

SEGMENTAL BRIDGES IN INDIANA

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INTRODUCTION

Indiana has the reputation of being a conservative state. I think in the field of bridge design and construction, we are about to lose that image.

We are moving rapidly into a new type of bridge design and construction with the use of precast segmental post-tensioned concrete box girders.

This type of bridge construction was first used in France in 1962 and is now being widely used all over Europe. The Bear River bridge in Nova Scotia was the first structure in North America to be built using this concept. The second such structure was the Corpus Christi bridge in Texas over the Intercoastal Waterway. The third structure to be built in North America using this concept was our North Vernon bridge, carrying U.S. 50 over the Muscatatuck River.

We have more structures of this type under construction and in design at this time than does any other state in the union. We have completed the construction of one such structure and have another under construction. We also have design plans complete for structures at two more locations and design in progress for several others. We are in the process of developing computer programs for the design of this type structure and expect to see this become a rather routine design in the near future.

I will not attempt to cover the design principles of segmental bridges at this time. I will invite those who are interested to sit in on our detailed coverage of the North Vernon bridge tomorrow afternoon.

SEGMENT TYPES FOR SUPERSTRUCTURES

There are many kinds of segments used in bridge construction; however, the word "segment" as used here today will refer to a piece of the bridge superstructure, of short length in the direction of the roadway and either full or partial width of roadway. The cross sections being used are trapezoidal boxes (either single or multiple cells) with a cantilevered slab to form the full roadway width.

These segments are match cast to ensure perfect fit when assembled into the structure. The segments can be all cast before the start of erection or, in the case of a large structure, the casting could take place while erection is in progress—provided enough segments were stock piled to permit curing time for the new segments.

PLACING AND JOINING SEGMENTS

The erection starts by securing one segment to the pier. The erection progresses from here by the placing of a segment on each side, then threading post-tensioned tendons through ducts in the segments and stressing to place the total joint surfaces in compression. Before erection, the joint faces are coated with an epoxy adhesive to give complete uniformity of bearing, prevent any intrusion of moisture into the joint and to provide a homogenous member for analysis. Temporary post-tensioning is used to hold the segments in place while the tendons are placed and stressed. This construction procedure is called the balanced cantilever method and reduces the overturning forces on the piers to a minimum.

REASONS FOR USING SEGMENTAL CONSTRUCTION

There are many reasons to consider the use of this type of construction. Economy is the first, of course. Speed of construction is another factor, as is the use of cantilever construction which permits erection over terrain where falsework would be impractical or impossible. The box section provides an excellent location for utilities which will need to use our structures more and more as ecological considerations force them to go underground. Aesthetics is a very strong point in many settings and could be the deciding factor.

METHODS OF ERECTION

Use of Cranes

Several methods may be used to erect the segments. The most common in this country will probably be by the use of cranes. This is the method used at North Vernon and is also being used in Parke County.

Launching Girder

The launching girder is a common method of erection in Europe and I am sure it will find a place in this country for large structures and for structures with difficult or limited access.

Cast-In-Situ Balanced Cantilever

A third possibility is the cast-in-situ balanced cantilever method of erection. This method is more suited to longer spans than to the short and medium spans we are likely to encounter. This method is also slower than use of precast segments.

Ground Assembly and Jacking

Another segmental construction method is gaining favor in Europe and has been proposed for one of our projects. This involves assembling the segments in back of an abutment and then jacking the superstructure out over the obstacle to be bridged. The design for the post-tensioning here is totally different from that for cantilever erection.

I am sure that, in time, we will use all of these methods either singularly or in combination.

SEGMENTAL CONSTRUCTION HAS ITS PLACE

We have considered, and will continue to consider, the use of segmental construction for a large number of our bridge projects. When the studies are complete the segmental construction does not always prove the most feasible and economical for a particular project. We do not consider the segmental box girder to be the answer to all our bridge problems. We do think it is another structure type which must be considered and evaluated along with the traditional types we have used in the past.

SEGMENTAL BRIDGES IN INDIANA

I will now give you some brief information on the projects in Indiana for which segmental construction is being used or considered.

North Vernon, U.S. 50 over Muscatatuck River

U.S. 50 over the Muscatatuck River at North Vernon is the first structure I wish to discuss. This structure forms one half of the roadway width for the stream crossing. The existing structure was an open spandrel arch with a badly deteriorated deck only 24 feet in width. There are no suitable detours in the area and the terrain at the bridge site made a temporary bridge too expensive to consider. It was decided to widen the bridge with a parallel structure while maintaining one-way traffic on the existing structure, then shifting traffic to the new portion while the old structure was partially removed and reconstructed.

