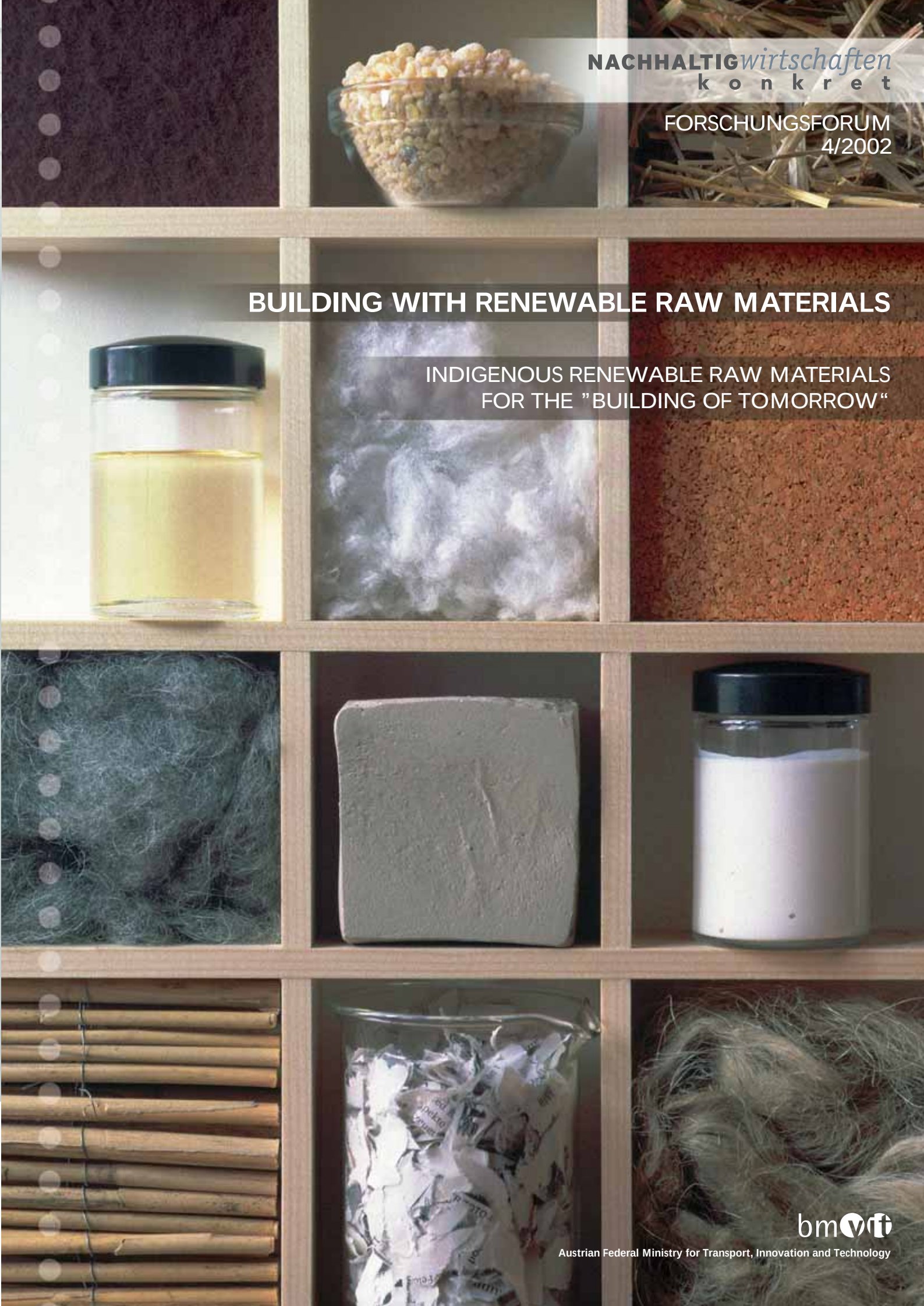

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BUILDING WITH RENEWABLE RAW MATERIALS

