Spliced Precast Girders

A New System for High Seismic Areas

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Over the course of the late 1980's and into the '90's, California saw a decrease in the number of bridges being built with precast concrete girders. What had once been a strong market for precast bridge elements, now saw less than a 3% market share. The market had been reduced to principally new girders for widenings of existing bridges built in the 1960's and 1970's. With the reactivation of PCMAC, the precast industry sought to address the declining market share issue. The standardization of new more efficient precast girders made continuous was the answer to the problem. The solution has now become a reality as the last hurdle to acceptance has been overcome with the successful testing of the system at the University of California, San Diego (UCSD).

Starting in 1992, PCMAC developed an initiative to revive the precast bridge girder market in California. Working with Caltrans and a bridge engineering consultant (LoBuono, Armstrong & Associates - LAA), concepts were developed that would return precast girders to a state of competitiveness with the typical California cast-in-place, post-tensioned box girder bridge. Studies by LAA indicated that the precast girder bridge form had not kept pace with the increasingly stringent requirements placed on structures in areas of high seismicity. Precast girders were still being used as simple beams supported on bearings which in turn were supported on drop cap bents - a system that is very inefficient in resisting high lateral forces generated by earthquakes. Simply stated, precast girders were losing out to continuous box girders due principally to the cost of the substructure.

A system therefore had to be developed that made the superstructure continuous and further, made the superstructure continuous with the substructure. In addition, the span range for the precast girders had to be increased from its present 125' limitation to the 200' range in order to enhance its appearance as well as to meet the needs of the California market. Since a new system would require new shapes and forms, full advantage could be taken of the advancements made around the country in precast girder technology and efficiency. Taking all factors into consideration, LAA developed a concept based on the following:

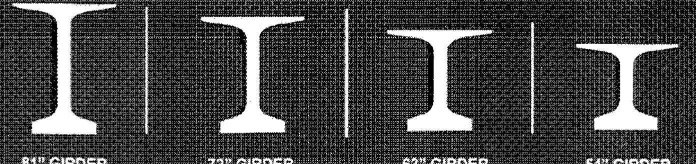
- ✔ a basic girder shape patterned after the Bulb T girder developed by the State of Florida, modified to contain post-tensioning ducts for superstructure continuity.
- ✔ the use of a pier segment that is continuous over the support thereby eliminating complicated splicing details in an area of maximum stress.
- ✔ an integral connection of the precast girders to the columns through the use of a simple, cast-in-place, post-tensioned diaphragm.
- ✔ splicing details using post-tensioning that provide continuity of the superstructure with spans up to 180' for a 72" deep girder and over 200' for an 81" deep girder.

The last step of the development process was the testing of the system to assure everyone of the correlation between theoretical and actual performance. Caltrans and PCMAC sponsored the testing program and the project was undertaken by UCSD. PCMAC is extremely pleased with the cooperative effort of the precast industry, Caltrans, UCSD and LAA in developing this new California system for precast girders in seismic areas.

NEW CALIFORNIA SYSTEM FOR SEISMIC AREAS

- Precast Bulb T's Made Continuous
- Integral Framing with Substructure
- Scaffolding Not Required
- Span Capabilities over 200'

PROPOSED STANDARD SHAPES



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LoBuono, Armstrong & Associates
Sacramento, California

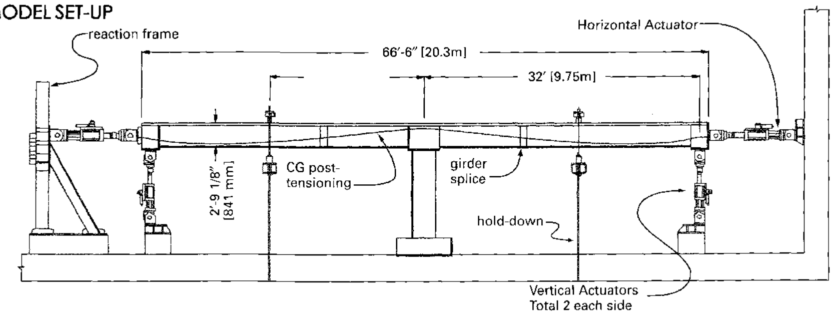
TESTING OF A SPLICED PRECAST GIRDER BRIDGE

Jay Holombo - Graduate Research Assistant (UCSD)

