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Advanced Industrialized Building Technology for the 1990's

Technologie industrielle de construction des années 90

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SUMMARY
The development of the new-generation of industrialized system building has been going on from the year 1986 and will continue until 1991. The results, which up till now have been documented as preliminary proposals, include new structural systematics described as the modulated hierarchical system. The system is intented for mechanized and automated production of structural members in prefabrication plants and for rapid assembly and finishing on site. The structural system allows the standardization of the types of structures and connection. A new connection technique has enabled rapid assembly on site.

RÉSUMÉ
Le développement de la nouvelle génération de construction systématique industrialisée commença en 1986 et continuera jusqu'en 1991. Les résultats, qui jusqu'alors ont été présentés comme propositions préliminaires, comprennent une nouvelle systématique structurale appelée système modulé et hiérarchique. Ce système fut élaboré en vue de la production mécanisée et automatisée d'éléments de construction préfabriqués et en vue de l'assemblage rapide et la finition sur place. Le système structural permet la standardisation des types de construction et d'assemblage. Une nouvelle technique permet un montage rapide sur place.

ZUSAMMENFASSUNG
Die Entwicklung der neuen Generation des industrialisierten Systembaus begann im Jahre 1986 und wird sich bis 1991 fortsetzen. Die Resultate, die bisher als vorläufige Vorschläge festgehalten worden sind, beinhalten eine neue Struktursystematik, die als ein moduliertes hierarchisches System bezeichnet wird. Dieses System soll einer mechanisierten und automatisierten Produktion von Baugliedern in Fertigteilfabriken sowie einer schnellen Montage und einem schnellen Ausbau vor Ort dienlich sein. Es ermöglicht die Standardisierung der verschiedenen Konstruktions- und Verbindungstypen. Eine neue Verbindungstechnik hat die schnelle Montage vor Ort ermöglicht.

1. BACKGROUND

The development of the industrialised building technology in Finland started in the 1950's, which saw the first generation of element building technology. No element building system was available then.

The second generation started with the development of the open element building system "BES" at the end of the 1960's. The second generation aimed at mechanised element production and economical construction for the mass production of new satellite towns. This type of production became dominant in Finland the market share of multistorey apartment and office buildings being about 70 - 80 %.

Currently, the requirements have changed. The keywords now are good architectural and technical quality and flexibility of design and operation. The BES-system has been applied to these requirements but the need for new industrialised building systematic has been recognized. A development project was started in 1986 aimed at the third generation of industrialised building system and technology for the 1990's. The project will last until the year 1991. The generations and the phases of the development project are presented in Figure 1.

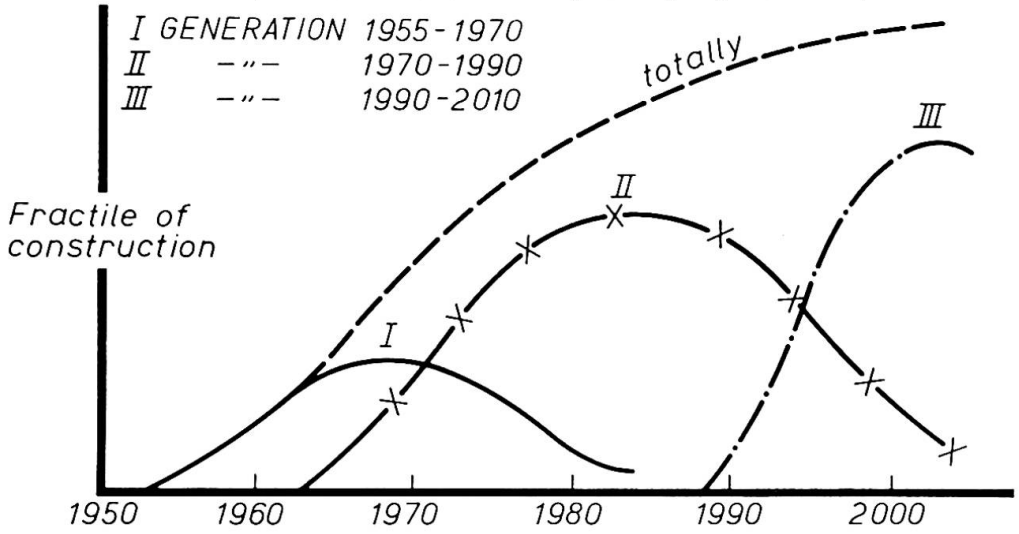

Fig. 1 The generations of the industrialised building technology in Finland and the phases of the development of the third generation.

