Robot Oriented Design of Variable Building Kits

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Summary

Based on the notion of Robot Oriented Design, which was presented at the 5.ISRC, this paper proposes a concept for modifyable building kits shown at the example of houses and apartment buildings. It is tried to design a marketable product, which is industrially produced by robots. The principle of modifying building kits allows adaptations to various demands of the housing market while simultaneously providing the customer with a product that is industrially produced. Even though today's state of construction technology does not support robotic production of houses by modifyable building kits, the future market potential is considered to be very high.

The Building System

The systematic concept of Robot Oriented Design can be applied for the analytic as well as for the synthetic planning of building construction.(1) Basically there are three criteria for this design strategy:

1.Hierarchical criteria
2.Functional criteria
3.Structural criteria

The hierarchical criteria consider the location of the building system within its environment. The functional and structural criteria however describe the inherent structure of thebuilding system and its relations to the environment. According to the structural criteria one may distinguish between parts (elements) and relations among these parts. This means that the structure of a building system might be constituted by certain elements and certain relations between these elements. Vice versa one could establish certain building systems by means of defined elements and their defined relations.

The Building Kit

The building kit represents an efficient principle concerning the design of different or variable building systems. Through the principle of building kits one can create building systems of different qualities or functions by combining limited building elements of various selection and/or amount and/or various relations among each other.See fig.1.

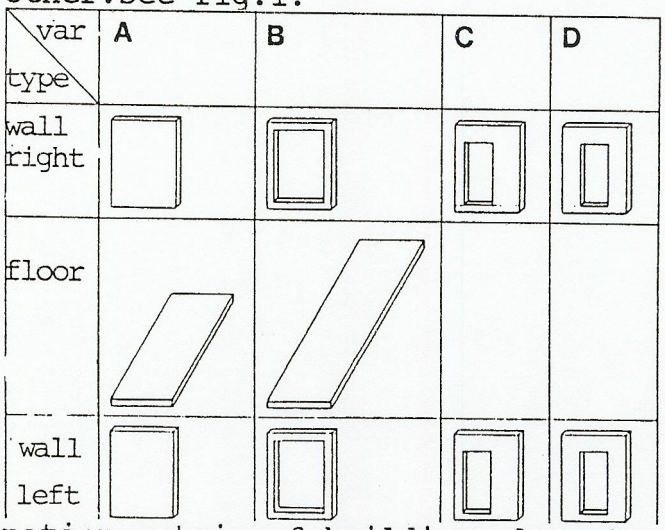


Fig.1:Combination matrix of building elements

Basically either the relations between building elements can be fixed while the building elements themselves are varied or the relations can be varied while the building elements are fixed. As far as the first case is concerned , it is necessary to provide the building parts with additional variants of building parts.

