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U.S. DESIGN ORIENTED RESEARCH ACTIVITY IN PRECAST CONCRETE

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SUMMARY

Two design oriented research programs are currently underway in the U.S. The precast connection part of the ATLSS program at Lehigh has focused on rational analytical models for dapped end connections. Industry input has been collected to assure that the design models chosen are economical from a design and fabrication point of view. The NBS/Frame project is a five year plan which will develop design and testing guidelines for precast concrete moment frame connections to be used in seismic zones.

INTRODUCTION

Englekirk and Hart,Inc. (EHI) is currently involved in two research projects oriented toward the structural designer of precast concrete. These are the Precast Concrete Connection parts of the Advanced Technology for Large Structural Systems (ATLSS) and the National Bureau of Standards (NBS) Frame Program.

ATLSS/PCI

ATLSS is a large research program conducted under the direction of Lehigh University sponsored by the National Science Foundation (NSF), with significant industry support. The researchers at Lehigh are studying various topics relating to large structural systems, however, Dr. Peter Mueller and his graduate student are working on precast concrete connection topics. EHI is involved with this project as the precast industry's representative, coordinating the efforts of the U.S. precast industry through the Precast Concrete Institute (PCI) and the Precast Concrete Manufacturers Association of California (PCMAC).

PCI and PCMAC are interested in the ATLSS program due to its impressive goals of developing new connector technologies and structural systems in precast concrete. As in any material, the connections in precast concrete are the most critical parts of any structure. However, currently in the U.S. codes, precast concrete connections are not given special consideration, thus the designer is limited to using connections that have been used successfully before, or have been tested. The ATLSS program intends to develop analytical models for the design of common precast concrete connections. This would allow the designer to develop new types of connections without basing his design completely on test data, but instead on rational models that would predict the

behavior of many types of connections. As a second step of the project, one that EHI will play a major role, the analytical models developed at Lehigh would be presented to the major governing bodies (i.e., ACI, ICBO) for inclusion in the model codes (Refs. 1, 2). This is the first step toward acceptance by the design community. Along with this codification, designers and fabricators will have to be educated in the use of the new models. This will be done through PCI publications and other reports which would be published at about the same time as the analytical models are included in the codes.

Past these immediate plans, the program hopes to develop new technologies for precast concrete connections. From the point of view of industry, these technologies would focus on technologies appropriate for seismic connections, and those allowing production of a completely precast building. In addition, new joining concepts will be investigated, and the incorporation of robotics both in the plant and on the jobsite will be considered. All of these topics are intended to help make the precast industry more competitive with both the steel industry (with its ease and speed of erection), and the concrete industry with the economics of the materials involved.

Dapped End Connections The current focus of the ATLSS program is the study of dapped end connections. This connection type was chosen specifically because significant research and testing work had already been completed by Dr. Mattock at the University of Washington (Ref. 3). The analytical model developed for this (and other) connection types was developed by Dr. Mueller. During the time that the Lehigh group was working on the analytical model, EHI was collecting information from fabricators across the U.S. regarding performance, ease of fabrication, and constructibility of several different types of dapped end connections. A survey was sent to representatives from each of PCI's geographic zones for their comments about five different connections tested by Dr. Mattock. Figure 1 shows three alternate connections also included in the survey for comments.

Prior to the work described in this paper, ACI Committee 445 had codified the truss model for use in shear and torsion design of concrete members, especially in connection regions. However, the revised Chapter 11 of the ACI code will not be published until the 1992 edition. This will allow the precast concrete industry, in conjunction with ATLSS, to develop design guidelines and sample designs to help the structural designer apply the provisions of the new code. These design procedures will be distributed through the PCI membership to designers and fabricators, before the new code is published. The comments already collected from industry representative fabricators will be taken into account when the design procedures are developed, in order to present a design model that is consistent with the analytical model and is still economical to design and fabricate. This may prove to need additional testing past that done and reported by Dr. Mattock.

Other Connections Study of other connection types has recently been started. EHI has compiled a list of connector types that may need further study. A second fabricator survey is being prepared requesting fabricator input regarding research priority, current details in use, and industry needs regarding these or other connector types. Once the results of this survey have been compiled, prioritized industry needs will be discussed with Lehigh to determine the direction of further research that is compatible with industry needs, research direction and analytical models currently being developed.

