INDUSTRIAL, FLEXIBLE AND DISMANTABLE (IFD) BUILDING TECHNOLOGY: A KEY TO SUSTAINABLE CONSTRUCTION

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Abstract

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. In this project three subprojects are distinguished: a. Integration of installation and structure; b. Developing of IFD facade-concepts; c. Interface of main construction and foundation. The project has been awarded with a substantial subsidy of the Dutch government. The paper describes the principles of IFD Building Technology, the objectives and measures of the Dutch government in this respect, the research-program of the IFD Apartment Housing Project, the objectives of prototype testing and some examples.

4. PRINCIPLES OF IFD BUILDING TECHNOLOGY

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 has the highest priority. In the framework of sustainable construction the most important 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 have to realise 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. It happens more and more often that office buildings already after a relatively short period thoroughly are remodelled and drastically changed.

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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 Dismantable (IFD) Building 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;
- dismantable also means that reuse or at least recycling is possible;
- perhaps IFD technology can mean: less construction (in general).

4. DESIGN CRITERIA

For the design on changeability the following criteria could be used [Hendriks 99]:

4.1. Integration and independency of disciplines:
- supporting structure
- installations
- building envelope
- interior finishing

4.1. Completely dry construction method, which means:
- no in situ concrete
- no mortar joints
- no screed floors
- no plaster
- no sealant
- no in situ polyurethane

2.3. Perfect modular measuring, which means:
- extreme attention to drawing work
- prototype testing on:
  - mountability
  - functionality
  - dismountability
- quality system drawing work
- assembly instructions

4.1. Changeability on all aspects:
- supporting structure (limited)
- installation (practically unlimited)
- building envelope (limited and modular)
- interior finishing (practically unlimited and modular)

3. DUTCH DEMONSTRATION PROGRAM IFD

3.1. General

The Dutch Ministry of Economic Affairs and the Ministry of Housing, Regional Development and the Environment have taken the initiative to develop a national demonstration program for projects which are built on the principles of Industrial, Flexible and Dismantable Building Technology. The aim of this
demonstration program is to make IFD construction a regular building method. The program is developed by co-operation of several building organisations, contractors, industry, architects and housing associations.

3.2. Objectives

At this moment more and more building components and even complete buildings are being industrially produced under good controllable conditions. The traditional execution on the building site is more and more replaced by assembly. The technical solutions which are necessary for IFD building have been developed in the past decades and this development will continue in the coming years. Industrial building offers important advantages for flexible and dismantable building. Flexibility is the key to success for principals who want to develop buildings which anticipate to the individual wishes of the users and which can be adapted to changing needs during the life of the building.

One of the important conditions for flexibility is the application of dismantable prefabricated building components. IFD building technology can to a greater extent contribute to the extension of the economic durability of buildings and a sustainable built environment.

At the same time IFD building technology will lead to economic growth of the building sector by co-operation and innovation.

3.3. Projects

The program primarily aims at clients, who can be granted a subsidy on the cost of preparation and the implementation, if they meet the criteria.

The projects can exist of new development-, renovation-, or re-purpose projects within the housing- and utility sector.

In order to interest the market for the program a series of applicability's for IFD building technology has been developed.

a. Flexible houses

Changing lifestyles and the need for workspace in the house need consumer-oriented flexible housing concepts. It is important to anticipate to the wishes of the first inhabitants and to build in conditions in which the same or the new inhabitant can simply adjust the house to his needs. Examples are a/o. the change of the arrangement, to replace the 'wet' parts (bathroom etc.) dividing or expanding the house. Light pre-fabricated building methods like timber frame building and steel frame buildings are good examples.

On the building part level especially dismantable floors and integrated roofsystems play an important role. On product level it is mostly modular pre-fabricated building components, such as meter cupboards, kitchens, window frames, modular walls and main systems.

b. Short cyclic real estate

The current dynamics in business demand building concepts which link up perfectly with changing demands of companies.

An example of short cyclic real estate is a temporary (5 years) office building.

The answer to this is a high quality industrial product that when it comes to technology and aesthetics can be compared a traditionally built office. The building method exists of a circuit of pre-fabricated units, which can be fast and turn-key assembled at the building site.

The unit exists of a light steel frame of which the client can choose form various dismantable facade finishing partitions and finishing materials.

c. Function-flexible buildings

This is related to a high-quality building on a good location and to the function of a building could be adapted to the changing demands of the same or the new user.

The IFD-concept aggravates especially on the realisation of free partitioned, roomy floors and a flexible network of pipes. In the Netherlands some examples have been realised, like an office building which can be rebuilt to an apartment block and the school-housing concept, a school which later, when the number of children decreases can be equipped for living.

d. Life-span durability

Especially dismantable building can be a good strategy to bring the technical and economical life-span of a building in line. Because of that the user or investor of the building can avoid early debiting.
Buildings are better exploited and remain a high standard of quality for use, which in return importantly contributes to the quality of the built environment. This way of building moreover stimulates the conscious handling of raw material, an important mark to come to sustainable development in the building industry.

e. Process and product innovation
The development of new products most of the time only occurs for the benefit of a specific building project. Long unconditional projects forms of co-makership are not common in the building industry. The contact between the suppliers and the designers is brief and oriented on single solutions. In order to come to a more to the IFD-concept tailored building practice it is necessary for co-operation structures to start in which the investments and risks are spread amongst the participants and the different projects.

4. IFD APARTMENT HOUSING PROJECT

4.1. Background

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 this houses has decreased substantially. An important reason for this is that the quality can hardly be improved and if so only at (too) high investments. The housed remain small, poorly equipped and noisy. Therefore the housing corporations are faced with the following question:

"In what way can possibilities to product differentiations 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 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. A possible solution is given in figure 1 [Jacobs 97].

Figure 1
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. The floor plan of roughly 10 by 100 metres enables modular, free partitioning.

4.1. Research projects

The IFD 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 four 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.

Some examples
The examples are limited to two-flooring concepts, because of the limited length of the paper. Figure 2 shows the principle of the INFRA+ floorsystem [Zanden 98], developed from the research on light construction systems at the Eindhoven University.

Figure 2
The underside of the elements consists of concrete slabs 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 3 [Jacobs 97].

Figure 3

This is a full steel framework consisting of so-called hood beams and open profiles. The element is on both sides covered with a system of gypsum boards and insulation.

4. CONCLUSIONS

4.1. IFD Building Technology can contribute substantially to the minimalisation of waste during production of building components and the actual construction, but also during the course of life of the building and the dismantling phase. Simultaneously there is a positive effect on the environmental criteria exhaustion of raw materials and energy conservation.

4.2. The Dutch government has set up this demonstration program for principals in order to be able to stimulate a development which leads to an increase of quality of the building product and a decrease of the building costs, also during the life-span of a building. The advantages of such a development can at the same time importantly contribute to sustainable development.

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