Application of IFD Technology to existing Apartment Buildings

Nico A. Hendriks¹, Haico van Nunen¹ and Paul G.S. Rutten¹

¹ Eindhoven University of Technology, Department of Building and Architecture, Knowledge Centre Building and Systems TU/e-TNO
PO Box 56, 5600 MB Eindhoven, the Netherlands

ABSTRACT: In the projects IFD Today and Flexible Breakthrough research has been done into the application of IFD Technology for the renovation of apartment buildings that were built between 1945 and 1975. IFD stands for: Industrial, Flexible and Demountable. From an environmental point of view building waste is at present 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. In the Netherlands the total waste of building and demolition is about 22 million tons per year, of which 5 to 6 million tons are ‘produced’ in the construction phase. It also happens more and more often that buildings are already thoroughly remodelled and changed after a relatively short period. In order to minimise building waste drastically, 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. The objective of the projects is to - more or less - reconstruct the apartment buildings, at the same time using, as much as possible, IFD-technology. In the IFD Today project the existing apartment building is demolished, leaving the foundation intact. On this foundation a new IFD building (with two more floors) is erected. The basic principle of the Flexible Breakthrough project is to completely remove (demolish) one of the four bearing walls in each apartment and replace this wall by a steel-supporting frame. The resulting much larger space is to be redesigned with IFD-technology. The paper describes the results of research and two full-scale test projects.

Conference Topics: 1 Recycling architecture and 6 Materials and Building techniques
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1. INTRODUCTION

1.1 Building challenge
For the period 2000 to 2015 the Netherlands are confronted with an important building challenge. Because of the lag that has developed in the quality of facilities and housing stock, the redevelopment of inner city areas requires a large-scale integrally organised approach. This is specifically the case for the restructuring of post-war (1945-1965) residential districts.

The owners of apartment blocks in these districts are faced with a very complex task. The most important question is how to renovate and improve the cramped and out-of-date housing stock, avoiding massive demolition. How can, by using IFD technology (Industrial Flexible and Demountable), the housing types be re-differentiated and the apartment blocks sustainable renovated in order to house the different target groups?

1.2 Aspects of IFD technology
The major aspects of IFD Technology [1] 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;

2. MARKET SITUATION

2.1 General
Housing consumers are demanding better quality and larger floor areas. In addition, there is a clear
need for greater flexibility and adaptability. The Netherlands is on the eve of extensive measures being taken to the housing stock. This concerns the large-scale redevelopment and restructuring particularly of residential areas built after 1945. This means flats accessed from a common entrance hall, blocks of flats, single-family houses and high-rise flats. This is a substantial part of the housing stock. The main problems these districts now face are:

- houses no longer meet current statutory, functional and technical requirements;
- amenities in the district and housing stock no longer meet the requirements of the residents;
- the composition of the residents has slipped down to the level of people with the lowest income. 80% to 90% of these houses are rented to ethnic groups.

The problems in these post-war districts in relation to the aforementioned characteristics require a district-oriented integrated approach. Based on forecasts made by the Economic Institute for the Construction Industry, the following trends in housing market are expected until 2005: A slight fall (7%) in the building volume of new houses and a substantial growth (15%) in the refurbishment and renovation sector. Quite a lot of information is available about the quality of the housing stock in the Netherlands. The main source of this is a national survey carried out by the government on the functional and technical quality of the whole housing stock. This is expressed in terms of the extent of the backlog in housing quality.

2.2 Tools for restructuring

The traditional approach of managing the housing stock, especially by housing corporations, has three forms:

- regular maintenance and replacement of building components aimed at maintaining the property;
- major repairs aimed at qualitative home improvements;
- replacement new building by carrying out massive demolition of houses.

This traditional approach has not proved to be adequate to keep the district as a whole up to a certain standard. Encouraged by government policy, progressive housing corporations and residents' associations, a range of strategies and solutions has been added to the existing traditional approach over the last 5 years.

The strategy employed in addition to this has the following broad elements:

- using the abundant public space especially the green areas to create more private spaces, such as allotments, play areas and private gardens next to stacked housing;
- breaking through the separation of functions by combining residential and business areas and encouraging urban living in the district;
- restructuring the existing unbalanced housing supply into a differentiated supply for several target groups, also with combined home and office;
- applying high requirements with respect to urban planning and architecture.

2.3 Objectives of research projects

The objectives of the projects 'IFD Today' and 'Flexibile Breakthrough' is to more or less reconstruct the apartment buildings, at the same time using, as much as possible, IFD-technology [1,2].

