Heavy Movable Structures, Inc.

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Case History 8th Street Bascule Bridge

by

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CASE HISTORY

8TH STREET BASCULE BRIDGE

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CASE HISTORY
8TH STREET BASCULE BRIDGE

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The South Eighth Street Bascule Bridge in Sheboygan, Wisconsin utilized three significant innovations.

1. Lightweight Concrete Deck.
2. Unbalanced Movable Leaf.
3. Unique Structural Framing System.

While these innovations were primarily driven by accommodating the unusual site conditions, the simplicity of construction and competitive construction cost challenges conventional practices for bascule construction.

PROJECT DESCRIPTION

The South Eighth Street bridge carries one of the two main arteries across the Sheboygan River to the Central Business District (CBD) in Sheboygan. The existing bridge was constructed in 1922 and generally at the end of its useful life. The bridge suffered particularly from deterioration of the superstructure from years of exposure to deicing salts. To maintain future access to the CBD, the existing bridge required replacement.

The new bridge (Figures 1 & 2) carries four lanes of traffic and two sidewalks for a total width of 68 feet. The bascule leaf is 90.5 feet from the centerline of trunnions to the centerline of bearings on the rest pier. The bridge provides a 75' channel and increased vertical clearance from 7.5 feet to 10.1 feet in the closed position.

In addition to the important functional requirements for roadway and waterway traffic, the bridge was required to fit esthetically with the adjacent developments. The City of Sheboygan is promoting redevelopment of the waterfront to enhance tourism to the community. The architectural features of the bridge house continued the riverfront theme. The bridge was painted a vibrant "Sheboygan Blue" with stainless steel handrails and decorative lighting to blend with the overall revitalization of the area.

LIGHTWEIGHT CONCRETE DECK

The Eighth Street bridge, like many bascules constructed in the Lake Michigan region in the early 1900's, was originally constructed with a timber and asphalt plank deck. In the 1960's many of the structures were rehabilitated to convert the decks to open steel grating. While the open steel grating offered many advantages such as reduced deck maintenance and smoother ride, it also exposed the superstructure to deicing salts. This exposure to salts, coupled with less bridge maintenance (washing), results in severe deterioration of the superstructure.

The obvious solution to limit exposure of the superstructure to deicing salts is to use a closed deck system. The not so obvious solution is which system to select. Systems that are common include concrete filled grating and orthotropic steel plates. But these systems have shortcomings. Concrete filled decks were considered undesirable due to the phenomenon of "deck growth". Over time, salt water seeps into the cracks between the concrete fill and begins to corrode the grating. The corrosion leads to an expansion in the length of the grating; closing joints at the breaks and potentially buckling of the deck. This phenomenon leads to frequent maintenance of joints and eventually replacement of the deck.

Orthotropic steel plate decks, while offering a light deck system, are plagued by the lack of a proven wearing surface. Evaluation of wearing surfaces yielded reports of erratic performance and many difficulties with maintenance. In general, surfaces that provide adequate adhesion tend to rut under traffic; while surfaces that provide adequate durability to traffic tend to debond from the steel. All wearing surfaces required frequent and costly maintenance.

The criteria for final selection of the deck narrowed to providing a smooth ride which could be maintained with conventional maintenance practices. These criteria led to the conclusion of using a concrete deck. With the selection of deck type, the efforts then focused on minimizing the short comings of a concrete deck; weight and cracking. The weight was minimized by using a lightweight concrete (115 pcf) and by optimizing the deck thickness/stringer system. The optimum thickness/stringer space combination for the 8th Street bridge was determined to be a 6" thick deck on 4'-0" spaced stringers.

Cracking of the concrete deck was a significant concern. Brainstorming sessions for potential causes of deck cracking focused the concerns to flexure of the deck when opening the leaf. The solution to address the tension in the deck while opening was to pour the deck with the leaf in the slightly open position. This results in the deck being relatively unstressed while opening of the leaf and in compression when the leaf is closed. The later condition, compression when closed, improves the deck performance under live load.