INTRODUCTION

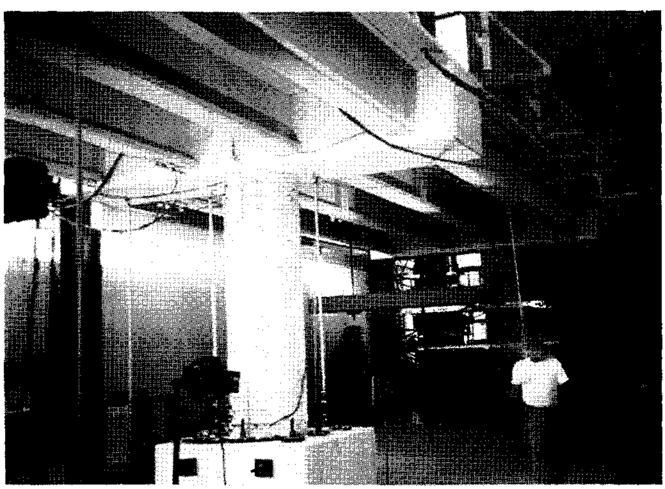
The research program to construct and test two 40% full scale models under fully reversed longitudinal seismic loading is currently underway at the University of California, San Diego (UCSD). Design, construction and testing of the first model, which utilized Modified Florida-Bulb-Tee girders, was completed in June 1996 and is featured here. The second test, planned for the beginning of 1997, is of similar scale and incorporates "U" or "Bath-tub" girders. The testing program at UCSD will not only verify the structural adequacy of newly developed integral column-superstructure details under simulated seismic loads, it also will allow Caltrans Engineers to evaluate the constructability of these details via large scale models in the laboratory.

TEST MODEL SET-UP



Schematic of Test Set-up

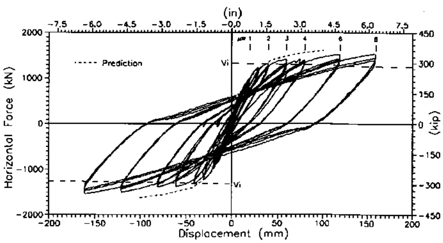
The main focus of this research is to study the effects of longitudinal seismic forces on the column-superstructure continuity. The prototype structure consists of four 160-ft [48.8 m] spans and single-column. The model test unit dimensions and forces were scaled directly from the prototype structure. The region selected for study includes the column, bent cap and the full width superstructure extending from midspan to midspan. Load was applied to the model through two horizontal actuators placed on both sides of the unit to model the seismic inertia forces acting along the bridge under longitudinal response. The four vertical actuators located at the corners of the test unit applied the seismic shear into the girders.



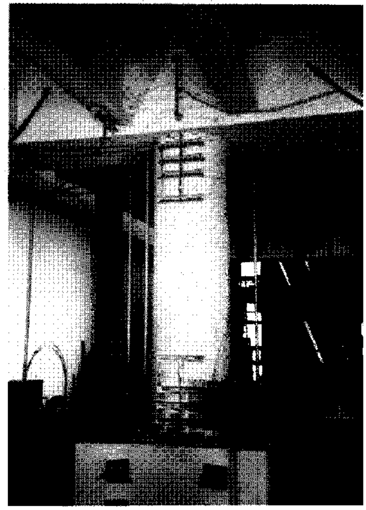
Test Model

TEST RESULTS

Columns: Testing of the first model was successful under simulated seismic loads. Ductile plastic hinges formed at the top and bottom of the column with little strength degradation up to a displacement ductility of eight (mD = 8), which was well beyond the design-ductility capacity of four (mD = 4), as shown in the Figure below. Confinement hoops in the plastic hinge region had fractured at mD = 8, which indicated the onset of plastic hinge failure.

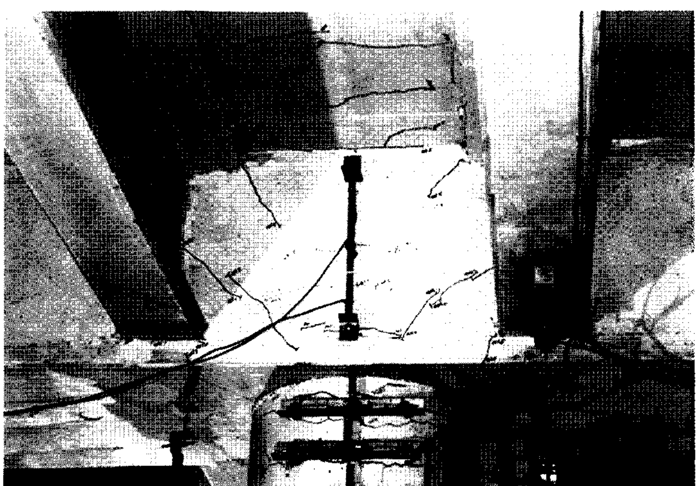


Hysteresis Loops



View of Column During Testing (mD=3)

Superstructure: The superstructure performed essentially elastic under simulated longitudinal seismic response with only minor cracking observed. Due to prestressing, the cracking in the bent cap and the girders closed up upon removal of the seismic loads, making potential repair of the superstructure after a design level earthquake essentially cosmetic. For a more detailed description of the testing program, please contact PCMAC.



