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REDUCTION OF THERMAL BRIDGE EFFECTS CAUSED BY JUNCTIONS BETWEEN EXTERNAL WALLS AND BALCONY SLABS

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Thermal bridges are localized areas of low thermal resistance in building envelope. Thermal bridges can occur at various locations of the building envelope and can result in increased heat flow, which causes additional transmission losses, lower inner surface temperatures and possibly moisture and mould problems. The additional transmission losses lead to a higher heating energy need and use and are becoming especially important in the case of so-called low energy or high performance buildings.

The international standard EN ISO 10211 [1] is dealing with thermal bridges, but there are national standards available in nearly every European State that cover calculation, requirements and good practice solutions.

Although new buildings present high insulation levels, thermal bridges affect heating needs for about 30% of the global value [2]. In case of existing buildings, thermal bridges contribute to 23% of the total transmission heat loss of a building envelope. After renovation, thermal bridges account for only 10% if windows are re-located into additional external thermal insulation and balconies are rebuilt according to best practices. Inversely, the impact of the thermal bridges might be up to 34%, depending on the wall insulation thickness [3].

At the same time, thermal bridge correction could determine an important reduction of the winter primary energy demand (25% for terraced houses, 17.5% for semi-detached house) with an overall annual energy savings about 8.5%.

Balcony is one of the critical elements in building envelope that leads to undesired heat losses. Concrete balcony slabs create a discontinuity in building envelope insulation, offer a less resistant path for heat flow, and result in a multidimensional heat flow phenomenon. Next to windows and doors, exposed concrete balcony slabs are the second-largest source of thermal bridging in building envelope [6].

The aim of the present work was to investigate the impact of thermal bridges due balcony slab junction on the energy performance of a typical old multi-residential house in Kyiv, Ukraine, and explore effective solutions to improve the building's energy performance and address the thermal bridge effects.

The balconies of a typical 5-story building known as "khrushchovka" (seria I-464) built in 1960th were taken for thermal analysis. Such buildings are known for their pure thermal performance. The external walls are made from light weight concrete and their width varies from 0.25 to 0.35 m. The balcony slabs as well as ceiling slab are made from reinforced concrete.

The model consists of a reinforced concrete balcony slab connected to the external wall. The balcony slab as well as the adjacent internal floor slab have a thickness of 10 cm. The external wall has a thickness of 25 cm.

The thermal conductivity of the external wall is 0.49 W/m·K. The materials of the balcony slab as well as the floor slab have a thermal conductivity of 2.1 W/m·K.

Regarding the application of insulation such different cases were analyzed:

- no insulation (reference case);
- case 1: external wall insulation (5 cm of mineral wool with thermal conductivity of 0,4 W/m·K);
- case 2: external wall insulation (5 cm of mineral wool with thermal conductivity of 0,4 W/m·K); insulation of the upper side of the balcony slab (5 cm of mineral wool with thermal conductivity of 0,4 W/m·K);
- case 3: external wall insulation (5 cm of mineral wool with thermal conductivity of 0,4 W/m·K); insulation of the upper side of the balcony slab (5 cm of mineral wool with thermal conductivity of 0,4 W/m·K); insulation of the lower side of the balcony slab (5 cm of mineral wool with thermal conductivity of 0,4 W/m·K).

Thermal performance of thermal bridges was analyzed with the two-dimensional (2D) steady-state finite element heat-transfer simulation program Psi-Therm 2D.

The results of simulation show that the linear thermal transmittance of the junction “balcony slab-external wall” in the building before retrofitting (reference case) is 0.344 W/m·K. The calculation of thermal transmittance of the junction “balcony slab-external wall” for the simultaneous insulation of the external walls as well as upper and lower sides of balcony slabs gives the lowest value of only 0.212 W/m·K. At the same time it may be said that the case of a single sided insulation is practically ineffective.

The most effective way to minimize the heat transmittance of structural components (balconies, parapets, canopies) penetrating the insulation layer is to thermally separate the exterior structure from the interior structure. With the aim of decreasing thermal losses at the connection, structural thermal breaks optimize the function and performance of each integral element at the junction. But such approach may be inappropriate in retrofitting old buildings.

REFERENCES

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