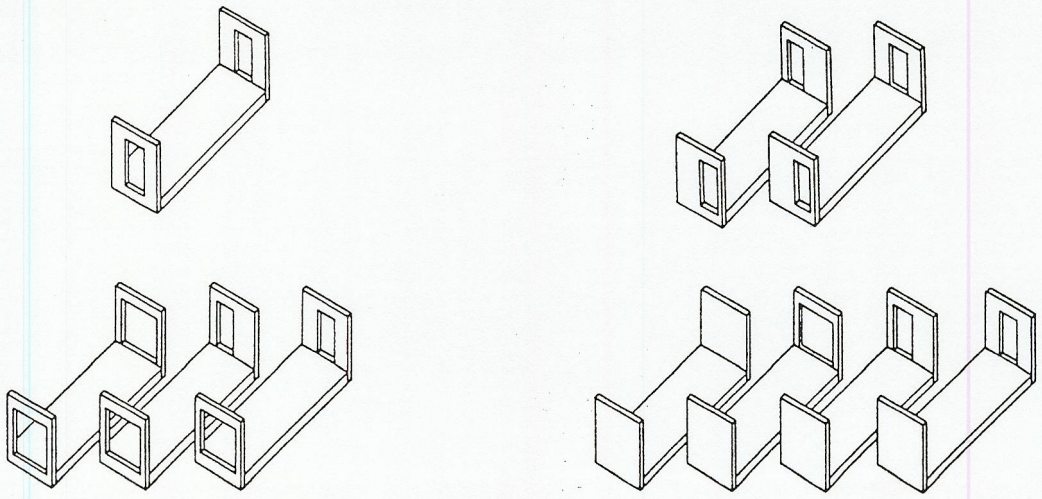


Fig.2: 3-D variants of the combination matrix

In the second case combinatoric rules for the potential relations (Variable relations) have to be defined in order to diversify the final building products. The principle of a building kit allows both of the above mentionned methods of creating variants.

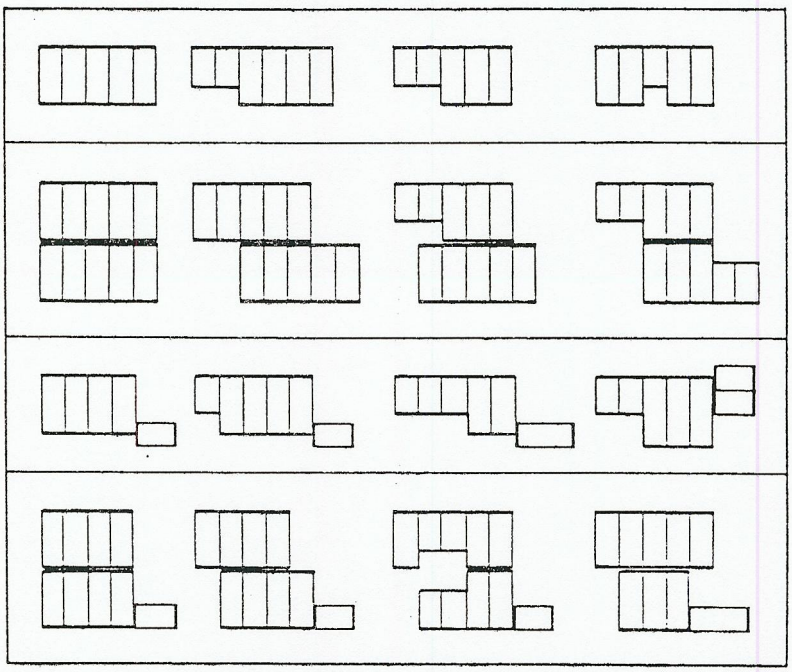


Fig.3: Variable configurations

Product Structure

For the creation of product variants, the building kit system has to be well structured and its variable parts have to be well defined. A building can be structured according to 3 criteria:

1.Functional product structure
2.Productional product structure
3.Specificational product structure

The functional product structure describes certain functions of the planned building construction. By designing functional building elements and by their various combinations different total functions of the final product can be achieved according to the demand.

