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Development of Industrialized Building Production

Développement de la construction industrialisée des bâtiments

Entwicklung des Fertigteilbaus

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SUMMARY

The evaluation of trends in prefabrication technology indicate that it will enter a decline phase within the next decade, which can be avoided only with immediately-undertaken innovative development. Precast concrete technology has many as yet unutilized potential assets which must be exploited. These changes are listed. Element systems must be developed further. Finnish open element systems for residential, industrial and commercial buildings are presented as examples of the possibilities that exist.

RESUME

Il semble que la technologie actuelle de préfabrication atteindra sa phase de déclin dans la prochaine décennie. Seul un développement innovatif entrepris immédiatement peut éviter une réduction de la part de marché. La technologie du béton préfabriqué présente certains avantages encore inutilisés et devant être mis en valeur. Ces changements sont mentionnés. Des systèmes d'éléments ouverts finlandais pour des bâtiments résidentiels, industriels et commerciaux sont présentés.

ZUSAMMENFASSUNG

Die Beurteilung der Wachstumstendenzen im Fertigteilbau zeigt, dass sich im nächsten Jahrzehnt ein Rückgang einstellen wird. Er kann nur mit unmittelbaren innovativen Entwicklungen verhindert werden. Viele Möglichkeiten der Fertigbautechnik sind bis heute ungenutzt und die Fertigteilbausysteme müssen weiterentwickelt werden. Im Beitrag wird darauf eingegangen und die offenen Fertigteilbausysteme aus Finnland für Wohn- und Geschäftsbauten werden als Beispiel vorgestellt.

1. EVOLUTIONARY TRENDS ON THE MARKET

1.1 Evaluation of the life cycles of prefabrication

The life cycle of a technical product or production system can be statistically evaluated using the same methods as for evolution in nature. This method is known as Darwin-Volterra methodology (3,4). The external conditions in nature correspond to the market conditions in techniques, and natural evolution corresponds to technical innovation.

The life cycle of a product or production technique consists of the introductory phase, growth phase, maturity phase, saturation phase and decline phase.

The prefabricated building production technique has a history spanning approximately 25 years, which is considered rather short in comparison with many other techniques. Several life cycle estimates for Finnish precast concrete production and German prefabrication are presented in Figures 1 to 3. The estimates are presented on the basis of statistics obtained for the years 1955 to 1965 and 1980 to 1982. Following the statistical period, the evolution curve is evaluated by means of the Darwin-Volterra methodology.

Finnish building production represents a small but very intensive market area within the observation time period. The German building production represents a large and intensive market area.