INDIGENOUS RENEWABLE RAW MATERIALS FOR THE "BUILDING OF TOMORROW"

bmvit
Austrian Federal Ministry for Transport, Innovation and Technology

SUSTAINABLE RAW MATERIALS IN BUILDING CONSTRUCTION – PROJECTS WITHIN THE SCOPE OF THE "HAUS DER ZUKUNFT" SUBPROGRAM

Photo: Harbusch

Straw Bale House at Dobersdorf, Bgld

Fundamental studies and practical experience in the field of renewables in building construction

■ Today, strategies toward sustainability are considered future-oriented fields of research and development. This includes using renewable sources of energy and renewable raw materials as well as improving efficient use of resources and user and service orientation. The Austrian Federal Ministry for Transport, Innovation and Technology (bmvit) supports these objectives by initiating and supporting innovative and trend setting projects within its stimulation program "Nachhaltig Wirtschaften" (Sustainable Development).

One of the important aspects in this field refers to building construction and dwelling. The "Haus der Zukunft" subprogram aims to pave the way for innovative building construction in practice. Building on solar low-energy and passive house concepts, R & D & D projects will be used to develop sustainable, cost-efficient solutions (i.e. at costs comparable to conventional construction) that can be put into practice.

While energetic optimization in building construction has made considerable progress, the building materials used have been somewhat neglected so far. However, with a view to sustainable building construction, the selection of building materials, their manufacture, and the consumption of energy and other resources involved in the production process as well as the whole life cycle including the stage of disposal are of eminent importance. More widespread use of renewable raw materials is one of the strategies that seem very promising with a view to implementation, particularly in the field of building construction. Smart materials are able to meet the demanding requirements as to function and user friendliness, but also to avoid environmental and disposal problems.

In addition to the functional and ecological ***benefits***, the use of building materials and system solutions based on renewable raw materials may contribute to supporting regional economic structures.

The three projects mentioned below were funded and implemented within the scope of the 1st call for tenders of the "Haus der Zukunft" subprogram:

1 Erfolgsfaktoren für den Einsatz Nachwachsender Rohstoffe im Bauwesen (Success Factors for the Use of Renewable Raw Materials in Building Construction)
Gruppe Angepasste Technologie, TU Wien, authors: Dr. DI R. Wimmer, DI L. Janisch, DI H. Hohensinner, Dr. Mag. M. Drack

The study analyzed enabling and limiting factors at the technical, legal/political, and organizational levels. The goal was to create a basis for an improved market penetration of renewable building materials and to highlight measures for a technology development geared to market requirements. The study focused on the investigation of straw bale construction, surface treatment, as well as on thermal and acoustic insulation.

2 Wandsysteme aus Nachwachsenden Rohstoffen (Wall Systems from Renewable Raw Materials)
Gruppe Angepasste Technologie, TU Wien, authors: Dr. DI R. Wimmer, DI L. Janisch, DI H. Hohensinner, Dr. Mag. M. Drack

This project aimed at transforming the innovative straw bale technology from an experimental phase to a professional stage by seeking the necessary technical certifications, by providing means for quality assurance, and by developing optimized designs for passive house construction.

3 Holzbauweisen für den verdichteten Wohnbau (Timber Constructions for High Density Housing Developments)
Schöberl & Pöll OEG, authors: Prof. DDI W. Winter (Institute of Structural Design and Engineered Timber Construction, Vienna University of Technology), Prof. DDr. DI J. Dreyer (Institute of Construction Materials, Building Physics, and Fire Protection, Vienna University of Technology), DI H. Schöberl (Schöberl & Pöll OEG)

This project focused on the development of cost-efficient timber construction for high-density housing developments with a view to future building codes. The investigation was based on a five-story housing project with 150 dwelling units in Vienna.