The new generation of industrialised building technology has been named as the "TAT-system", which could be described in English as "Totally Adaptable Technology". The project is founded and realised by the two biggest prefabrication companies: Lohja Co and Partek Co and the four biggest contractor companies: Haka Co, Polar Co, Puolimatka Co and YIT-consern. The project is financed by the companies and the Technology Development Centre of Finland. The research and development work has been distributed among the Technical Research Centre of Finland, consulting companies and prefabrication and contractor companies. The structural system employed will mainly consist of concrete structures completed with composite structures.

2. BASIC IDEAS AND SOLUTIONS

The basic problem was to solve the complicated interactive contradiction between the requirements: quality, serviceability , flexibility and economy. Traditionally the view has been that industrialised production can lead to economical result, but with the loss in quality and flexibility. The model of the solution is presented in Figure 2.

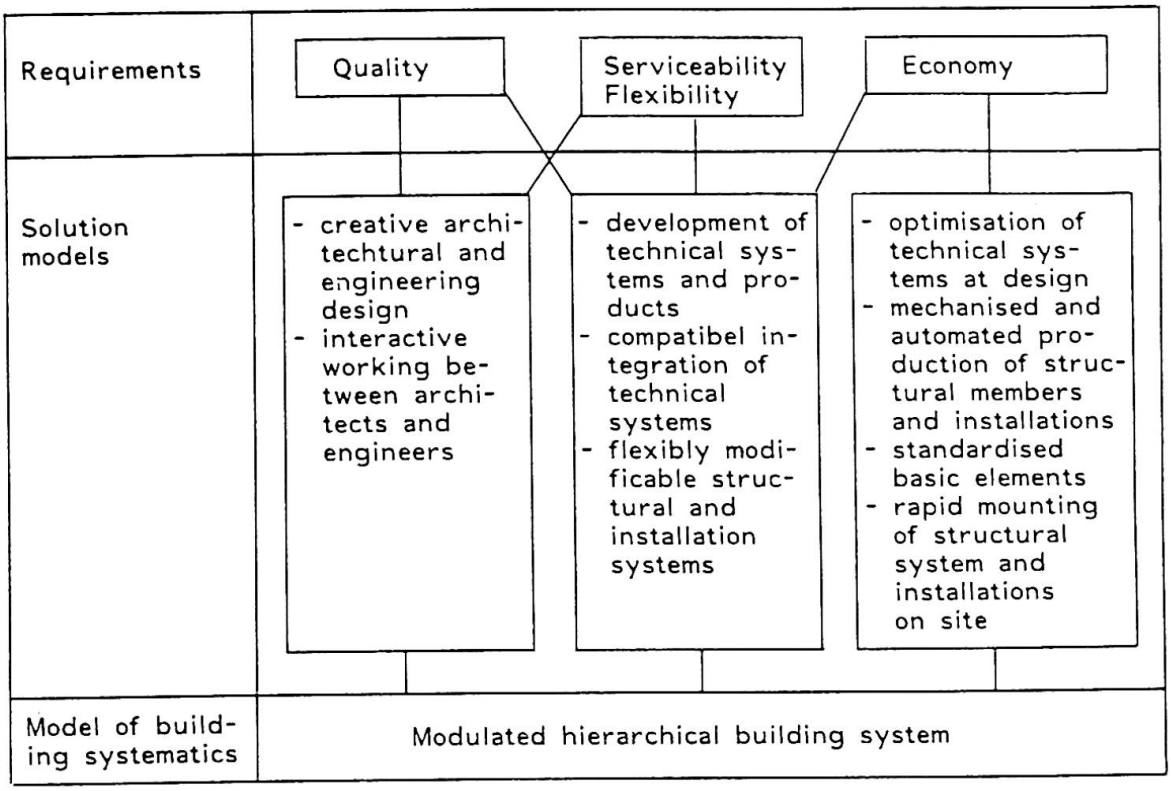

Fig. 2 Solution model for the fulfilment of requirements of the new generration of building technology

The key to the solution is the new line of thought in system building, which is concretized as the modulated hierarchical building systematics. It affords the possibility of flexible design of building using a limited number of installation and structural basic element types. The design methodology is based on a combination technique at the following levels of hierarchy: building level, sub-building level, module level and basic element level.

Typically, the architectural design at the phase of ideas and preliminary sketch mainly works on the sub-building and module levels. At the phase of drafting and final design the functional and optimization-based architectural and technical solutions will be concretized as technical systems, sub- systems, modules and basic elements resulting the designs for the basic elements of production at factories and the assembly plans for the site. The principal model for the adaption of the modulated hierarchical systematics is presented in Figure 3.

