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Timber-Concrete Composite Structures

Structures mixtes bois et béton

Holz-Beton Verbundkonstruktionen

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SUMMARY

Two timber concrete composite structures, TP-slab and BP-slab, developed by the author and manufactured in Finland since 1979 and 1985 will be presented. Both structures are concrete slabs with timber joists connected to concrete with nail plates. TP-slab is used mainly as a floor and PB-slab as a wall structure. The composite behavior creates a considerable increase of strength and stiffness. Also other structural benefits are gained e.g. deformation stability, dynamics, acoustics, fire and moisture resistance.

1. INTRODUCTION

Two slabs which consist of the timber joists and the concrete slab connected with nail plates is presented. The special thing lies in the nail plate connector which brings some advantages e.g. allows a gap between the joist and the concrete. Further, the nail plate has turned out to be a reliable connector with a low ratio of prize/stiffness and prize/strength.

Many other similar slabs have been developed with different connection means e.g. nail, stable, bolt, steel rod, friction (caused by grooving the joist edge). These timber concrete composite slabs have been studied in Lund, Sweden; Luleå, Sweden; Lodz, Poland; Krakow, Poland; Hildesheim, Germany; Lausanne, Switzerland; Florence, Italy.

2. PB-SLAB

PB-slab is manufactured in a prefabricated element plant on a horizontal mold, fig. 1. The joists will be located 600...1200 mm apart. PB-slab is mainly used as a wall element of 1 or 2 store dwelling or hall type buildings. Figure 5 shows a typical wall cross section. The building has usually a trussed rafter roof. The trusses are supported directly on the concrete slab and the forces are transported to foundation in the concrete. The joists make the buckling support and resist the moment due to wind load. The joist are cut ≈30 mm above the ground floor level, so the contact between timber-concrete and also timber-humid air is eliminated. According to analysis and test a wall like this carries a very high compression force.

3. TP-SLAB

TP-slab is a floor structure, fig. 2, 3. Concrete is on the upper side and it will be cast on site. Concrete casting is made on 0.4 mm noncorrugated, membrane behaving steel sheet which also works as a reinforcement, no other reinforcement is usually used. The concrete can be liquid, selflevelling type and as thin as 25 mm. However, 50 mm standard concrete is mainly used and recommended due to dynamics and acoustics. The steel sheet is punched 12 mm into the nail plates. This is made with a lath and a mallet or with an especially developed machine. The nail plates connect the joists to the concrete and also the steel sheet to the concrete. Before the concrete will be cast the steel sheet can be used as a working platform. While the concrete is cast a temporary support is used at the middle of the span. This support is utilized to get a camber of appr. span/500...1000.

4. NAIL PLATE

The nail plate has especially been developed for the purpose, fig. 4. To increase the strength of the plate spikes are not punched on the gap area, further this part of the plate is slightly corrugated. The spikes which are cast into concrete have anchoring barbs to ensure the connection. The nail plates are usually pressed only on the other side of the joist, in cases where high strength or stiffness is needed double plates are used. The nail plate is strong enough to allow a gap of ...50 mm between the joist and the concrete.

5. DESIGN METHOD

At present the design is based on a finite element vierendel model with a semirigid connection between the nail plate and the joist. The constraint forces due to concrete shrinkage, temperature and moisture deformation are either neglected (assumed to be included safety factor because these forces are small in controlled climate conditions) or assumed to be ±0.02% which is added to all other loads.

6. EXPERIENCE

The main idea in developing the PB-slab and the TP-slab was to utilize the composite behavior of the joist and the concrete. The benefit due to composite action is significant because the I-cross-section of the joist is changed to T-cross-section and in a typical case strength is increased 2...3-times and stiffness 5...10-times compared to noncomposite behavior. However, these slabs have turned out to have many other properties which in many cases are more important. E.g. concrete is fire resistant, water tight, deformation stabile, acoustically and dynamically well behaving, the thermal insulation is got easily by having the insulation between the joists, the piping and the wiring may be set between the joists, the sheeting may be nailed or screwed directly to joists. The structure is light enough to have similar structural details as other light weight structures but it still has most of the benefits of heavy structures e.t.c.

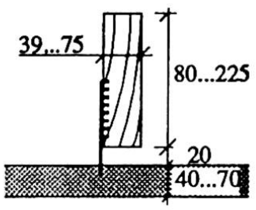

Fig 1, PB-slab

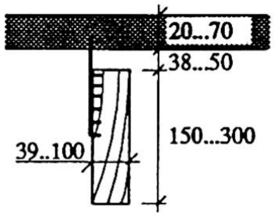

Fig 2, TP-slab

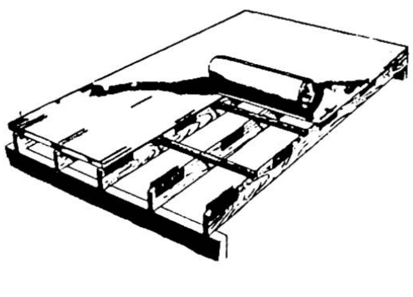

Fig 3, Principle of TP-slab

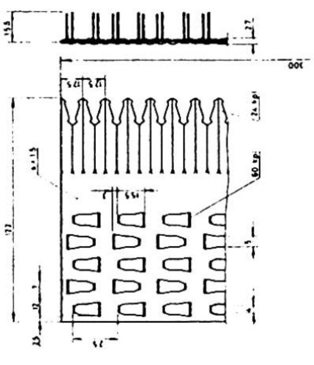

Fig 4, Nail plate

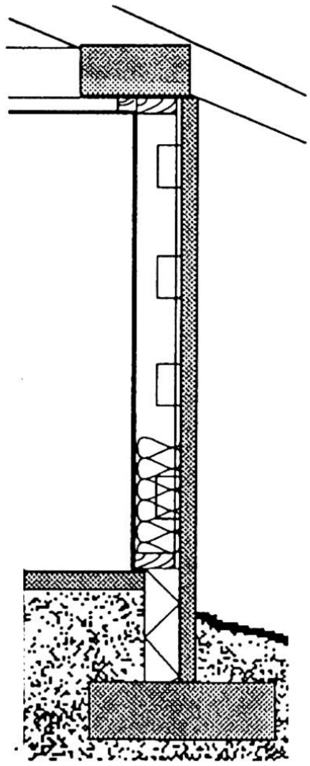

Fig 5, PB-slab-wall