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CONSTRUCTION OF A PROTOTYPE OF AN INDUSTRIAL, FLEXIBLE AND DEMOUNTABLE (IFD) APARTMENT BUILDING SYSTEM

Nico A. Hendriks*
and
Frans J.M. van Gassel**
Department of Building and Architecture, Eindhoven University of Technology
P.O. Box 513, 5600 MB Eindhoven, the Netherlands
n.a.hendriks@bwk.tue.nl;f.j.m.v.gassel@bwk.tue.nl

Abstract
In the framework of the Sustainable Construction Program the Dutch government wishes to support the development and use of IFD Building Technology, which is considered to be a potentially successful integral construction concept.
In the context of this program two industrial partners, a large building owner and the Eindhoven University of Technology are developing an IFD system-concept for the construction of multi-storey apartment buildings. The project has been awarded with a substantial subsidy of the Dutch government. Prototype testing is carried out in the 'DUBO-park' (Sustainable Building Park), a special testsite on the premises of the Eindhoven University of Technology.
The paper describes the principles of IFD Building Technology, the research-program of the IFD Apartment Housing Project, the objectives of prototype testing and experiences during construction of the prototype.

Key words: Industrial, flexible, demountable, IFD, Building Technology, sustainable Construction, integrated Design, prototype construction

* Nico A. Hendriks is professor in building materials and sustainable building technology at the Eindhoven University of Technology, department of Building and Architecture, Eindhoven, The Netherlands; he is also principal partner of the BDA Group, consultants for roofs and facades, Gorinchem, the Netherlands.

** Frans J.M. van Gassel is assistant professor and PhD student at the Eindhoven University of Technology, department of Building and Architecture, Eindhoven, The Netherlands; he is also secretary of CIB TG27.

Introduction

For quite a long time the objective of the Dutch government was to stimulate energy conservation. The result of this is that in the Netherlands we now have reached such a low level of energy consumption, that energy saving no longer should have the highest priority. In the framework of sustainable construction the most important judgement tool is life cycle assessment (LCA). In this respect the following environmental criteria are used:

- exhaustion of raw materials;
- energy consumption;
- emissions (aquatic and airborne);
- waste.

Specifically looking to "waste", we may observe that life cycle assessment is a bit awkwardly expression. After all, with building materials only very seldomly there is a closed life cycle. In the present building practise from an environmental point of view waste is a much bigger problem than energy consumption. Usually this is related to the demolition phase but at least as important are the construction phase and the actual course of life of the building. During the building phase the amount of waste still is about 10% of all the used (and paid!) building materials. Also during the course of life the amount of wasted materials, specifically in commercial construction has taken gigantic proportions. In the Netherlands the total waste of building and demolition is 16 million tons per year, of which 3 million tons are 'produced' in the construction phase. It also happens more and more often that office buildings already after a relatively short period thoroughly are remodelled and drastically changed.
If we would find a substantial solution for the waste problem, then this would have a direct positive effect on the other environmental criteria, like specifically exhaustion of raw materials and also energy consumption. A good contribution to this solution is: Industrial, Flexible and Demountable (IFD) Building Technology.

IFD technology

Important aspects of IFD technology are:

- industrial construction: prefabrication, which means also less waste with the actual production, often production recycling is feasible;
- no waste on the building site, which is a boundary condition;
- construction becomes assembling: completely dry building method, which is also a boundary condition;
- flexible also means "changeable" during the course of life of the building, so there is also less waste;
- flexible in the design phase means for example that the developer of the building can wait until the last moment with final decisions about the lay-out of floors;
- demountable also means that reuse or at least recycling is possible;
- perhaps IFD technology can mean: less construction (in general).

Design criteria

For the design on changeability the following criteria could be used [Hendriks 99]:
Integration and independency of disciplines:

- supporting structure
- installations
- building envelope
- interior finishing

Completely dry construction method, which means:

- no in situ concrete
- no mortar joints
- no screed floors
- no plaster
- no sealant
- no in situ polyurethane

Perfect modular measuring, which means:

- extreme attention to drawing work
- prototype testing on:
  - mountability
  - functionality
  - demountability
- quality system drawing work
- assembly instructions

Changeability on all aspects:

- supporting structure (limited)
- installation (practically unlimited)
- building envelope (limited and modular)
- interior finishing (practically unlimited and modular)

Some examples of IFD technology

The need for IFD solutions already has resulted in a lot of new developments.
The examples are limited to two flooring concepts, because of the limited length of the paper.
Figure 1 shows the principle of the INFRA+ floorsystem [Zanden 98], developed from the research on light construction systems at the Eindhoven University.

