Replacing the Kansas City "Triangle" Urban Interchange

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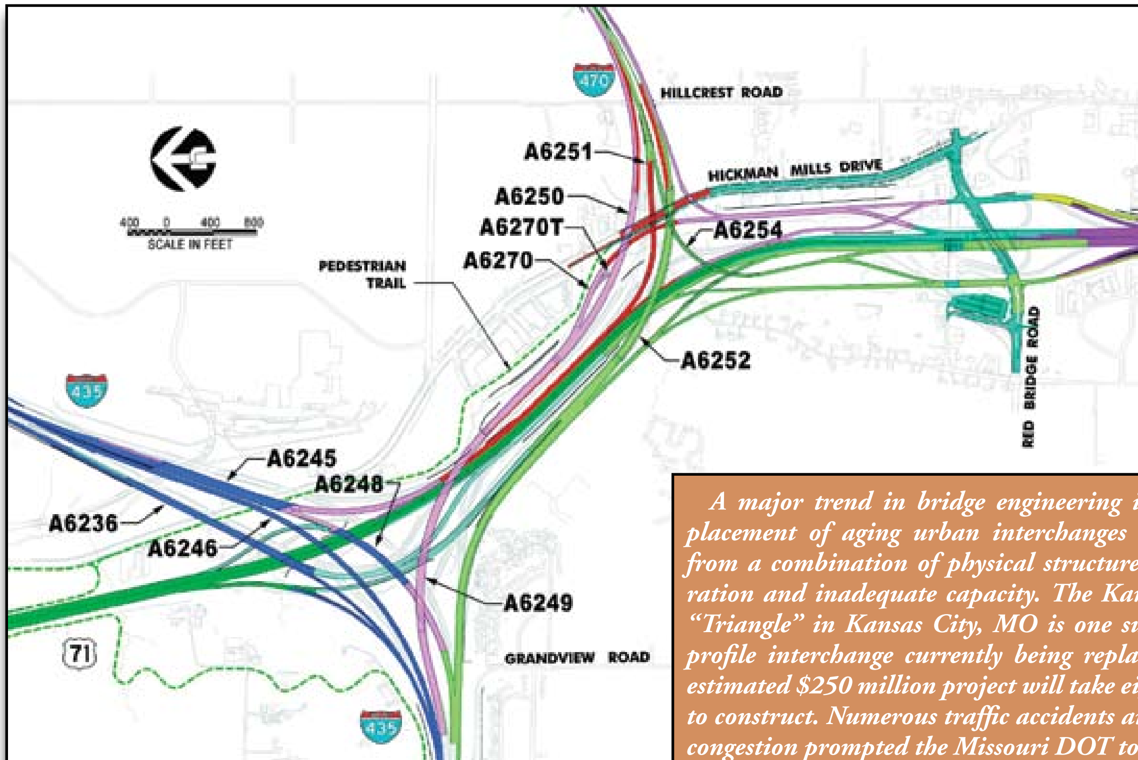

Figure 1: Plan view of the Kansas City Triangle interchange

A major trend in bridge engineering is the replacement of aging urban interchanges suffering from a combination of physical structure deterioration and inadequate capacity. The Kansas City "Triangle" in Kansas City, MO is one such high-profile interchange currently being replaced. The estimated $250 million project will take eight years to construct. Numerous traffic accidents and severe congestion prompted the Missouri DOT to redesign this complex interchange.

The "Triangle" interchange contains over 900,000 square feet of bridges and provides for the intersection of I-435, I-470, and U.S. 71 highways. Highway bridges within the interchange cross the four-lane U.S. highway, several local streets, and two creeks. A key requirement of the project is that interchange replacement cannot impede current traffic flow. This condition required highly intricate construction phasing so that new bridges could be built alongside the existing traffic.

To accomplish phasing, MoDOT broke construction down into six contracts — one scheduled to be let each year. The duration of construction for each contract ranged from one to three years. The first two contracts, A and B, consisted of roadway work to provide additional traffic capacity. Contracts C, D, and E were the main bridge contracts, which were let in successive years starting in 2001. Budget constraints pushed a portion of one bridge into a later contract. *Figure 1* shows a plan view of the project, and locates the ten bridges. *Table 1* provides basic data on each bridge.

The bridges in Contract C consist of composite prestressed beam units in their tangent portions, and composite plate girder units in the curved and flared portions. The substructures of these bridges, as well as those of Contracts D and E, are hammerhead piers with form liner and rustication treatments applied for aesthetics. All the bridges in Contracts D and E have continuous composite plate girder superstructures.

Table 1: Basic Bridge Data

Bridge	Spans	Length, ft	Width, ft	Contract
A6245	11	1199	86.67-110.91	C
A6248	6	781	62.67	C
A6246	23	2452.5	44.67	C
A6236	17	1780	58.67-79	C
A6249	12	1839.5	74.67	D
A6250	14	1700	62.67-112	D
A6270	5	603	42.67	D
A6252	12	1669	74.67-79	E
A6254	13	1553	32.67	E
A6251	11	1249	42.67-89	E*

**Two units of this bridge to be built on a later contract for budget purposes*

Construction Phasing

Effective construction phasing contributed heavily to the successful replacement of this urban interchange (*Figure 2*). Proper phasing:

- showed progress to the traveling public
- eased congestion incrementally (instead of increasing it)
- provided cost savings to the owner.