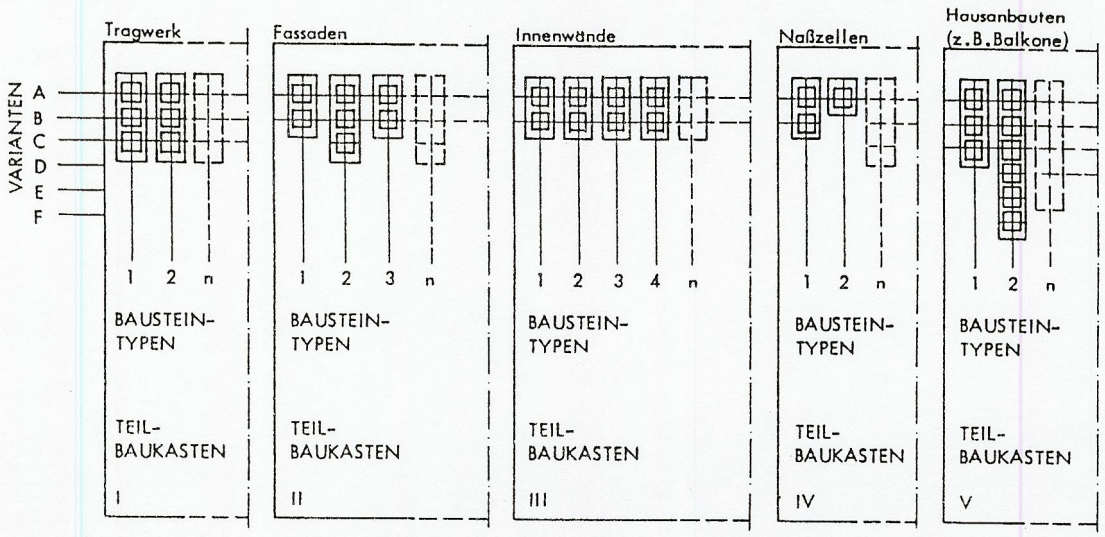


Fig.4: Functional building kit

Due to the result of the ABC analysis, which is shown in fig.5, it is recommended to design few basic types of building elements, which represent mostly the building kit of the structure of buildings. The common technology of the structure such as material, construction, production process etc. can contribute to an efficient robotic production.

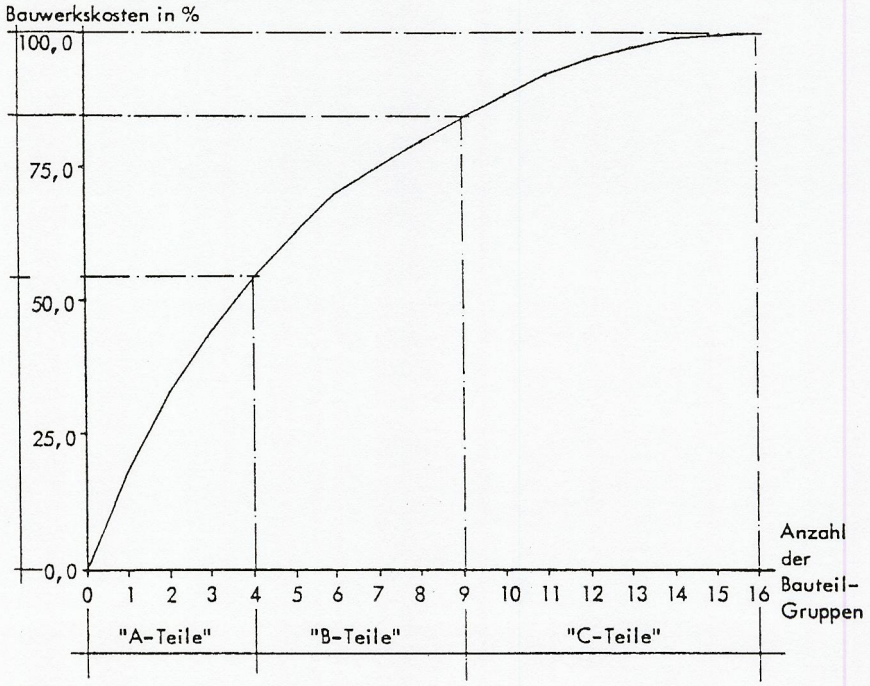


Fig.5: ABC analysis

The building elements of the servicing building kit vary more frequently due to their wider functionabilities such as facade building kit, interior wall building kit, sanitary building kit etc.(B-parts). Furthermore special building functions can be covered by an assecory building kit , which is not necessarily required for the functionability of a building (C-parts).

A production oriented building product structure maximizes the use of many repetitive building parts concerning the single building part as well as the total final product. The result can be seen in figure 6 where few typical building parts and variants have been used and the elements were related always in a known manner.

