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Study on a Frame System with Composite Slim Floors

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Abstract

Building frame systems based on the slim floor construction have recently gained increasing success especially in the Northern and Western Europe. Slim floor construction is competetive with conventional construction based upon reinforced concrete and composite beam solutions when savings in fire protection, cladding costs and ease integration of services are taken into account. An extensive research project has been conducted in the Laboratory of Steel Structures at Helsinki University of Technology to investigate and improve the existing methods in the slim floor design and construction. By combining the results of the structural detailing and the frame overall assembly studies, this research will establish a basis for developing a structurally competetive and cost-effective steel-concrete composite slim floor frame system and ensures an optimized quality for both the design and construction of the frame system.

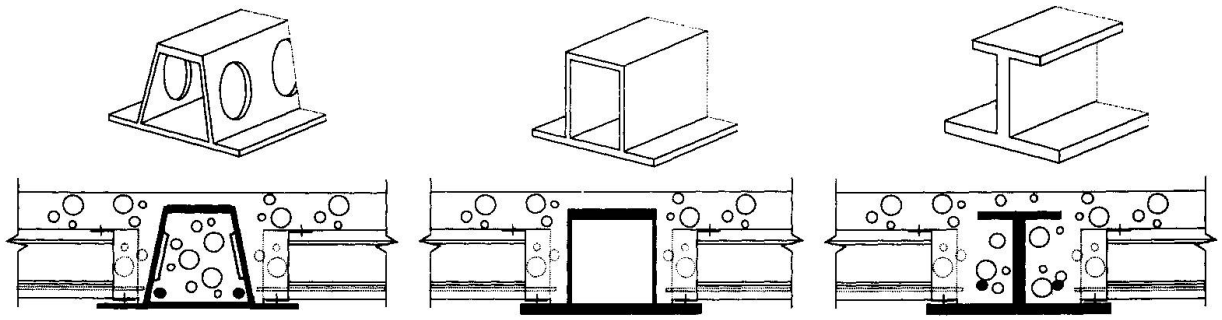
Nowadays, greater flexibility and open-planning in building layout are required and there is a strong demand for longer column-free floor spans. Due to the small structural depth of a slim floor, special attention should be paid in the design to increase the overall flexural stiffness of the floor. Traditional simplified floor design approaches, based on pinned or rigid connections, can not lead to the most economical solutions. Especially in the slim floor construction, it is important to connect the floor rigid or semi-rigid to the columns in order to get higher stiffness and strength, and higher lowest natural frequency for the floor. The partial continuity provided by multi-span continuous structures and semi-rigid beam-to-column connections is an important factor affecting the floor performance and allowing significant reductions in the floor depth, permitting shallower and lighter beams and reducing the overall cost of the floor system. Lot of research has been done and many national standards and design recommendations have been published recently on the slim floor design and construction. To establish a basis for the design and further development of the slim floor construction, this research project at Helsinki University of Technology is started.

In the slim floor construction, the beams are contained within the depth of the concrete of the slab and the concrete is cast to fill the voids around the steel beams in order to increase the fire resistance, the sound insulation and the strength and the stiffness of the beams. In this research, the capacities of the most common slim floor beam sections are analysed and compared. Calculations are carried out for single-span, two-span continuous and single-span precambered beams in order to find out the maximum floor spans and the critical design conditions for the slim floor beam.

In practice, the reinforcement in a concrete slab contributes to the resistance and the stiffness of the beam-to-column connection and the majority of the connections may be considered as semi-

rigid with a partial resistance. The modelling of connections as semi-rigid is more realistic and it utilizes the semi-continuity between the members of a frame offering a potential for significant benefits. Satisfactory prediction models are currently proposed covering the most popular connection forms in conventional composite frames and manuals including tabulated connection capacities for standard connections are prepared for designers. For slim floor systems, the application rules available are very few in number and further research is required in order to realise the benefits of the semi-continuity also in the design of composite slim floor frames. Ongoing extensive research project at Helsinki University of Technology focuses on the behaviour of the semi-rigid connections in a frame system consisting of slim floor elements. At present, the beam to I-shape steel column connections are widely studied internationally. A new technology is necessary to connect the slim floors to the tubular composite columns and the methods approximating the moment-rotation (M-ϕ) curve of the connection for this type of connection should be created. The experimental part of the research project, including full-scale beam-to-column connection tests for a slim floor subframe will be carried out by spring 1999.

The main objective of this study was to analyse both experimentally and theoretically the behaviour of the low-rise composite slim floor frames and to develop a structurally efficient frame system with a high construction quality. The influence of the new stricter requirements for the fire and sound insulations in the building frame is studied and applied for the slim floor structures. To achieve long column-free floor spans, the continuity of the beam connections is to be taken into account in the frame design. Final results of this research project for developing a new slim floor frame system will be collected and analysed after the extensive full-scale testing on the frame system.



a) Delta-beam b) HQ- or Closed top-hat beam c) Asymmetric I-beam

Fig. 1 Slim floor beam sections.

Keywords: Composite construction; steel-concrete; slim floor; frame; semi-rigid connection