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**Summary of the research project**

**Cost efficient multi-floor Passive houses in urban environment**

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**The author is responsible for the contents of the report**

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## 1. Aim of the project

The aim of the project was to verify, that the passive house standard can be achieved even in urban environment (adverse orientation of the main facades, shading problems). Within the project, basic principals were developed, enabling the passive house standard to be realised even in case of urban multi-floor buildings by application of new rational construction methods and innovative energy efficient components.

## 2. Proceeding of the project

Before the start of the project, the work schedule was defined within the working group together with the body of experts. The different tasks were shared out among the project participants. The scientific body, represented by Mr. Werner, Mr. Selk and Mr. Dr. Lützkendorf, introduced a lot of valuable hints and ideas, especially in terms of the user manual.

In the following, the procedure of the project is described according to the sections of the final report.

### **Part 1: Construction Manual for passive houses**

Based on the experiences with single- and multi-family dwellings in passive house standard, existing and advanced solutions of building details were checked for their suitability in multi-story buildings. Basic principals and methods were assembled and prepared for the delineation within the construction manual. The experience from the pilot project, where a multi-floor passive house was realised, were very helpful. Some of the advanced details were tested for the first time (for example the levelling layer made by polyurethane recycling material to minimise the thermal bridge effect at the wall footing, opaque evacuated door modules). Some of the advanced Details can be realised with available materials, but not for sale as readymade construction product. All detail drawings were designed with respect to thermal bridge reduction and air tightness. Mostly perspective views show the three dimensional connections of different plains more didactically than two dimensional sectional views. The coloured sketches show the materials in a very realistic manner, so that the assembly can be identified without inscription. The texts only need to explain details and the construction process.

In order to quantify the thermal bridge losses of selected details, the multi-dimensional heat transfer was calculated with specialised programs. The results are given as numerical values and are shown as isothermal lines and colour graphics.

### **Part 2: Simulation of the thermal behaviour of a multi-floor passive house in urban environment**

Dynamic building simulation by DYNBIL (Program for calculation of the energy balance of multi-zone Building models under dynamic boundary conditions, author: W. Feist) was applied to two different segments (centre and north zone) of a typical multi-floor passive house. This model was used to investigate the temperatures within individual dwellings in different floors as well as their interdependence. The input structure of the program had to be adapted to allow a total of 14 zones of the mathematical model. The model consists of three dwellings with adjacent staircase. Each of the dwellings was subdivided into four zones. The ventilation system was

supposed to work with one common heat exchanger (which is considered as an individual zone) for all dwellings.

By parameter variation the influence of building parameters (such as glazing area, thickness of thermal insulation) and operational parameters (i. e. nightly temperature drop during nighttime, temporary drop of set temperature) as well as boundary conditions (shading, orientation, climate) on the specific heat demand, the peak heat load and the summer comfort index (percentage of hours with room temperature above 25 °C) was investigated within a wide range.

Several conclusions were drawn from the results of these investigations in terms of the viability of the passive house standard for multi-floor buildings in urban environment. Moreover directions for use of the residual heating during the cold periods of winter were acquired.

### **Part 3: Requirements for cost efficient ventilation systems for multi-floor passive houses and check by measurements at the pilot project.**

Requirements were formulated especially adapted for ventilation systems with heat recovery and residual heat supply which comply with the specifications in multi-floor passive houses. These requirements were documented in the part 3 A of the final report. On one hand, the formulation of the requirements are based on the experiences of the realised passive houses, but on the other hand important special features of ventilation systems for multi-floor buildings had to be developed. Within the pilot project Kassel Marbachshöhe measurement procedures were performed, for example to check the air-tightness of the air ducts. In section B of this part of the final report the results of the measurement procedures are described.