Several alternative structure types were studied, both for cost and appearance. Building a parallel arch structure would have pre-

served the appearance of the existing structure and from an aesthetics standpoint alone would have been the best solution. The cost of this solution was far greater than any of the other schemes. The segmental box girder offered economy and the appearance blended well with that of the existing structure.

Brice Bender of Segmental Technology and Services offered to provide the Indiana State Highway Commission with the superstructure design for this structure. Bender's offer was accepted. The design was checked in our bridge design office and final construction plans developed.

The main span of the existing structure was 190 feet with tail spans of 57 feet. The piers for the new construction were spaced to align with the existing structure which produced a 190-foot center span for the new construction. Ninety-five-foot tail spans were used to provide a balanced cantilever for the construction of the center span. If we were doing this same job today, I think we would anchor the end spans or provide counterweights instead of the extra length.

Funding and right-of-way problems delayed this project. The condition of the existing structure demanded early completion of the new structure. In an effort to speed up the construction a contract was let for the production of the segments in March 1974. The segments were fabricated by Construction Products Corporation Inc. (CPC) of Lafayette and stored in their yard until needed by the erection contractor. The contract with CPC specified that the segments would be delivered to the job site when requested, along with post-tensioning tendons and anchorages, epoxy, bearings, and other incidental material needed for erection. The contract also specified that CPC was to furnish erection expertise to the contractor doing the final construction.

A contract was let on September 17, 1974, for the construction of the bridge. This construction included the erection of the segments. Tousley-Bixler Construction Company was low bidder on this contract. Shortly after the notice to proceed, one-way traffic was established over the existing structure and the north railing and edge of roadway slab was removed to make way for the new construction. The new substructure was completed and erection of the superstructure segments was started on May 15, 1975. The west cantilever was completed June 23, 1975. The east cantilever was started on June 19, 1975, and completed on July 7, 1975. The increased efficiency of erection for the second cantilever was due strictly to the knowledge and experience gained in the erection of the first. This increase in effi-

ciency and resulting cost savings would be much more dramatic with a longer structure and a greater number of segments to be erected.

The midspan splice was poured on August 22, 1975, and the new portion of the structure was opened to traffic on October 13, 1975. Construction is now proceeding on the rehabilitation of the original structure. When this construction is complete the two portions will be joined with a flexible rubber expansion joint placed along the centerline of roadway and each portion will carry one lane of traffic.

Parke County—County Road 1220 N over Sugar Creek

The second bridge in Indiana to be designed as a precast segmental box girder bridge is in Parke County. This structure will carry Parke County Road 1220 North over Sugar Creek, about three-and-one-half miles north of Byron. The structure will consist of three spans (90 feet, 6 inches, 180 feet, 6 inches, and 90 feet, 6 inches). The clear roadway between railings will be 28 feet.

This structure was designed for the county by the consulting firm Beam, Longest, and Neff of Indianapolis with assistance from Bender's firm. The structure type was selected from economic studies and some consideration for the setting of the bridge. The bridge is located over the most heavily used canoe stream in Indiana. In the warm months of the year more traffic will pass under the bridge than will pass over it. The contractor's maintenance of traffic problems for this project are all with boats; the automobile traffic is detoured over other roads in the area. There is, however, no suitable detour for the canoes.

The span lengths for this structure are very similar to that of the North Vernon bridge; therefore, it was designed to use a similar cross section. This permitted the use of the forms from the previous job for fabricating the segments. Only minor modifications were necessary to increase the cantilever overhang and thereby increase the roadway width.

The contract for the construction of this bridge was let June 24, 1975. The low bidder was J. L. Wilson Company. J. L. Wilson Company sublet the fabrication of the segments to Construction Products Corporation of Lafayette. The fabrication of the segments is progressing smoothly and is expected to be completed soon. The substructure work is on schedule and it is anticipated that erection of the segments will start in early May. The price of this structure worked out to be \$52 per square foot with the superstructure cost being \$39 per square foot. This is somewhat higher than originally estimated; however, as experience is gained in this type of construction, and when larger structures are involved, this price should drop drastically.