UNBALANCED MOVEABLE LEAF

Complicating the replacement of the bridge was the designation of the Sheboygan River as a USEPA Superfund site. Years of dumping of untreated industrial wastewater into the River upstream of the bridge left the river sediments laden with pollutants. Designation of the river as a Superfund Site jeopardized the start of the project until after clean up of the River could be complete. However demonstration to the USEPA that the project could be completed with a minimum of removal or disturbance of the sediments allowed the project to proceed.

Minimizing the river sediment disturbance required rethinking the bridge systems. Conventional (balanced) bascule spans require a counterweight arm. This arm rotates below the trunnion when the leaf opens, requiring a deep pit below the bridge to house the counterweight. Studies of roadway profiles and arm lengths resulted in the conclusion that any pit would require significant excavation. Hence, the conclusion to eliminate the counterweight.

To feasibly eliminate the counterweight a drive system with sufficient power and reasonable operating cost had to be conceived. The system selected (Figure 3 & 4) consisted of large bore hydraulic cylinders and crank plates. Cylinders provided large forces to move the leaf. Working with the vertical space constraints of roadway profile and river bottom elevation the position of the cylinders was optimized to impart the maximum torque through the crank plates for opening the bridge.

With the drive system deemed technically feasible, the next question to address was cost. Conventional bascule bridges, by the virtue of being balanced, require relatively little power to operate. Obviously, the unbalanced leaf would require significantly more power. A present value analysis comparing the additional cost of constructing a pit for a balanced bridge versus the operational cost of the unbalanced leaf was performed. The results of the present value analysis found the unbalanced design to be the least cost alternative. Conservatively, this analysis had assumed disposal of river sediments as special waste.

Convinced that the unbalanced design was feasible technically and financially, the last step was to review operations. Through this analysis, a number of operational scenarios were hypothesized, then drive system improvements were developed to address the scenarios. A couple of scenarios and improvements were:

What happens if the bridges is up and power is lost?

Add accumulators to the hydraulic circuit to provide hydraulic fluid for manual lowering of the bridge.

What happens if a drive system component fails?

Add redundancy to the system such that the bridge can operate with the remaining elements. The bridge has two hydraulic systems. Each system consists of 4 motors, 4 pumps and 2 cylinders.

STRUCTURAL FRAMING SYSTEM

The key to the structural framing system of the Sheboygan bascule bridge is its massive cylindrical cross girder. This steel girder is 5 feet in diameter and runs across the full width of the bridge under the roadway deck, near the hinged end of the structure. It serves as the rigid spine on which all other primary structural components of the bridge are mounted.

The main longitudinal girders, one on each side of the bridge, are steel I sections of varying depth fastened rigidly to the cross girder. Also mounted rigidly on the cross girder are four pairs of "crank plates," one pair on each side of each longitudinal girder. Each pair of crank plates has a trunnion bearing at the bottom and a piston rod end bearing at the top. Thus, the crank plates support the cylindrical cross girder and, when acted upon by the hydraulic pistons, impart torque to the girder to lift the bridge.

An important benefit to this arrangement of bearings, crank plates and cross girder is that the inherent rigidity of the cylindrical cross girder holds all the bearings in proper alignment, regardless of the flexibility of the longitudinal girders and other superstructure components.

There are no bearings mounted on the longitudinal girders, which do not, therefore, need to be particularly stiff. Longitudinal girders of I section can be used; the greater torsional and lateral stiffness of a box section (as used typically for bascule girders) is not required.

The use of I-section longitudinal girders (instead of box sections) has many advantages. It permits the use of much simpler floor beam connections; the low torsional stiffness of the I sections permits the longitudinal girders to twist freely as the floor beams deflect under load, without inducing the secondary end moments that have caused problems in other bridges. The I sections are also far more economical to fabricate and more convenient to inspect, maintain and paint.

Due to complexity and uniqueness of the structural framing system finite element analyses were undertaken for specific components and for the bridge as a whole (Figure 5). Analyses of specific elements, crank plates, cylindrical girder, and bascule girder haunches, were completed to insure that stress intensities and stress ranges in the elements under different load combinations and different angles of openings were acceptable.

While the catalyst for the innovative design was the unusual site conditions, the results were surprising. Construction of the bridge, even though in a Superfund Site was completed in just 18 months, compared to 24 months for similar balanced bridges. The time savings is primarily attributed to elimination of the counterweight pit, counterweight, and commissioning time for start-up. The bridge cost was $7.5 million with less than 1 percent in change orders. These results of the construction duration and cost demonstrate that innovation in engineering is not necessarily a risk.

