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Elastic Composite Construction between Timber and Wood-Based Materials

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born 1941.
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Summary

Due to higher demands reconstruction of timber floors often request elastic composite construction between timber and wood-based materials. To commence construction, building or renovating it is necessary to uncover the existing timber beams. Afterwards sheathing panels (chip boards) are fixed to the beams with special connectors. A method of calculation and construction as well as the building process itself will be shown. This will be demonstrated with the example 'Salzburger Decke' ('Salzburg-type floor') in the ancient building 'Höllbräu' in the city of Salzburg.

1. Introduction

Many of the floors in old buildings are made of timber. These floors have not lost their workability through many centuries under dry conditions. However, dereliction and poor maintenance has lead to ingress of water and as soon as the moisture content in the timber elements increase the possibility of infestation by insects rises and then the wooden constructions may be destroyed within a short period. Today such structures are not completely demolished, but redeveloped due to the following reasons:

- Previous renovations of damaged timber beams in old and new buildings has not been executed correctly.
- Valuable and cultural antiquities and many examples of such losses (e.g. ceiling frescos or ceiling stucco) would be lost if the load-bearing timber beams are not restored properly are known.
- Recently the importance of construction substance especially in the old towns has been recognised and their preservation has been supported by politicians, sociologists and architects. Wherever possible the original floor load-bearing structures are to be maintained and not to be replaced by other building materials or structural members.

For these reasons the knowledge of the possibilities to redevelop timber floors are important.

2. Wood damage

Wood preservations have to be realised according to the degree of damage and will change from case to case. An overview of defects will be given, such as:

2.1 Defects related to living organisms

- Fungi
  - in living wood
  - in sawn timber
  - in timber in already erected structures
- Bacteria
- Insects
  - in living wood
  - in timber in already erected structures
- Marine pests

2.2 Other defects

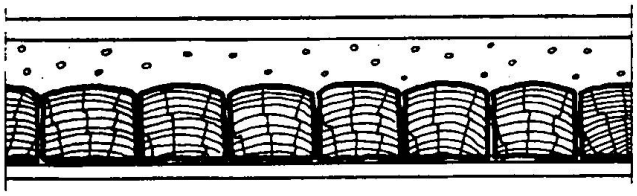
- High temperatures
- Chemical defects
- Meteorological conditions
- Mechanical defects

3. Timber floors

3.1 Types of timber floors

At the turn of the last century types of timber floors in buildings in Austria were mainly the so-called 'Dippelbaumdecken' ('Dippel-tree floor') and later on 'Tramdecken' ('Beam floor') in the most cases with loose filling.

3.1.1 'Dippelbaumdecke' - 'Dippel-tree floor'



floor covering (e.g. marble)
bearing layer
pugging
dippel-trees (e.g. spruce logs)
reed matting
plaster

Fig 1 'Dippelbaumdecke' - 'Dippel-tree floor'

Belonging to the today's unusual 'dippel-tree floor' several 'dippels' (beams from logs) are situated side by side connected to each other with wooden dowels. The latter have the advantage that concentrated stresses are distributed on several 'dippels' and therefore the deflections and vibrations are reduced.

3.1.2 'Tramdecke' - 'Beam floor'
Several beams are spaced at app. 600 to 1000 mm depending on their cross-sections, spans and loading. In principle there are 'simple' and 'normal' floors. The 'simple' flooring lies on the beams directly and the 'normal' flooring (*see Figure 2*) floated on boarding joists in the loose

filling (pugging) which is supported by a lintel frame or pugging board fixed between the beams.

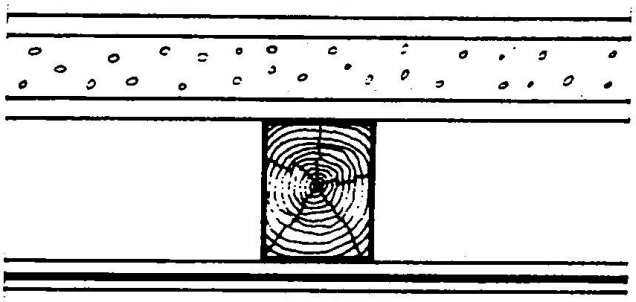


Fig 2 'Tramdecke' - 'Beam floor'

3.1.3 'Salzburger Decke' - 'Salzburg-type floor'

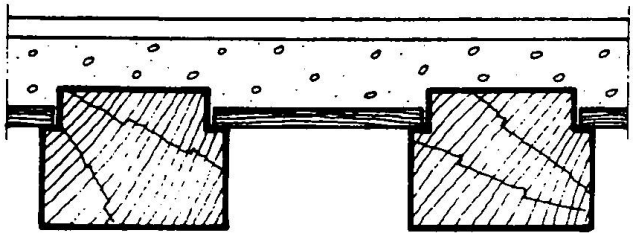


Fig 3 'Salzburger Decke' - 'Salzburg-type floor'

The cross-section of a beam is app. 270 and 270 mm and are spaced at app. 270 mm. Apart the edges of the beams are rebated to carry the pugging board which is doweled into place. The underside of the pugging board and the exposed faces of the beams are very often highly decorated.