Close-up View of Integral Cap Connection

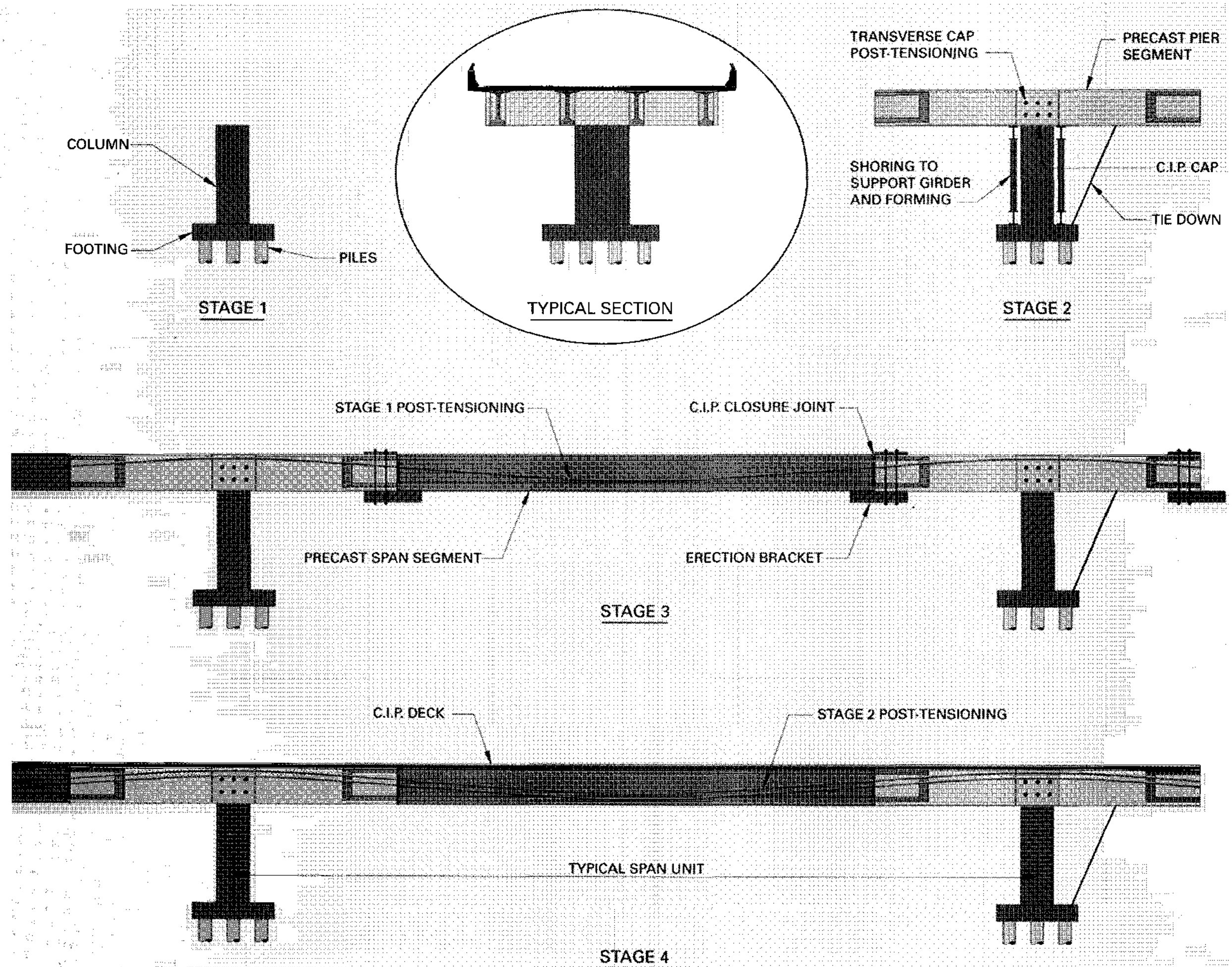


DIAGRAM OF CONSTRUCTION STAGING