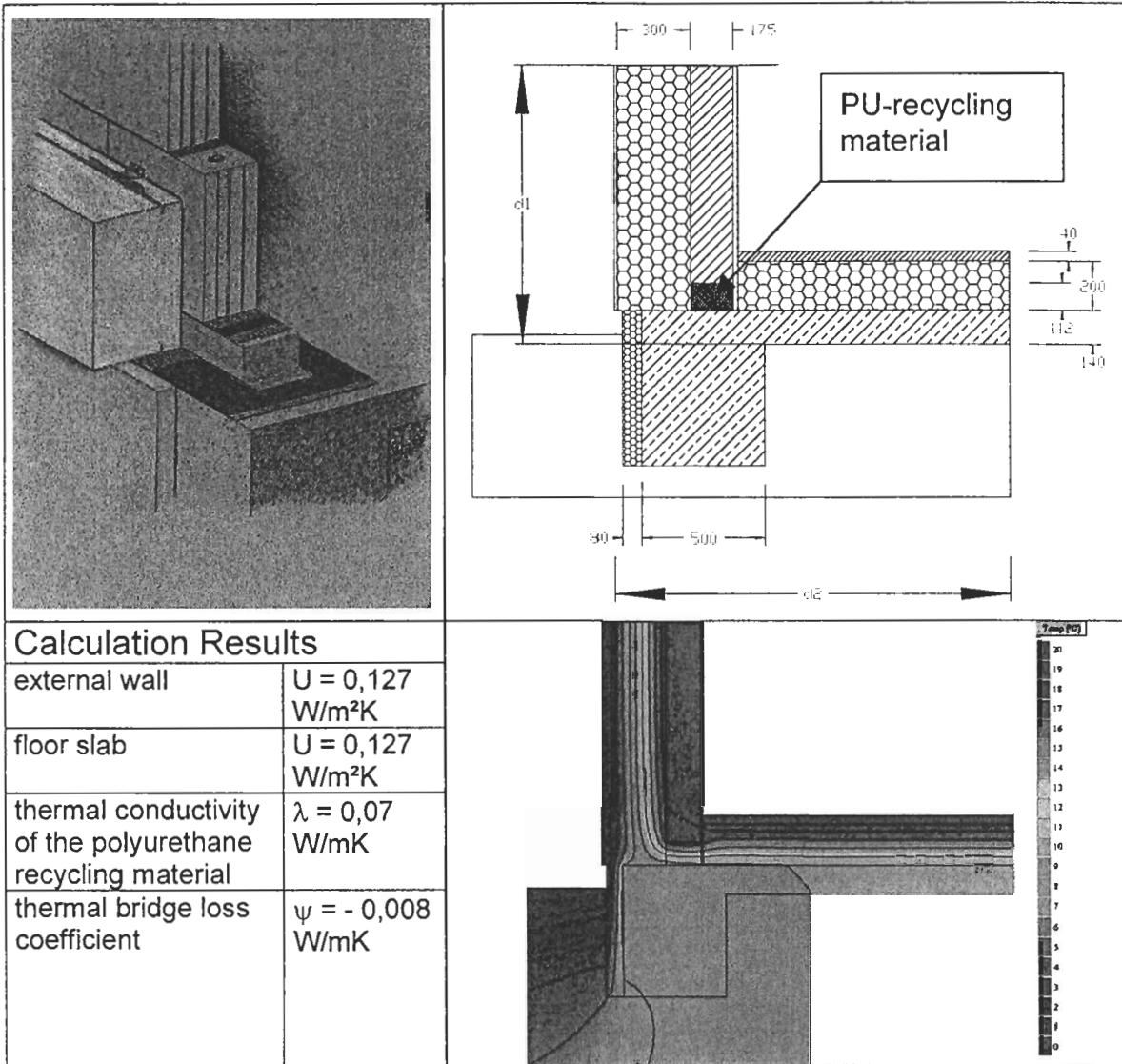
### **Part 4: User Manual for multi-floor passive houses**

Living in a multi-floor passive house requires some basic information about the main elements of the building as well as the handling of the ventilation system. Especially for this purpose a user manual (part A) was written, giving general hints for the adjustment of the ventilation system, the protection from summerly overheating as well as for maintenance and energy saving. A summary, called "living in a passive house - at a glance" points out the most important items.