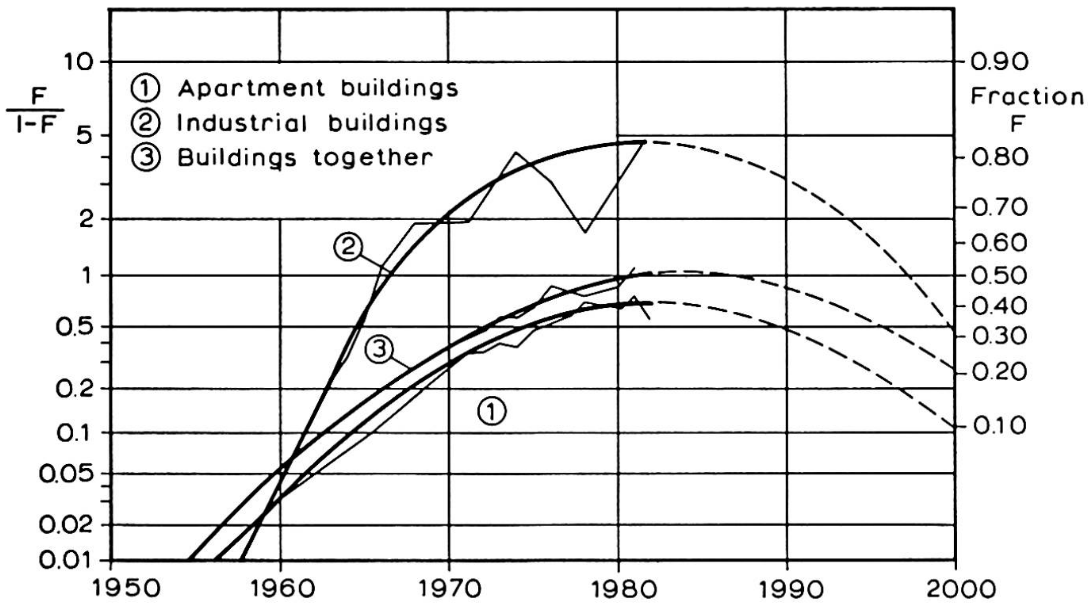

Fig. 1 Life cycle estimates of precast concrete production in Finland, illustrated by the market fraction evolution curve

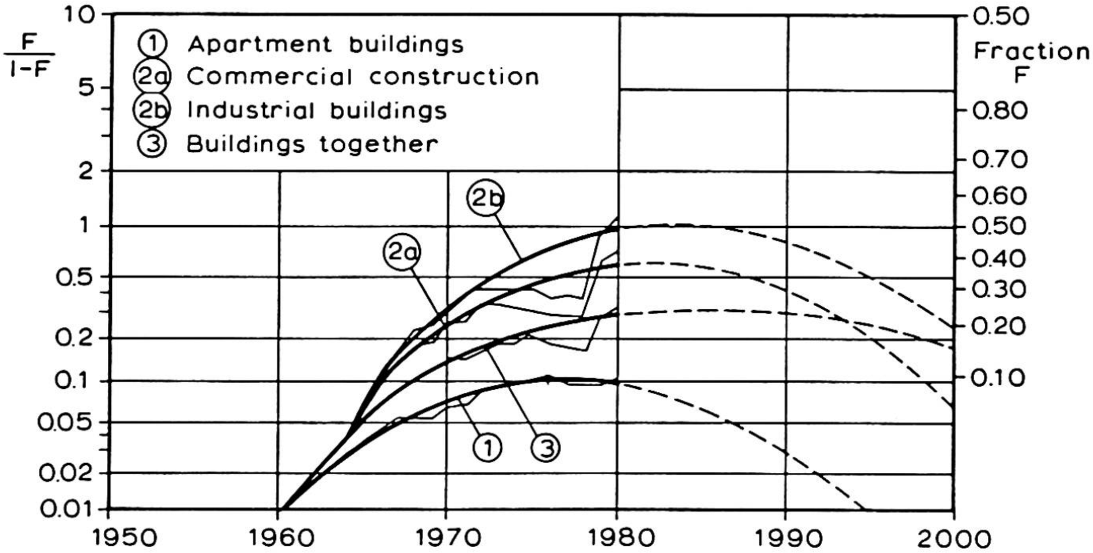

Fig. 2 Life cycle estimates of prefabricated building production in Germany, illustrated by the market fraction