If the whole life cycle is taken into account, renewable raw materials show ***benefits in the following areas:***

- *building biology benefits during use (healthy interior climate)*
- *regional and economic benefits on account of their regional availability and their potential of creating regional chains of value added drawn from an agricultural waste product*
- *ecological benefit (low energy consumption during manufacture, CO_2 neutral, simple disposal)*

1 ENABLING AND LIMITING FACTORS FOR THE USE OF RENEWABLE RAW MATERIALS IN BUILDING CONSTRUCTION

The study investigated possible applications and the potential of renewable raw materials in building construction and developed strategies to step up the use of such materials and to improve market penetration in the future. Enabling and limiting factors were analyzed at three levels: technical, legal- political, and organizational.

With a view to the possible **technical applications**, the study analyzed 330 building products and systems grouped in 9 categories. The main emphasis was on innovative approaches that are expected to achieve a high market potential. Investigations were carried out in the fields thermal insulation, soundproofing, home textiles, surface treatment, interior design, mounting aids, wall, ceiling, and roof elements, structural members, prefabricated systems as well as windows and doors. The results of the investigations were presented in the form of a product catalog, which includes a comprehensive description and evaluation of all products.

As expected, wood turned out to be the most frequently used raw material, followed by sheep's wool, linseed oil, and cellulose. However, more than half of the products are compounds made up from different materials. Many new products are adapted to the requirements of low-energy and passive house technology. Thus, many new products are being developed particularly in the field of insulating material, because this sector is expected to meet with increasing demand.

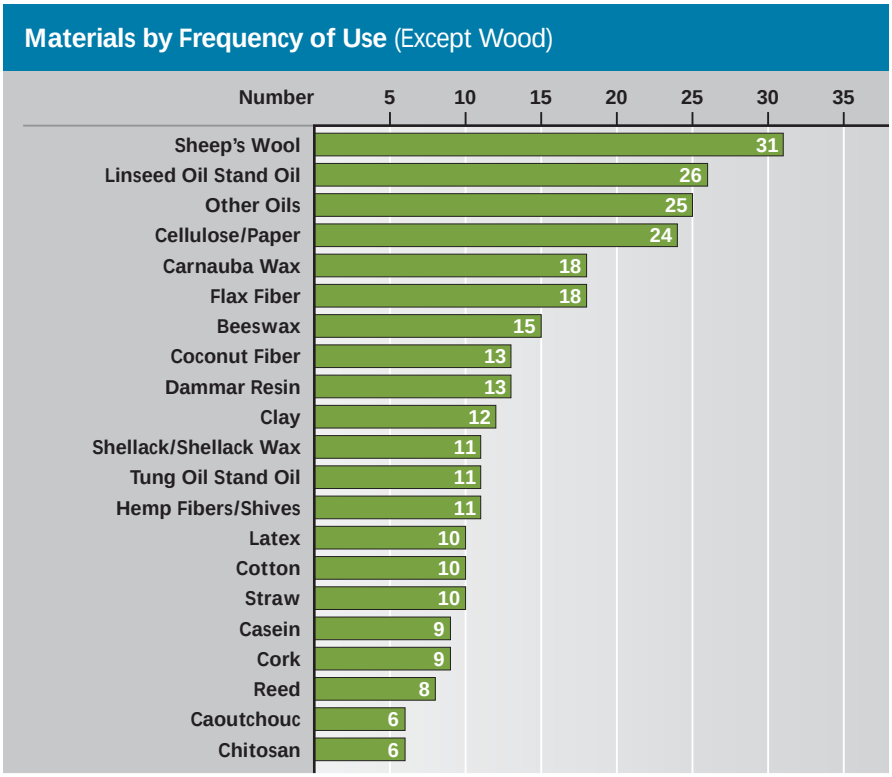
Concerning the **legal-political level**, the study analyzed the legal background (building codes), the possibilities of active promotion (subsidies), and the role of the public bodies as developers. In Austria, building codes fall within the purview of the individual laender (provinces), and the nine building codes differ in their overall conception as well as in numerous details. Harmonization has been achieved only in parts.

