Zukunft Bau

Abstract of BBSR-research project

Title

Title: „Thermal decoupling of reinforced concrete walls“

Motivation

At present, walls in the transitional zone from unheated to heated rooms are not or only partially insulated. This results in thermal bridges. An improved wall-slab connection could significantly improve the thermal insulation properties of the building (see Fig. 1). So far, there is no suitable integral system with insulating effect and load-bearing function for the wall-slab connection in reinforced concrete construction. Therefore, the scientific basis for connections for thermal decoupling of the reinforced concrete walls from slabs is investigated.

Scope of Research

The research approach is to develop a wall connection that complies with the original wall geometry (external dimensions) and meets both the requirements for thermal insulation properties and load transfer.
In terms of methodology, the project is divided into three parts: the theoretical part, the experimental part and the analytical part. In the theoretical part (*work packages* 1 to 4), the static and building physics requirements for thermally decoupled connections of reinforced concrete walls are developed. A theoretical variant investigation with selected materials is carried out. In the experimental part (*WP* 5, 8 and 10), the individual variants of the wall connections are subjected to a test program. The static load tests are carried out both on a small scale for sections of the connection and on wall sections on a scale of 1: 1. In the analytical part (*WP* 6, 7 and 9) computer-aided modeling of the static and thermal properties is carried out.
The basis for the applicability of the wall connection is the fulfillment of the building physics influences. Essential here is the requirement from fire protection that force-transmitting areas may only consist of non-combustible materials. The required thermal conductivity for the wall connection could be calculated by using a numerical method to determine the heat flow at the wall-slab node.
Taking into account the normative foundations for wall-slab connections and defined geometric specifications, the vertical effects on the wall-slab connection could be determined. In the horizontal direction, effects of earth pressure, impact and temperature were investigated. It was found that the effects of temperature are decisive. A distinction is made between the winter and the summer load case and always the highest loaded 1m wall strip is taken into account.
The materials identified were evaluated on the basis of static, building physics and economic criteria. Lightweight concrete and ultra-high-strength concrete proved to be suitable materials for transferring pressure forces in the wall connection. Based on this, two variants (full-area and point load transfer) were developed and evaluated.
The main issue is the resistance of the joint for the transmission to horizontal forces from temperature. The carrying behavior of this joint was experimentally investigated on small bodies made of lightweight and normal concrete. For this purpose, a suitable geometry of the joint was first explored in preliminary experiments and a solution was identified for imaging defects in the contact layer. Furthermore, the influence of the joint inclination and the use of joint reinforcement were examined. The load-bearing capacity was significantly increased through the use of joint reinforcement and larger deformations before breakage were measured.
Large-scale test specimens made of lightweight and normal concrete were developed (see Fig. 2) to test a bending stress occurring simultaneously with the shear force. Only splined joints with joint reinforcement were tested. In the test, a bending moment of $0.7 \cdot M_{Rm}$ (resistance moment of the joint using average values of material strength) was applied. The factor of 0.7 was taken into account in that the bending moment represents the accompanying effect. For the simultaneous occurrence of a bending load and the load from the load case temperature, a reduction of the load-resistance was necessary. At the same time, the results show that the overlapping length of the reinforcement, which is present in the later structure and shown in the test specimens, is sufficient to anchor the joint reinforcement in the wall-slab-connection.
On the basis of the joint tests of the small bodies a numerical model was created, with which the carrying capacities could be recalculated. At the same time, the fracture conditions for the different joint designs were modeled realistically.

Results and key findings

The novel wall connection achieved by an optimized design of the joint geometry and a joint reinforcement in monolithic design sufficiently high loads to absorb the relevant loads, such as bending moment and from temperature change. Through the use of lightweight concrete this is also inexpensive to manufacture and meets the requirements for material with respect to fire protection. At the same time, the wall connection significantly reduces the heat losses at the thermal bridge. In order to translate the research results into an approved construction product, detailed questions must be clarified, in particular with regard to the design values or application limits. Overall, the novel connection based on the results of investigations for external walls with contact to soil (except south-west side) and internal walls is suitable.

Basic information

Short title: Thermally decoupled wall connections

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Overall costs: 198.079,28€
Federal Government subsidy: 123.079,28€
Project duration: 30 Monate

Figures:

Figure 1: Temperature distribution in a wall-slab node

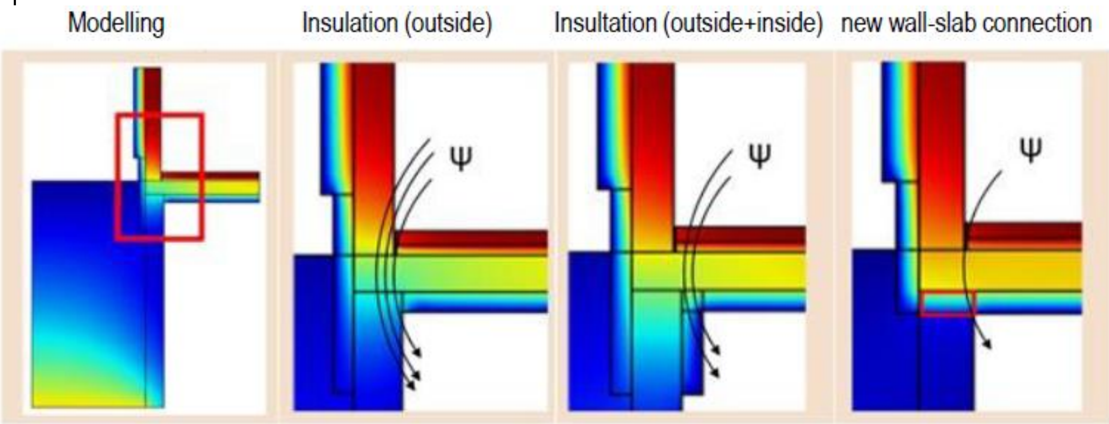

Figure 2: Large-scale test specimen in the testing machine