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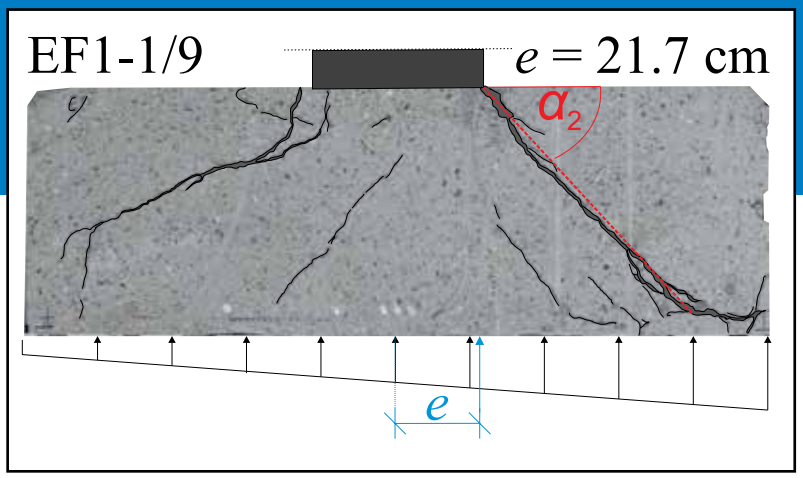

Punching Shear of Concrete Slabs: Insights from New Materials, Tests, and Analysis Methods

SP-357

Editors:
Aikaterini Genikomsou, Trevor Hrynyk,
and Eva Lantsoght

American Concrete Institute
Always advancing

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The design, analysis, and performance of structural concrete slabs under punching shear loading conditions are topics that have been studied extensively over many decades and are well documented in the literature. However, the majority of the work reported in these areas is generally related to conventional concrete slabs subjected to highly idealized loading conditions.

Structural engineers need to find new, innovative ways and methods to design new structures but also to strengthen existing infrastructure to ensure safety, resilience, and sustainability. These challenges can be addressed through the use of integrated systems and high-performance technologically advanced materials. We live in a new era of improved computational capabilities, advances in high-performance computing, numerical and experimental methods, and data-driven techniques, which give us broader access to larger and better data sets and analysis tools. These new advancements are essential to develop deeper insights into the structural behavior of concrete slabs under punching shear and to implement and analyze new materials and loading conditions.

This Special Publication presents recent punching shear research and insights relating to topics that have historically received less attention in the literature and/or are absent from existing codified design procedures. Topics addressed include: the usage and impacts of alternative/modern construction materials (new concrete and concrete-like materials, nonmetallic reinforcement systems, and combinations thereof) on slab punching shear resistance, novel shear reinforcement or strengthening systems, the influence of highly irregular/nonuniform loading and support conditions on slab punching shear, impact loading, new design and analysis techniques, and the study of the punching shear behavior of footings.

This Special Publication will be of interest to designers who are often faced with punching-related design requirements that fall outside of traditional research areas and existing code provisions, as well as for researchers who are performing research in related areas.

Perspectives from a broad and international group of authors are included in this Special Publication, relating to a variety of punching-related problems that occur in research and practice. In particular, researchers from the United States, Canada, Ecuador, the Netherlands, Italy, Brazil, Israel, Portugal, Spain, the United Arab Emirates, and Germany contributed to the articles in this Special Publications.

To exchange views on the new materials, tests, and analysis methods related to punching, Joint ASCE-ACI Committee 421, “Design of Reinforced Concrete Slabs;” Joint ASCE-ACI Committee 445, “Shear and Torsion;” and subcommittee ACI 445-C, “Punching Shear,” organized two sessions titled “Punching shear of concrete slabs: insights from new materials, tests, and analysis methods” at the ACI Spring Convention 2023 in San Francisco, CA. This Special Publication contains several technical papers from experts who presented their work at these sessions, in addition to papers submitted for publication only.

Co-editors Dr. Katerina Genikomsou, Dr. Trevor Hrynyk, and Dr. Eva Lantsoght are grateful for the contributions of the authors and sincerely value the time and effort of the authors in preparing the papers in this volume, as well as of the reviewers of the manuscripts.

Aikaterini Genikomsou, Trevor Hrynyk, and Eva Lantsoght
Co-editors

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EFFECT OF THE SHEAR REINFORCEMENT ANCHORAGE AND DETAILING ON THE PUNCHING RESISTANCE OF FLAT SLABS

Guilherme S. Melo, Maurício P. Ferreira, Marcos H. Oliveira, Henrique J. Lima, Manoel M. Pereira-Filho, Victor H. Oliveira, João P. Siqueira and Rodolfo Palhares

Synopsis: Flat slabs with shear reinforcement not properly detailed and anchored as stated by ACI have been used in practice due to simplicity and the gained construction speed. This paper presents the results of 12 tests on slab-column connections with closed stirrups with anchorage variation and prefabricated truss bars as punching shear reinforcement. The behavior of the slabs, in terms of cracking pattern, displacements, and shear reinforcement strains, were analyzed, and ultimate loads were compared with estimations by ACI 318-19. Comparisons with the reference slabs without shear reinforcement showed that these two types of shear reinforcement effectively increased the load-carrying capacity of the tested slabs. For tests on slabs with closed stirrups, it was observed that if ACI detailing rules are followed, improvements in response and ductility of the slab-column connections should be expected. In the case of the slabs with prefabricated truss bars, it was observed that they were able to reach levels of punching shear resistance close to those of a reference slab with well-anchored stud rails. In both cases, further experimental research is needed. ACI 318-19 presented safe strength predictions for the different types of shear reinforcement tested, and in the case of the prefabricated truss bars, this was due to the conservative limitations imposed for calculating the crushing strength of the concrete strut close to the column.

Keywords: Closed stirrups, Experimental analysis, Flat slabs, Punching shear results, Prefabricated truss bars, Shear reinforcement, Shear reinforcement anchorage, Stud rail.