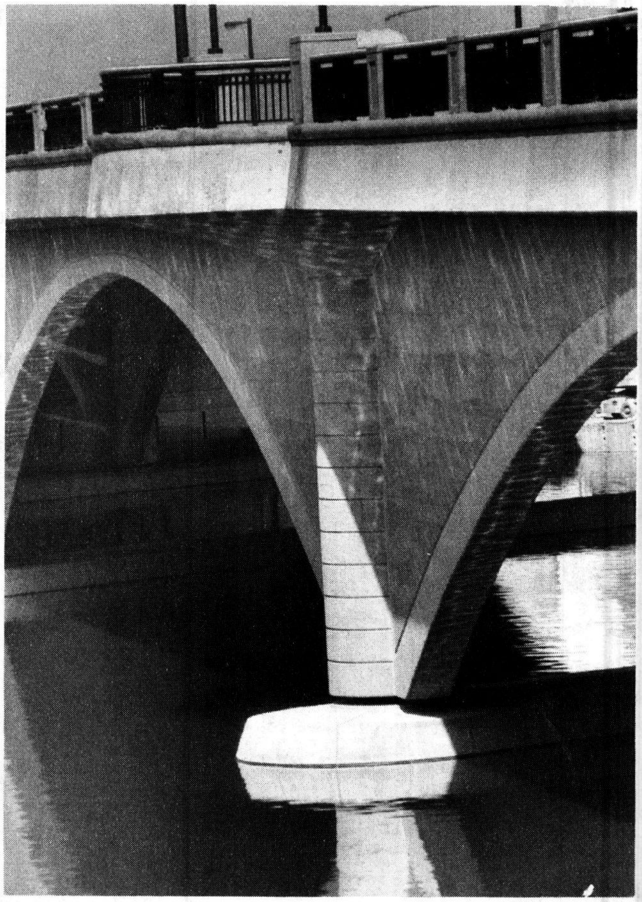

FIGURE 11 Pier pilaster, trumpet, and balcony.

FIGURE 12 Rail segment with bronze cast center medallion.

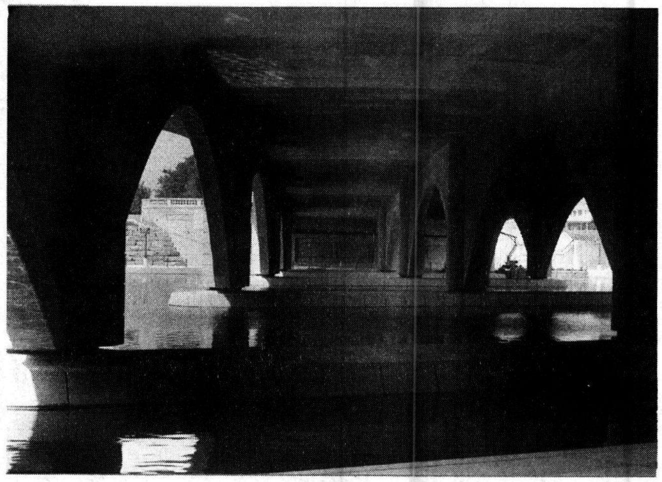

FIGURE 14 View of circular southwest plaza.

The riverwalks extend along the river and under the bridge and connect into adjacent parks. Walking along the river people experience a friendly, peaceful feeling. The bridge itself provides a feeling of safety and permanence. The view of the bridge and abutments from the riverwalks shows the graceful, uncluttered lines and the repetition of the arch form and articulated surfaces (Figure 14).

The design concept for the bridge itself is a unique solution to both the technical and nontechnical issues of this project. Six lanes of traffic and two sidewalks are carried by a deck 100 ft wide. A deck thickness of only 1 ft 6 in. is achieved through the use of the post-tensioning structural system. The deck is supported by three plated arched girders. Post-tensioning allows the heavy loads to be carried by these girders that are only 2 ft 6 in. wide. The interaction between the deck and

