INPUT DATA FILE GENERATION IN I-BUILDS BY AN EXPERT SYSTEM

전문가 시스템에 의한 I-BUILDS의 입력데이타 파일 작성

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요 약

I-BUILDS는 기존의 CAD 프로그램인 BUILDS와 지식베이스를 일관된 시스템으로 통합한 건물설계용 전문가 시스템이다. 본 시스템을 구축하기 위한 노력의 일환으로 본 논문에서는 추론에 의해 발생된 데이타들을 다양한 계산능력을 가지면서 특별한 업무도 수행할 수 있게 설계된 건물의 일괄구조설계 시스템인 BUILDS의 부시스템(BUILDS-A)에 이용되도록 입력파일화하기 위한 기본적인 개념을 기술한다.

ABSTRACT

I-BUILDS is the building design expert system conceptually modeled for synthesizing the conventional CAD programs (BUILDS: an integrated BUILding Design System) and the knowledge base into an unified system. As a part of the efforts to build this system, this paper presents the conceptual model by which the data items generated by inference are transformed into a formatted input file to be used for several BUILDS subsystems, each of which is assigned to have various computational capabilities and to perform specialized task.

INTRODUCTION

The increased availability of expert system tools that simplify the construction of expert systems made it easier to build special purpose automating systems. These expert systems are the very appropriate tools for solving the ill-structured problems that much rely on the domain expertise and expepriences[Ref.1-4]. A lof of efforts to develop these systems have been made by the structural engineers to utilize accumulated heuristic knowledge obtained implicitly through long years of experiences in their computer aided design process. [Ref. 5-9] Because computers have been

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extensively used for numerical computations these days, it is desirable that any emerging expert system would integrate existing algorithmic codes to construct a new automated design system.

When the knowledge-based expert system needs to be combined with the procedural code to maximize its capability and vice versa, the problem occurs that much information must be communicated among them. Doing this may contribute to data consistency and memory savings of the systems and avoid the time-consuming works otherwise the procedural programs must be translated into the language provided by its environments. Although hybrid tools provide this ability, most of the tools which run on microcomputers have such limited capabilities that they solve the problem by re-coding the procedural algorithms into LISP or PROLOG, or utilizing the tools based on the conventional languages such as C, FORTRAN or PASCAL etc. Most of the systems solve this problem by communicating each other through passing data values or sharing structured working memory with procedural code. The latter is recommendable for its simplicity.

I-BUILDS : AN INTELLIGENT BUILDS

The building design expert system, named I-BUILDS[Ref. 10], which is an acronym of an Intelligent BUILding Design System, is conceptually designed to provide users with consultations and manage BUILDS as the design phase proceeds. Figure 1 shows the architecture of this system, where the knowledge of design process, identified by Knowledge Modules(KMs) control BUILDS sub-systems, making use of the domain experiences implemented into Knowledge Bases and Data Bases.

Since I-BUILDS expert system handles BUILDS sub-systems, the interface problem naturally occurs. In order to solve this problem,I-BUILDS communicates with BUILDS partly through sharing working memory and also partly through transmitting data by utilizing external files. In spite of input / output time consumed, sometimes the latter is particulary required.