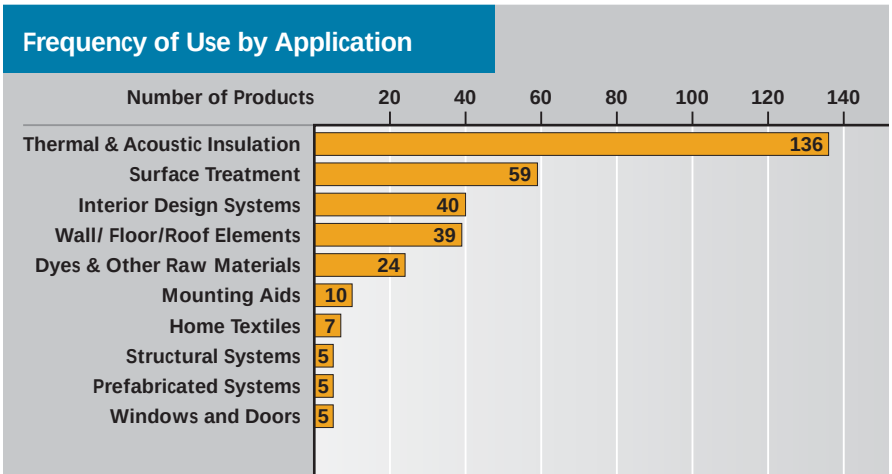
An important factor for the acceptance and diffusion of renewable construction materials consists in certification (Austrian technical certification and European technical certification, respectively). In order to advance the continual process of "normalization" of renewable raw materials in building construction, manufacturers should increasingly aim to have their products tested and officially certified.

In this context, active promotion programs for housing projects serve as steering tool and have been successfully realized in the field of energy saving building construction. Extending the existing guidelines for promotion programs to include building materials would be an effective measure. A targeted adaptation of the criteria for invitations of tenders for public building projects could also have a stimulating effect.

An analysis of the **organizational aspects** highlighted the different interests represented by the various groups of actors involved (agriculture, manufacturers, dealers). Encouraging cooperation between the various actors along the production chain and joint marketing activities constitute important strategies towards an intensified diffusion of renewable building materials. An independent platform could support networking between the actors involved in the process.

Source: GrAT, Study 1





2 WALL SYSTEMS USING RENEWABLE RAW MATERIALS

The study investigated three particularly promising areas in greater detail:

Surface treatment:
This sector has developed numerous innovative technologies, however, only 5% of these products have been successfully introduced on the market. Natural surfaces feature a number of advantages concerning building biology and health aspects compared with conventional products; in addition, they can be refinished without destroying the substance, which brings about a considerable cost reduction. A very promising application can be found in pre-finished parquet flooring; offering complete service packages in this field could also open up new market segments.

Thermal and acoustic insulation:
Natural insulating materials have been developed from various plant and animal fibers; the market share of these products ranges from 3 to 5%, at present. However, the growing trend towards passive house constructions may create new opportunities for the diffusion of renewable raw materials in the thermal and acoustic insulation sectors in the future. What is needed in this context, is an improved cooperation between agriculture and manufacturers as well as professional marketing strategies.

Straw bale construction:
This construction relies on two different technologies: the load-bearing straw bale construction and a timber post and beam construction with straw bale infills. In Austria, the latter design seems to have better chances of diffusion. Prefabricated elements afford considerable cost savings and avoid potential problems such as moisture in the building. The study also investigated the legal situation and socio-economic aspects. Also included in the study is a documentation of the results of an international survey dealing with this topic.

This project, which was conducted in parallel to the abovementioned study, elaborated important fundamentals for the implementation of new developments in the field of straw bale construction. **Research and development focused on the following issues:**

- Technical tests and certification concerning fire resistance and thermal conductivity in accordance with Austrian and European building standards
- Development of solutions for wall constructions and details of joints between building components
- Development of a mobile testing laboratory with a view to continual quality assurance of the straw bales from the field to the finished house

The technical fundamentals developed within this project and the certification of straw bales as building material will support a market-oriented technology development and facilitate the use of this renewable material for low-energy and passive houses. The straw bales and a straw bale wall construction have been tested as to their behavior in fire (Austrian OENORM B 3800 standard) and as to their thermal conductivity (OENORM B 6510). The results of the fire stability test B2, the fire resistance test F90, and the thermal conductivity test (λ_R= 0.0456 W/mK) demonstrated excellent function of the material and the wall construction.