REFERENCES

(1) Cassity, P.A., Patel, V.C., Nair, R.S., "Rebound of the Bascule", Civil Engineering Magazine, August 1996.

(2) D. H. Timmer "A Study of the Concrete Filled Steel Grid Decks in Ohio", Bridge Maintenance and Rehabilitation Conference/ASCE, TRB, IABSE, WVDOH, 1980.

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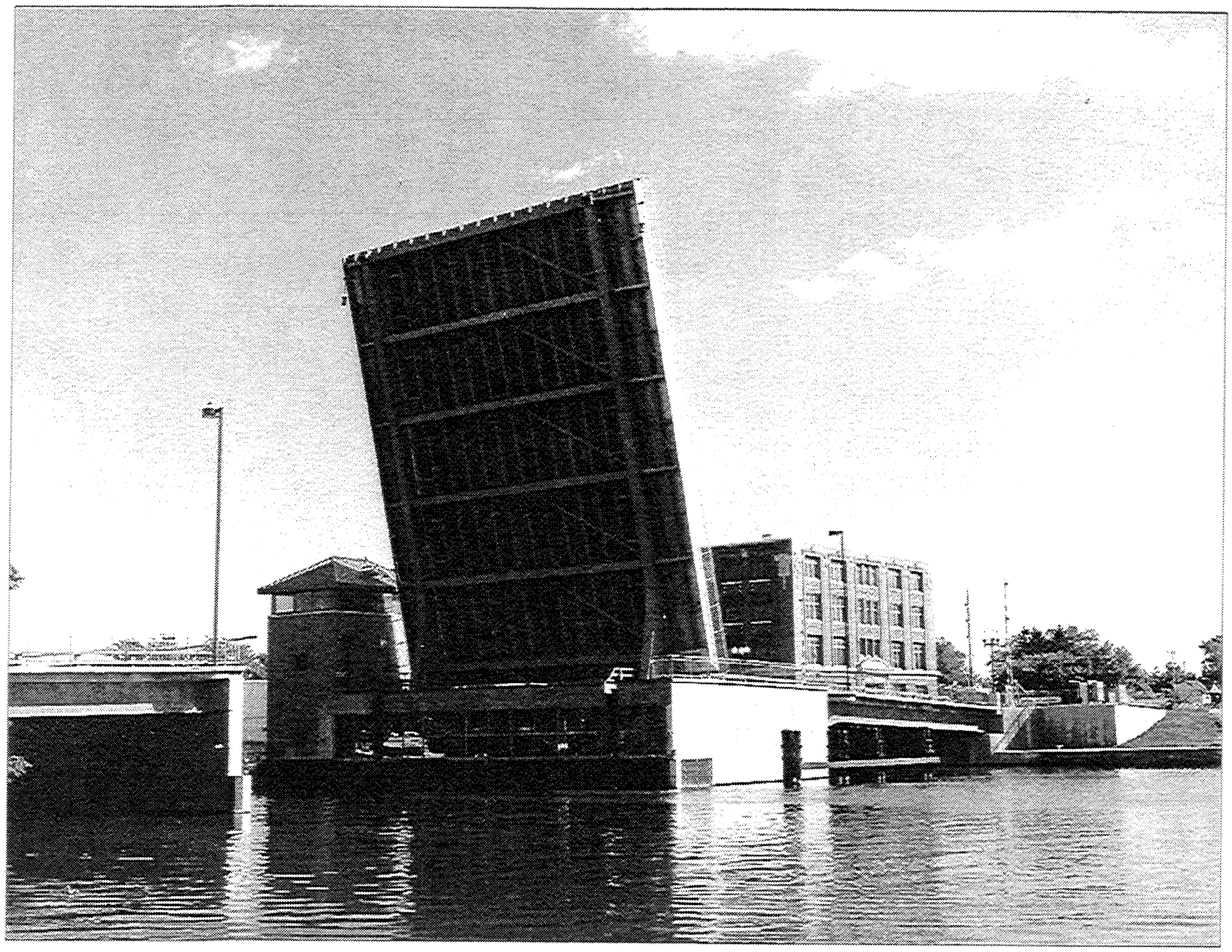
Case Study
8th St. Bascule Bridge



