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Hygrothermal Performance Difference of Wooden Beam Embedded in an Internally Insulated Masonry Wall in 2D and 3D Models

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1 Introduction

Internal insulation of masonry walls may significantly increase the decay risk of embedded wooden beams (Zhou *et al.*, 2017; Zhou *et al.*, 2018). Moisture and heat transport in masonry wall with wooden beam is in reality a three-dimensional problem. However, many studies use only 2D hygrothermal models to study the moisture risk of wooden beam-ends in internally insulated masonry (Harrestrup and Svendsen, 2016). In a 2D model, wooden beam is assumed to have the same width as the wall envelope. However, in reality, the width of wooden beam is much smaller compared to that of wall envelope. It is still an open question whether a simplified 2D numerical model can represent accurately the hygrothermal conditions as modelled in 3D. The aim of this paper is to compare 2D and 3D hygrothermal modelling of the hygrothermal performance of wooden beam-ends embedded in internally insulated masonry wall.

2 Modelling

A 2D model with simplified distribution of bricks and mortar joints is built. Based on the simplified 2D model, a 3D model is developed. The 3D model follows the geometry of the simplified 2D model.

3 Results

In 3D model we consider the real width of the wooden beam of 20 cm, while in 2D model the wooden beam covers the total width of the wall. Although the rather low thermal conductivity of wood, the wooden beam still works as a kind of thermal bridge in the internally insulated masonry wall. Due to the higher heat flux in the beam, the middle cross section of the wooden beam embedded in masonry wall is the warmest cross section of the wooden beam during winter period, while the outermost surface in contact with masonry wall is the coldest one. The higher temperature in the 2D cross section is due to larger width of wooden beam and thus larger thermal bridge effect in the 2D model.

The differences in relative humidity among different cross sections is large at point A (Figure 1). The largest difference is in the wall envelope with mineral plaster (low liquid permeability), which can reach 0.06. In general, the fluctuation of relative humidity at the outermost cross section of 3D model is larger than at the central cross sections, especially during the cold periods. Relative humidity at point A at the central and outermost cross sections is quite different whereas relative humidity at points B and C at the central and outermost cross sections is very close. For the wall envelope with mineral plater, relative humidity at point A is continuously below 0.8 in the 2D model while it can be above 0.8 continuously from February to June at the outermost cross section in the 3D model. The 2D model will in general underestimate to some extent the moisture risk compared to 3D model.

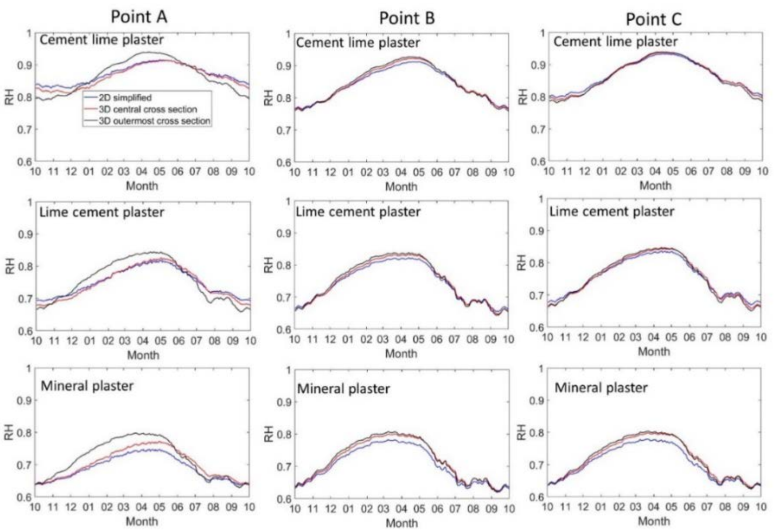

Figure 1. Relative humidity at Points A, B and C in simplified 2D model and central and outermost cross section of 3D model.

4 Conclusions

- The difference of temperature and relative humidity in wooden beam-end between 2D and 3D models is in general small. However, 2D hygrothermal models show much lower relative humidities and thus lower moisture risk at some locations in the wooden beam-end. We find that a 3D hygrothermal model more accurately simulates the hygrothermal behavior.

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