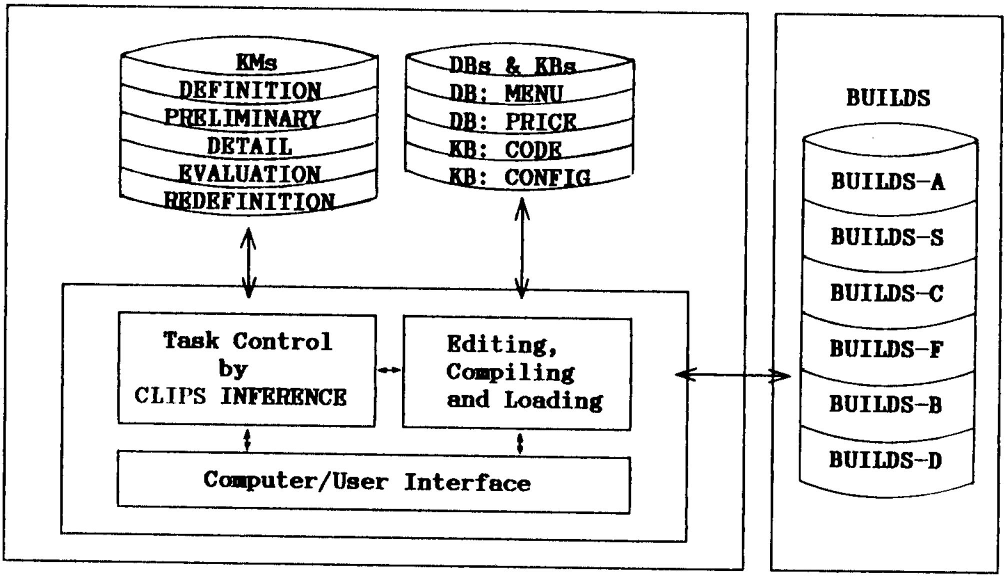

Figure 1 Architecture of I-BUILDS

THE NEED TO DEVELOP AN INPUT DATA FILE GENERATOR

The commercially available structural analysis softwares which were sequentially programmed by systematic algorithms are widely spread over the worldwide engineering community. But with these codes, the fact that the more capabilities they perform the more knowledge the user must have to use effectively makes users occasionally aside from them. Due to the cost for purchasing commercial software, and its bulkiness of user's manuals, structural engineers can no longer be experts in using every special purpose package.

Therefore, a user of commercial packages may face with many difficulties in being skilled with the preparation of input data file for the program unless an expert system is utilized.

Making effective use of data structures provided by an expert system tool, the user can systematically handle all items of data. For an example, it is possible that the data about physical description of structural topology is represented into context network through using frame / object knowledge representation. When there are absense and incompleteness of required data, inference mechanism could verify or generate them utilizing experiences implemented. This paper presents an input data file generator model that may be thought as a semi-manual expert system which substitutes for text manuals for the conveniences of users. This model also can play a consultant's role in modeling the structure.

INPUT DATA FILE GENERATOR MODEL

Tasks done before the structural analysis are sequentially shown in Figure 2. At the first stage, user prepares all the data such as structural configuration, loading condition and design constraints from design specifications, codes and standards, etc. Then, referencing user's manuals, a user synthesizes all the data needed until their completeness is confirmed and establishes input data file. Using this prepared data file a user tries to run and if any, pre-processor is utilized to check out errors. If runtime errors occur, user searches clues relative to this phenomena through the data file, referencing user's manual, and retries until he succeeds in running.

To improve the defaults described above which the conventional software accompanies, and for user's convenience, I-BUILDS affords users facilities for converting current data into input file, which is immediately applicable to BUILDS subsystems. The inference system automatically diagnoses errors utilizing the knowledge extracted from experiences and guidelines of the manual, and