Covington—U.S. 136 over Wabash River

The third precast segmental post-tensioned concrete box girder bridge to be designed for construction in Indiana is to carry U.S. 136 across the Wabash River at Covington. This structure is to be 948 feet in length. The six spans will be 93 feet, 6 inches and four at 187 feet and 93 feet, 6 inches. The structure will be shoulder width, 44 feet face to face of rail.

This structure was designed for the Indiana State Highway Commission by the consulting firm of American Consulting Engineers, Inc. Segmental Technology and Services provided assistance in the design of the superstructure.

The plans are complete for this structure and construction should start shortly after the end of the fiscal year. This bridge will replace an old steel truss bridge which was built in 1915. The existing structure is in poor condition with only a 19-foot clear roadway and load limit of 15 tons. The new construction will be funded from the Special Bridge Replacement Program established by Congress in the 1970 Highway Act. Provisions have been made to carry a city water main and Indiana Bell Telephone lines in the structure.

The box girder segments are designed for balanced cantilever construction to be erected by cranes; however, other methods may be used. The plans stipulate that other design concepts, employing the same cross section and span arrangements, may be proposed and used subject to the approval of the state. This will permit consideration of poured-in-situ cantilever construction or even poured-in-situ on falsework.

This structure will use a new cross section. It will be a two-cell box configuration with cantilevered top slab to form the full roadway width. It is anticipated that the size of this structure will help to reduce the cost of fabrication and erection and give us a very economical bridge.

Turkey Run Park Area, S.R. 47 over Turkey Run

The fourth segmental bridge to be designed for construction in Indiana is to carry S.R. 47 over Turkey Run just west of the entrance to Turkey Run State Park. This structure was designed totally in the bridge design department of the Indiana State Highway Commission. The construction plans are now complete. This structure will replace an open spandrel arch at the same location. The open spandrel arch is too badly deteriorated to repair.

Turkey Run State Park borders the highway on both sides at this location. The park officials and Indiana Department of Natural Re-

sources expressed the desire to have this construction done with a minimum of disturbance to the adjacent area. No additional right-of-way is available from the park lands, not even for temporary use. Turkey Run is in a deep ravine at this point and a park hiking trail follows along the bank. These considerations placed a high value on aesthetics for our construction. Several possibilities were considered before we settled on a two-span segmental structure for this location.

The cross section used at North Vernon was usable by joining two segments at the centerline of roadway. We, therefore, initiated design on this basis. Fahim Batla of our bridge design department did most of the design check for the North Vernon job. He is currently developing computer programs for the design of this type structure. Batla did the preliminary design which showed the two-span scheme would work. The project was then assigned to a design group for final design and development of construction plans. The structure will be 325 feet in length with spans of 158 feet, 6 inches. The clear roadway between rails will be 44 feet.

The structure is designed to be constructed as a balanced cantilever from the center pier. The cantilever spans are greater than the segment cross section was designed for; therefore, temporary supports are necessary in each span. Once the erection is complete, and post-tensioning tendons are in place and stressed, we can remove the temporary false work.

The superstructure will be erected with each spline as a separate structure. After erection is complete and the stressing is finished, the longitudinal joint in the slab between the two splines will be formed and poured.

It is anticipated that this structure will be let to contract in the late summer or early fall. A Joint Highway Research Project has been set up to monitor this structure. We are hoping to get some very useful information to check our design procedures.

Interchange I-70 and I-465

The interchange of I-70 and I-465 on the east side of Indianapolis will be revised to eliminate the loop carrying westbound I-70 traffic to southbound I-465. This loop will be replaced with a ramp starting at Franklin Road on I-70 and crossing over I-70 and I-465 then joining I-465 south of 16th Street.

This crossing of I-70 and I-465 will require two structures, both curved. Economic studies showed the cost of curved steel girders and segmental box girders to be about the same. There were, however, several reasons to select the segmental box girder type for this location.

Aesthetics was one of the considerations and another was the fact that the segments could be erected without stopping traffic on the busy expressway below. In order to maintain two lanes of traffic at all times, it will be necessary to construct temporary pavement blisters on the shoulders. This will keep traffic from the area directly below the segment being erected.

