LONG TERM IN-SITU MEASUREMENTS OF DISPLACEMENT, TEMPERATURE AND RELATIVE HUMIDITY IN A MULTI-STOREY RESIDENTIAL CLT BUILDING

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ABSTRACT: In a multi-storey residential housing project comprising of four 8-storey timber buildings, the bottom storey being designed with concrete and storeys 2-8 in timber, the vertical relative displacement, the temperature and the relative humidity (RH) have been monitored. Displacement measurements started during construction and presented herein are results of 6.5 years of in-situ measurements. Temperature and relative humidity measurements have been ongoing for about 5.5 years. The temperature and RH measurements were performed at six different locations in the building, at each location in eight positions through the exterior wall with a sampling frequency of 1 measurement every 15 minutes. The results show that the total vertical displacement over six storeys after 6.5 years of service life is approximately 23 mm as a yearly average, and over the year the displacement varies from this value by approximately ±2 mm. The main cause for the relative displacement is the decrease of moisture content in the wood material leading to shrinkage after completion of the building. The results obtained show also that the exterior wall design of the building behaves well in terms of not comprising a general risk for damp or mould in the timber core of the external walls.

KEYWORDS: CLT, long term displacement, relative humidity, temperature, in-situ measurement

1 INTRODUCTION

In the town of Växjö, a project called “Limnologen” was launched in autumn 2006. The project consists of 134 apartments in four 8-storey CLT-buildings. In a collaboration between Linnaeus University, the property developer (Midroc Property Development) and the building system provider (Martinsons Byggsystem), two measurement projects were launched during 2007-2008. The first project relates to in-situ measurement of the vertical displacement in the outer load bearing CLT-wall of one building, [1]. The second project relates to the measurement of temperature and relative humidity (RH) through the outer wall construction at six different locations in another of the four buildings. The monitoring of RH and temperature was of interest, since the wall design includes the use of a non-ventilated façade covered with cementitious cladding. This type of design has for some cases shown to be risky in terms of leading to high RH with an increase in risk of mould growth and rot.

2 BUILDING DESCRIPTION AND MEASUREMENT METHODS

2.1 BUILDING DESCRIPTION

The load bearing structure consists of prefabricated CLT elements, delivered by the company Martinsons Byggsystem AB. CLT is used in both walls and floors. In addition, traditional timber framed walls are used in some walls (those separating apartments). The bottom floor is made of concrete mainly due to the benefits gained by the increased self-weight which facilitates the anchoring of the above storeys.

All exterior walls are parts of the load bearing system. Some of the vertical loads are also taken by interior walls. The stabilising system consists of the exterior walls, the floors and the apartment-separating walls. The horizontal loads are transferred by the floors – acting as stiff plates – to the walls. In some parts of the buildings glulam columns and beams have supplemented the load bearing system in order to reduce the displacements.

Three main wall types are used in Limnologen for the load bearing structure. The exterior walls, of interest here, consist of a 3-layer CLT load bearing core. The façades are either plastered or covered by wood panels. All walls are finished on the inside, on-site by being covered with

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gypsum boards (type Protect F). The external walls consist of facade material (wood or plastering), mineral wool insulation, CLT-core, internal insulation layer (used also for electrical installations) and internal sheathing (gypsum boards or moisture proof boards in the bathrooms), see Figure 1. Note especially that there is no vapour barrier (plastic film) in the external walls.

![Figure 1: Section of exterior CLT-wall](image)

### 2.2 MEASUREMENT METHODS

#### 2.2.1 Vertical displacement

Vertical measurement rods made from a low-expansion steel alloy were installed during construction. Each rod had a length of approximately 3 m, and covered a measurement length equal to one storey. In one of the rod ends, a potentiometer was mounted and made to come in contact with a fixed bracket mounted on the structure. A total of six storeys are being monitored by such devices.

#### 2.2.2 Temperature and RH

At six different locations in the building, eight measuring devices were mounted at 8 different positions through the external wall, see Figure 2. Each measuring device consists of a humidity sensor and a temperature sensor.

![Figure 2: Positioning of RH- and temperature gauges. 8 gauges are used: indoor, outdoor and gauges number 1-6](image)

### 3 RESULTS

After an initial drying out period, the total vertical displacement (measured over six storeys height) was in the range of about 18 mm. Following this, the displacement shows a clear annual variation, with a tendency of increasing average vertical displacement during the first years, although this tendency is less pronounced for the last years. After 6.5 years, the annual average displacement is about 23 mm, with a variation over one year of ±2 mm from the average, Figure 3.

![Figure 3: Measured displacement. Dashed curves are tendencies of yearly max and min displacements](image)

The main aim of the temperature and RH measurements was to obtain an indication of whether the design of the exterior wall (without vapour barrier) is adequate. The measurement results support this. The levels and combinations of RH, temperature and time, indicate no risk of mould or rot due to high moisture levels.

### 4 CONCLUSIONS

The main conclusions drawn from this work are that the measurement methods used have been accurate for the purpose, and that the technical performance of the CLT-design is adequate in relation to the properties measured here. The main cause for vertical displacement is variation of RH in the timber causing shrinkage and swelling.

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### REFERENCES