Systematic design methods and the building design process

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Several methods of making the design process more public and therefore better suited to the collaborative design of complicated products have been proposed in recent years. The term "systematic design methods" was used to identify such methods at the London Conference on Design Methods in 1962. Some of the techniques described at that meeting[1] and a few others of similar intent have been applied to the complex design problems of missile detection, guidance and control, to the design of such engineering novelties as the "Bluebird" speed record vehicles, to the determination of town plans intended to accomodate unknown technical innovations, to the exploration of man-machine links in equipment design, to the devising of advertising campaigns, to the cost-reduction of engineering components and to the teaching of architects, industrial designers and engineering designers.

Not all these attempts have been successful but enough has been done to suggest that systematic design methods, or developments of them, could be of considerable value in the design of buildings and their associated engineering systems. This paper is a brief review of some of these techniques and a suggestion for the re-organising of the building design process so that such methods could be more readily applied.

Divergence

Design methodologists seem to agree that the design process must begin by widening the field from which ideas are sought before deciding to concentrate on one favoured solution. This is called "divergence".

The advocates of creativity in design, of whom Osborne[2] has been perhaps the most influential, propose "brainstorming" meetings at which persons of very varied experience are asked to suggest any conceivable way of tackling a design problem. The inhibiting effects of criticism are avoided by a rule that no idea is to be evaluated until the meeting is over. There is evidence[3] that group brainstorming does not produce better ideas than does solitary thought but there is little doubt that it is an extremely quick way of extracting information from the memories of persons whose experience may be relevant to the problem.

Norris[1] shows how morphological charts can oblige a designer to think of several solutions for each of the major design requirements and how these solutions can be combined to form thousands and sometimes millions of alternative designs. Unfortunately neither brainstorming nor the morphological method include a reliable way of selecting a feasible or optimum design from the many alternatives that are generated.

Thornley[1] and Jones[1] propose a rather more controlled widening of the field of search at the start by the collecting of alternative ways of providing separately for each of many detailed design requirements, regardless of all the others. Unacceptable partial solutions are eliminated either by judgment or by matching against carefully worded performance specifications. Incompatibilities between the surviving partial solutions can be explored systematically using an interaction matrix before attempting to find feasible complete solutions. In this way the problem of having too many alternatives is reduced to more manageable proportions while considerable flexibility is retained.

Alexander[1,4] proposes a mathematical method of breaking down a set of design requirements into reasonably independent sub-sets. Physical components designed to match such sub-sets will not interfere with each other. This absence of conflict between different parts of the design is intended to increase the possibility of subsequent modification, adaptation and change. Such adaptability appears to be particularly desirable in the components of industrialised buildings.

Each of these systematic methods differs from conventional design procedures in one important respect: the design problem is divided into pieces each of which is solved on its own without reference to the overall design into which the pieces are afterwards combined. Step-by-step analysis of the relationships between the parts replaces visual insight as the means of combining them into a coherent whole. Intuition and experience are directed instead towards definition of boundaries within which a variety of acceptable designs are to be found.

Convergence

Page [1,5] discusses the strategy of starting the design process with models that are as rough as can be tolerated and changing to more refined models only after the major design problems have been solved. He suggests that design effort must not be squandered on detailed studies of designs that are later found to have major faults and that ideas must not be developed very far unless there is definite indication of convergence on an optimal solution. He does not show exactly how the convergent properties of a design may be decided before it has been explored in detail. Marples[6] has described how engineers direct their knowledge and experience to the avoidance of design decisions which are likely to create difficulties at later stages. The feasibility of avoiding blind alley decisions in the design of very novel products, of which nobody has sufficient experience to anticipate difficulties of manufacture, tolerance etc., is a vital point about which we seem to know very little.

Matchett[7] has developed the questioning methods of work study into what he calls "Fundamental Design Method". Engineering designers who have been persuaded to use this method have been able to reduce by about half the complexity and cost of engineering components without loss of performance. This method appears to throw some light on the difficult problem of convergence and seems well suited to the detailed design of building components that are to be made in large quantities. The method is intended to make it obvious when a product is unsuited to the resources of the organisation that is considering its marketing and manufacture; it may therefore be a useful technique to companies that are proposing to set up as makers of industrial buildings.

