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Ledge Punching Shear Advisory

A recently completed PCI-sponsored research project concerned with torsion design of load-bearing spandrel beams was conducted at North Carolina State University (NCSSU) under the direction of professors Sami Rizkalla and Paul Zia. Full-scale spandrels were tested as a part of the experimental portion of this project. In three instances, ledge punching shear failures occurred, each at test loads substantially less than the nominal strength calculated by the current (seventh edition) *PCI Design Handbook: Precast and Prestressed Concrete* Eq. (5-44) through (5-47). Because it was outside the scope of the project, specific modifications to existing design recommendations that address these failures were not developed by the researchers. Concerns regarding these ledge failures have prompted reexamination of the report from a specially funded research project completed in 1985 and titled *Design of Spandrel Beams*, which was prepared by Wiss, Janney, Elstner Associates (WJE). While not the focus of the research, two ledge punching shear failures at loads less than calculated were observed during the course of that project as well. For that project, funding limitations also prevented development of appropriate modifications to the design procedures.

The problem identified was that the observed failures occurred at loads less than the capacity calculated by the *PCI Design Handbook* equations. Common current applications for spandrel beams typically involve full service loads that induce ledge loading demands substantially less than the punching shear capacity provided by the concrete alone as currently calculated. The trend over recent years has been to produce wider double tees; widths have increased from 8 ft (2.4 m) to 10 ft (3.0 m) to 12 ft (3.7 m) and even 15 ft (4.6 m). Also, as green roofs and mixed occupancies are becoming more popular, significantly heavier stem loads are being encountered. The PCI Technical Activities Council wants to highlight these findings for the industry. A research project has been created and awarded to develop more accurate design procedures through analysis and testing. However, it will be about two years before the work can be completed.

In the interim, it is recommended that heavy stem loads on spandrel ledges be carefully considered. Because the extent of the problem is presently not well understood, it is suggested that the NCSU and WJE research reports be used as guidance for specific conditions that you may encounter. For your convenience, the full reports have been loaded on the PCI website; the reports may be accessed at www.pci.org/research/.

It should be pointed out that the NCSU project, which imparted heavy loads on the ledge to adequately test the spandrels, used some armored ledges to enhance punching shear capacity. The concept is illustrated in the research report. Should you find a situation in which additional capacity would be prudent, it is recommended that something similar to these armoring details be used.

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