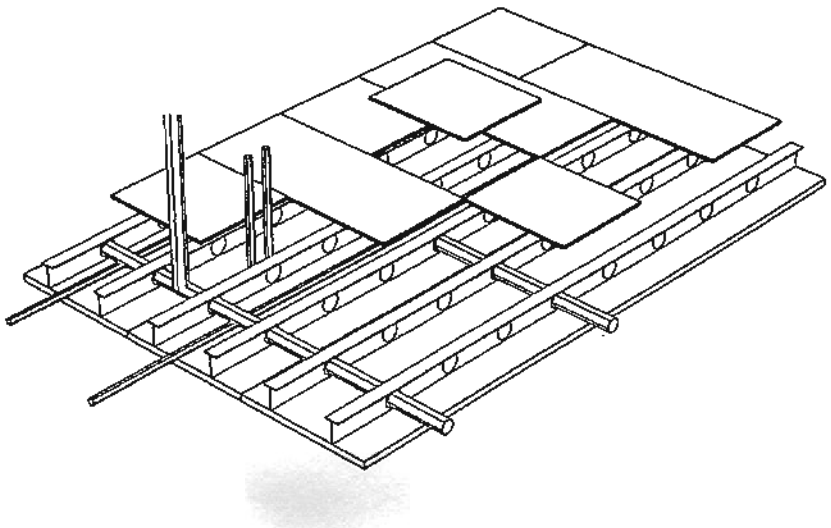


Figure 1 INFRA+ floor system.

The underside of the elements consists of concrete slaps connected to steel I-beams. This system is covered with a dry flooring on elastic supports to obtain good acoustical quality.
The other example is given in figure 2. This is a full steel framework consisting of so-called colf-formed and open profiles. The element is on both sides covered with a system of gypsum boards and insulation.

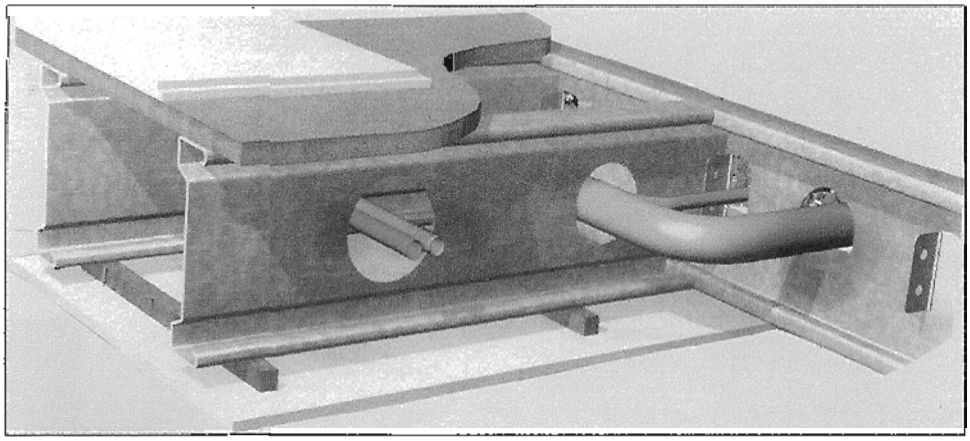


Figure 2 SADEF floor system.

IFD Today Apartment Housing project

Between 1945 and 1975 in the Netherlands about 2.5 million houses where built. Of these about 1.3 million are managed by housing corporation, and of these about 600,000 houses are realised in apartment blocks. Despite several efforts of the housing corporations in the years '80 and '90, the market position of these houses has decreased substantially. An import reason for this is that the quality can hardly be improved and if so only at (too) high investments. The houses remain small, poorly equipped and noisy.

Therefore the housing corporations are faced with the following question:

"In what way can possibilities to product differentiation's be realised in order to offer flexible possibilities for reaccommodation for inhabitants of the present apartment buildings, at the same time offering good accommodation to people with more purchasing power".

One of the answers to this question could be the demolition of an apartment block to the foundation and to construct a new apartment building on the old foundation with IFD technology. This was the basis of the IFD Today apartment housing project.

The floor system plays a key role in the concept. In order to achieve a fully flexible and changeable floor plan it was necessary to turn the span direction 90°, which means that the floor elements would have to span from facade tot facade. See for the ceiling of the two floors figure 3.

