

# Building energy analysis of an industrial hall based on dynamic simulations

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## Introduction

evaluate the heating energy  
consumption by calculations and with  
dynamic simulations, by setting the  
input parameters as close as possible

dynamic whole-  
building simulations  
coupled with thermal  
bridge simulation

calculations according  
to the Hungarian  
7/2006 TNM. Decree  
and the Austrian OIB 6  
Directive

evaluate the effect  
of different internal  
loads on the  
heating energy  
consumption

examine the effect  
of whole surface  
insulations in case of  
ground contact  
floors

## Previous research – steel fibre reinforced concrete

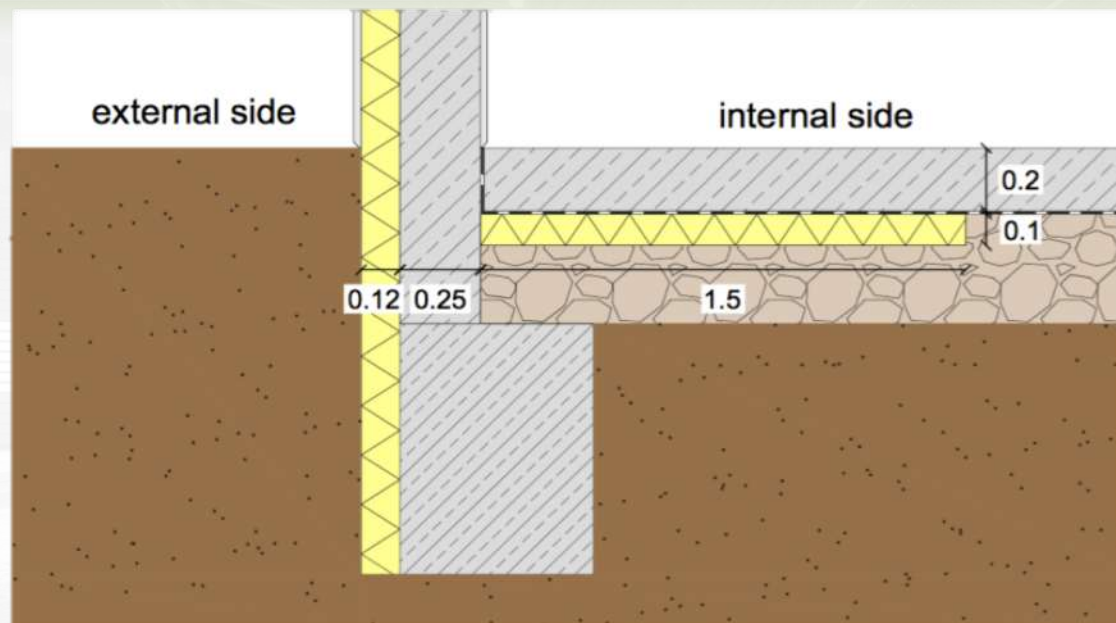
Material properties of steel fibre reinforced concrete are based on measurements:

- *thermal conductivity*
- *specific heat capacity*
- *vapour diffusion properties*
- *water absorption coefficient*
- *moisture storage function*
- *liquid transport coefficient*





## Building design



|                       | Warehouse              | Offices              | Restroom             | Mechanical room      |
|-----------------------|------------------------|----------------------|----------------------|----------------------|
| <b>Net floor area</b> | 247.73 m <sup>2</sup>  | 24.77 m <sup>2</sup> | 6.00 m <sup>2</sup>  | 7.39 m <sup>2</sup>  |
| <b>Net volume</b>     | 1578.83 m <sup>3</sup> | 89.13 m <sup>3</sup> | 20.48 m <sup>3</sup> | 26.82 m <sup>3</sup> |