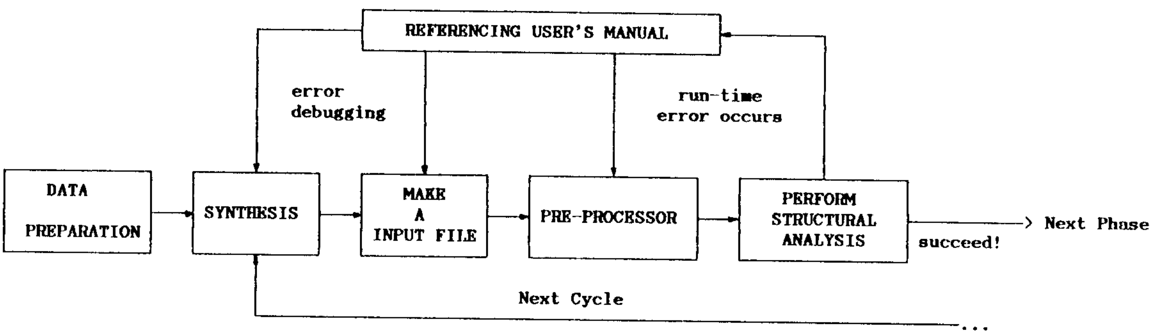

Figure 2 Conventional Pre-processor Model

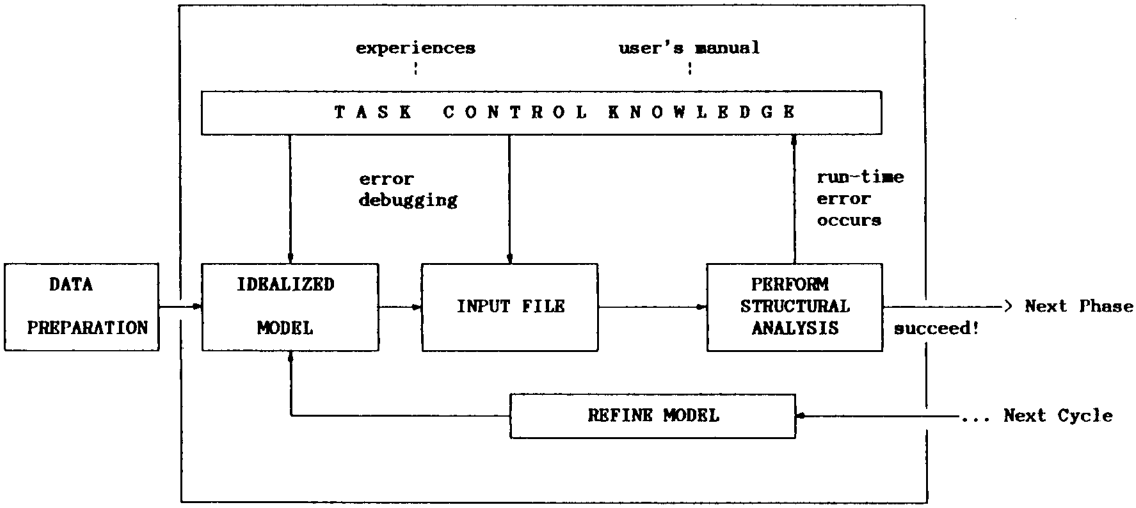

Figure 3 Input Data File Generator Model

gives prescription to users if errors occurred. In addition, this model can improve the member properties in the re-analysis cycle later, referencing the analysis results. This model is a part of building design model of I-BUILDS shown in Figure 4. Each knowledge units shown in Figure 3.functions as described below.

IDEALIZED-MODEL: For a chosen candidate configuration of structure, it is required to initialize various design parameters such as the sectional properties of the members. It generates initial values from heuristic rules (e.g., span / depth ratio) or some approximate analytic algorithms such as portal method. And all items of data are synthesized to make an input file.

REFINE-MODEL: This unit plays the same role as IDEALIZED-MODEL does in generating the required data except that it partly updates the input data with newly modified design parameters such as geometric properties.

INPUT-FILE : This Unit prepares the complete input file for the later use in structural analysis. To do this, job control data is directly read in or set by default values. Then the input file is diagnosed with knowledge implemented into expert system in terms of FORTRAN format statements and their data structures.

BUILDS-A : A CONVENTIONAL STRUCTURAL ANALYSIS PROGRAM

BUILDS-A is one of sub-systems in BUILDS, which is an integrated building design system capable of performing entire processes of building design, i.e., from analysis to drafting.

Capability :BUILDS-A is a special purpose computer program for the linear three dimensional analysis of building structures for gravity, lateral and earthquake loads. The building structure is assumed as an assemblage of a series of rectangular frames, frame-shearwalls and frame-shear trusses interconnected through a rigid floor diaphragm. The analysis by BUILDS-A includes non-symmetric, non-rectangular building structures which have various kinds of frames located arbitrarily in the plan. The static loads may be combined with lateral earthquake input which is specified as a time dependent ground acceleration or as an