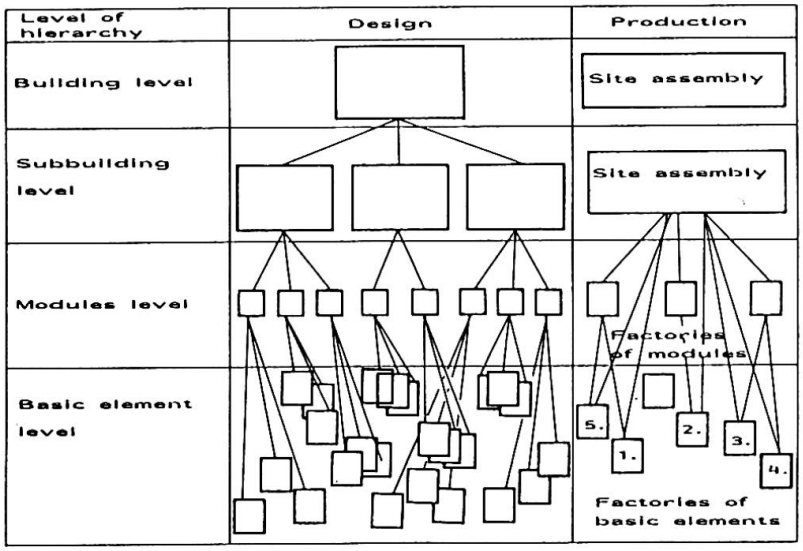

Fig. 3 Principal model for the hierarchical modulated building system in the design and production process.

As regards the work of structural engineers the structural combination and optimization technique plays an increasing role. A typical change will also be the increased importance of the design of structures to other factors in addition to traditional statical or generally mechanical requirements such as the design of operations and maintenance and the interactive compatible integration of structural and installation systems.

3. TECHNOLOGY FOR FABRICATION AND ERECTION

3.1 Principles

The principles of the structural production in TAT-technique are

- Mechanical and automated production of standardised types of basic elements in factories utilising flexible manufacturing methods
- Rapid assembly of structural members and compatible installations on site
- Assembly of prefabricated modules which are either structural modules or integrated structural and installation modules
- Possibility of applying increased automation and robotisation to on-site assembly
- Rational finishings and installation on site.

3.2 Fabrication

Mechanized, automated and computerized manufacturing is aimed at in the fabrication of structural members in element factories. The manufacturing methods will be selected taking into account the suitability for small portion flexible production. This aim raises the need for the structural type selected to suit the manufacturing methods.

Typical manufacturing methods in precast concrete plants are long line extrusion, long line continuous casting, slipform casting, battery forming, spraying and centrifugal casting. The extrusion and slipform casting without moulds can be used for slabs, beams, columns and walls. The battery forms are suited for columns, beams and walls. The spraying is best suited for architectural panels of external walls.

The application of flexible manufacturing methods and the "just on time" production principle in element plants is an important part of the new production process. The computer-aided production planning is a central part of the system. The computerised system of production planning and control also includes the automated manufacturing control, such as control of concrete mixing, control of concrete transport, control of casting and compaction machines, cutting of elements on long line production, transport of ready elements into store and the storage and delivery control. The most automated hollow core slab plants in Finland already apply the described level of automation and computerisation. This kind of production will also spread into the production of other structural members utilising the prescribed manufacturing methods.

Some structural parts and their installations are suited for assembly of integrated modules including the installation. Such modules are for example the bathroom, sauna and wc units.

3.3 Erection

The site production includes the assembly of structural members, modules, installation and furniture and the finishing work. The organization is based on the coordination by the main contractor company and on the realization distributed among several subcontractors. The subcontractors are at the same partly producers of products, partly specialised assemblers only.

Important factors pertaining to the development of rapid erection technique are connections, stabilising structural systems and the compatibility between structural and installation systems. All these factors are included into the TAT-system. As new connection technology the moment stiff connections made with prestressed bolts are applied. Therefore, it is possible to assemble stiff frames for the stabilization of the building. The connections work immediately after the assembly. The role of mortar is to quarantee additional statical, fire and corrosion resistance of the connection.

In the future, automation and robotisation can be applied to erection and finishing. In regard to erection the possibilities of automation increase especially regarding the assembly of connections and crane lifting automation with address system using suited sensors. In regard finishing the spraying robots and coating laying robots are possible.

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