3. IFD Today

3.1 Principle

One of the solutions 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 to facade.

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

3.2 Prototype

Figure 1 shows the prototype that has been built in the ‘Dubopark’ on the campus of the Eindhoven University of Technology.

![Figure 1: IFD Today prototype.](image)

The Dubopark is a laboratory site where experimental technologies for sustainable construction are investigated.
Figure 2 shows the installation of one of the two different floor systems that have been applied. A major IFD aspect of the floor systems is the integration of building services in the bearing structure.

Figure 2: Installation of floor system in IFD Today prototype.

3.3 Further research

Several research projects have been executed with respect to aspects such as: vibration behaviour of the floor systems, integration of building services, façade systems and adaptability of components [3,4]. At present the most important ongoing research is a PhD study by S. Zegers on the mechanical behaviour of light-weight integrated floor systems. The first publication is expected by the end of 2004.

A research proposal has been submitted to further investigate the adaptability and functionality by actually occupying the prototype building by students. Unfortunately the obtaining of the necessary permits is quite a time consuming procedure. The start of this research project is expected by the end of 2004.

4. PROJECT FLEXIBLE BREAKTHROUGH

4.1 Principle

Basic principle of the project Flexible Breakthrough is to completely remove (demolish) one of the four bearing walls in each apartment and replace this wall by a steel-supporting frame. The resulting much larger space is to be redesigned according flexible principles.

In order to test the validity of the concept a full-scale demolition test project was executed.

The desk study on the project Flexible Breakthrough [3] showed that the specific advantages of the (partial demolition) approach are:

- Substantial reduction of waste, due to less demolition and application of IFD-technology.
- Better possibilities for the improvement of the houses with respect to acoustical properties and quality and flexibility of building services.

- Complete demolition and new construction would cost per house about € 27,000,- more.
- Faster availability of apartments for rent.

Because one of the four bearing walls has to be demolished it was not possible to apply all the principles of IFD-technology in every detail. The consequence of the removal of such a wall is that the floor slabs also partly must be demolished. After the installation of the new steel-supporting frame the floor slabs have to be reconnected, which must be done with in situ concrete. But for the remaining part IFD-technology can be applied.

4.2 Methodology

The methodology that has been used by the design team is based on the approach that has been introduced in [5]. The applied balanced multi-criteria selection process not only showed a high degree of industrialisation during construction, extreme flexibility during use of the building and demountability at the demolishing stage, but also a high degree of sustainability and personal comfort. The following system development areas have been selected:

1. Foundation
2. Position of supporting beam
3. Sound proofing
4. Demolition
5. Construction and stability
6. Façade
7. Building services
8. Execution

More details are given in [3]. Figures 1 through 3 give an impression of the demolition and rebuilding process.

Figure 3: Installation of integrated supporting frames.
4.3 Demolition test project
The next phase of the project was prototype testing of the demolition phase in combination with the installation of the steel supporting frame. This testing was done on an apartment building that had to be demolished anyway. Figures 5 and 6 give two stages: the removal of the bearing wall elements and the situation after the installation of the steel frame.

4.4 Results
The most interesting results of the demolition test were:

- The removal of the bearing wall elements through the opening in the roof required four times less labour than conventional demolishing.
- The installation of the four floor steel frame only took half a day.
- The connection of the concrete floor to the steel beam proved to be very simple and cost effective. A loading test showed a good structural integrity.
- The complete costs of reconstruction with this concept will be at least 15% less expensive than complete demolition and new construction on the basis of equal building physical quality.

4.5 Further research
So far several (graduation) research projects have been performed on aspects such as façade concepts and the integration of building services. In the course of 2004 a full scale model of one of the building services concepts will be built and tested in the FAGO laboratory. The housing corporations that were involved in demolition test project are studying the possibility of a demonstration project. In this project eight apartments will be renovated according the Flexible Breakthrough project. There is also interest from some East European countries to apply the concept to existing apartment buildings.

5. CONCLUSION

From the two research projects the following conclusions can be drawn:
1. IFD Technology offers fascinating possibilities to combine Sustainable Building with Economical Building.
2. IFD Technology can be successfully applied to the renovation of existing apartment buildings.
3. Concepts like IFD Today and Flexible Breakthrough should also be considered for the redevelopment of residential districts built in the period between 1950 and 1965.
4. Further research is required to fine tune the technology.

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