The redesign of this interchange is being done by the consulting firm of Reid, Quebe, Allison, Wilcox, and Associates, Inc. The plans for this project are in the preliminary stages. The structure over I-70 will be 320 feet in length with two spans of 158 feet, 6 inches. The cross section will be similar to that of the Covington bridge. The depth of the section will vary from 8 feet, 3 inches at the pier to 6 feet, 3 inches at the span quarter points. The clear roadway face to face of rails will be 40 feet. The structure will be built to a 12° horizontal curve and will be superelevated 1 inch per foot.

The structure over I-465 will be 800 feet in length and will be built to a 5° horizontal curve. The spans for this structure will be unsymmetrical due to the need to cross 21st Street at the same location as I-465. This will form a three-level intersection at this point.

The construction date for this project has not been set.

East Chicago—Cline Avenue Extension

The proposed extension of Cline Avenue in East Chicago, Indiana, includes the largest structure ever considered for segmental construction in Indiana. It will have the largest deck area of any segmental post-tension box girder bridge in North America.

This structure will carry S.R. 912 over the Indiana Harbor Canal. It is being designed to clear the water surface by a minimum of 100 feet with a 300-foot span. These requirements were set out by the U.S. Coast Guard for navigation clearances on the canal.

The structure is 6,260 feet in length and varies in width due to the Riley Road interchange ramps tying into the mainline structure. The basic width is for three lanes of traffic in each direction or about 111 feet out-to-out of coping. This figures out to be something over 16 acres of bridge.

The spans vary in length from 100 feet to 300 feet to accommodate the existing topographic features. In addition to the Indiana Harbor Canal, the structure will cross the Penn Central Railroad, the Indiana Harbor Belt lines, the E. J. & E. Railroad as well as industrial sidings and Riley Road.

Segmental post-tensioned concrete box girder construction was chosen for this structure based solely on economics. The extensive cost studies showed a savings of \$2,000,000 or more was possible using this type of construction. The construction plans will be prepared for a precast segmental box girder structure using the balanced cantilever method of erection. It is anticipated that a launching girder will be used for the erection of the segments; however, other methods will not be ruled out. The specifications will be written to permit the contractor to submit a proposal based on another design concept should he desire.

This structure is so large that plans are being prepared to let a separate contract for the substructure and another for the superstructure. The substructure design and construction will be based on the segmental superstructure and only the superstructure will possibly be changeable to another structure type. The specifications will require that any alternate proposal submitted for evaluation must meet all current design standards and codes. It must not overstress the substructure in place. It must provide the minimum vertical clearance of 100 feet over the canal and the profile grade must remain the same.

The Riley Road interchange geometrics, as originally proposed, was to have been a figure eight mostly on structure. This was necessary because of the limited right-of-way available and because of the 100 foot \pm difference in elevation of the two roadways involved. The ramps were set for a 150-foot minimum radius. The combination of the short-radius curves and long spans necessary to cross over roadways and other features below made the use of segmental concrete box girders much more economical than any other structure type. The box section has a very high torsional resistance and is ideal for this application.

There is a proposed change in the Riley Road interchange geometric which would eliminate the figure-eight structure and replace it with a more conventional configuration. The new proposal will involve four-ramp structures to tie into the mainline bridge. It is anticipated segmental box girders will prove economical for these structures.

We have just received design approval for this project from the Federal Highway Administration and the consultant has been notified to proceed with the preparation of final plans for the mainline structure.

The consultant for this project is American Consulting Engineers, Inc. American Consulting Engineers has retained the firm of Segmental Technology and Services to provide expertise and design assistance for the segmental superstructure.

OTHER SITES BEING CONSIDERED FOR SEGMENTAL BRIDGES

The Indiana State Highway Commission has a number of projects in the planning stage which will be studied for the feasibility of using segmental construction. These include, but are not limited to, the following projects:

- S.R. 7 over the Muscatatuck River at Vernon
- U.S. 41 over the Wabash River at Attica
- S.R. 44 over Williams Creek in Fayette County
- S.R. 129 over Indian Creek in Switzerland County
- S.R. 154 over the Wabash River at Hutsonville, Illinois
- S.R. 157 over the West Fork of White River, Greene County
- S.R. 257 over the Patoka River in Pike County
- S.R. 257 over the East Fork of White River in Pike County

COUNTIES SHOULD CONSIDER SEGMENTAL BRIDGES

There are many locations on the county highway systems in Indiana where this type of construction will be both feasible and economical. It is hoped the consultants doing the county projects will recognize this and include the segmental structure in their cost studies for selection of structure type.