TECHNICAL NOTE

Development of an Expert System for the Support of Oil Storage Tank Design

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Abstract

The design of oil storage tanks is carried out based on various kinds of codes and regulations. These codes and regulations have precedence in their applications. And in addition to these codes and regulations, the experiences of the constructions and/or operations of the past tanks have to be taken into account to carry out a reasonable design. And what is just as much important as these knowledges is the so-called engineering judgement.

But as oil storage tanks are produced to order, these design procedures are repeated individually from tank to tank and moreover, the decision making in these procedures is made more or less in a trial-and-error manner, so that the burden of a design engineer is not small.

We noted that if we introduce the programming language Prolog, we can easily correspond to such trial-and-error decision making processes and we developed an expert system for supporting design of an oil storage tank. What should be stressed about our system is that the present available Fortran numerical analysis programs and/or graphic packages can be called in the form of subroutines and data are transferred through files between Prolog and Fortran.

KEY WORDS: (Expert System) (Structural Design Support) (Oil Storage Tank) (Prolog) (Fortran) (Symbolic) (Numerical Manipulation)

1. Introduction

As the operating conditions of structures have become more severe, and the structures have become more complex, more large-scaled and more multi-farious, the design of structures has become increasingly complex and difficult. But generally the design of structures has such difficulties as,

(1) There are many "difficult to quantify" factors involved in design and fabrication.
(2) Most structures, especially large ones, are produced only in small numbers. Therefore, there is almost always the problem of lack of sufficient data.
(3) Most structures, especially large ones, are produced to order. Therefore, various conditions in design and manufacturing often change remarkably from structure to structure.
(4) Factors are too many and too diverse, and furthermore, the relations among these factors are quite complicated.

Therefore, structural design calls for quite a wide variety of knowledge, so that it is most essential for a structural designer

(1) to fully utilize the limited amount of available engineering and/or technical information and experience, and
(2) to extract the common and unvarying information or knowledge under varying conditions of design and manufacturing.

Codes, standards and regulations are considered to be some forms of solutions along these lines.

Now, although the structure of an oil storage tank is quite simple, in fact, it is composed of only two or three kinds of major components, there are still many problems pressing for solution in relation to designing against corrosion and earthquake in the case of an oil storage tank, in addition to the difficulties of structural design as a whole which are described above. What makes the problem quite difficult is that the conditions of corrosion and/or earthquake vary quite extensively from structure to structure and from location to location. Further, the rapidly changing situations such as the change of contents and/or the demand for larger amount of oil storage call for the reexamination of the present design codes, standards and regulations and call for the institution of the new ones. But it is most difficult to correspond to such extensively

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Transactions of JWRI is published by Welding Research Institute of Osaka University, Ibaraki, Osaka 567, Japan

and rapidly changing conditions by the conventional computer programming techniques.

And what must be stressed in structural design is that structures are designed according to codes, standards and regulations and it might not be too much to say that designing a structure is nothing other than to demonstrate the compliance with these requirements and to justify the design and its changes. As these processes of decision-making are more or less trials and errors, it is also quite difficult to be dealt with by the conventional techniques.

This work is an attempt to develop an "expert system" for the design support of an oil storage tank. But what must be stressed is that in this work attention is given more to the pursuit of generic techniques for the construction of an "expert system" for the design support of structures in general rather than to the completion of the system immediately applicable to the practical design of an oil storage tank in particular.

2. Characteristics of Oil Storage Tank Design

(1) The process of design is nothing other than the process of demonstration of the compliance with the requirements of the codes and regulations.
(2) The manner of decision-making is more or less trials and errors.
(3) Expertise and/or experience play quite an important role in decision-making itself and in facilitating its process.
(4) It is not always the case that all relevant information is supplied beforehand. Rather, it is more often the case that relevant information is obtained through many repetitive applications of design procedures.

3. Characteristics of the Present System

(1) Use of Prolog as a Kind of Macro

The greater part of the Prolog usage here in our system is different from the usual ones. Here, predicate names correspond to the "titles" in Fig. 1 and their corresponding pieces of knowledge on each memo are described as a body of Prolog.