In order to avoid errors and to optimize the junctions between individual building components, eight more types of wall construction have been calculated and optimized. All designs meet passive house standards through excellent thermal insulation. The porosity of the construction permits diffusion and thus avoids problems due to moisture in the wall. As far as soundproofing is concerned, double wall constructions have yielded good results while single wall constructions still need improvement. Joints between individual components of the structure can be designed in

Photo: GrAT

Measuring Moisture in Straw Bale Walls

such a way as to avoid thermal bridging; window mounts, ceilings, and basements have also been designed to meet passive house standards.

Participants in the project developed and tested a mobile laboratory in practice in order to ascertain the quality of straw bales and to create the basis for a quality assurance system. Investigators analyzed dimensions, weight, temperature, and humidity of the straw bales in order to ascertain dimensional accuracy, density and other factors referring to building physics. An additional visual inspection focusing on color, shape, homogeneity, purity, and possible mold formation is used to round off the quality assessment procedure.

The results gained from both studies demonstrate the promising potential of straw bale construction. Investigations have confirmed that straw bale construction fulfills all technical prerequisites for a great number of different uses. Possible applications range from single-family homes to multi-story residential buildings to industrial halls to farm buildings.

3 TIMBER CONSTRUCTIONS FOR HIGH-DENSITY RESIDENTIAL BUILDINGS

Structure of the Prototype

Photo: Schöberl & Pöll OEG

■ Since April 2001, an amendment to the building code for the City of Vienna has, for the first time in Austria, approved five-story mixed timber structures (i.e. four timber structure stories on a mineral-based foundation story with strict fire protection requirements for structural members and fire barriers). This has opened up new categories of high-density residential buildings for timber structures; until recently, there were hardly any built examples in Austria or the other German speaking countries. Innovative constructions in the field of apartment houses are viable only if the cost-benefit ratio is comparable to that of the market-leading masonry / reinforced concrete constructions. Research and development activities in this area have to be intensified in order to gain new insights for the planning and erection of multi-story timber constructions and to develop marketable solutions.

A one-year research project conducted by the Vienna University of Technology within the scope of the "Haus der Zukunft" subprogram aimed to analyze various designs for load-bearing wall and ceiling constructions and to compare them with a view to costs. The study analyzed a five story residential building project with 150 units that a large Austrian non-profit building organization is planning to realize in Vienna. The investigation focused on load-bearing interior partition walls and ceilings, which have been known as key problems and a decisive cost factor in multi-story residential timber structures. Problems arise especially from high static loads; strict sound proofing and fire protection requirements, and the considerable humidity load caused by the utilization of the building.

The project was conducted in **4 work phases:**

■ The first phase concentrated on the **analysis and evaluation of different design variants;** special attention was given to the design of the critical junction between ceiling and wall.

■ The second phase included **investigations concerning soundproofing and moisture behavior** as well as **a cost analysis of timber and solid constructions.** In order to be able to compare building costs, a special tool was developed in this project.

■ The third part of the project developed **different design variants of post and beam and massive timber constructions.** In the field of massive timber construction, an alternative to conventional glue-bonded board products has been developed. Contrary to industrially manufactured timber walls, the posts used for these massive timber walls are not glued together but rather use craftsman-like mechanical joints. Therefore, any carpenter is able to realize the construction. The design relies on commercially available timber products. These newly developed designs as well as two commercially available systems and several massive concrete solutions were evaluated with a view to costs and compared with each other on the basis of uniform criteria.