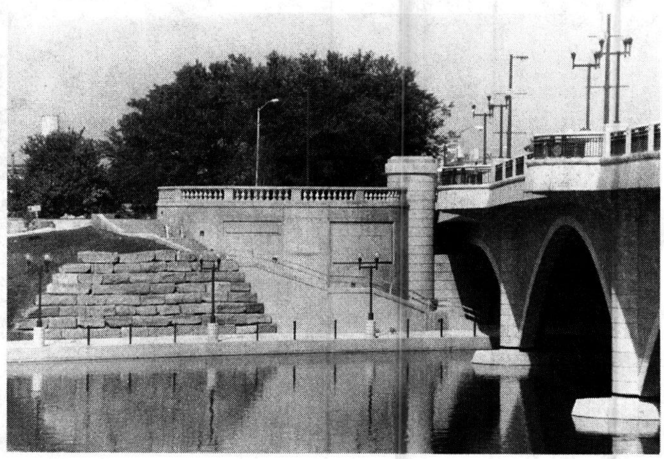

FIGURE 13 View beneath bridge from riverwalk.

girders maintains the stability of the entire bridge without the use of cross frames that would add clutter and block the view below the bridge (Figure 14). Each arch forms three full arches and two half arches at each end. These are reminiscent of the previous bridge and provide a continuity with the adjacent Town Street bridge and a feeling of openness (Figure 15).

The entire bridge is made of concrete. This is in harmony with the district that surrounds the bridge. The color of the concrete used was modified through the use of the same local natural sand used in the previous bridge and existing floodwalls. Concrete also provided an opportunity for surface textures, sculptural forms, and rustications. This greatly enhanced the visual appeal of the bridge, abutments, piers, and riverwalks.

The urban setting of the project made the nighttime appeal of the bridge as important as the daytime appeal. A portion of these architectural designs focused on the project lighting. Riverwalk, sidewalk, and roadway lighting were designed together to complement each other and the district. The light also creates a feeling of safety and comfort. In addition to the normal street and pedestrian lighting, aesthetic lighting has been designed. This system of fiber optic lights and floodlights highlight features of the bridge.

Early in the project the design team recognized the significance of the bridge with regard to the 1992 Columbus's Discovery of America celebrations. The new bridge, appropriately named "The Discovery Bridge," is dedicated to the spirit and accomplishments of Christopher Columbus and other great discoverers. An arts program was conceptualized to commemorate this theme. The program would create specific elements on the bridge that would focus on a specific subject. These elements and their subjects would include the following:

FIGURE 16 Overall view of bridge.

- Portal sculptures—discoverers of the cosmos;
- International discovery medallions—global discoverers;
- Ohio discovery plaques—Ohio discoverers; and
- Landscaped plazas—local discoverers.

Throughout the design, major efforts were made to integrate the historic, aesthetic, and structural elements. The overall view and feel of the completed bridge is proof of how well this was accomplished (Figures 16 and 17).

Looking back on the design process, there are several lessons to be learned. The primary lesson is that the process is as important as the final outcome. Without the support developed through the process, the project will not reach its ultimate potential. Involvement of all

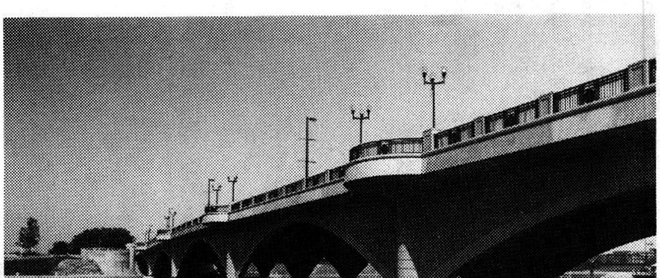

FIGURE 15 Overall view of bridge from east riverwalk.

FIGURE 17 View of Discovery Bridge from Civic Center Drive.

interested parties from the beginning of conceptual design to the final design is crucial. However, this involvement must be channeled and focused on the issues of the bridge. Part of this involvement will be honest debate and disagreement. This controversy is an important part of the project, and how it is dealt with and incorporated into the project may determine the overall level of success.

Another lesson learned is that the design team should be involved from the beginning with the task force in the development of the design parameters. This would help in the development of parameters that could be more easily incorporated into the design and would provide a thorough understanding by the design team of the meaning behind each parameter.

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