

BCA-NTU research on Irregular Flat Plate Structures

In the past several years, the BCA and NTU have been jointly doing research on flat plate floor or flat plate building system. The flat plate construction has been known to result in more economical buildings with high degree of buildability. The use of flat-plate construction leads to simple formwork and facilitates simple arrangement of electrical & mechanical systems. Thus, the resulting building will be technology-friendly and conducive to modern design concepts. Compared to a typical beam-slab system, the flat plate system should be able to save structural costs by about 20%.

The joint BCA-NTU research on Flat-Plate Structures has been a pioneering research endeavour since beginning. The research results form significant contributions to the body of knowledge in concrete structures. The overall research is divided into three phases.



The Phase 1 research was started in July 1998 and it was completed in June 1999. The purpose was to investigate the punching shear strength of slabs with opening and supported on rectangular columns. Inputs from a number of local professionals were taken into consideration in planning for the research programme. Twenty slab specimens had been tested. The specimens were based on structural details used in local high-rise residential buildings. The resulting design recommendations had been published in international technical journals and they have also been disseminated locally through conferences and short courses.



The research was then continued with the Phase 2, involving the testing of 7-column and 14-column irregular flat plate floor specimens. In the last few years, irregular flat plate floors are commonly used in high-rise residential buildings in Singapore. Architectural shapes, interior layouts, and requirements often dictate the use of a flat plate floors with irregular column layout. However, the currently available building codes do not provide specific guidelines for designing an irregular flat plate floor or building. So, the purpose of the Phase 2 research was to investigate the moment distribution in irregular floor slabs as compared with finite element computations and to come up with recommendations for designing irregular flat plate floors. The results of the research have also been disseminated to local engineers through short courses and conferences at the Construction Industry Training Institute of BCA.



With the success and completion of the Phase 2 programme, the research was continued with the Phase 3 research. In this phase, a closer look at the behaviour of the slab-column connections was conducted. In a flat plate building, the joints or the slab-column connections represent weak points. Even though the joints will not be designed to be earthquake resistant (the shear walls will be the main lateral load resisting members), they should at least be able to withstand story drift ratio of at least 1.5%, which may be generated by strong wind or minor earthquake forces. So, Phase 3 research involves the testing of a number of full-scale slab-column connections with irregular slab geometry subjected to static as well as cyclic lateral loading. The behavior of the slab-column connections subjected to gravity shear as well as biaxial unbalanced moments were investigated in details. Also included in the Phase 3 study are the following: behaviour of interior, edge, and corner connections with various slab geometry, with and without slab openings under various load combinations; effects of different slab thickness framing into a joint on punching strength; connections with flat-bottom surface (with varying slab thicknesses) as well as those with varying bottom surface elevation (with constant slab thickness); design and detailing of shear reinforcement for punching shear, including the effectiveness of several commonly used shear reinforcements, etc. The results of Phase 3 and previous research are also being disseminated in timely manner.

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