CURRENT U.S. PRECAST-PRESTRESSED CONCRETE RESEARCH PROGRAMS

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OVERVIEW

Currently there are four coordinated research programs in the U.S.A. concerned with the development of new precast-prestressed concrete technology. Those programs are: (1) the Precast Seismic Structural Systems (PRESSS) program; (2) the Repair and Rehabilitation (REPRR) program; (3) the Advanced Technology for Large Structural Systems (ATLSS); and (4) the Precast/Prestressed Concrete Institute's (PCI's) Research Fellowship program. The first three programs are sponsored primarily by the U.S. National Science Foundation (NFS), with limited additional support from PCI for projects (1) and (3). Project (4) is funded primarily by PCI with recipients also expected to raise money locally. In addition to these four national programs, there is also a National Institute of Standards and Technology (NIST) program on post-tensioned connections for precast concrete frames for seismic zones and a Federal Highway Administration program on concrete bridge research.

PRESSS This program (1, 2, 3) is now in the second year of a seven year plan. The program has two basic aims: (1) the development, based on fundamental experimental information, of comprehensive and rational design recommendations, for precast concrete building systems, and (2) the development of new materials, concepts and technologies for precast-prestressed concrete construction. In the current two and one half year long Phase I there are four research projects: concept development; connection classification and modeling; analytical platform; and design recommendations. The PRESSS program is a joint U. S.–Japan program and there is close coordination between research teams in the two nations on concept development and connection classification and modeling. Recently NSF requested proposals for Phase II work to start early in 1992. That phase involves physical testing to: 1) determine the performance of precast ductile frame subassemblages (frame PRESSS); 2) precast panel systems (panel PRESSS); prototype cladding or similar systems (mixed PRESSS), with all three of those projects involving pseudo-dynamic reversed cyclic loading of half scale or larger specimens; and 4) dynamic response tests of small scale versions of those same three systems.

Early this year two-day workshops on the concept development and connection classification and modeling projects of Phase I were held at four different locations throughout the U.S.A. (4). Those workshops involved researchers, producers, designers and contractors and as a result the PRESSS project now focuses on three prototype structures, a 15 story building for Seismic Zone

4, and 15 and 5 story buildings for Seismic Zone 2. The former structure permits comparison with Japanese results while the latter structures are more representative of the largest markets for precast buildings in the U.S.A. For the U.S.A. it is becoming increasingly clear that, for dry joint construction, post-tensioning will be needed for assembly of precast units in Zone 4 but not in Zone 2.

REPRR The program is now in the second year of a seven year plan (5). Of particular interest for precast concrete construction is the work on tilt-up construction, a precast concrete wall system with a wooden roof, that is widely used for warehouses, manufacturing concerns, and shopping malls in the U.S.A. Some of those systems have performed relatively poorly in earthquakes in the last two decades and many design changes have been made in panel to panel connections, panel to floor, and panel to roof connections in an effort to improve that performance. The program on tilt-up construction will extend over three years and involve both analytical studies and physical experiments on typical connections as constructed, and connections retrofitted to improve their seismic performance. One of the main concerns in this study is the development of connections which can perform adequately for the temperature range of almost 80°C encountered in central U.S.A., and still be able to function satisfactorily after construction. This temperature range directly impacts the panel to panel connections that form the perimenter tie and the use of post-tensioning for that tie is one option to be evaluated.

ATLSS This program, at LeHigh University, is built around four activity clusters: 1) materials, connections and processes; 2) sensing and infrastructure assessment; 3) design and construction information systems; and 4) integrated building systems. Each cluster contains between five and nine projects which follow the large structure life-cycle processes of experimentation, design, fabrication and construction, and finally operation. In the first cluster there is a project "Unified Design Methodology and Rational Models for Precast Concrete Connections." The objective is to develop a consistent design methodology, based on rational models, that will encourage the creation of new connection types and hardware that allow for more automated fabrication and erection. To date truss models and failure mechanisms have been developed analytically for typical precast connections (6) and a pilot physical test program planned. This project is linked to the "Automated Construction Systems" and "ATLSS Connections and Structural Systems" projects. Both tose projects are in the fourth cluster. Included in the objective of the latter is the development of a precast connection that is ductile with little or no field welding and incorporation of that connection into an innovative seismic-resistant building system. In the past year passage-type (splice sleeve) interior joint concepts have been developed, analyzed in detail and pilot tests conducted on three simulated joints (7). The former project focuses on the erection of members on site and the handling of materials on site, including material ordering and inventory management, and the generation of an as-built database. It is anticipated that project will identify the basic methodologies needed for productivity improvements in the erection process. To date the project has focused on steel systems but in the future will also include precast systems.

PCI Each year the PCI Research Committee identifies approximately six high priority research topics for which member companies would like information. Most of those projects are directed primarily at building construction. Topics of the last five years have included; minimum prestress level for prestressed concrete columns; diaphragm action of hollow-core slab systems under lateral load; design of moment resistant beam-column connections; performance of stud groups loaded in shear and torsion; Kevlar prestressing of concrete (8); behavior of composite panels; effect of temperature on bond strength of epoxy coated prestressing strand; horizontal shear strength of machine-cast slab and C.I.P. topping; precast concrete shear wall connections; development of a standard test for bond characteristics of epoxy coated and uncoated prestressing strand; prestressed double tee slab bridge decks; and stress-strain and shrinkage properties of high strength silica fume concrete.

NIST This work involves performance testing of 1/3rd scale model precast concrete beam-column connections (9, 10). The results suggest that grouted post-tensioned beam to column connections, particularly those of a dog-bone form, can provide adequate absorption and dissipation capacities. A structure built with such connections, and adequate precautions, can be expected to show a seismic performance that compares favorably with an equivalent monolithic concrete frame built to ACI 318 Appendix A provisions.

FHWA Each year FHWA produces a ranked list of research topics it wishes to see investigated by State Highway Departments with Highway Research Program funds, or if no state wishes to undertake that work, using its own funds. The highest priority projects at present are those concerning seismic vulnerability assessment and seismic retrofit, and those concerning condition assessment and durability evaluation. Prestressed related projects of high priority within those two groups are the development of improved equipment for detection of the condition of strands, reinforcing bars and stay cables.

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