System engineering techniques

The most striking benefits of using systematic methods have been in the design of enormously complicated and yet very reliable systems for the detection and launching of missiles and space vehicles. These are cases in which the standard techniques of system engineering can be applied because the design is entirely composed of distinct components through which there is a flow of information, energy or materials, Gosling[1]. When the behaviour of the flow and of the components is well understood and is not too complicated, and when there is little or no direct interference between the components, it is possible to predict very accurately the performance of the system as a whole under various conditions. Even when the behaviour of each component is not understood, much can be done if the nature of the outputs and inputs to each component can be specified precisely. In such a case the matching of inputs to outputs throughout a flow diagram can ensure the detection of a large proportion of the operating faults of the system before the components have been connected together.

System engineering techniques seem to be very relevant to the design of the heating and ventilating services, and pedestrian circulation routes, in buildings. These methods may be equally applicable to the combining of the decision sequences of the many members of the building design team into a single logical process.

The application of systematic methods to the design of buildings

The conventional sequence of designing and constructing a building is of four stages; 1) Client's brief. 2) Sketch design. 3) Working drawings. 4) Construction, each of which is completed before the next begins. Systematic methods do not seem to be compatible with this serial design-strategy. The new methods

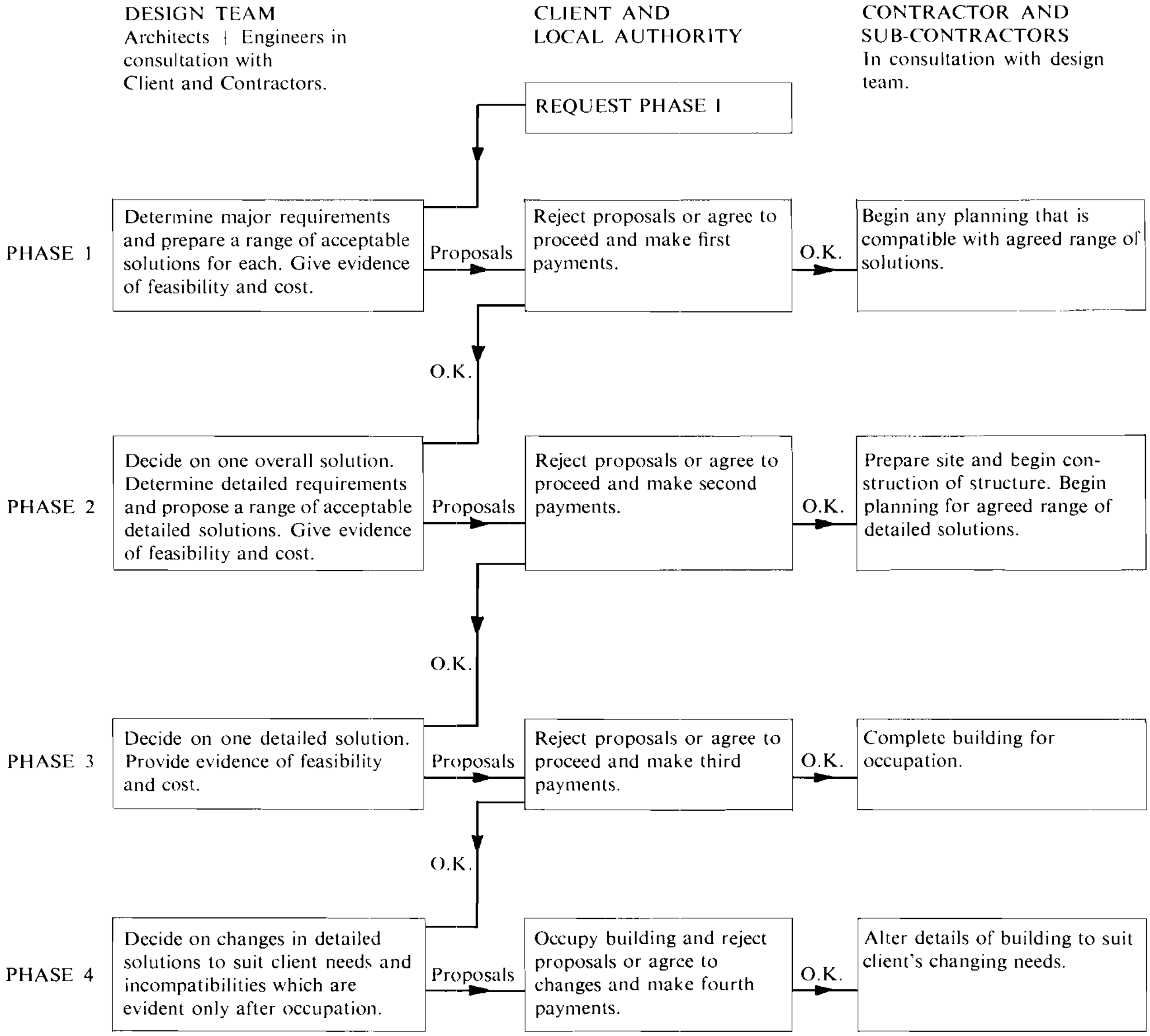

Fig. 1. Flow Diagram for the Systematic phasing of building design and construction allowing four opportunities for mutual adjustment of user requirements, structure, services, insulation, site and constructional problems before detailed design decisions are made.

pre-suppose detailed exploration of many more alternatives at the start and much greater opportunities to make changes in the overall design during slow convergence towards a detailed solution. There is not likely to be time for this protracted procedure in the design of an urgently wanted building and probably not enough money to spare for detailed analysis of many alternative designs and their many implications.

Is there an alternative strategy of building design that is quick and cheap and yet capable of sufficiently wide divergence and sufficiently slow convergence to permit the flexibility of a systematic method? As a first suggestion the writer proposes a scheme of design for building in four distinct phases—at each of which the client's needs are reassessed, Figs. 1 and 2. A controlled amount of divergence occurs in all phases and convergence of detailed design is deferred until the final phase when the client has been occupying the building for some time. It may be that this proposal would be feasible if there were few interactions between the major decisions and the detailed decisions. The avoidance of such interactions might well be a major objective in the design of components for industrialised building. Much research and development may be necessary before these suggestions can be expected to take a more practical form.

