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Definition of a Knowledge Base for Structural Design

Définition d'une base de données pour le projet de structures

Definition einer Wissensbasis für den Tragwerksentwurf

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SUMMARY
The criteria adopted in the preparation of the knowledge base to be used in an expert system specialised for the preliminary design of civil structures are briefly illustrated. In particular the organisation of that part of the knowledge base which is concerned with long span floors and roofs is described. The importance of the use of these criteria in the preparation of a "non-idiosyncratic" knowledge base is emphasised.

RÉSUMÉ
L'article décrit les critères adoptés dans la préparation d'une base de données destinée à être utilisée dans un système expert aidant à l'avant-projet de structures de génie civil. Il traite en particulier l'organisation de cette partie de la base de données relative aux planchers et toitures de grande portée. Il souligne l'importance de ces critères dans la préparation d'une base de données aussi peu influencée que possible par des critères subjectifs.

ZUSAMMENFASSUNG
Es werden die Kriterien zur Vorbereitung einer Wissensbasis erläutert, die in einem Expertensystem dem Vorentwurf von Ingenieurbauwerken dient. Insbesondere wird die Organisation des Teils beschrieben, der sich auf weitgespannte Decken und Dächer bezieht. Es wird betont, wie wichtig diese Kriterien für eine Wissensbasis sind, um sie so wenig wie möglich subjektiv zu beeinflussen.

1. INTRODUCTION.STRUCTURE OF EXPERT SYSTEM

An Expert system shell for the preliminary design of structures is now being prepared according to the method explained in ref.[2].The system is based on two basic criteria:
-Knowledge is organized in "models";by "models" we intend a rule where the premise(cause) is the design choice and the conclusion(effect) is the performance(predicted behaviour) of that choice.
-The design space is divided in a number of separated,hyerarchically organized sub-spaces,to which separated knowledge bases correspond.
The design proceeds from general to particular sub-spaces according to a "top-down" refinement plus constraint propagation process[6]. This is nothing else that a simulation of the procedure which is naturally adopted by every designer,who makes basic decisions first and then proceeds to more particular decisions taking into account the constraints which are consequences of "strategic"choices already made.

2. SUBDIVISIONS OF DESIGN SPACE

The first subdivision of design space is made according to the definition of structural types corresponding to different categories of structures. This definition is an uneasy task and,given the enormous variety of structural shapes and layouts which can be used in practice,could never be complete and entirely satisfying.
For some categories of structures this task can be made easier by the fact that in most cases the structural shapes are well defined and limited in number. Such is the case of bridge structures and ,to some extent,also of tall buildings.
A broad classification of structural types which can include most of those structures whose design requires a careful attention has been proposed in ref.[3]. Among the three types which were individuated(the other two are bridges and tall buildings) we shall consider briefly the following(defined as type B in ref.[3]):
-"Structures whose most important elements lie essentially in an horizontal plane" or whose dimensions in the two horizontal directions prevail on the vertical one. This is the case of long span low rise buildings,such as industrial buildings,multistoreys parking lots,assembly and sports halls. The main structural elements in this case are floors ,roofs and theirs supporting beams(all horizontal or sub horizontal elements).
This is maybe the most "crowded" structural type and also the one with the greatest number of layout and shapes and therefore the most difficult to classify.
A trial partial classification of layout and shapes for square grids is represented on fig.1.
The second subdivision of design space concerns the definition of structural layout. Given the almost unlimited possible plan layout of buildings the classification of layouts can only be made in our opinion according to the geometry of the structural grids. We can thus individuate square and rectangular grids with different span ratios,isolated and multiple spans, equal or unequal spans.
In the scheme of fig.1 only square grids ,isolated and multiple equal spans are considered.
The third subdivision of design space concerns the definition of structural shapes.
Some possible shapes suited for square grids are indicated on fig.1.
At last,the final purpose of the expert system is the definition of basic structural dimensions.

3. PREPARATION OF KNOWLEDGE BASES FOR THE INDIVIDUATED DESIGN SUB-SPACES

The knowledge bases for the defined design sub-spaces should be based on careful examination of a great number of existing structures more than on the "practical"experience of single designer.
In other words the knowledge base should be "extracted" in an as much as possible objective way from a great number of valid and well tested designs,so that the decisions can exploit the much broader practical experience of a great number of engineers in different countries and environments.
If the data base is organized in the way that has been described the preparation of rules can be performed in a rather "mechanical" way,possibly using "perceptron type" neural network as is explained in ref.[8]

