NEW PRECAST BENT CAP SYSTEM

Saving Texas Time and Money

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Building bridges in congested urban settings is becoming more challenging for the Texas Department of Transportation (TxDOT). Concerns about traffic delays and public safety in congested construction zones intensify, and the costs associated with traffic control and disrupted traffic increase substantially.

TxDOT already had begun to use economical, standard superstructure elements—such as precast I-girders with precast concrete deck panels—to facilitate rapid and cost-effective construction. Consequently, the department expected that the next opportunity for swift construction and cost reduction was the development of precast substructure elements.

Problem

The Pierce Elevated section of Interstate Highway 45 in Houston's central business district required replacement of 113 spans in 1996, but the columns were still in good condition. A conventional TxDOT bridge system—a precast superstructure and cast-in-place bent caps—would have taken more than a year and a half to construct. Since user delay costs were estimated at greater than $100,000 a day in urban Houston, TxDOT bridge designers decided to use precast bent caps to expedite construction.

Two problems with using precast bent caps became apparent—first, there was no comprehensive design methodology for bent cap-to-column connections; and second, during the design phase of Pierce Elevated, of the myriad of commercial products and published information available for detailing the connection between the columns and bent caps, nothing satisfied the cost-effectiveness and constructability demands as a complete system. This new technology was expected to be introduced incrementally and near the bounds of current construction practice.

Therefore, the bent caps for Pierce Elevated used conventional reinforcement without prestressing—the connections were detailed to allow this. The success of Pierce Elevated as well as discussions with the contractors led to minimized deviation from conventional bent cap reinforcement in the development of precast connections.

Solution

TxDOT contracted with the Center for Transportation Research at the University of Texas to study the use of precast bent caps for the conventional bridge systems that are predominant in Texas. The research study had three major objectives:

- To develop details for connecting precast bent caps to cast-in-place concrete columns and precast trestle piles,
- To evaluate candidate details with full-scale specimens in the laboratory, and
- To finalize standard connection details for precast bent caps through the construction and testing of full-scale bents in the field by a highway contractor.

Standard cast-in-place bent cap reinforcement details were used in the cap, so that precast bent caps could be incorporated easily into the plans. In this way contractors could determine for themselves the optimum construction technique for a given bent. Shipping weight limitations would be accounted for by constructing wide bents as a series of smaller independent bents.

The researchers worked closely with TxDOT bridge designers and contractors to develop and validate a design procedure for several connection systems and to obtain predicted connection strength with the laboratory specimens. State-of-the-art connection hardware and grouting tech-

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nology were used in developing the connections; the importance of these step-by-step grouting procedures—designed to accommodate a range of common dimensional field errors—soon became evident.

The resulting two laboratory-developed, full-scale bents, built and tested by a highway contractor, contributed to quality design and detailing standards, which are currently under final revision.

Application

This research and development project was strengthened through the combined creativity and experience of participants from industry, academia, and TxDOT. The connection details produced by the collaboration were highly constructable and efficient.

TxDOT intends to use this technology as an optional construction method, including a connection detail standard and specification in construction contract documents. The maximum cap weight is expected to be limited to the maximum crane capacity on a given job, which is determined by the weight of the beams placed on the project.

The connection details are appropriate for typical highway bridges with multiple columns and a relatively low bending moment demand at the top of column. With this technology, it is feasible to construct a single-span bridge using precast piles, bent caps, wing walls, and beams with a cast-in-place wearing surface in days instead of weeks or months.

This technology is most advantageous in long and highly repetitive bridges, bridges spanning water, and off-system bridges with long detours and difficult and costly phasing.

TxDOT is working on an implementation plan to use precast bent caps on a large project on Interstate Highway 35 that will require 200 similar bents and on a project in the Dallas district for building a long bridge over water. The implementation plan calls for the researchers to monitor the project, document the work, and report the results.

Benefits

The research cost $289,200—three days of saved user costs on the Pierce Elevated project alone would have paid for the research. The precast bent caps allowed completion of the 113-span Pierce Elevated in 95 days instead of the 548 days that conventional construction would have required. Even by conservative estimates, the savings to road users on this one project exceeded the total cost of TxDOT's $18 million research program in 1999. The use of precast bent caps resulted in faster construction and reduced user costs; there is no way to determine exact construction cost savings because construction costs are project specific.

Precast bent cap being lowered onto its column connections during construction of Pierce Elevated in Houston, Texas. *Inset:* Close-up of column connection.

Precast bent caps undeniably speed up construction and maintain or improve concrete quality. Shorter project duration means less risk associated with construction zone traffic control and detours. Construction phasing can be reexamined or eliminated with the construction time reduced. Monetary benefits are difficult to quantify because they are proportional to timesaving at a project-specific rate. But, without exception, reduced project time greatly increases public satisfaction.

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EDITOR'S NOTE: *Appreciation is expressed to David Beal, Transportation Research Board, for his efforts in developing this article.*

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC 20418 (telephone 202-334-2952, e-mail gjayapra@nas.edu).