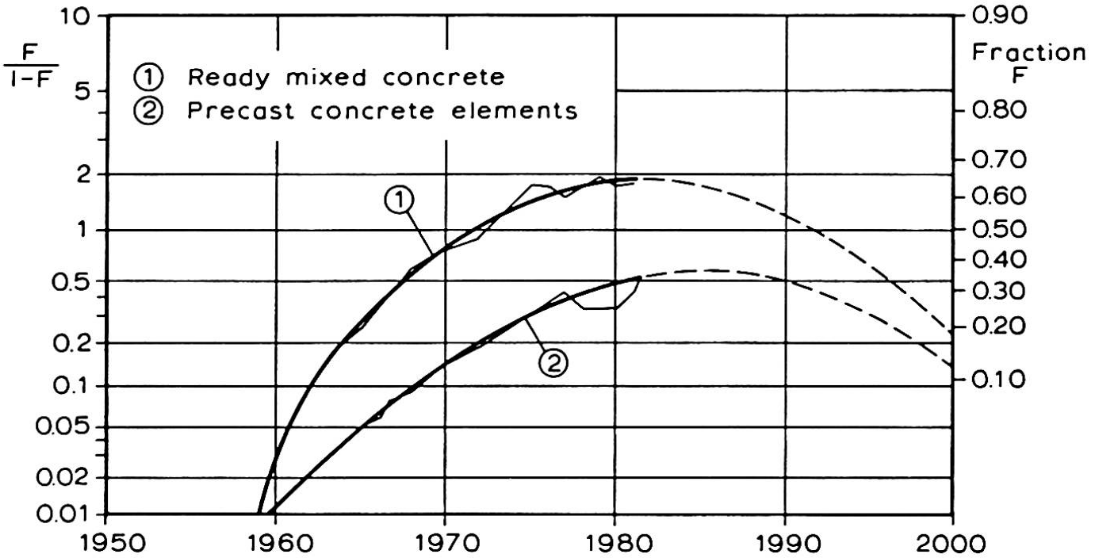

Fig. 3 Life cycle estimates of ready-mixed concrete and precast concrete production, illustrated by the fractions of total cement consumption in Finland

1.2 Conclusions drawn from the trends

On the basis of the trend estimates the following conclusions can be drawn:

-1. The prefabrication technique can be estimated to have got a remarkable market share of the percent fraction both in Finland and in Germany between 1955 and 1960.

-2. The modes of life cycle curves are very similar in all cases.

-3. The evolution shows some kind of disturbance period from 1976 to 1980, corresponding to the common economical disturbance during those years. Following the local disturbance, the evolution has returned to the earlier trend.

-4. The introductory phase of the life cycle occurred in the late 1950's and early 1960's, the early growth phase up until the mid 1970's, and the maturity phase in the late 1970's and early 1980's.

-5. Within the next few years, it seems that life cycles will reach saturation phase and switch to a phase of more rapid decline subsequent to 1990. In the apartment building sector, the decline phase seems to have begun in the early 1980's.

-6. It appears that the estimated market situation will produce a demand for new technology in the 1990's.

-7. Large variability in the market fraction of prefabrication over the last few years indicates a high sensitivity to changes in market conditions. The reason lies behind a weak competition ability, typical in the saturation phase of technology.

1.3 Challenges for improvement in the evolution of precast concrete technology

Principally, there are two ways in which evolutionary trends can be improved. The first possibility is that of a positive change in market conditions and the second is that of an active innovation process in precast technology.

The total size of the building construction market will in the future be either stable or even on the decrease across the whole of the developed world. The evolutionary trends in precast concrete technology indicate that these types of marked conditions are unfavourable for actual prefabrication technology. The main reasons for this are:

- the weak ability for economic competition
- the weak flexibility of prefabrication technology in adjusting to changing market requirements, such as an increase in small house construction and the development of lightweight construction techniques.

Following this conclustion, the only way to improve the future trend of evolution is the innovative development of prefabrication technology. In addition, market-orientated management and new marketing methods will naturally be needed in order to support the development of technology.

The construction markets will, in the future, also show a rise in developing countries and in some areas of energy production. The needs on these markets often differ from those in usual construction. Therefore, new technologies, as well as new orientations in marketing, must also be developed for these areas of production.

2. BASIS FOR INNOVATIONS IN PRECAST CONCRETE CONSTRUCTION TECHNOLOGY

2.1 Changes in precast concrete construction

The basic demands in construction and finalized buildings are for quality, economy, flexibility, durability, ergonomy, energy consumption and resources of raw materials.

In comparison with competing construction techniques, the precast concrete construction exhibits the basic properties presented in Table 1.

The most important potential assets not as yet put to good use are:

- the mechanization and automatization of production in the element factories and consequent savings in labour costs
- the flexibility in production, speedy erection
- the dismountability of buildings and
- the architectural properties.