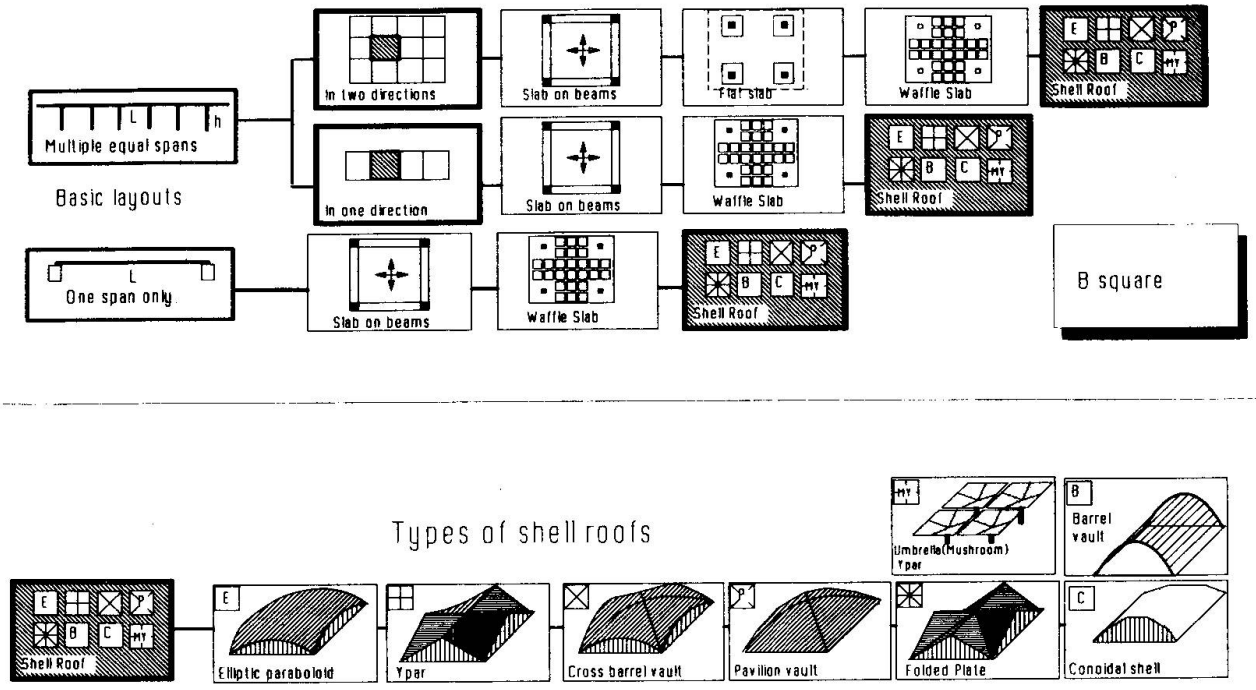

Fig.1-Reinforced/Prestressed concrete floors and roofs classification

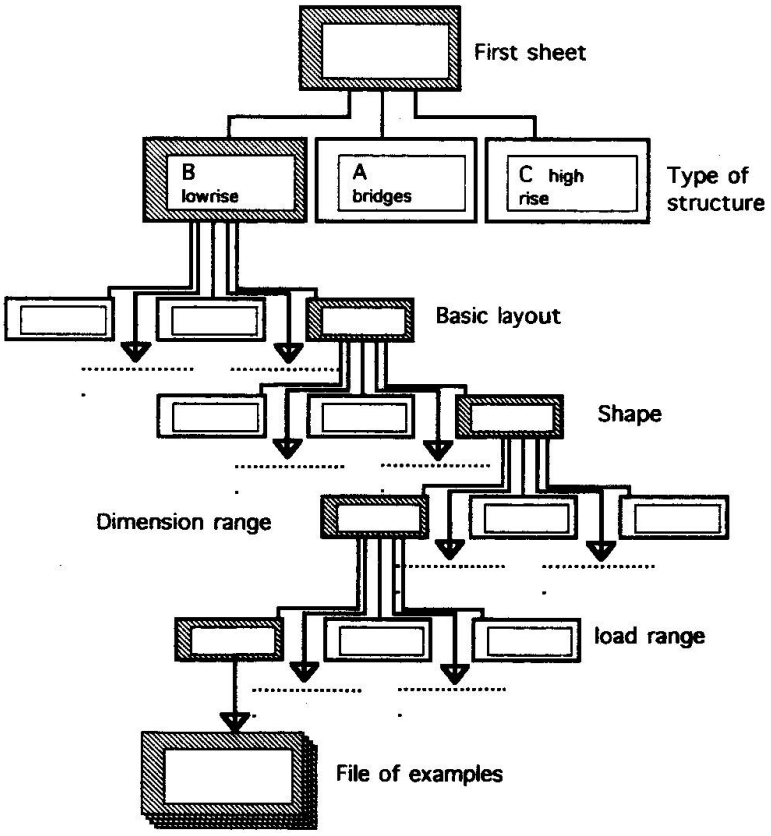

Fig.2-Structure of Hypermedia data base

To collect the needed data , the operation to perform is the organization of a graphical data base in which relevant data concerning realized succesful designs are organized in such a way that data interesting the building of the knowledge bases can be quickly extrapolated.
It is convenient to organize the data in an hypermedia environment[1][7],in which drawings as well as numerical data can be easily stored in the form of "sheets".
For easy access the data base can be organized according to a "treelike"structure,adopting a classification similar to the one used for the definition of the design sub-spaces.
The "leaves" of this "tree" represent short descriptions of realized designs organized according to structural shapes,loadings and spans.
In addition ,for every structural shape ,sheets containing diagrams devoted to the trial dimensioning of structural elements should be included(for example diagrams giving the floor depth in function of span and loads)

4. USES OF DATA BASE IN HYPERMEDIA FORM

In addition to its main purpose,that is the definition of models ,and functions giving element dimensions ,to be introduced in the knowledge bases, the hypermedia data base can also be used for the refinement of a preliminary design such as the one which is obtained with the procedure which is illustrated in [2] by comparison with existing designs.
In fact at this level,it should be extremely useful a rational overview of existing ,realized and tested designs whose specifications be not much different from the design which is being elaborated.
In other words at the level of detail definition "case based" design procedures should be used.

5. CONCLUSIONS

In the preparation of an expert system devoted to design two basic steps can be individuated:
-The preparation or adoption of a "Shell" containing an inference mechanism and graphical interfaces suitable for structural design .A similar shell,with a discussion concerning its use is described in ref.[2]
-The definition of knowledge bases for each design level which can incorporate as much experience and wisdom as possible.
To get this result interviews with single designers are not sufficient;the exam of data relative to a great number of existing designs in different countries and environments to extract rules and dimensioning criteria are necessary.
This data ,to be correctly used,must be organized in a suitable data base.
A data base organized in Hypermedia form according to criteria similar to those utilized in defining the stages of design seems the most useful to perform the task of "building up" the knowledge base.

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