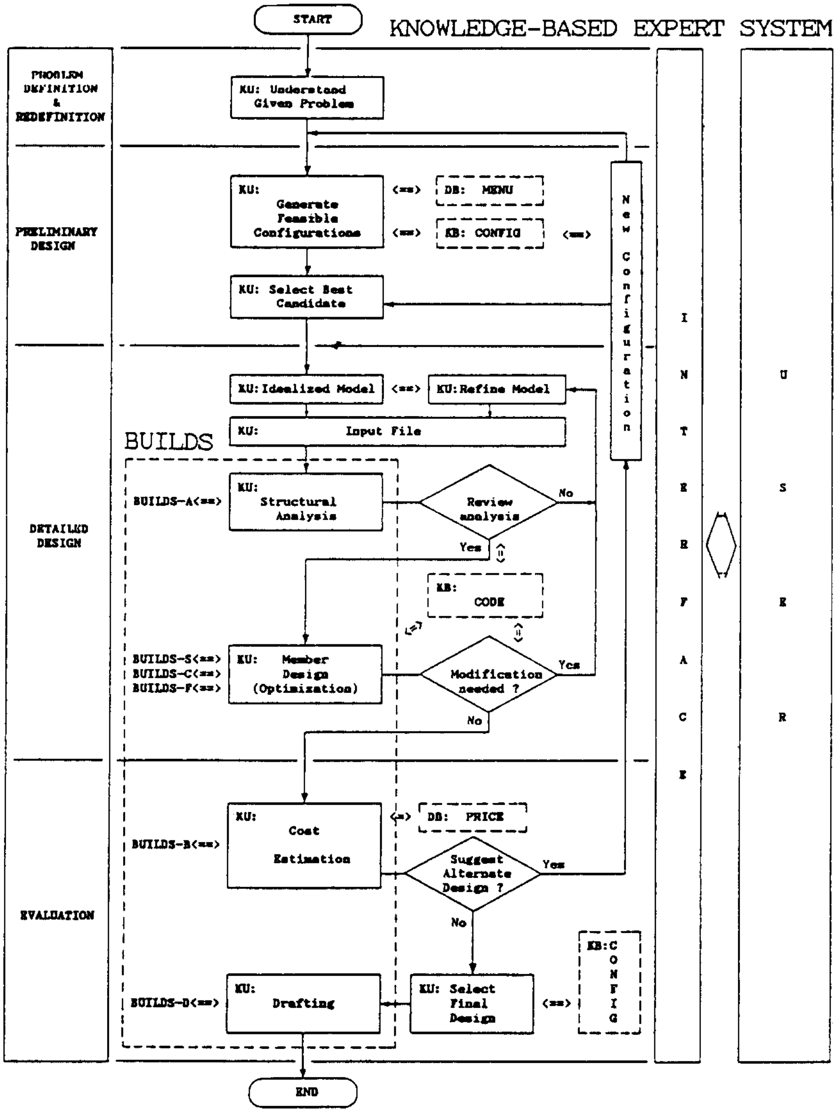

Figure 4 I -BUILDS Task Control

acceleration spectrum response.

This program has two unique features, i.e. 1) the use of newly developed rectangular "plate element with cut-outs" for the analysis of perforated shear wall and 2) the structural analysis model for the gravity loads which take the construction sequence into account. In addition to these two features, the program also utilizes well-known characteristics of the building structures such as the fact that building consists of mostly vertical and horizontal members of identical dimensions. Therefore, input data preparation can be minimized and a significant reduction in computational efforts can be resulted. This program also provides computer graphics for checking the input data and more efficient interpretation of the results.

Data Classification : Input data contents to BUILDS-A are classified into following four categories. Interested readers are referred to the references[Ref. 10-13] for the detailed informations.

○ Execution Control Data
○ Structural Configuration Data
○ Element and Material Properties
○ Applied Loads

Execution control data is mostly related to the task control knowledge implemented, therefore it can be input directly by a user or set by defaults. But the rest of data is dealt by the inference mechanism of expert system. To represent data items effectively, the hierarchical physical description is made as a context network.