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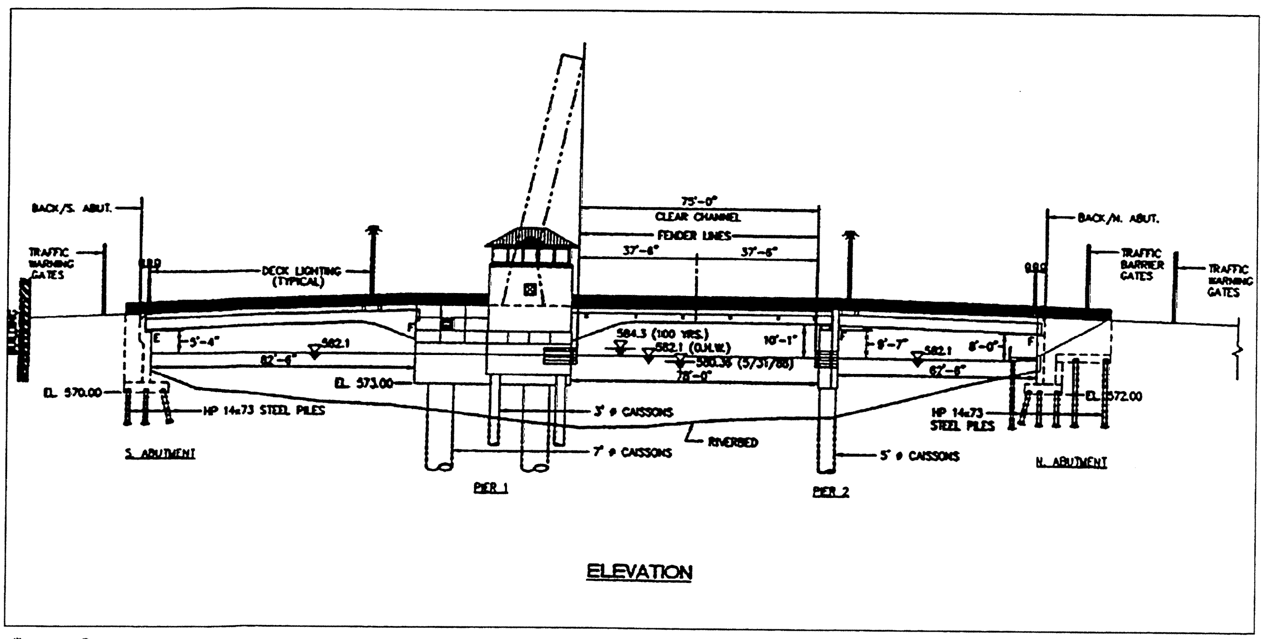

