Concrete Q&A

Checking Punching Shear Strength by the ACI Code

Q. *With the advent and popularity of finite element analysis software, engineers can create sophisticated mathematical models of two-way slabs supported by columns. To comply with ACI 318-05,[1] should a designer check punching shear stress with the simultaneous biaxial moments reported by such a model?*

A. The equations for checking combined transfer of shear and moment at slab-column connections are found in Section 11.12.6 of ACI 318-05 and were originally published over 30 years ago. These equations were derived assuming the transfer of moment from one principal direction at a time. For typical building applications, this is the common approach, and it is not considered to be necessary to check biaxial moments with these equations. Some textbooks and design guidelines suggest that designers apply moments from both principal directions simultaneously when making this shear stress check. However, this approach would calculate a point of maximum stress at the corner of the critical section, while the Code requirements only provide shear strength limits for total force over a defined cross-section.

Thus, in normal practice, structural engineers typically check the maximum shear stress on the perimeter of the critical section due to the transfer of shear and moment in only one direction at a time. Of course, this check needs to be made in both orthogonal principal directions for which moment is transferred to the connection. The shear force to be considered would be from the full dead load and appropriately reduced live load acting on the tributary area for the column. The fraction of the unbalanced moment to be transferred from the slab to the column by eccentric shear stress is defined in Section 13.5.3, and may be reduced as allowed in 13.5.3.3.

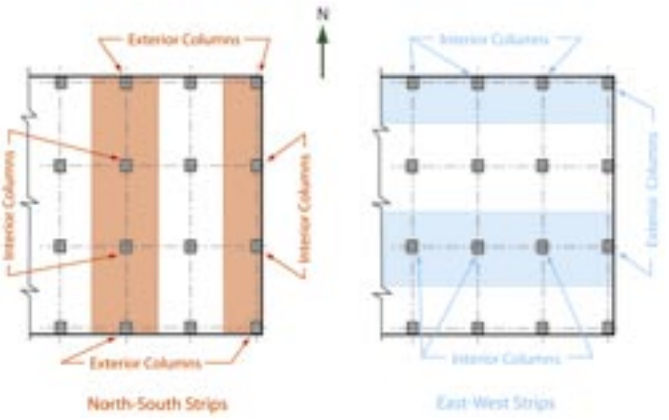

Fig. 1: Definition of interior and exterior columns for (a) north-south strips and (b) east-west strips. Note that the definition can change for columns along the edge of the structure depending on which frame and direction is being considered

When using the equivalent frame method or another stiffness-based analysis method, the moments transferred from the slab to the columns should be calculated using a live load pattern equivalent to that used in the direct design method to develop Eq. (13-7). Thus, for the interior columns shown in Fig. 1, half of the reduced live load would be applied to the longer adjacent span and no live load would be applied to the shorter adjacent span. At an exterior column (Fig. 1), the moment transferred from the slab to the column should be determined by applying half of the live load to the exterior span adjacent to the connection.

When using the direct design method, the gravity load moment transferred from the slab to the interior columns is defined by Eq. (13-7). At exterior columns, the gravity load moment to be transferred from the slab to the column is defined in Section 13.6.3.6.

References

1. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-05) and Commentary (318R-05)," American Concrete Institute, Farmington Hills, MI, 2005, 430 pp.

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