Avoidance of crack formation at exterior masonry walls as a result of the deformation of slabs

1 Introduction

Since several years a big attention is kept to the junction between concrete slabs and exterior masonry walls. A main reason for this is the appearance of cracks in the joint between the two different materials. In most cases, the cracks are caused by the different material behaviour (coefficient of thermal expansion, shrinkage, creep factor, poisson ratio, etc.) between masonry (clay-bricks, calcium-silicate-units, AAC-units, concrete-masonry units) and concrete.
Within this research project, several constructional solutions concerning the junction between the concrete slab and the masonry walls were investigated. The target was to find the relevant parameters which are causal for the cracks and to find adequate solutions to avoid these types of cracks in future.

2 Crack pattern

As a result of the study of literature, cracks could be observed, even if all rules of the German masonry standards DIN 1053-1 have been considered correctly. It was found, that almost all cracks were located nearby the joint between the concrete slab and the masonry wall.
Generally these types of cracks do not affect the ultimate limit state, but they may reduce the durability of the structure.
As a consequence of the different deformation parameters of masonry and reinforced concrete on the one hand and the deformation as a result of the load impact on the other hand, restraints between these elements occur. These cracks in the exterior walls appear mostly in the corners of the upper ceiling slab. One reason for this is a low external vertical load in association with the bending deformation of the slab. As the compressive stresses resulting from the external load are smaller than the tensile stresses caused by the bending deformation of the slab, these incompatible large deformations of the reinforced concrete slabs or circular beams are the reason for the cracks.

The literature review showed the following typical crack pattern:

- Horizontal cracks caused by the rotation of the concrete slab nearby the support of the slap

- Cracking as a result of torsional bending deformation of the slap
- Elongation of the slab caused by shrinkage and temperature
- Crack formation caused by shrinkage of circular beams of reinforced concrete

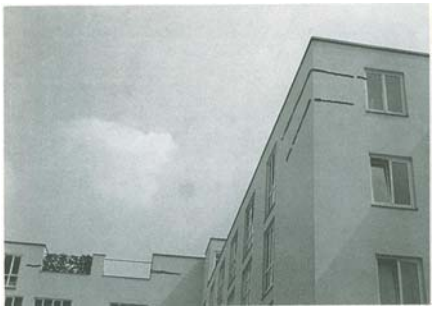

Figure 1: Crack formation caused by shrinkage of a circular beam (reinforced concrete)

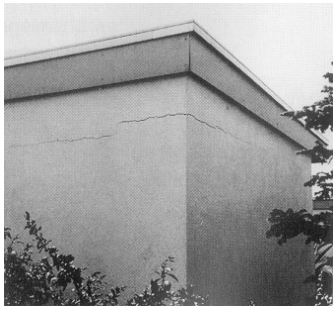

Figure 2: Crack beneath the corner of a concrete slab

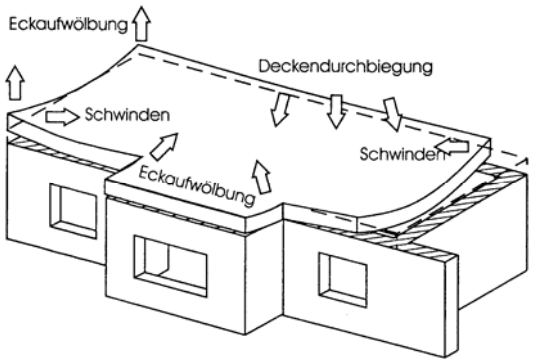

Figure 3: Diagram of possible deformations of the upper ceiling

3 Structural provisions to prevent cracking

The investigation of the different types of cracking showed that the deformations of the concrete slab are deciding. The cracks result from the time-dependent deformations, creeping and shrinking in combination with load- and respectively temperature-dependent deformations. The results of numerical investigations which considered especially the time depended behaviour of reinforced concrete, showed clearly that only additional provisions could lead to an effective avoidance of cracks in this junction. In consideration of the results from the numerical calculations, the following design features could be recommended to prevent cracking:

- Reduction of the shear resistance at the joint between the concrete slab and the masonry wall (soft layer in between)
- Decline the rotation of the bearing of the concrete ceiling by use of a concrete with higher strength and Youngs-modulus

- Anchorage of the tension forces at the corners of a upper ceiling
- Decoupling of the twisting moment in the triangular shaped areas in the corners of the concrete slabs

4 Conclusions

Cracks in exterior walls in the joint between concrete slabs and masonry walls could be avoided considering the different deformation behaviour of the two materials. The numerical investigations using the finite element method showed a discrepancy between the traditional assumptions of linear material behaviour for simple calculations, and the behaviour of the real structure. In fact, the results of known, simple calculations are not feasible for the estimation of crack propagation in this case. Therefore, to avoid cracking, special design features has to be carried out.

All structural methods named before are suitable to prevent these cracks. The effectivity of these different methods has been showed through accompanying numerical calculations. In some cases new simplified calculation formulas have been derived for a approximate calculation of the desired deformations. Especially the last method to decouple the twisting moment in the triangular shaped areas in the corners of the concrete slabs is a very promising solution. The installation of the proposed mounting part is simple and fast. Hence, this is an easy and low cost way to prevent the typical cracks in corners beneath the upper concrete ceiling slab in masonry constructions.