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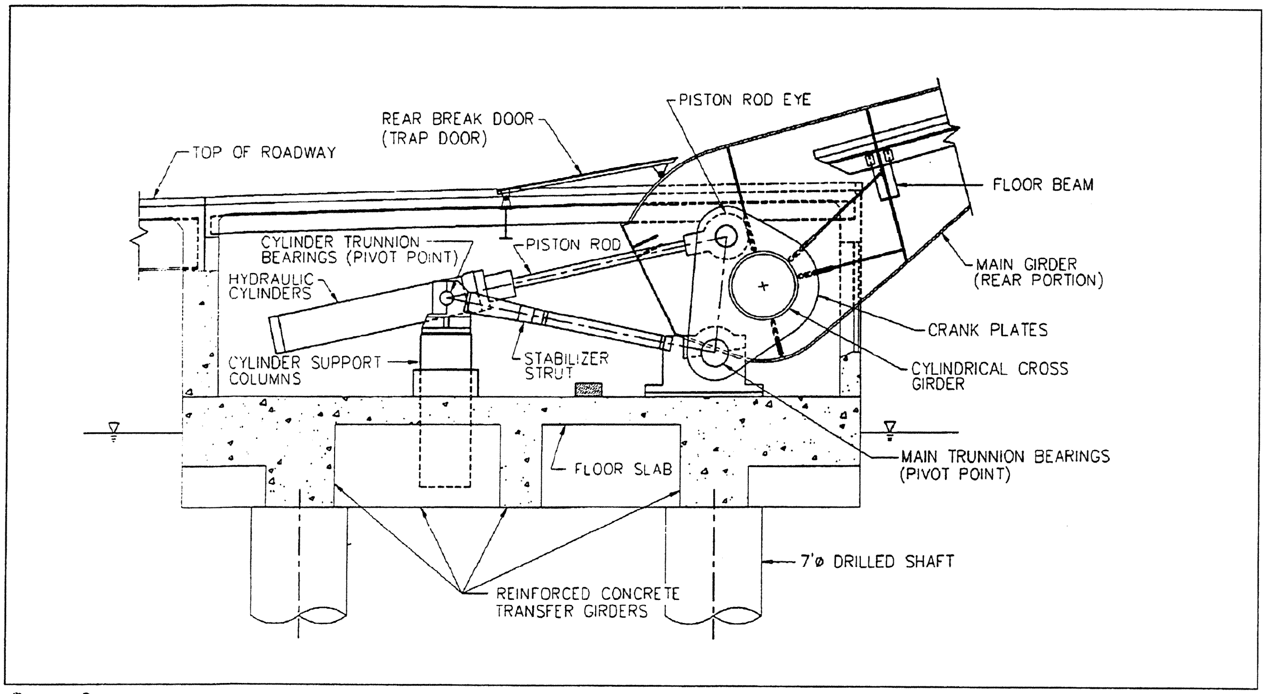

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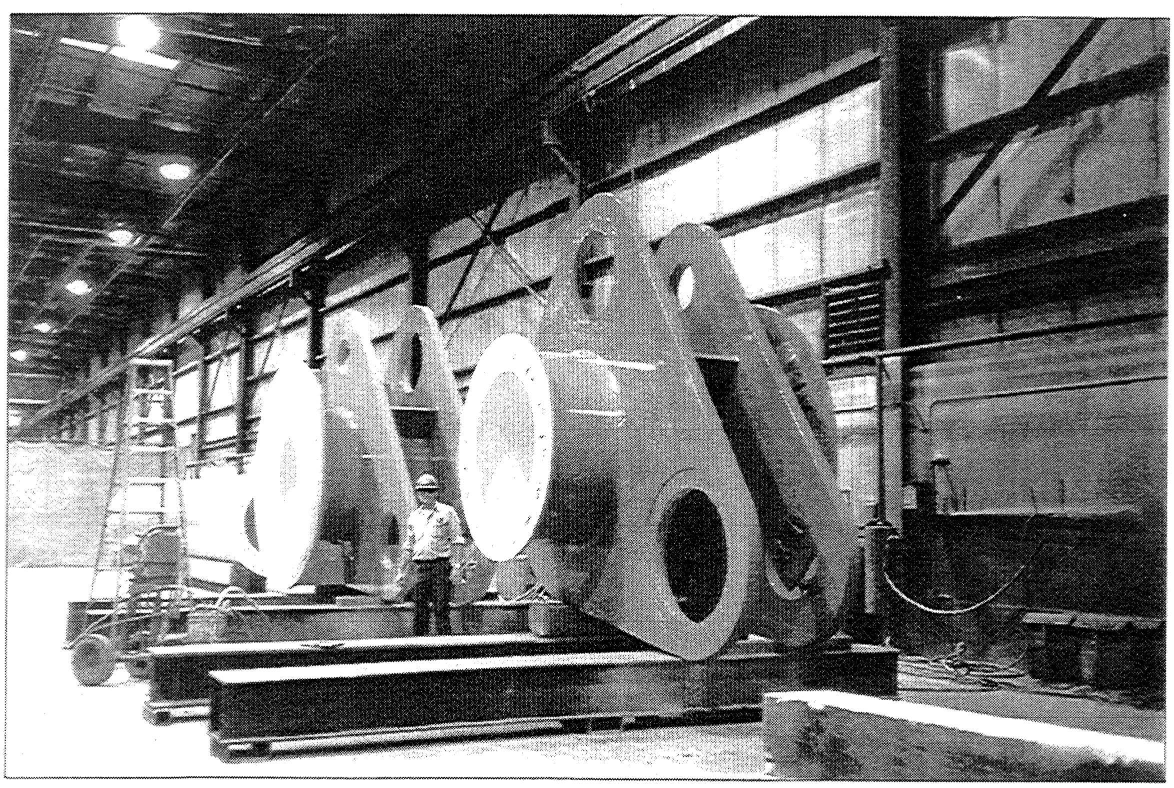