- the walls and roof structure were made with insulated panel systems, with 0.4-0.6 mm of metal skin and with 10 cm (walls) and 16 cm (roof) of IPN core thicknesses
- the plinth wall was built with 25 cm monolithic reinforced concrete, 12 cm of XPS insulation, internal and external plaster layers
- the floor is made of steel fibre reinforced concrete, where 10 cm XPS perimeter insulation was applied

## Main differences between the regulations

|              | 7/2006<br>TNM                                 | OIB 6                                         | Original<br>structure                         |
|--------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Structure    | Prescribed<br>U-value<br>[W/m <sup>2</sup> K] | Prescribed<br>U-value<br>[W/m <sup>2</sup> K] | Calculated<br>U-value<br>[W/m <sup>2</sup> K] |
| wall         | 0.24                                          | 0.35                                          | 0.21                                          |
| plinth wall  | 0.3                                           | 0.35                                          | 0.23                                          |
| roof slab    | 0.17                                          | 0.4                                           | 0.16                                          |
| window       | 1.15                                          | 1.4                                           | 1.10                                          |
| ground floor | 0.3                                           | 0.4                                           | 3.82 (0.47)                                   |

- primary energy conversion factors are different
- thermal transmittances
- different air exchange rates
- outdoor temperature and relative humidity

|              | Months     | I    | II  | III | IV   | V    | VI   | VII  | VIII | IX   | X  | XI  | XII  |
|--------------|------------|------|-----|-----|------|------|------|------|------|------|----|-----|------|
| MSZ<br>24140 | Temp. [°C] | -2   | 0   | 5   | 13   | 19   | 22   | 25   | 23   | 18   | 12 | 5   | 0    |
|              | RH [%]     | 90   | 85  | 74  | 73   | 70   | 70   | 63   | 67   | 73   | 80 | 86  | 91   |
| OIB 6        | Temp. [°C] | -2.3 | 0.8 | 5.4 | 10.6 | 15.3 | 18.6 | 20.4 | 19.7 | 15.9 | 10 | 4.1 | -0.5 |
|              | RH [%]     | 80   | 80  | 80  | 80   | 75   | 75   | 75   | 75   | 80   | 80 | 80  | 80   |

## Main differences

In case of ground floors, the transmission losses would be 79.29 W/K according to the Hungarian regulation, in contrast, 637.46 W/K according to the Austrian Directive. Taking into account the 1.5 m perimeter insulation these values are 38.38 W/K (Hungarian) and 48.03 W/K (Austrian) with using national regulations.