3.2 Observation of wood damage

3.2.1 Exposed beams

In most cases these beams are exposed on at least three sides and therefore any defects are clearly visible.

3.2.2 Concealed beams

In practice concealed beams are widespread and it is necessary to expose them for inspection by the removal of the floor covering and loose filling. Only in this way a full report on the bearing construction and its condition can be prepared. Reasons for exposure of the beams are:

- Traditionally every fifth beam would be tied to or through the external walls to prevent spread by means of an iron strap and this has to be checked and the number increased if necessary.
- Large depths of loose filling have to be reduced to save dead weight and to allow for the increasing the capacity of payloads.
- Loose filling could become dangerous because of the accumulation of moisture or pests.
- The real extent of the damage can not often be established until a whole examination of the timber construction is possible.

- Without uncovering the construction elements any rehabilitation work is unpracticable.
- In the course of the restoration the building domestic services can be installed in the area of loose filling.

Therefore a hundred percent judgement of the timber construction as well as a repair or restoration is possible only in connection with total exposure.

The following expertise has to give answers to the question:

- relating to stability,
- assessment of serviceability (use of the rooms),
- constructional wood preservation, hot-air procedure, supported by chemical wood preservation if necessary,
- realisation of procedures for redevelopment.

4. Reconstruction

4.1 General

Fig 4 'Höllbräu' (view from 'Waagplatz')

Valuable historic timber constructions with localised defects should be renovated. To find the optimal solution how to repair it is necessary to have the exact knowledge of the kind of damage as well as the knowledge of previous attempts at refurbishment.

4.2 Example of reconstruction

The architectural aura of the city 'Salzburg' is mainly determined by its old buildings. In the middle of the city the ancient building 'Höllbräu' is located and is one of the oldest buildings. Its history traces back to the year 1377. After renovation it is now a high-class hotel. To increase the load bearing capacity and to reduce the deflections of the 'Salzburg-type floor' one possibility is to create the floor structure given in *Figure 6*. After the timber beams have been exposed, sheathing panels (flat chip boards) are connected to the beams with special nails. This floor structure represents an elastic composite construction between timber and wood-based materials.

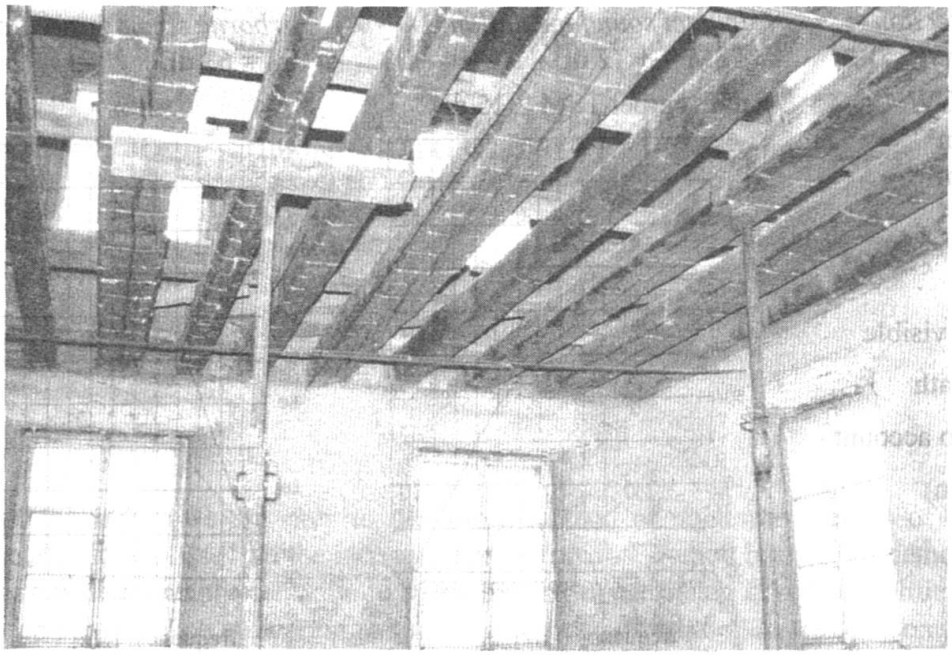
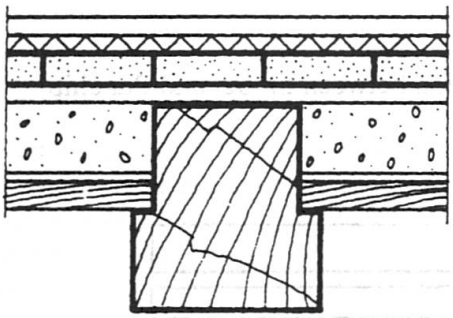


Fig 5 'Salzburger Decke' - 'Salzburg-type floor' after uncovering the existing timber beams