DATA CONTROL STRATEGY

Design Process : Design is considered to be the iterative process of constructing artefacts which satisfy a number of constraints. The design process is usually iterated until the solution is optimized. The design process can be divided into the qualitative design, which includes the preliminary design and evaluation phase, and the quantitative design, which includes detailed design. While the detailed design which is called routine design mainly relies on so much numerical computation that it can be characterized by quantitative solution, the preliminary design which is called creative design deals with symbolic processing so that it is appropriate for qualitative non-numerical problems. The evaluation phase is also included in the latter domain because of its illstructured characteristics, which require much of designer's experiences.

The application of I-BUILDS is limited to the structural design problems, so that its domain is reduced to starting with planning stage. From given space allocation determined by space planners, I-BUILDS assumes the building structure as an assemblage of 2-D frames. These selected 2-D frames in two directions combined to generated 3-D structural configuration and the best among the possible candidates is firstly chosen based on quantitative and qualitative comp arisons using heuristic functions in I-BUILDS. Any configurations whose performance and acceptability fall well below those of others are abandoned and the other selected are saved to be retrieved in the later design. Then the properties of members of the selected candidate in the preliminary design process are determined by the iterative conventional technique. This detailed design phase involves the processes of preparation / checking of input file, structural analysis / design, reviewing the results and feedback control, etc. If this process is completed, the effectiveness of the current candidate is evaluated. If it is acceptable, it proceeds with the next process. But if not, preliminary design process is reiterated. This concept is represented in detail as shown in Figure 4.

Hierarchical Approach : The approach which many experts take in their design process is a hierarchical approach, in which determination of the overall concepts (e.g. building plan) precedes to the detailed determination (e.g. member proberties). I-BUILDS also deals with abstract to detailed structural data as design proceeds as shown in Figure 5.

Generation and Test : During design process, I-BUILDS generates all passible alternatives and evaluates them to select the best candidate. As an example this approach is used in the process of selecting the best 2-D frames and 3-D configuration. It contributes to innovative design or creative design.

Forward / Backward Changing : While engineering design problem which makes artefacts from given data tends to be solved by a forward changing, a backward changing is more useful

DATA CLASS	INFORMATION FLOW	DESIGN PHASE	SOURCE
Execution	-	Task Control	read in
Structural Configuration	T O P ↓ BUILDING SYSTEMS ↓ 3 - D	Planning	read in
	↓ 2 - D	Prelimi. Des.	heuristics
Elements	↓ ELEMENT	Detailed Des.	heuristics & procedures (BUILDS)
Material			

Figure 5 Data Management Strategy

for the issue in this paper, which has goals like diagnosis / prescription of making completeness of input data file. I-BUILDS utilizes these two inference strategy to make it possible that inference mechanism is selectively used in the special sub-problem domain, and it includes sub-goal, sub-rulebase and meta-rule to solve problems by using problem reduction[Ref.14].

DATA STRUCTURE OF INPUT FILE

Data structure adopted in input file usually consists of large blocks, each of them can be hierarchically divided into principal and auxiliary cards. Principal cards usually control the condition of subsequent input cards. The auxiliary cards are so length variable that it is difficult to deal with fixed-size memory such as an array. Since the variable data structures can not be predicated before run time, the use of pointers rather than arrays to achieve an efficient and reliable implementation is desirable. Utilizing their dynamic nature, it is possible for nodes to be added to or removed from a list at any time. Then ordering sequence of needed cards can be made through handling the nodes of linked list[Ref.15, 16]. I-BUILDS inference mechanism, which utilizes this characteristics of knowledge representation, converts the fact existing in the working memory into a formatted input file in accordance with requirements of BUILDS-A. Quite a lot of rules, of course, check the compatibility of all the data items before this function is used.

CONCLUSIONS

Integrating all the design phases of building structures with conventional procedual language is very difficult work because of having to deal with large amounts of data items. To overcome this difficulty, I-BUILDS combines algorithmic BUILDS and knowledge based expert system. The inference mechanism can be used to make abstract decision, e.g., preparation of the input file for BUILDS in FORTRAN, and current procedural software can be also embedded into the expert system to perform most of the numerical computation without any convension. In this paper the prototype of input data file generator for the procedural code is presented. Although this work is in the infant stage of development, this system will make the access to the conventional software easier and more effective.

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