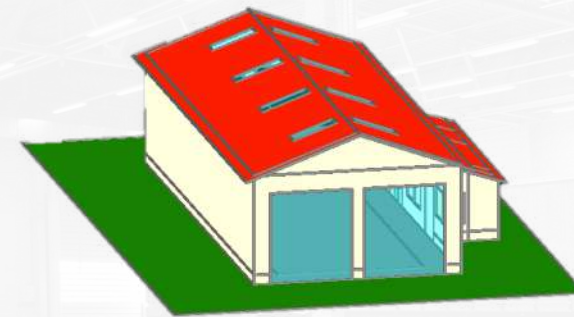
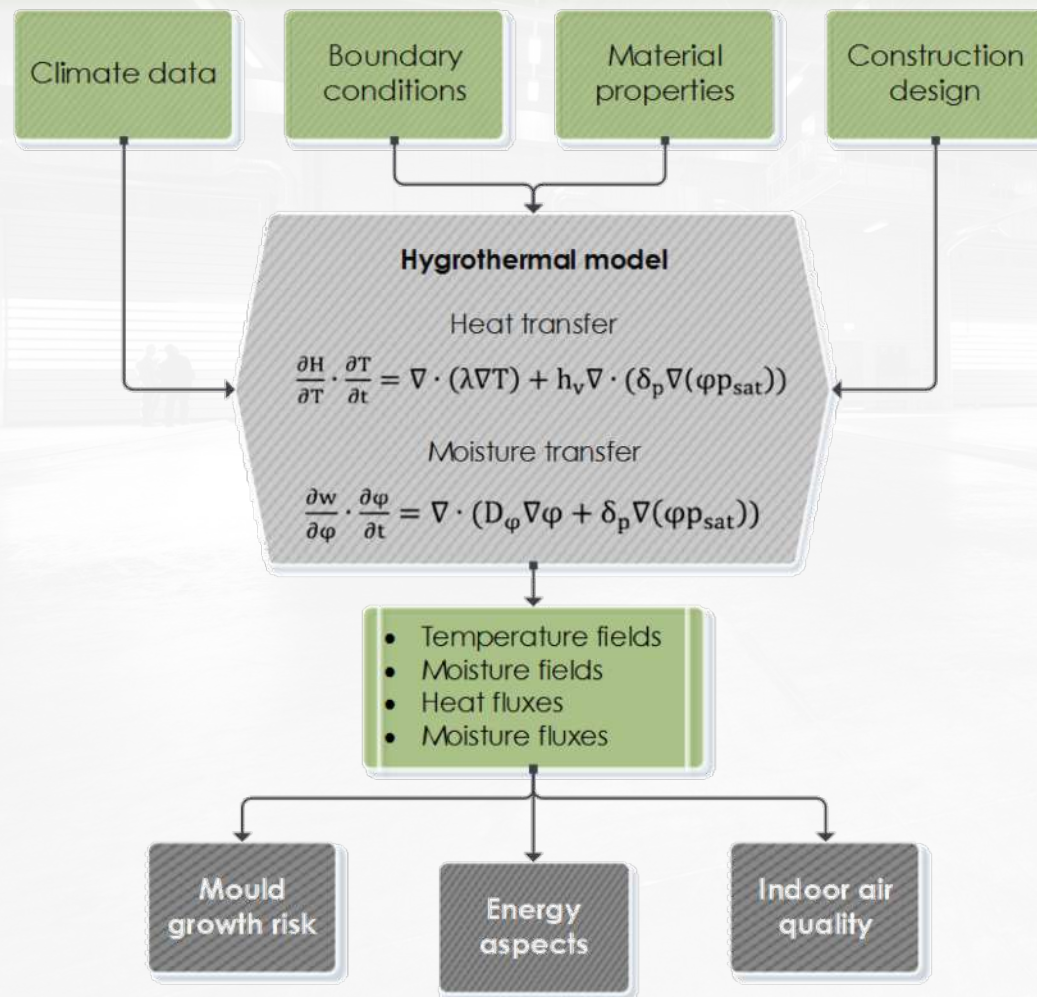


We used ISO 13370 for the final results.

*It is essential to use the available simplifications correctly during the calculations, to get reliable and comparable results.*