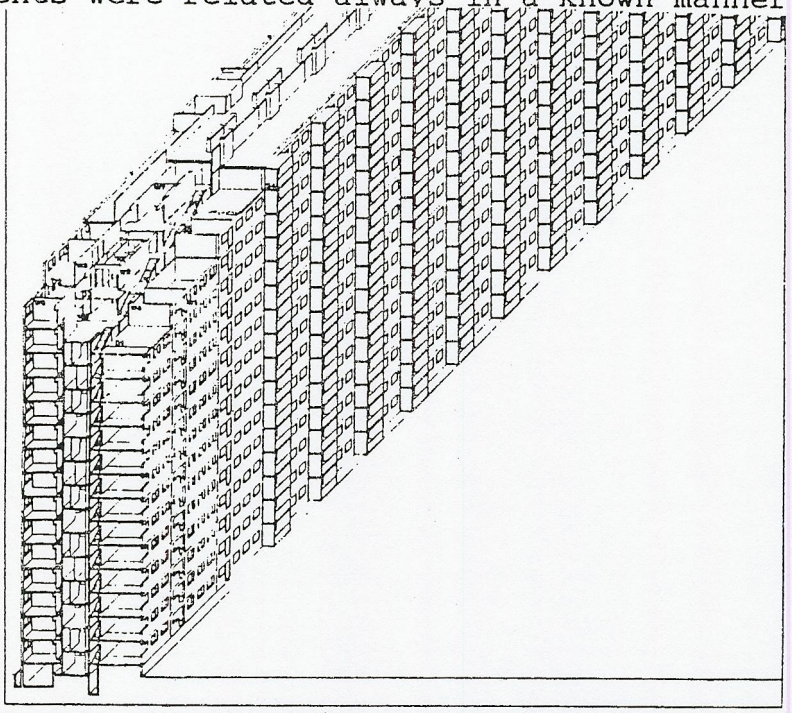


Fig.6: Example of production oriented building system

From this example can be concluded that a production oriented product structure and a function oriented product structure have to be well coordinated. Production- and function-oriented product structures consist also of material building parts. A specificational product structure is based on product specifications that comprise production-oriented and function-oriented criteria in order to achieve different product variations by a systematic combination of certain well defined specifications. The building parts of such a kit consist of certain qualities that enable them to be exchangeable and compatible with other elements.(2)

The successful marketability of a robotic construction and building system is decided by the specifications which are defined by the customer for example such as living area, design, floor plan and finnish of houses. These data describe the criteria for the design of the various building elements. A building kit can consist of predefined and combinable specifications in order to create various one and two family housing units as can be seen in figure 7.

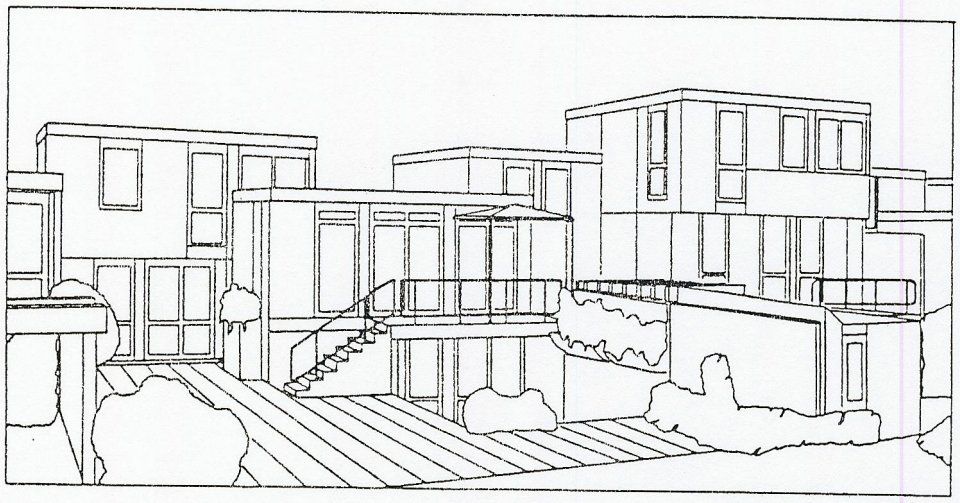
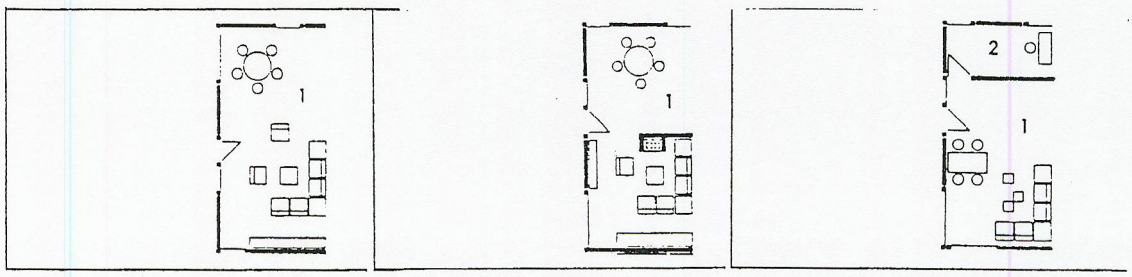