■ In the fourth phase of the project participants erected a **two-story prototype** and used a measurement program to ascertain various parameters such as sound absorption and static-dynamic load-bearing characteristics. The design used for this prototype relied on the newly developed variant of craftsman-like massive timber construction. Measurements have shown that this design fulfills both, the soundproofing and the static-dynamic requirements.

In addition to research institutions, planners, representatives of relevant authorities, and timber construction enterprises cooperated in the project.

The investigations yielded some **important findings:**

■ Given equal building physics requirements, both, the optimized timber frame construction and the massive timber construction can compete with commercially available massive concrete constructions.
■ In spite of a higher timber consumption, the craftsman-like massive timber construction can compete with timber frame constructions as far as costs are concerned.
■ Single wall timber constructions are considerably more cost-effective than double wall constructions and, as a rule, using large elements also reduces costs.
■ Even single wall constructions with continuous elements can fulfill the soundproofing requirements of the OENORM B8110 construction standard if mineral-based cladding is mounted to the wall.

FUTURE STRATEGIES

In order to advance the market introduction of building products and technical solutions based on renewable raw materials, all actors should contribute to the process.

The production of plant and animal raw materials plays a particularly important role. On the one hand, using common and widespread crops as raw materials could contribute to reduce excess capacities in the foodstuff sector. On the other hand, cultivating uncommon and rare crops would open up new market niches for agriculture. The various agricultural institutions play an important role in establishing appropriate cooperative and information networks.

Realizing the production process with a high level of regionally generated value added requires adapted logistics concepts, which have to be developed with the support of agricultural management consultants or regional management consultancy institutions.

Manufacturers are called upon to develop "raw material adapted" production processes that are highly flexible and can cope with an inhomogeneous and seasonally changing supply of raw materials. Other important issues refer to an efficient cooperation between manufacturers and experts in the field of research and technology development as well as to manufacturers' active participation in standardizing committees. Comprehensive consultancy at all levels is to improve professionalism and expertise. Users (home stores, customers, practitioners), too, are in need of competent consultancy by manufacturers.

Accompanying measures and strategies initiated by public bodies will play an important role in the further dissemination of renewables in the construction sector. Opportunities to support these innovative technologies lie in legislation, allocation of subsidies for agriculture, promotion of technology and the housing sector, but also in the public sector's role as builder and administrator. In addition, major developers and housing associations could publicize construction materials from renewable raw materials on account of the large quantities they use.

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PROJECT SPONSORS

„Erfolgsfaktoren für den Einsatz Nachwachsender Rohstoffe im Bauwesen"
Gruppe Angepasste Technologie (GrAT), authors: Dr. DI R. Wimmer, DI L. Janisch, DI H. Hohensinner, Dr. Mag. M. Drack, Wien 2001, in cooperation with GLOBAL 2000 Umweltforschungsinstitut, and IBO – Österreichisches Institut für Baubiologie- und Ökologie

„Wandsysteme aus Nachwachsenden Rohstoffen"
Gruppe Angepasste Technologie (GrAT), authors: Dr. DI R. Wimmer, DI L. Janisch, DI H. Hohensinner, Dr. Mag. M. Drack, Wien 2001, in cooperation with the Austrian Strohballen Netzwerk asbn, StrohTec GesmbH and IBO – Österreichisches Institut für Baubiologie- und Ökologie

„Holzbauweisen für den verdichteten Wohnbau"
Schöberl & Pöll OEG,
authors: Prof. DDI W. Winter (Institut für Tragwerkslehre und Ingenieurholzbau, TU Wien), Prof. DDr. DI J. Dreyer (Institut f. Baustofflehre, Bauphysik und Brandschutz, TU Wien), DI H. Schöberl (Schöberl & Pöll OEG), Wien 2001, supported by the Austrian Federal Ministry for Economic Affairs and Labour (bmwa)

INFORMATION

Information on the bmvit subprogram "Haus der Zukunft":
www.HAUSderzukunft.at

The project reports have been published in the bmvit series "Berichte aus Energie- und Umweltforschung" and are available from:
www.NachhaltigWirtschaften.at
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