Flat chip board V 100, 25 mm (700 kg/m³)
Noise reduction mineral fibre
insulation elastic material 30/25
Concrete paving slabs 300x300x40, non-reinforced
Flat chip board V 20, 30 mm (700 kg/m³)
Loose filling 60 mm
Plaster board 25 mm
Wooden boards 40 mm (existence)

Fig 6 'Salzburger Decke' - 'Salzburg-type floor' after renovation

4.3 Standards

4.3.1 Resistance against fire
Classification of fire resistance has to be proved in accordance with national (ÖNORM, DIN, ...) respectively today with international standards (CEN-, ISO-Standards, Eurocodes, ...).
The 'Salzburg-type floor' after renovation complies to the requirements of the Austrian standard ÖNORM B 3800, Part 2 and to the more specific regulations of ÖNORM B 3800, Part 4.

4.3.2 Defects with respect to building physics
It is not surprising that the high demands in present standards with respect to thermal protection as well as to impact and airborne sound insulation are not obtained by the existing and insufficient former renovation. Local authorities now demand the removal of this 'deplorable state of affairs' by insisting that timber floors are therefore renovated by.
The valuable historic timber floors can be reinstalled over the new structure thereby maintaining the historic appearance of the building.

For verification see *Figure 7* and *Figure 8*.

Thermal Protection:
k = 0.38 W/m²/K
D = 2.41 m²K/W
m_{spu} = 45 kg/m²
m_{spo} = 37 kg/m²

Beams partly visible from underneath (not taken into account for verification)

Impact sound insulation:
TSM = + 12 dB
with carpet TSM ≥ 15 dB

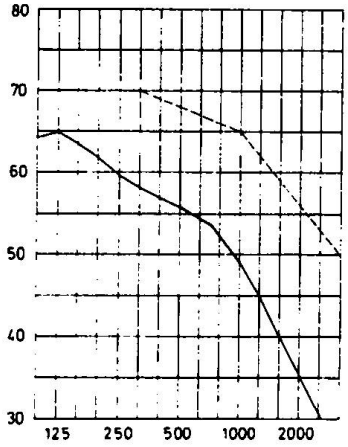


Fig 7 Impact sound insulation

Airborne sound insulation:
R_W = 63 dB

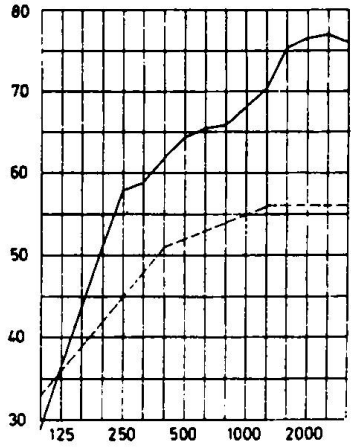
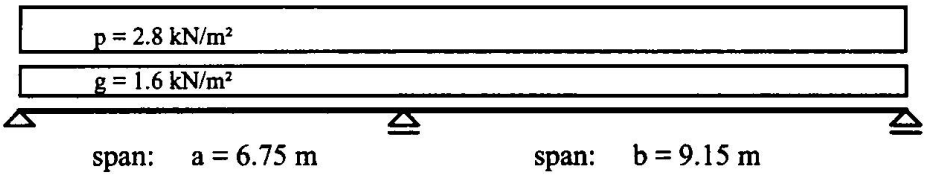


Fig 8 Airborne sound insulation

4.3.3 Calculation

Calculation was carried out with an elastic composite cross-section between timber and flat chip board including effective board width.

Static system:



Bending moment line:

Shear stress line:

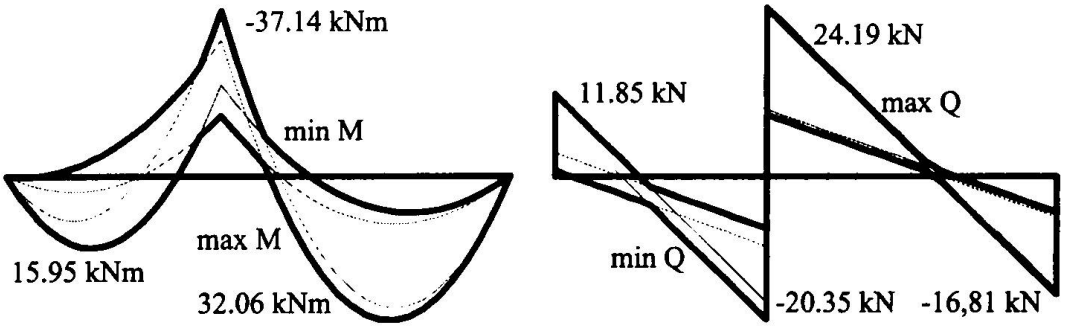


Fig 9 Static system, bending moment and shear stress lines

In conclusion the achievement of renovating of an old building in addition to the restoration work shown supplementary structural work is needed.

Hans Hartl