Fig.7: Example of function oriented building kit

These structural specifications can be produced and constructed by construction robots. In order to produce industrially by robots while considering individual customer demands, the potential product variants have to be completely and systematically predefined.



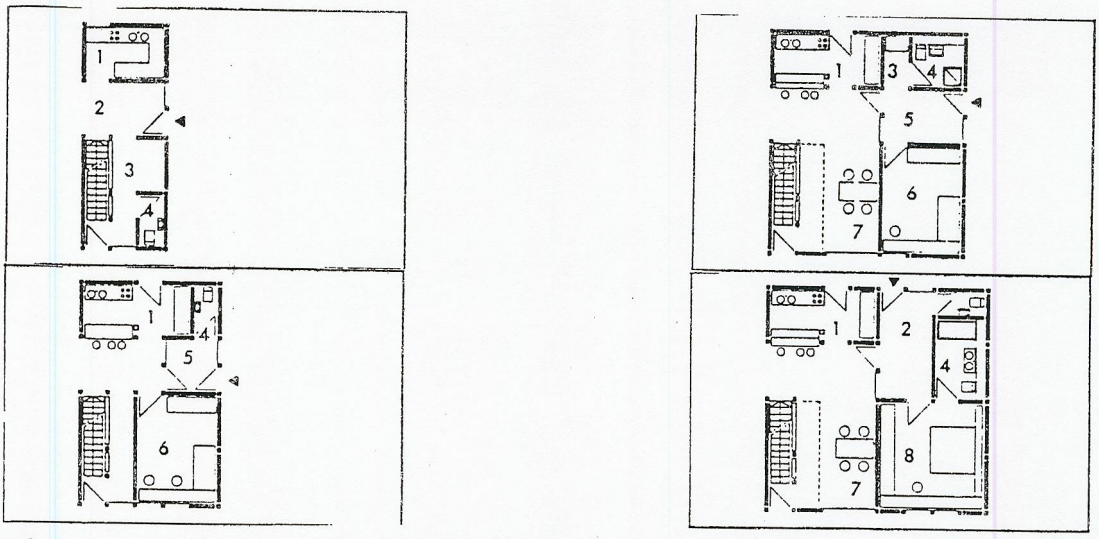


Fig.8: Example of building elements and their variants of a floor plan building kit

Production related benefits can be achieved by planning, testing, describing the variants concerning their structure, quantity and quality of material, production process, if the market was properly evaluated. A definition of product specifications and their variations, which determine the Gestalt of individual building products, allows the industrial production of a larger variety of building products by robots than can be realized by conventionnal construction technology today.

It is obvious that the concept of a building kit which is industrially produced by robots transforms the construction industry in a service industry by generating yet unknown new solutions.

Conclusion

Future robot oriented design of building kits will also be evaluated concerning their building performance, variability and adaptability in time. The notion of building kits and their robotic construction enable new combinations through creativity and phantasy.

References:

(1) Bock T.,1989,"Systematic design analysis for (ROD) design synthesis shown at the example of a structural joining system suited for robotic assembly.6.ISARC

(2) Bock T.,1988,"Robot Oriented Design"5.ISRC