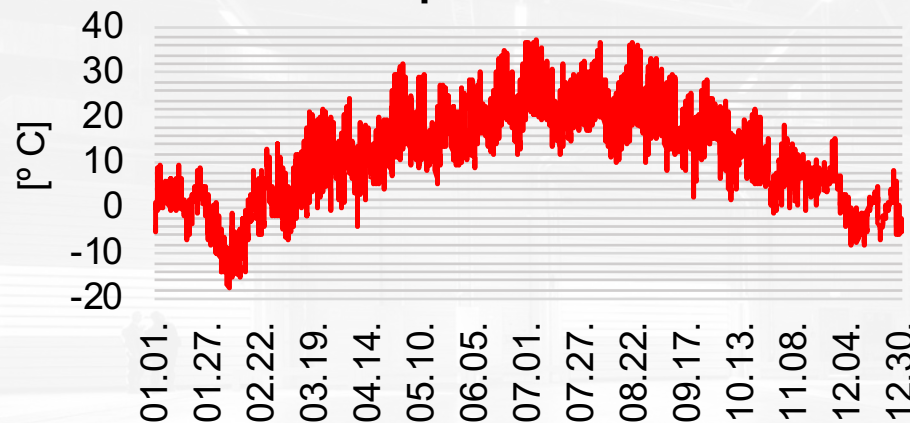
## Dynamic whole-building simulation



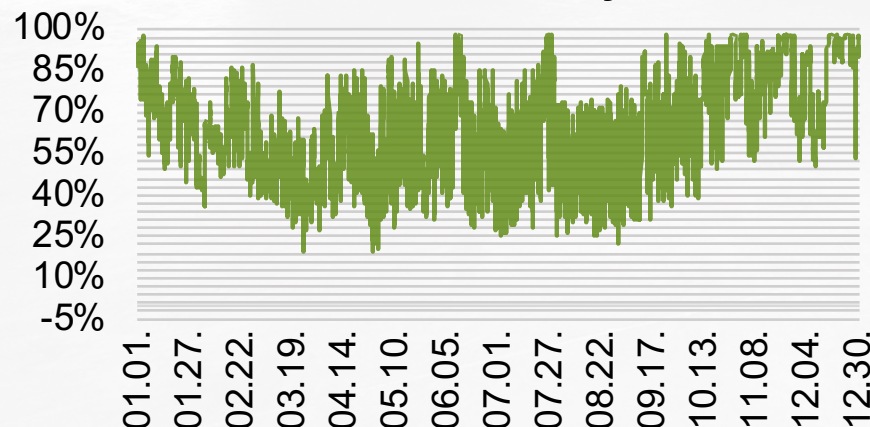
- WUFI Plus software
- multizone models with 4 different zones
- different internal loads (group load, individual loads, according to TNM)
- including 3D thermal bridges

