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Light Sandwich Components Based on Mineral Wool

Eléments légers en sandwich avec noyau en laine minérale

Leichte Sandwichbauelemente mit Kern aus Mineralwolle

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SUMMARY

The paper describes the elaborate testing of a light sandwich component produced by glueing plywood or other sheet materials to a core of mineral wool. The following characteristics have been investigated: Structural performance, reaction to humidity, fire and sound and to economy and production. The testings have proved that the components are suitable for use as load bearing components in one and two storey buildings in Denmark.

RESUME

Ce rapport décrit les essais intensifs effectués sur un élément de construction léger, de type sandwich, et obtenu en collant du contre-plaqué ou tout autre matériau similaire à un noyau de laine minérale. Les propriétés, suivantes de l'élément ont été examinées: résistance et rigidité, résistance à l'humidité et au feu, isolation etc. Il peut être utilisé comme élément porteur dans les bâtiments n'excédant pas deux étages.

ZUSAMMENFASSUNG

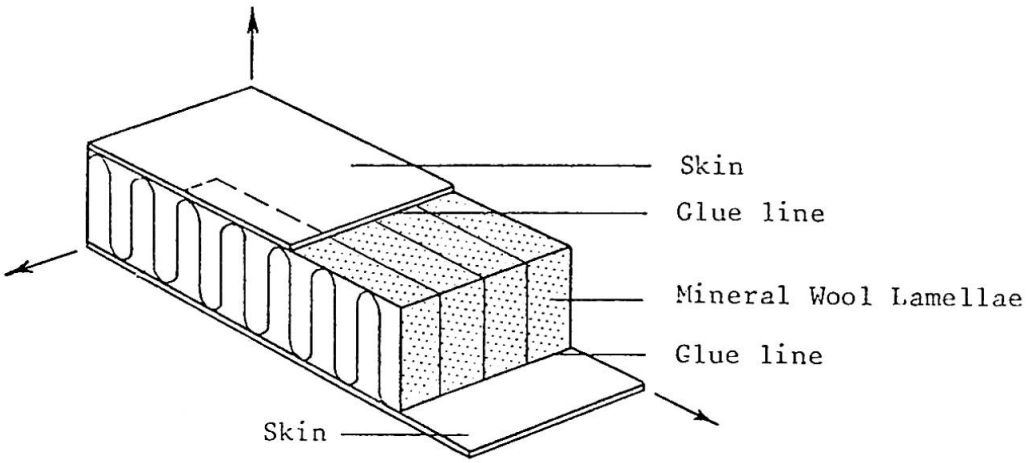
Diese Arbeit beschreibt die intensive Erprobung eines leichten Bauelementes in Sandwichbauweise, bestehend aus aussenliegenden Sperrholzplatten (oder Platten aus anderem Material) mit zwischenliegendem eingeleimtem Kern aus kantgestellter Mineralwolle. Folgende Eigenschaften dieses Elements wurden untersucht: Tragfähigkeit, Steifigkeit, feuchtigkeitstechnische, brandtechnische, schalltechnische Eigenschaften etc. Die Bauelemente eignen sich für ein- und zweistöckige Gebäude.

1. INTRODUCTION

The report describes the elaborate performance testing of a light sandwich component produced by gluing plywood or other sheet material to a core of mineral wool.

The purpose of the testing is to study the components' performance when used as wall, floor and roof components in low rise buildings.

The skins of the component are Douglas Fir Plywood, scarf jointed where components longer than approx. 2.5 m are required. The core consists of mineral wool, of for instance coarse glass-wool or Rockwool lamellae with a density of 50 kg/ m^3. The fibre direction is oriented perpendicular to the face of the component. The skins are glued to the core with a one-component polyurethane glue.



2. PROGRAMME

The main subjects for the performance tests are:

- Structural performance
- Climate shield (heat, rain and moisture)
- Reaction to fire (fire resistance, flame spread, etc.)
- Acoustic performance, and
- Economy and production.

2.1 Structural performance

In the floor- and roof-components the bending moments are transmitted by the skins, and the shear forces mainly by the core. It is, therefore, essential that the core materials provide sufficient shear strength.