Factor	Existing or potential properties
Concrete material	
-technical properties	Good statical, dynamic, resistance, durability and visual properties in common
-energy consumption	Small energy consumption
-amount of raw materials	Usually large resources, local lack may exist in some areas
-variability	Good variability of properties (strength, weight, ductility, colour)
-properties in the production process	Good processing properties
-economy	Potentially very good economy due to the simple production and low energy; the possibilities are as yet unused due to high labour consumption
-ergonomy	Some problems with noise and allergy in production
Precast concrete production	Simple production techniques in comparison with most of the other building materials; potentially very good possibilities for mechanization and automatization
Erection	Potentially very speedy erection, also suitable for special conditions (cold or hot climate, offshore construction etc); also dismountable construction technique possible
Flexibility	Potentially good flexibility on the basis of flexible material properties in products as well as in the production

Table 1 Properties of basic factors in precast concrete construction

The development areas presented in Table 2 can be used in the exploitation of potential assets.

Potential asset	Demands for developments in the utilization of the potential asset
Economy and flexibility in production	Mechanization and automatization of the element factories, use of CAD/CAM (Computer-Aided Design and Manufacture) techniques in the design, manufacture and change of information
Speedy erection technique	Connection and joint techniques, computer-aided project planning and project control, development of the erection techniques, increase in the stage of prefabrication
New structural techniques	Flexible modular element systems, architectural development, dismountable construction, lightweight construction system, small house construction system. Structural components suitable for flexible use and automatized production

Table 2 Demands for technical development of precast concrete construction

3. OPEN MODULAR ELEMENT SYSTEMS

3.1 Principles for improving the economy, flexibility and quality of precast element construction

The flexible open modular element system serves an an important basis for the following scheme:

1.- Prefabrication is based on a limited number of national or even international open systems. The system includes common agreement of modular dimensions for each group of buildings, such as apartment houses, commercial buildings and industrial buildings.

2.- Each firm or group of firms produces some special type of prefabricated unit. The units are of standard types, yet still allow for individual variations in dimensions and holes within the frame of the modular system. Standard elements can be produced economically and good quality can be achieved when using industrial production methods. The designer, contractor and user can choose from among several types of element in each case, fulfilling the requirements in the best possible way.

3.- In order to enable the individual design of buildings, additional special units are made on an individual basis. Special units are far more expensive to produce than standard elements, but only form a small proportion of the total elements.

4.- Standard connections are used for the montage of the elements during erection of the building. Especially rapid montage is important. The connections also often have great influence on the quality of buildings, notably on the thermal and acoustic insulation properties and on the aesthetic properties of facades. The importance of being able to dismount the buildings is rapidly increasing.

The assets of the open system are of special importance in small market areas as well as in the international construction trade. The basic asset in small market areas is the increase in the series within production. The assets in international construction trade are improvement in design and management, and a choice between competitive offers.

3.2 The Finnish BES-system

The system is used mainly for residential buildings. The building is composed of prefabricated elements forming modular grids in all directions. The modular planes surround the modular space, the projection of which is termed modular area. The element fills its modular space, still allowing sufficient room for connections and joints. The hierarchical horizontal planning modular grids are:

- a detailed planning modular grid at block plan level primarily n x 3M (M=100 mm)
- a frame structure planning modular grid A x 12M (M=100 mm)
- a related structural component planning modular grid n x 3M (M=100 mm).

The structural components used in the system are transversal load bearing wall panels between the apartments, floor slabs, self-bearing or hung concrete sandwich external wall units, non-bearing internal walls and supplementary components including, for instance, balconies, staircases, WC's, saunas, kitchen components etc. An example of the modular element system in a horizontal direction is presented in Fig. 4.

The system also includes rules for standard connections and joints.