Phasing often required modifying typical construction methods. In this case, modifications included the delayed opening of Bridges A6245 and A6248 in Contract C, specialized column construction on Bridge A6236, the need for a temporary bridge (Bridge A6270T), and a specialized erection sequence for the steel capbeams over highway U.S. 71.

For example, constructing Bridges A6245 and A6248 simultaneously with the other two in Contract C turned out to be cost effective even

Figure 2: MoDOT mandates that bridge construction at the interchange site not interfere with current traffic flow

though they couldn't be opened for several years after completion. The commuting public didn't voice any concern over these delayed openings, because the other two long bridges in contract C opened on schedule and provided immediate traffic congestion relief.

Certain piers on Bridge A6236 required modification to facilitate construction under contract C. The proximity of an existing embankment ruled out the typical hammerhead pier shape. Instead, the contractor constructed the piers as two drilled shafts with a typical capbeam. After the existing bridge and embankment are removed in a later contract, the contractor will modify the piers by constructing a "shell" around the drilled shafts that will replicate the other piers.

In Contract D, the connection of a ramp to Bridge A6270 could not be completed for several years, and traffic had to be rerouted to allow for ramp construction. A temporary bridge A6270T solved this phasing problem. This bridge consisted of a composite rolled beam superstructure of four 50-foot simple spans supported by steel pile bents. A cost analysis supported the choice of a steel pile bent over the typical concrete multi-column, partially because the steel had salvage value.

Figure 3: Construction of two steel capbeams over U.S. 71

Minimizing the shutdown of U.S. Highway 71 (temporary closures of 15 minutes to erect girders were acceptable) required careful planning. Placement of field splice locations for the erection of the steel capbeams spanning U.S. 71, along with coordination with traffic control plans, helped to meet this criterion. Planners specified a construction sequence on the bridge plans that determined the erection sequence of the girder segments and steel capbeams.

Steel Capbeam Solutions

Innovative engineering solutions helped to solve the complicated problems arising from building large bridge structures next to active traffic lanes in a coordinated manner. One effective solution embodies the use of steel capbeams to accommodate limitations on placement of substructures. In some cases these capbeams span up to 180 feet while carrying six lanes of traffic. In other cases, the capbeams are supported by 110-foot tall columns to span across a new bridge.

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Figure 4: The steel girders welded to the capbeams are continuous and handle torsional moments

Framed-in steel capbeams at key locations accommodate the locations of ramps and a bridge. They also allow for the future possibility of widening U.S. 71 — a four-lane highway that passes underneath most of the bridges (*Figure 3*). Bridges A6249, A6252, and A6254 have five, three, and two steel capbeams, respectively. Bridges A6249 and A6252 each have steel capbeams at three successive bents. Pot bearings atop columns support all the capbeams.

Bolted connections frame the girders into the steel capbeams, as in *Figure 4*. The contractor welded an end plate to the girder before erection. Workers then bolted the end plate to the side of the steel capbeam.

Since the girders act as continuous over the steel capbeam, the girder-capbeam connection design and details provide continuity for the top and bottom flanges of the girders. To achieve this, the top flange of the girders extends to the centerline of the steel capbeam. A splice carries the full moment capacity of the section. An end plate welded to the girder web and bottom girder flange is bolted to the web of the steel capbeam. Inside the box, a diaphragm resides at the centerline of each girder and plates corresponding to the bottom flange align with it.

For a typical framed-in steel capbeam, the steel girder and capbeam depths are 6 and 10 feet, respectively. The design of steel capbeam box section handles the torsion induced by the longitudinal moments of the girders.

In planning for future road widening, the capbeam design on certain bridges permits the placement of two exterior girders. At these locations, the steel capbeams are detailed and fabricated with diaphragms at the future girder locations.

Aesthetics

Aesthetic treatments represent an increasingly important aspect of urban interchange replacements. To provide a view that's visually pleasing to motorists and local residents, the design uses extensive form liner treatments. Designers for the Kansas City Triangle Interchange project identified several areas to apply aesthetic funds:

- pier shapes
- form liner treatments on the substructure
- rustications on the substructure, and
- form liner treatments for MSE walls and sound walls.

After several public meetings to gather input, combined with consultation with HNTB's bridge architect, MoDOT decided on using form liner treatments where applicable and modifying the pier to be more aesthetically pleasing.

Based on the results of public meetings, MoDOT chose the random Ashlar Stone pattern for the form liner. To achieve continuity of the pattern within each contract, the plans specified that the same form liner pattern be used at all locations — piers, abutments, MSE walls, and sound walls. Manufacturers for the patterns were limited to four to minimize variation.

Additionally, MoDOT elected to use a modified hammerhead type pier shape rather than the typical multi-column bents. An 8- by 12-inch chamfer on the corners of the columns modifies the appearance of the pier shapes. Rustications of the columns are spaced at about 12 feet. Another aesthetic feature added to the column is a recessed portion of its wide face to contain a form liner pattern (*Figure 5*). Typical overall dimensions of these columns are 4 feet wide by 12 feet long. A similar shape serves for the larger columns that support the steel capbeams.

To date, the Kansas City "Triangle" project serves as a successful example of urban interchange replacement. This success hinges on the use of construction phasing, creative engineering solutions, and aesthetic considerations.▪

Figure 5: Similar aesthetic treatments decorate piers, abutments, MSE walls, and sound walls

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