In the wall components, mainly exposed to normal forces, the skins transmit the normal force, and the core has to be sufficiently rigid to prevent buckling of the skins.

The following has been examined:

- Mechanical properties of core and skin materials
- Mechanical properties of glued joints
- Long and short time reaction to lateral and axial loads.

The structural tests have been carried out at the Technical University of Denmark as follows:

Material tests

- Compressive and tensile stress-strain-tests of plywood
- Compressive, tensile and shear stress-strain-tests of mineral wool
- Shear and tensile strength tests of glued joints.

Mineral wool	Compression		Tension		Shear	
Density kg/m^3	Strength σ_t kN/m^2	E-modulus E_t kN/m^2	Strength σ_c kN/m^2	E-modulus E_c kN/m^2	Strength τ kN/m^2	G-modulus G kN/m^2
MW 50	135 (12%)	13850(12%)	54 (17%)	5250(19%)	62 (6%)	4740(12%)
MW 70	196 (22%)	22960(29%)	82 (17%)	5840(12%)	82 (10%)	7500(21%)
MW 90	300 (16%)	35700(17%)	156 (35%)	16650(33%)	124 (14%)	11920(14%)

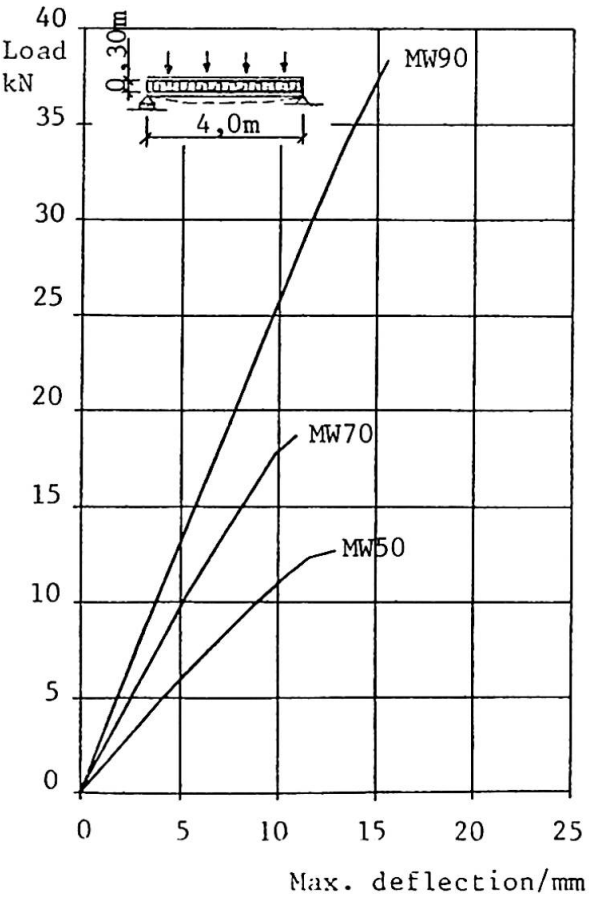
Strength and modulus of elasticity.
Each figure is the mean of 10 tests, figures in ( ) are variation.

Full-Scale Tests of Components

- 64 short term load tests with floor- and roof-components
- 32 long term load-deflection tests with floor- and roof-components
- 33 short term load tests with wall components.

In the short term load tests the floor- and roof-components were 4 m long, 0.6 m wide and there were no edge web-plates in the span direction