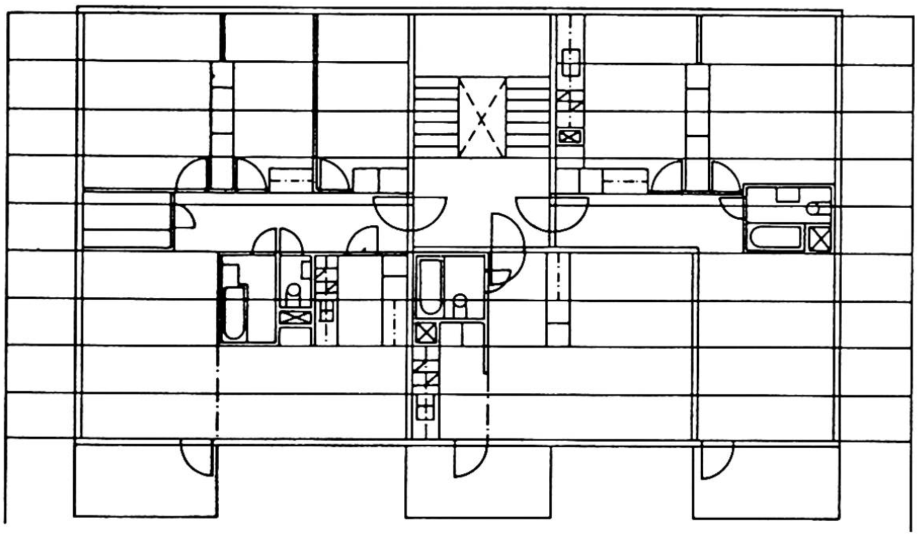

Fig. 4 Horizontal plane of the apartment building on the Finnish BES-element system

3.3 The Finnish Frame-BES system

The Frame-BES system is planned for application mainly to the construction of industrial and commercial buildings. The basic modular system is based primarily on dimensions of n X 6M (M=100 mm).

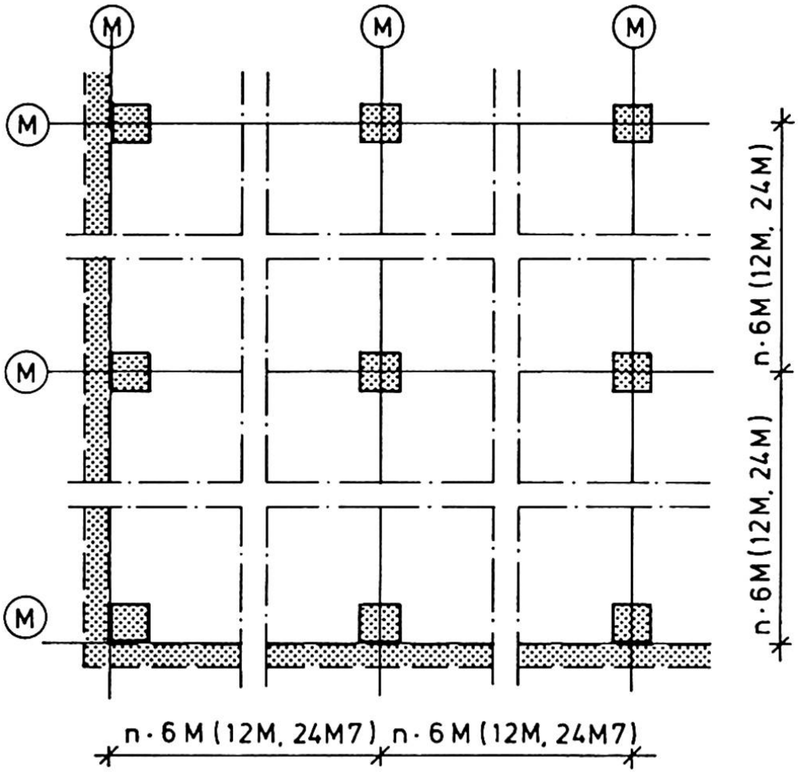

Fig. 5 The modular Frame-BES system

The structural components consist of columns, beams, TT slabs and hollow core slabs. The standard dimensions of structural components and openings as well as standard connection details are also included in the system.

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