Conclusions. Systematic design methods are intended to make the design process more public so that a number of persons of differing experience can collaborate more readily in the design of complicated products.

The methods proposed so far are very different from each other but have in common the intention of widening the area of search so that a range of alternatives can be explored before converging on the final solution.

The feasibility of applying such methods to the design of buildings may depend on

(a) the development of components which are less likely to interact with each other. A systematic method of designing non-interacting components has been suggested by Alexander.

(b) altering the architectural design sequence so that many of the decisions at present made in the form of a sketch design are deferred until the user requirements, structure, services, insulation, site and constructional problems have been explored in stages and mutually adjusted.

It may be both necessary and feasible to begin construction before detailed analysis is complete and to continue analysis and redesign during the client's occupation of the building.

References

1 Conference on Design Methods, edited by J. Christopher Jones and D. G. Thornley, Permagon Press, 1963.

	INTERNAL SPACES	EXTERNAL APPEARANCE	STRUCTURAL SYSTEM	SERVICES	INSULATION	SITE	ACCURACY OF QUANTITIES AND COSTS
PHASE 1	Numbers and kinds of rooms. Areas and volumes decided.	Alternative block plans.	An acceptable range of systems	Acceptable types of systems.	Acceptable range of types of cladding, roof, floor, windows, etc.	Range of alternatives agreed for access, foundations, etc.	± 20%
PHASE 2	Positions of walls and partitions.	One block plan and alternative elevations.	One type of structural system and foundations in outline.	One type of system chosen and ducts fixed.	One type of cladding, roofing, flooring, etc. chosen.	Access, services and foundations agreed.	± 5%
PHASE 3	Details of doors, windows, etc.	Final elevations.	Details of structural system.	Selection and detailing of components.	Selection and detailing of components.	Details of paving and landscape.	± 1%
PHASE 4	Alternative positions of partitions.	Changes to elevations.	Modified in detail.	Modified in detail.	Modified in detail.	Modified paving and landscape.	± 1%

Fig. 2. Decisions at each phase of the scheme for building design and construction proposed in Fig. 1.

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3 Taylor, D. W., Berry, P. C., Block, C. H., Does Group Participation When Using Brainstorming Facilitate or Inhibit Creative Thinking?, *Administrative Science Quarterly*, Vol. 3, No. 1, June 1958.
4 Alexander, Christopher. Notes on the Synthesis of Form, Harvard University Press, 1964.
5 Page, J. K. Environmental Research Using Models. *Architect's Journal*, 11 March 1964.
6 Marples, D. L. The Decisions of Engineering Design, Institution of Engineering Designers, London, 1960.
7 Matchett, E. Proceedings of the Conference on the Practice of and Education for Engineering Design, Institution of Mechanical Engineers, Proceedings 1963–64, Vol. 128, Part 3B, pages 41–43.