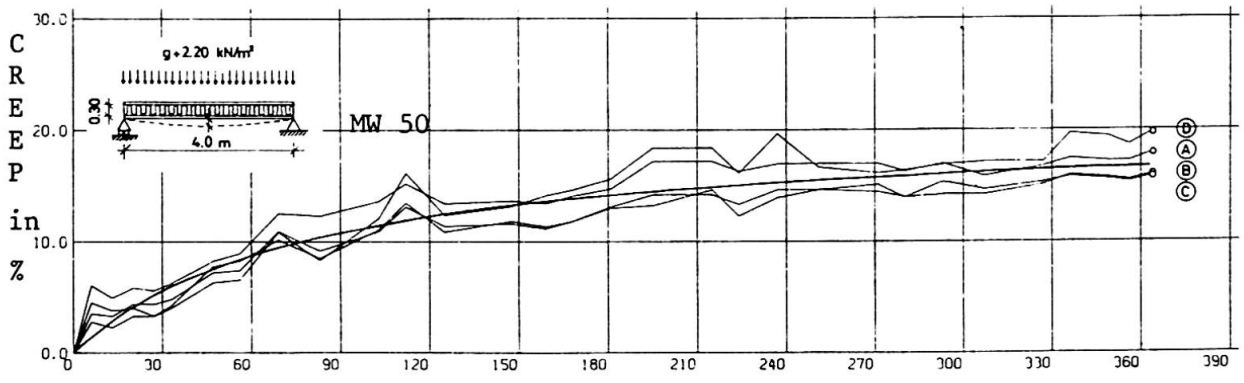
Several parameters such as core thickness and the density of mineral wool were varied. Tests with skins of 12 mm plywood and core of 300 mm glass wool gave the following results:



Failure occured as shear failure between skin and core close to the supports.

The long term load tests with floor- and roof-components were continued over one year and showed small time depending deflection.

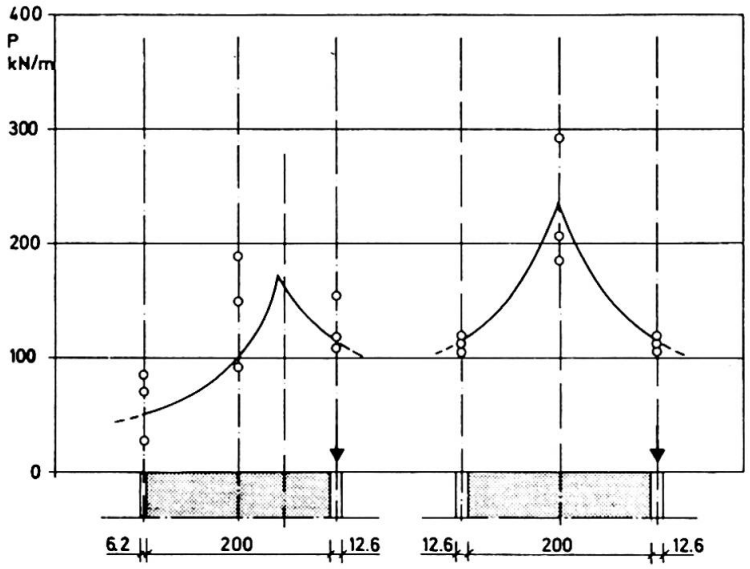
The results of 4 tests can be seen in the graph below. Test conditions were: 50 per cent of ultimate load, 20°C and 65% RH.



Time in days

In the short term load tests with centrally and excentrically loaded wall-components these were 2.4 m high and 1.2 m wide. The components had no web-plates. In the tests with 20 cm thick wall-components the following results were found:

Load capacity for centrally and excentrically loaded walls
Core: MW 80
Skins: Douglas Fir Plywood



The tests showed that the components have sufficient strength to be used for loadbearing construction in one- and two-storey buildings.

2.2 Climate Shield

Insulation

According to the standard thickness of the insulation, the following U-values were obtained (calculated and verified through tests in a guarded hotbox at the Technical Institute, Copenhagen).

- 145 mm = U-value of 0.26 W/m^2°C
- 195 mm = U-value of 0.21 W/m^2°C
- 235 mm = U-value of 0.18 W/m^2°C
- 295 mm = U-value of 0.14 W/m^2°c

Humidity

Long-term tests have been carried out at the Danish Building Research Institute and a number of buildings with sandwich-components have been observed over a two year-period to study their reactions to the natural climate.