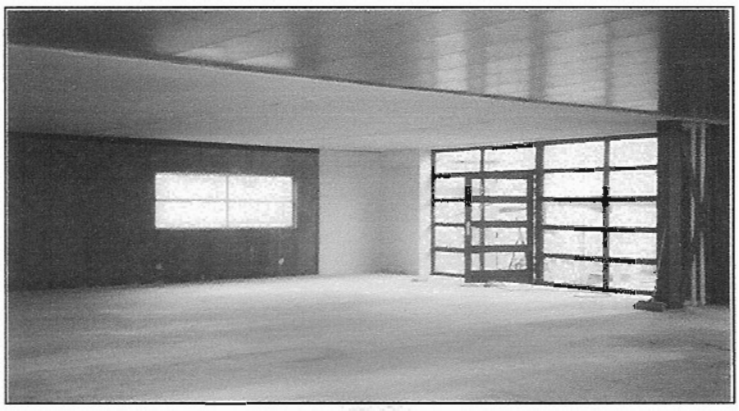


Figure 3 Interior test module with the two different ceilings.

The IFD approach enables the housing corporation to the construction of a modern apartment accommodation for several social classes. The majority of the post-war apartment blocks has four floors and no lifts. By using the IFD technology it is possible to construct a building with at least six floors and lifts, which also means good economic feasibility [Hendriks 00]. The floor plan of roughly 10 by 100 metres enables modular, free partitioning.

The IFD Today apartment housing project is a joint venture research program with the following participants:

- Amnis, a housing corporation in Utrecht
- Royal IBC, a contracting company in Best
- Stork Installatietechniek, an installation contractor in Amersfoort
- The Eindhoven University of Technology.

The input of the Eindhoven University is basically provided by three PhD-students, working on the following sub-research projects:

a. Supporting structure

The basic objective is to obtain knowledge and understanding of the statical, dynamical and fire behaviour of light construction systems. This is done by the development of evaluation models, based on fundamental and experimental research with the use of simulation and prototype testing.

b. Building physical aspects

The requirements on heat transfer, moisture transport, avoiding of thermal bridges and acoustical and vibration behaviour play a major role. The aim of this sub-project is to develop a building physical evaluation model, with help of experimental research, simulation and prototype testing. The Eindhoven University already has a lot of experience with building physical research on lightweight constructions.

c. Installations and integration

The connecting key in the project is product development with respect to installations and integration. Specifically the floor elements but also the elements of the facade and partitions will have to facilitate piping and duct for the several installations in the building. The aim of the project is to integrate the newest technology. This is also investigated by prototype testing.

After realisation of the research prototypes a real life pilot project will be built for Amnis in Utrecht. This pilot project will also be used for further research and evaluation.

Prototype testing

During the first phase of the project the design and research groups have selected some alternatives that would meet the requirements for IFD. On the basis of this designs were made. The groups developed two different basic principles for the flooring concept. These are shown in figures 4 and 5.

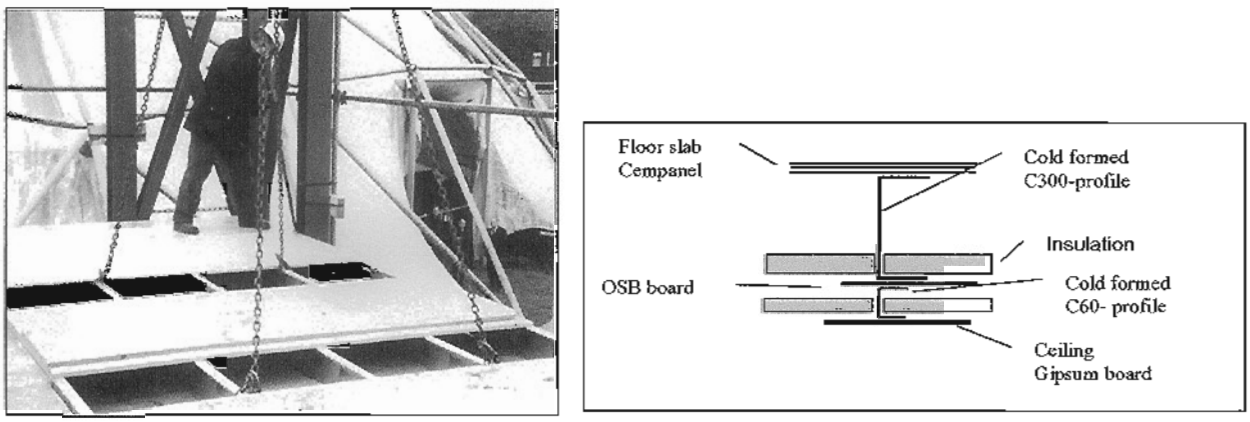
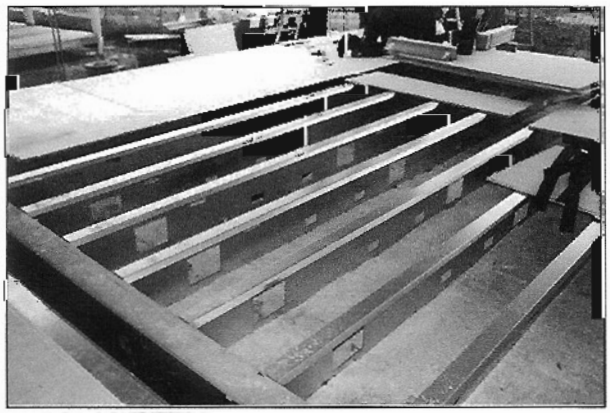