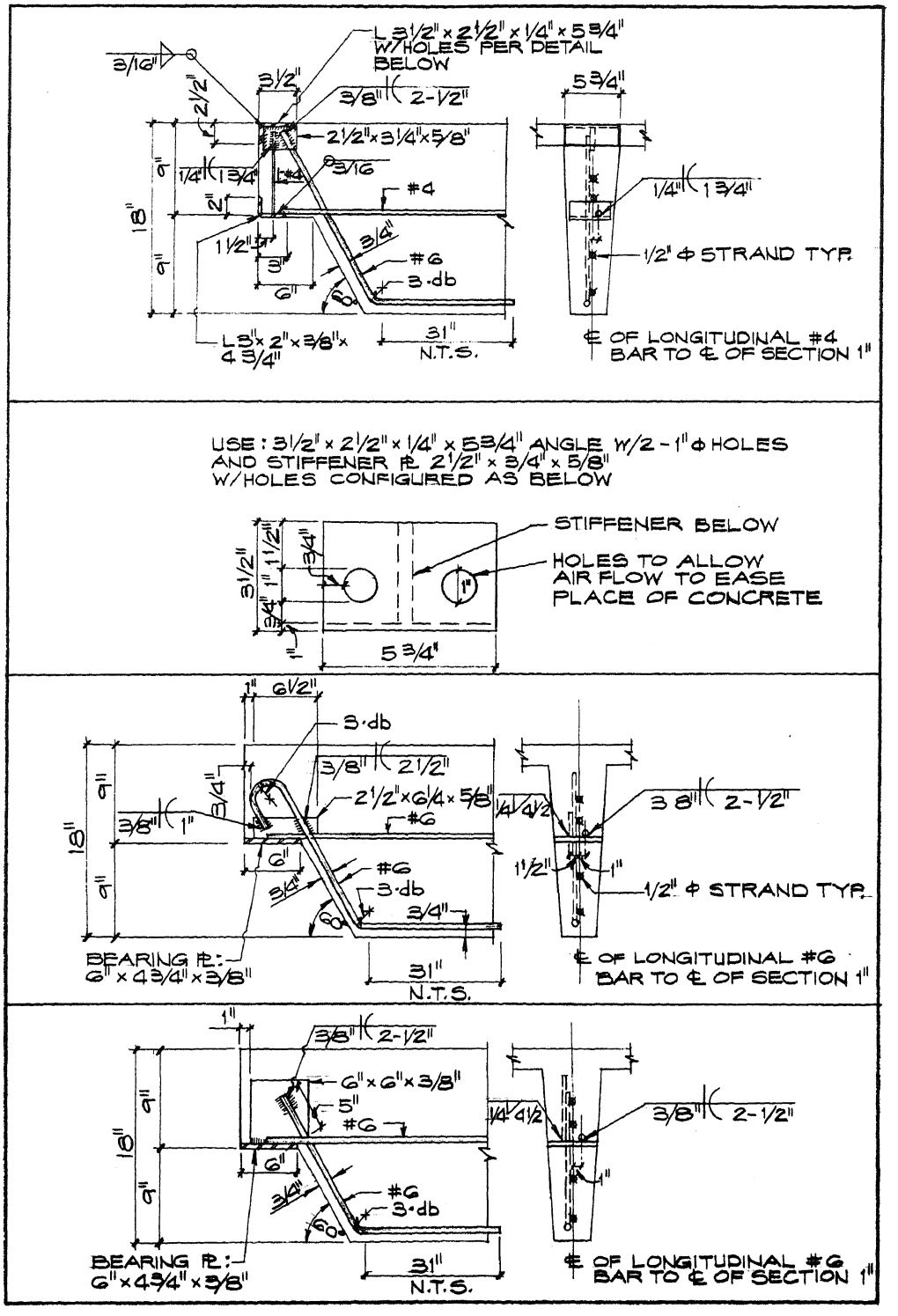


Figure 1 Dapped End Survey Alternates

NBS/FRAME

The NBS/Frame project is a test program intended to develop technical data necessary to formulate rational and consistent design provisions for precast concrete frame structures. This will be a five year project which will also help the precast industry be more competitive in the seismic zones of the U.S.

NBS Structural Evaluation Group Leader, Dr. H. S. Lew and Principal Investigator, Dr. Geraldine Cheok, have selected an advisory committee to provide industry and designer input to the test program. With the committee's guidance, the tentative test program is a follows:

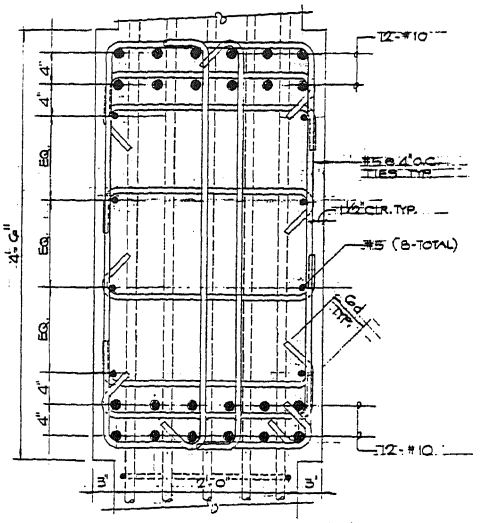
Fiscal Year 1988	Test two c.i.p. connections (zone 4)
Fiscal Year 1989	Test two c.i.p. connections (zone 2) Test three post tensioned-precast connections Interim Report
Fiscal Year 1990	Test different tendon arrangements Move hinge away from joint Welded connections
Fiscal Year 1991	Lightweight Aggregates
Fiscal Year 1992	Design guidelines

Currently, the zone 4 connection design is complete, and the test specimens are being constructed. Ductile frames were designed for a theoretical 15 story building. The joint being investigated is an interior joint from the third floor beam (see Figure 2), with a design moment capacity of 1700 Kip-ft, and an estimated yield strength of 2300 Kip-ft (at 75 Ksi). The actual test specimen will be reduced to 1/3 scale for testing. The beam, column and joint have been designed to meet the requirements of the 1985 Uniform Building Code, and detailed consistent with current design practice. The test criteria will be similar to that used for testing ductile frame connections in New Zealand with respect to number of cycles and ductility demand per cycle. The zone 2 design is in progress, and these connections should be tested during the next fiscal year.

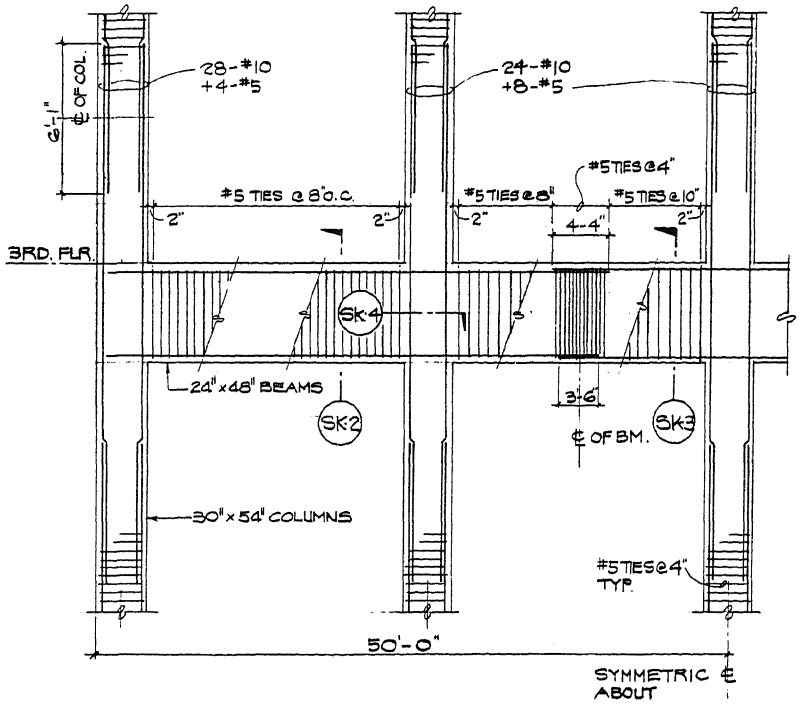
Once these tests are complete, they will be used to characterize joint behavior for cast in place ductile concrete joints. The advisory committee is of the opinion that the most feasible type of connection for precast concrete frames would be one using post-tensioned tendons. Therefore, post tensioned connection designs will be developed and tested during 1989. The tested behavior will then be compared to the cast-in-place connections, and an interim report published.

Depending on the results from the first two years of testing, other tendon arrangements or hinge locations may be investigated. In addition, ductile frame connections incorporating welded connections may also be tested. Lightweight aggregates may also be studied to determine any effect on the behavior of these types of connections.

As a final goal, the program will develop design and testing guidelines so that different types of precast connections can be used in seismic zones. Then any frame connections could be analyzed or tested with specific criteria used to determine acceptable performance.



INTERIOR COLUMN (2'-6"×4'-6") BAR LAYOUT SK-4



PARTIAL FRAME ELEVATION @ 3RD. FLR.
NO SCALE

Fig. 2 Interior Joint

ACKNOWLEDGMENTS

As an industry coordinator, EHI plays a minor role in the actual research conducted. Without the efforts of Dr. Peter Mueller and his graduate student, John Pensiero, at Lehigh University, there would be no precast connection program at ATLSS for PCI to be involved with. The authors express their thanks to PCI and PCMAC for their support and the members of the PCI/ATLSS steering committee for their direction. The help of Dr. Geraldine Cheok at NBS is also gratefully acknowledged.

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