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Construction and Design of Composite Concrete - Timber Floors

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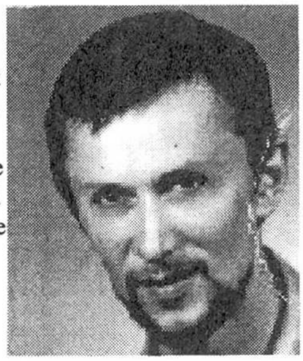

Summary

The concrete-timber floor consists of timber joists connected with concrete slab by means of mechanical connectors. The concrete-timber technic is specially predestinated for rehabilitation of timber floors in old buildings. In comparision to timber floor double load bearing capacity and triple stiffness may be expected on an average. An overall stiffness of the building significantly increases, concrete slab makes the floor more resistant to fire and acoustic is improved.

1. An experiance from applications of concrete-timber technic to rehabilitation of old timber floors in Poland

In Poland concrete-timber floors were first applied in 1980 for rehabilitation of timber floors in state nursery school. Since then several other apartment and public buildings were rehabilitated. The most important element for succesfull rehabilitation of timber floor with concre-timber technic is precise assessment of timber joists for biological corrosion and material properties of timber. The best way to carry out such assessment was by total removing all floor boards and clay pugging until all floor joists were visible. The joists with damaged ends at the supports had to be reconstructed by joists nailed to the beam from both sides. The demaged ends were cut off or precisely cleaned from biological corrosion. The timber joists may also be reconstructed by channel iron steel or by so called „concrete shoe".
When the floor joists were excessively deflected, the depth of the slab over the joists were increased and additional reinforcement (loop shaped) given.
In order to decrease the biological corrosion all wooden elements were impregnated by fungicide. It was recommended to impregnate the joist ends by pouring the agent into preliminary drilled skew holes at boths ends of each joist.
Becouse the floor joists and other wooden elements are covered by concrete slab, closed space is formed and has to be ventilated. In order to make the movement of air in that closed space possible it was necessary to leave openings in concrete slab adjacent to walls at both ends in all interbeam spaces.

2. Recommendations for design

It is recommended to assume slab depth from 6 to 8 cm and the grade of concrete minimum B20. Reinforcement of the slab made of round oridinary steel diameter 6 to 8 mm should be placed in the middle of the slab depth. Main bars should be laid perpendiculary to the timber joists at spacing less than 12 cm, distributing bars at spacing less than 33 cm.

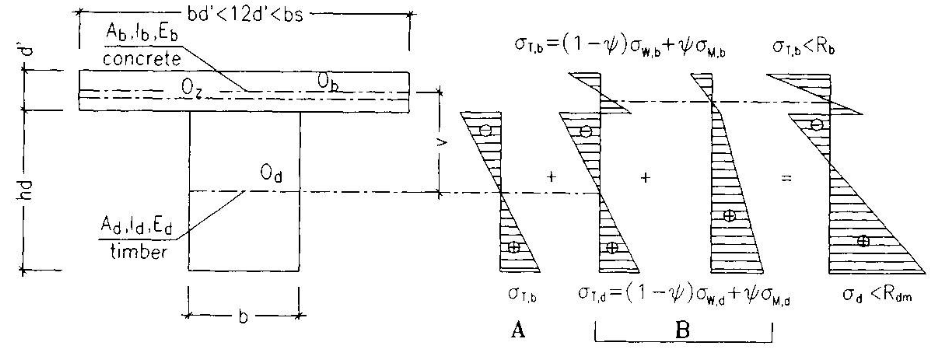

Fig. 1 The distribution of stresses in concrete slab and timber joist:
A - erection phase, B - service phase

The concrete-timber sections must be designed on the assiumption the joint at adjacent sides of joist and concrete is flexible, Fig. 1. The stress in timber joist section is calculated from equation:

$$\sigma_d = \sigma_m + \sigma_{T,d} = \sigma_m + [(1-\psi)\cdot\sigma_{W,d} + \psi\cdot\sigma_{M,d}] \quad (1)$$

where:

σ_m - the stress in the timber joist before connection with concrete slab caused by erection load (moment M_m), when the floor is supported σ_m is relatively small,

$\sigma_{T,d}$ - the stress in the timber joist after connection caused by moment $M=M_o-M_m$ calculated from the live load and part of the dead load (load of the floor layers),

$\sigma_{W,d}$ - stress in the timber joist caused by moment M in the multilayer section (C = 0),

$\sigma_{M,d}$ - stress in the timber joist caused by moment M in combined section (rigid joint, $C = \infty$),

ψ - coefficient taking into account the influence of joint flexibility on distribution of stresses in the section.

For the notations on Fig. 1 the coefficient ψ is calculated as follows:

$$\psi = 1 / (1 + \pi^2\cdot\Sigma EJ\cdot\beta / (C\cdot l^2 v^2 (1+\beta))) \quad (2)$$

$$\beta = (E_oJ_o / \Sigma EJ - 1) \quad (3)$$

where:

E_oJ_o - flexural rigidity of the combined section, [kNm^2], $\Sigma EJ = E_bJ_b + E_dJ_d$ - the sum of concrete and joist section flexural rigidities, l - calculated span, [m], C - joint flexibility modulus, [kN/m^2].

The stresses in the extreme fiber of the timber joist and concrete slab must not exceed the permissible value.

The increment of concrete-timber floor deflection over the preliminary timber floor deflection may be calculated from equation:

$$f = (1 + \varphi)\cdot f_M \quad (4)$$

where:

f_M - deflection calculated as for combined section (rigid joint, $C = \infty$),

$\varphi = (1-\psi)\cdot\beta$ - the coefficient taking into account the influence of flexibility on deflection.