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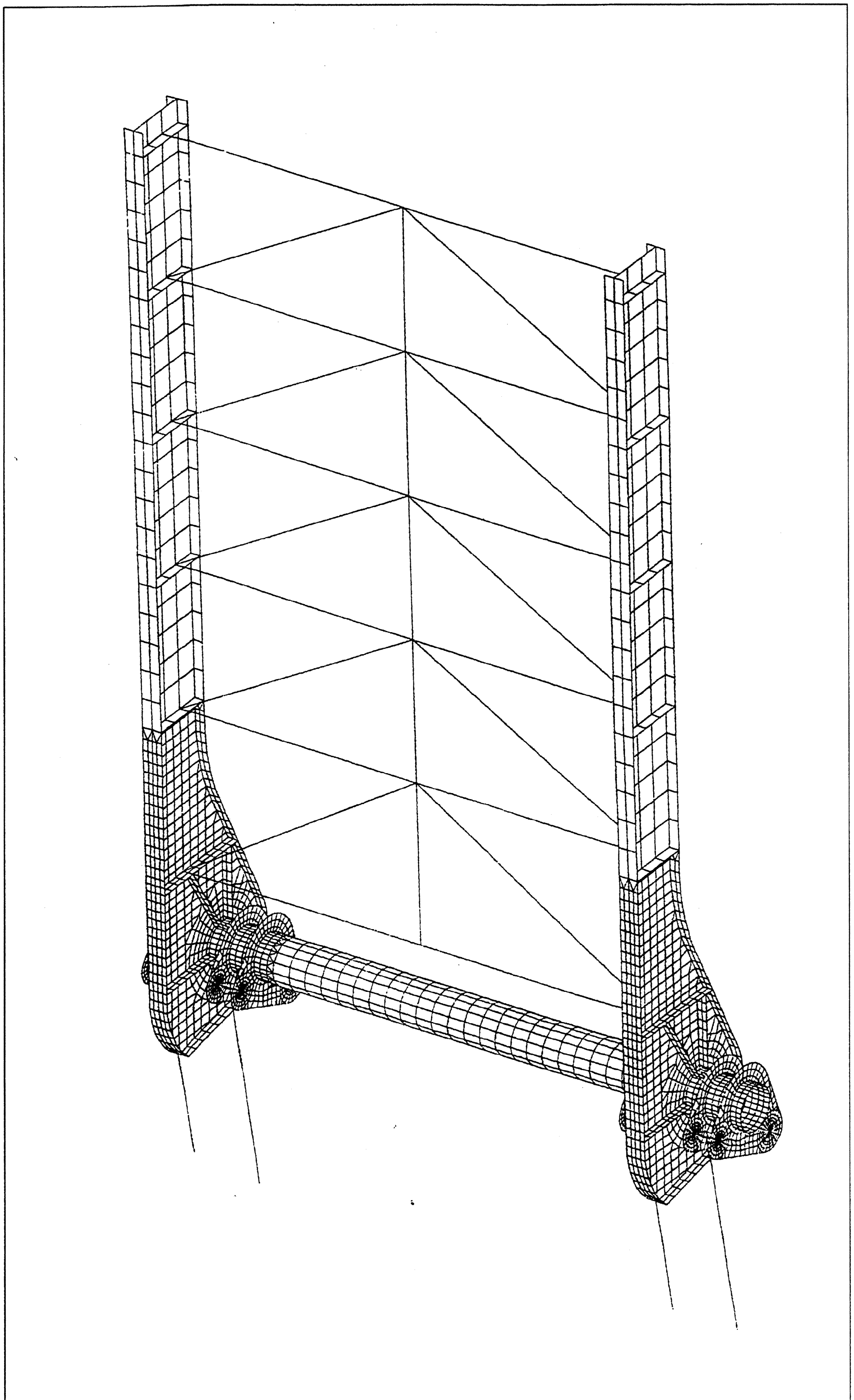

figure 5.