The major part of the mechanical services in a multi-floor building is not operated and maintained by the tenants but by the caretaker. Part B of the user manual was dedicated especially for those persons.

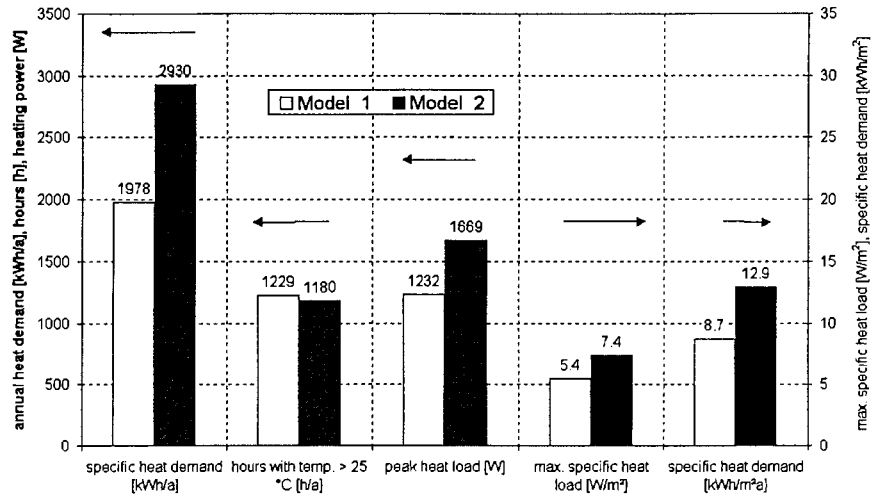
## **3. Summary of the results**

Numerous construction details shown in the construction manual demonstrate, that multi-floor passive houses can be erected in a cost-effective way, anyhow. Efficient production methods and advanced building components contribute to simplify the building work, minimise the costs and help to enhance the thermal quality of building. The following example shows a wall footing made by large-size limestone blocks with thermal insulation (300 mm PS). The levelling layer is made by polyurethane recycling material (thermal conductivity 0,07 W/mK, maximum permissible compressive stress load 8 N/mm<sup>2</sup>). This is no additional working cycle, because the levelling layer is necessary anyway.



The results of the dynamic building simulation showed, that the passive house standard can be met even with unfavorably east/west oriented main facades and shading from neighbourhood buildings. The reason is the usually low surface to volume ratio of multi-floor buildings.

The Next graph shows the thermal performance of the basic model of the dynamic simulation.



The investigations of the thermal coupling of individual dwellings in a multi-floor passive house showed, that a restriction of the comfort level of adjacent dwellings is not to be expected, even after several weeks of shut down of the heating system of a single dwelling during winter time (for example during Christmas holiday).

A short summary of the requirements for ventilation plants for multi-floor passive houses is given in the next table (Assumption: air flow rate of 1000 m<sup>3</sup>/h).

sensible heat recovery	> 75 %
max. admissible total leakage of the heat exchanger	≤ 0,5%
pressure loss at nominal air flow rate	≤ 50,0 Pa
thermal insulation of enclosure and ducts	≤ 2,0 W/K
air tightness of discharge air duct at 200 Pa	better than EUROVENT class III
air tightness of supply air at 200 Pa	better than EUROVENT class IV
fresh air filter	at least class F7 acc. to EN 779
discharge air filter in kitchen and bathroom	at least class G3 acc. to EN 779
sound level in rest rooms	max. 25 dB(A)

The measurement procedure and adjustment of the ventilation system in the pilot project Kassel Marbachshöhe indicated, that the requirements can be met in practice. First experiences of the tenants since moving in May 2000 are already worked into the user manual as part of the final report.