## Boundary conditions

**Temperature**

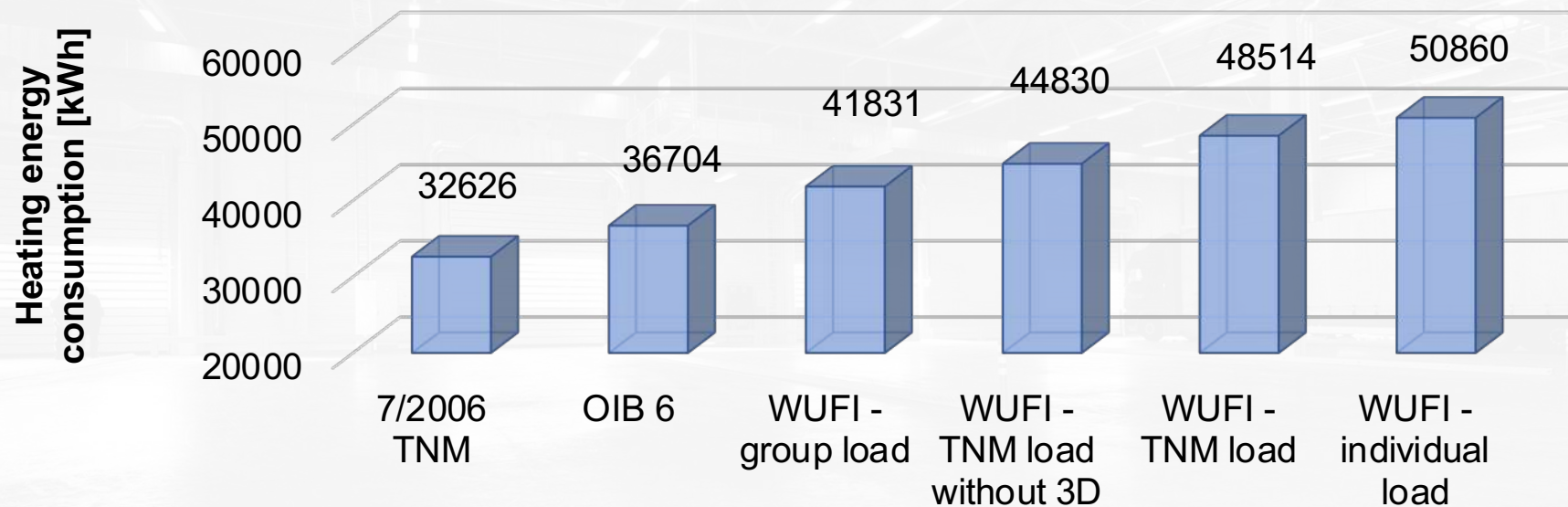


**Relative humidity**



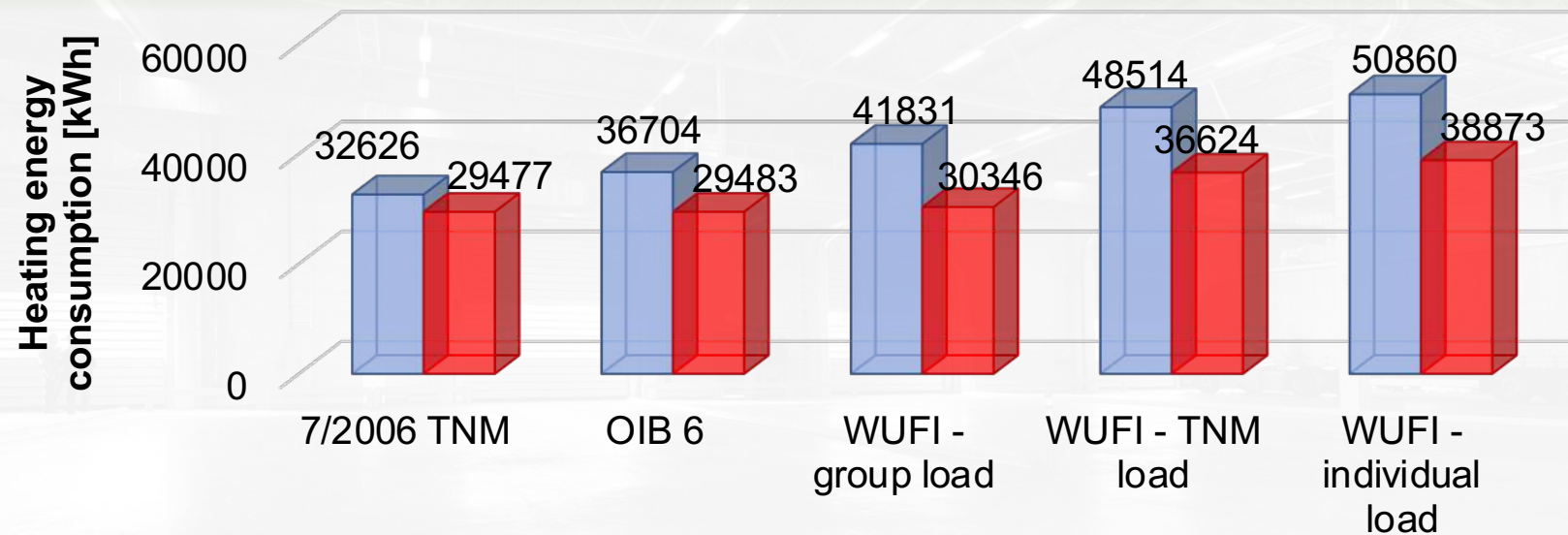
- Hungarian climate data
- 1 m thick soil layer (13 °C mean value and 90% RH)
- 0.5-0.8 natural infiltration rate
- general requirements were 20 °C, and 50-65% relative humidity in the hall during working hours
- HVAC system divided between the zones
- plinth wall - 3D thermal bridge