Figure 4 IBC floor system with different kinds of cold formed profiles.



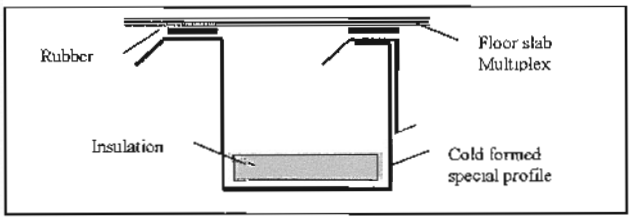
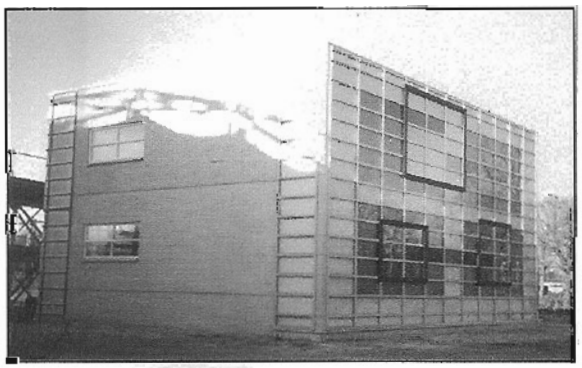


Figure 4 Van Dam floor system with one cold formed profile.

These concepts are tested in the 'DUBO-park' (Sustainable Building Park), a special testsite on the premises of the Eindhoven University of Technology. Figure 6 shows photos of the test module.



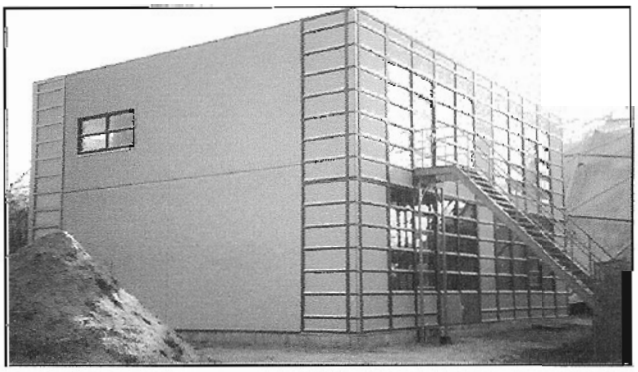


Figure 6 The test module situated on the 'DUBO-park'.

For the façade four different wall concepts are selected .
The first test phase will be concentrated on the following aspects:

- Mountability
- Vibration characteristics of the flooring concepts
- Sound insulation properties
- Amount of waste (target: zero)
- Technical performance
- Demountability

Construction of the prototype

Industrial building traditional means:

1. The production takes place in the factory.
2. The production is mechanised.
3. Mass fabrication.
4. Collaboration undependent of one project
5. Application information technology

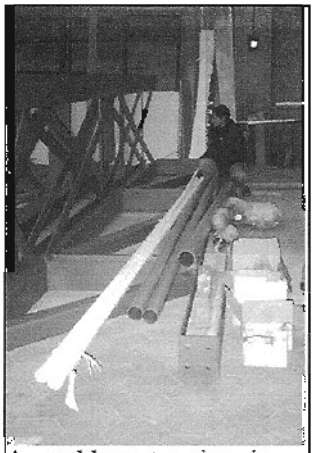
Todays industrial building means:

1. Client driven production and marketing.
2. Flexibele production systems.
3. Independent subsystems.

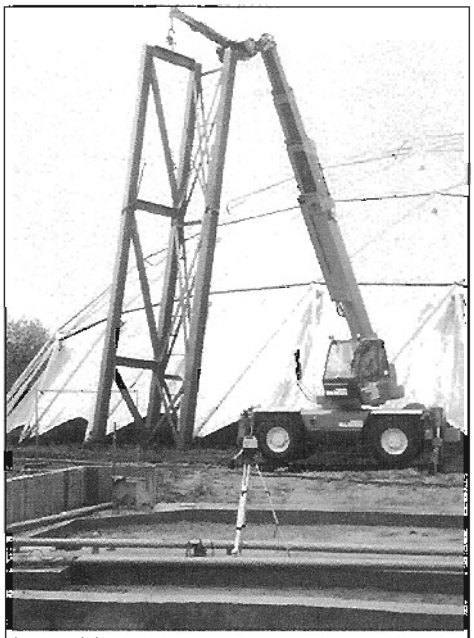
By building the test module, industrial building aspects are applicated. In tabel 1 some pictures shows the construction process.

Tabel 1 The assembly of the test module in Eindhoven.

Traditional concrete foundation

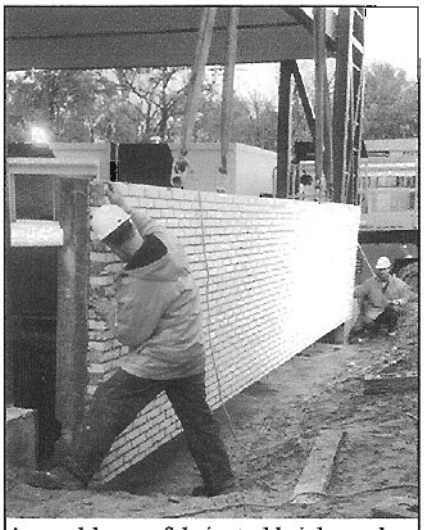


Assembly water pipes in the factory

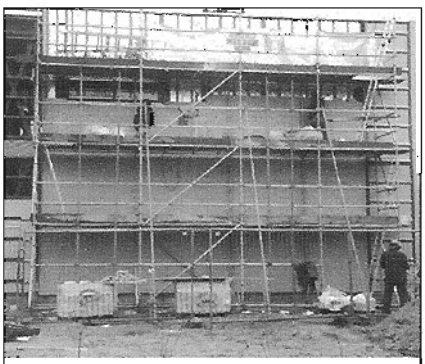


Assembly steel structure

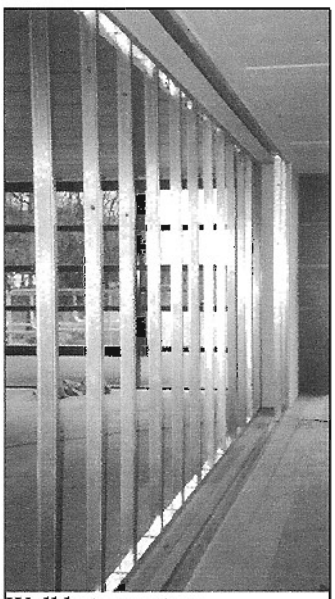
Assembly floor panels



Assembly pre fabricated brick work panels

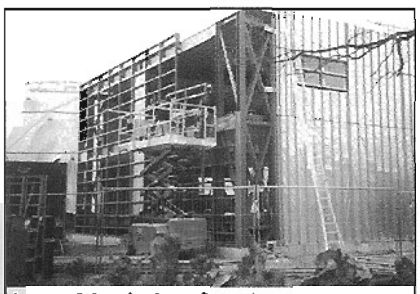


Assembly demountable bricks

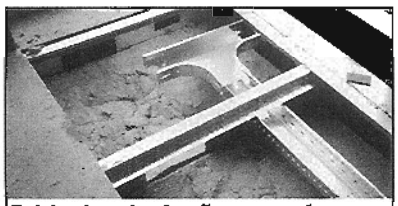


Wall between two appartments

Assembling tomber facade



Assembly timber facade



Cable duct in the floor panels

ifd today

Conclusions

IFD Building Technology can contribute substantially to the minimisation of waste during production of building components and the actual construction, but also during the course of life of the building and the demounting phase. Simultaneously there is a positive effect on the environmental criteria exhaustion of raw materials and energy conservation.
The IFD Today research program for apartment buildings will provide for detailed information to be applied on a real life pilot project.

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