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The structural behaviour of a composite timber and concrete floor system incorporating steel decking as permanent formwork

SUMMARY

Timber and concrete composite construction facilitates the use of timber, but with improved structural efficiency and increased thermal mass. In this study, a novel composite system is investigated through experiments, analytical methods and finite element analysis. The composite system consists of a concrete slab, cast on profiled steel decking, acting compositely with glue-laminated timber beams. Composite action is achieved with coach screw shear connectors between the beams and slab. The connectors have been tested in "push-out" shear tests, and a three-point bend test of a full-scale composite floor slab has been completed.

A total of 18 short-term push-out shear tests were carried out on various shear connections. Preliminary tests showed that coach screws were the preferred connectors for the composite system investigated. Subsequent tests were carried out with coach screw shear connectors inserted into the timber beam at various angles of inclination to the vertical. It has been shown analytically that the stiffness and ultimate strength of vertically inserted shear connectors increase with increasing depth of penetration into the timber. However, a plateau is attained, beyond which there is no further gain in stiffness or strength with deeper penetration into the timber. The push-out shear tests show that further increases the stiffness and strength of the connection can be attained by inserting the screw at an angle to the vertical. An angle of inclination of 30° to the vertical was found to be an optimum for strength. Inserting the screws at this angle was found to give a connection that is 42% stiffer and 38% stronger than that obtained if the screws are inserted vertically.

Two tests were long-term push-out shear tests. One was carried out on a specimen connected with vertical screws and the other with screws inclined at 30° to the vertical. These showed that, under a constant load of 27% of the ultimate strength of each shear connection system, the additional slip due to creep after a period of about 6 months was only 0.2mm (for both connections). The ultimate strength and the initial stiffness of the load/connector slip response were found to be unaffected by the sustained loading.

An analytical model based on plasticity theory has been developed to predict the strength of inclined screw shear connectors in composite timber and concrete floors. The model gives conservative predictions of the shear capacity of the connections at yield. At the ultimate load, the predictions were even more conservative because a significant change in geometry occurs to the connections. It is shown that if this is taken into account inter-member friction accounts for the high ultimate strength. It was observed experimentally that if screws are displaced laterally, the withdrawal strength reduces with increasing lateral displacement. However, the prediction model shows that the effect of this on the strength of the connection is not significant.

A full scale composite floor was tested with the vertically inserted shear connectors and was found to be more than three times as stiff and almost twice as strong as the same beam/slab configuration without composite action. However, if the shear connectors were to be inserted into the timber at 30° to the vertical then the stiffness and ultimate strength of the floor is predicted to be about four times and two and a half times greater, respectively, than that of the non composite configuration.

Finite element models of the shear connection were much stiffer than the experiments but had a reasonable agreement with the ultimate strength. The analytical and design methods and the finite element predictions of the behaviour of the composite floor show good correlation with the experiments.