## Results



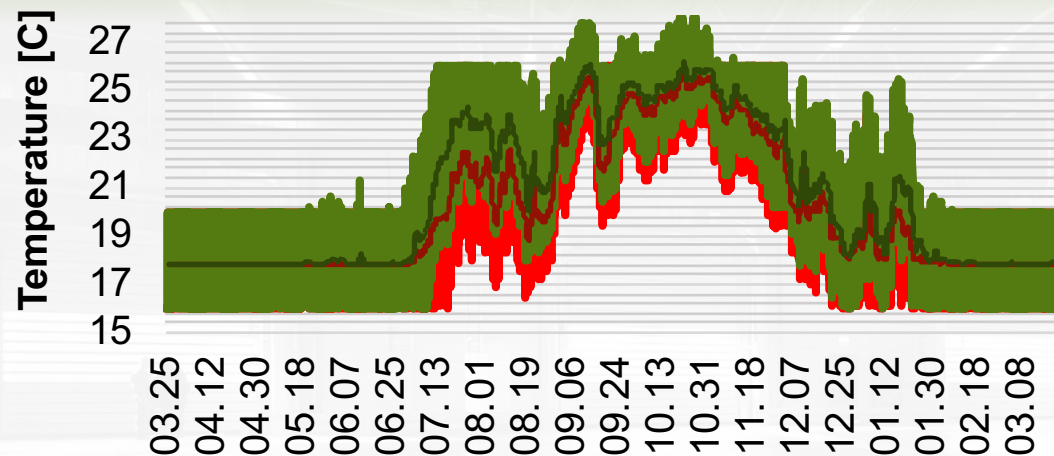
- ~10 % difference between the calculations (Hungarian and Austrian method)
- difference between the simulations are more relevant, depending on the applied internal loads → 20% difference in the heating energy consumptions

## Results – modified structure

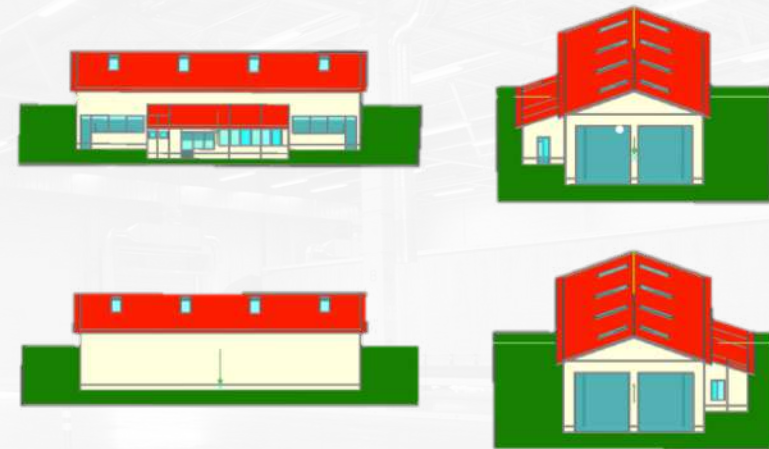


- modified structure: the warehouse is not only insulated along the perimeter, but on the entire surface
- the overall heating energy consumption can be reduced by 25%
- maximum heating energy consumption was achieved with original structure with individual loads

## Results – internal conditions



— Original structure - group load — Modified structure - group load



- Comparing the temperature in the warehouse it can be seen, that depending on the structure, the temperature of the internal air also varies.
- In the case of the original structure (with perimeter insulation) the temperature of the warehouse can cool down more in the summer, than in the whole surface insulated case.
- There is also a minimal difference in relative humidity due to the modification of the structure.

## Conclusion

- The difference between the results is mainly due to the fact that the calculation methods are seasonal (Hungarian), monthly (Austrian) and hourly (simulation) based.
- It is essential to consider the effect of three-dimensional thermal bridges in the simulation, because the difference in the results can be almost 10%.
- It is worth mentioning that in the calculations it is very important to use the available simplifications correctly to get reliable results.
- With using full surface floor insulation instead of perimeter insulation, the heating energy consumption can be reduced by at least ~10%.
- With dynamic simulations, heat losses and gains can be evaluated grouped by components, and with the additional information of temperatures, relative humidities and water contents, the possible problems within the structures can be discovered to help optimizing the building structures' design process.



# Thank you for the attention!

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