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Attempt of Numerical Mapping of a Real Model of Slab-Beam Connection Using the Simplified Shell Model

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Abstract: A great advantage of computer calculations is the opportunity to map the whole floor, including the supporting beams, columns and walls, in one model, with the elements fully cooperating with one another. In this way the need for a strenuous compiling of the loads on supporting elements and independent searching for extreme values becomes eliminated. As a separate part of a floor, in this case a beam is appears occasionally. Beam mapping in a model can have various forms. The paper presents a comparison of the influence of the way in which a rib is modelled on the results of statistical calculations. As a reference point for substitute shell models a solid spatial model was adopted.

Introduction

In order to determine the most adequate way of modelling the behaviour of a beam element in a beam-and-slab floor, several different spatial floor models have been developed in a computer programme. The exemplary dimensions of a spatial model are visible in Fig. 1. The models were prepared with 8-node solid elements with the dimensions 2.0×2.0×2.0 cm. Simplified models were prepared using shell and bar elements. During the analysis the following substitute models were proposed:

1. The floor was modelled with shell elements only (Fig. 2a).
2. The floor slab was cut off the beam on the edge of the horizontal contact beneath the slab surface and connected using rigid elements fastened in the axis of the slab (modelled with shell elements) and the axis of the cut-off beam (also modelled with shell elements). It was assumed that cross dimensions if each such rigid element are 1.0×1.0 m^2 (Fig. 2b).
3. The floor slab was cut off the beam on the edge of the horizontal contact beneath the slab surface and connected using rigid elements fastened in the axis of the slab and the axis of the cut off beam, as in point no.2; however, instead of the beam modelled with shell elements, at the end of the stiff bars a bar was placed with the dimensions $\boldsymbol{b_w}\times\boldsymbol{h}$. It was assumed that cross dimensions of each such rigid element are 1.0×1.0 m^2 (Fig. 2c).
4. Along the rib axis, a bar was inserted in the slab with stiffness calculated according to the standard guideline for T-shaped cross-sections – (actual height of the rib, the cooperating slab b_{eff} width consistent with standard guidelines) (Fig. 2d).
5. The slab in the spot of the rib was thickened to ***h’***, so that it its stiffness corresponds to the stiffness calculated for the rib in point no.4 (Fig. 2e).
6. The slab was thickened in the spot of the rib in accordance with the real height of the rib (Fig. 2f).
7. The thickening was adopted as in point no.6 with the change of the material parameters, so that the flexural and torsional stiffness of the beam were compliant with the standard guidelines of the model, as in point no.4 (Fig. 2g).

During the simulation the analysis of the following parameters was conducted: the length ***l*** of the beam, the spacing ***a*** of the beams, the thickness $\boldsymbol{h_p}$ of the slab, and the height $\boldsymbol{h_b}$ of the beam.

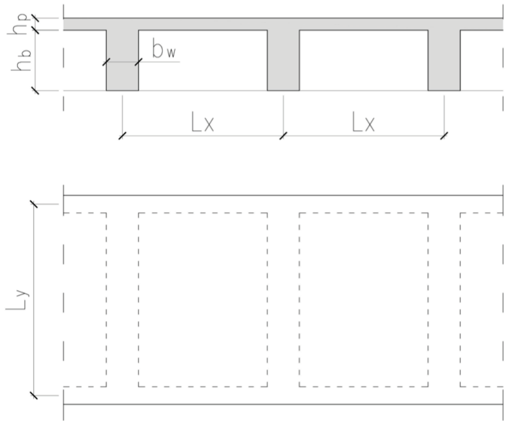

Fig.1: View of the plan and cross section in the numerical model

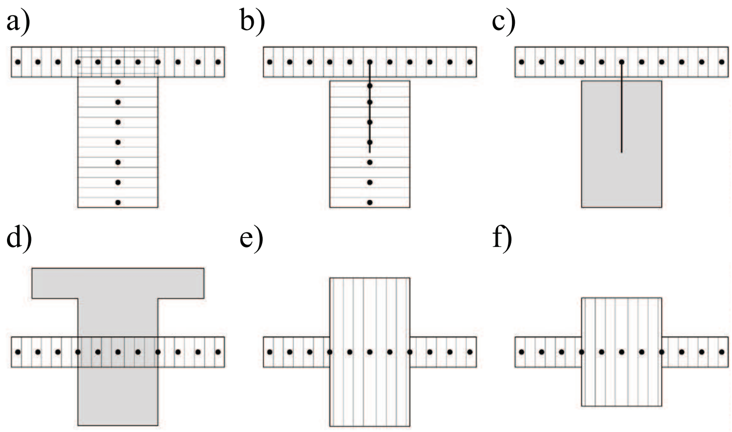

Fig. 2: Suggested simplified models

Synthesis of the results

The shell model (Fig. 2a) is a rather faithful mapping of the actual situation. What is inconsistent about the model, apart from adopting the isotropy and the linear elasticity of the material, is reciprocal overlapping of horizontal and vertical shell elements that occurs on a certain length. Due to a considerable width of the cooperating slab this impact is minor and usually neglected in calculations. The obvious advantage of approximating the beam using a bar (Fig. 2d) in the 2D floor model is faithfulness to the standard guidelines concerning the stiffness of the beam. Simultaneously, the disadvantage of this type of modelling is the impossibility to calculate the loading of the construction with its dead weight on the basis of the construction volume, as well as difficulties with taking into account the increased stiffness of the slab on the beam area. The advantage of thickening the slab to the beam dimensions (Fig. 2f) is the opportunity to directly determine the dead weight of the construction and direct stiffening of the slab above the beam. The indisputable disadvantage lies in a simultaneous decrease of the flexural and torsional stiffness in relation to the reference model which is a solid model.

Summary

Numerical modelling of buildings is always a compromise between the accuracy of mapping, the opportunities offered by a particular programme, the time of calculations, and the expected results. Modelling using volumetric elements always constitutes a far better source of results than shell or shell-bar models. The conducted calculations confirm the argument stating that modelling of internal floor beams that work unidirectionally is not connected with a significant error in calculation of the bending moments, as the beams are treated as local thicker elements of the floor and their value is consistent with the actual height of the beams. The obtained conclusions apply only to models with traditional proportions of slab and beam dimensions.

References

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