The following has been registered:

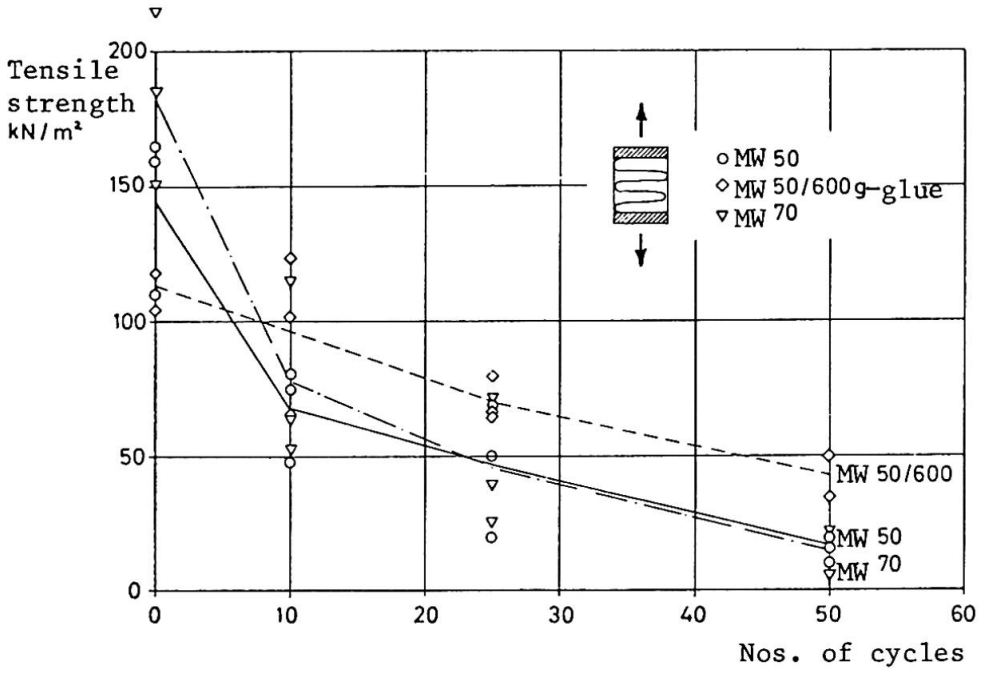
- Humidity properties of the skin materials
- Humidity accumulation in wall-components
- Humidity accumulation in roof-components
- Deflection due to asymmetrical humidity.

Humidity accumulation in components without a vapour-barrier have been investigated, and the result is, that both wall- and roof-components can be used under Danish climate conditions when the relative humidity is less than 40-50 percent at a temperature of 20-22°C in the buildings.

Special caution must be taken when using roof-components with asphalt roofing felt directly on the top skin. This prevents the humidity from escaping the construction.

If the interior climate has a higher humidity than indicated above a plywood with a build-in vapour-barrier must be used on the warm side of the component.

If the components are subjected to varying climatic conditions, especially changing humidity, it is necessary to take into account a reduction in the strength of the joint between core and skin. This is illustrated in the figure below:



2.3 Fire

The Fire testing of the roof- and wall-components, including joints has shown sufficient residual load capacity to classify the components as BD 30. This means that the components under load can resist a standard fire for 30 minutes.

Components classified as BD 30 may be used as load bearing components in most one- and two-storey buildings in Denmark.

The components can also be produced with plywood skins impregnated with fire retarding chemicals, which will prevent the spread of flame.

2.4 Acoustics

The sound insulation of the components has been tested according to ISO/R 717 at the Acoustical Laboratory, The Technical University of Denmark, for noise abatement. A component with 300 mm core of mineral wool and skins of 12 mm plywood has a sound insulation of $I_a \sim$ 30-35 dB.

2.5 Economy and production

Easy-to-Erect

The small components can in many cases be erected without the use of a crane. Depending on the skin material and the thickness of the components, the weight is 25-50 kg/m^2.

Flexibility

The cheapest production price is obtained by using standard sizes of the skin material, but components may be produced according to individual requirements. Components up to a length of 600 cm can be produced by scarf jointing the plywood.

Windows and doors can be incorporated in the components. Shaping can take place at the building site by using a saw.

Economical Production

The simple structure of the component allows for an economical mass-production which makes the component competitive in both price and quality; especially considering its strength, easy erection and excellent insulation characteristics.

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