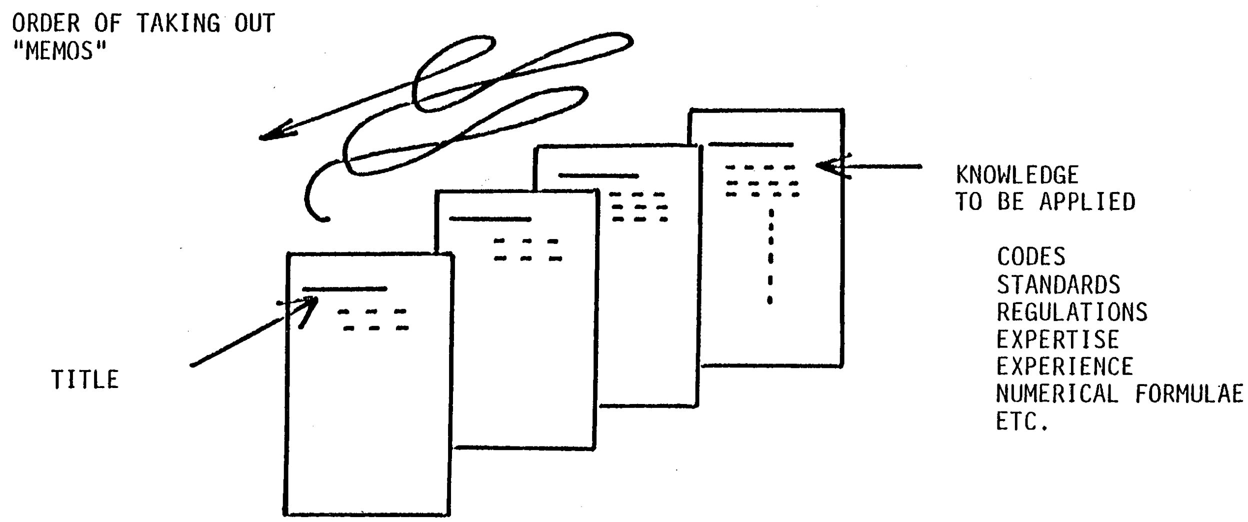


Fig. 1 "Image" of structural design flow

(2) Flag and Its Identifier to Cope with both Design Flows of Skilled and Poor Experienced Engineers

While an unexperienced designer make decisions by many trials and errors, a designer with much experience generally has his own faster and more convenient way of decision-making. Therefore, flag and its identifier are introduced and by letting each flag correspond to each procedure, both types of decision-making can be duly followed. And a predicate name is alloted to each chunk of design knowledges or flow of procedures of skilled engineers and Prolog is evoked as a kind of Macro.

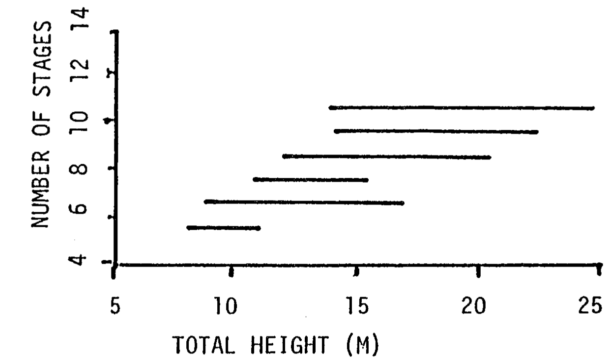
(3) Data Transfer between Prolog and Fortran through Files

Although Prolog/KR supports floating point operation, complicated and large scaled calculations are processed much faster by Fortran and in addition with the aim of making the most of existing Fortran packages and its large wealth of built-in functions, the function of transferring numerical data between Prolog and Fortran through files is added. The use of files are for reducing the degree of machine dependence as much as possible.

(4) Use of the "World" Concept to Determine Precedence in the Application of Codes and Regulations

Although the pieces of knowledge in the lower "world" are visible from the upper, the pieces in the upper cannot be seen from the lower. This mechanism was utilized for deciding precedence of the application of codes and regulations. For example, such specific rules as prefectural regulations are placed in the upper and the more comprehensive Fire Prevention Law is placed in the lower. Consequently design variables are determined to comply first with a prefectural regulation and then with Fire Prevention Law. Any particular restrictions such as the limitation of diameter size, etc. may be placed in the upper.

A sample of a display screen in a TSS session is shown in Fig. 2.

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DETERMINATION OF PLATE WIDTH (HEIGHT OF ONE STAGE)

HEIGHT ADJUSTMENT IS USUALLY MADE AT TOP SIDE PLATE
YOU HAD BETTER SELECT WIDTH AS CLOSE TO COMMERCIALLY AVAILABLE PLATE WIDTHS AS POSSIBLE
THUS YOU CAN REDUCE MANUFACTURING PROCESSES AND THEIR ENTAILING TROUBLES
THEREFORE, SELECT AMONG 3, 4, 5 OR (LONG PLATE) 5, 6, 8, 9 FEET
GENERALLY THE USE OF LONG PLATES REDUCES THE AMOUNT OF FABRICATION AND WELDING
IF YOU WISH, JIS STANDARD WIDTH CLOSE TO THE ONE YOU SELECT WILL BE AVAILABLE.
INPUT Y IF YOU WISH. OTHERWISE INPUT N. ---Y
FOR REFERENCE
TOTAL HEIGHT OF THE TANK = +0.2200000E+02 M.
NUMBER OF STAGES = 9
CALCULATED AVERAGE PLATE WIDTH +0.2444444E+01 M. OR +0.8066667E+01 FT.
WILL YOU CHANGE THE NUMBER OF STAGES TO GET ANOTHER PLATE WIDTH? Y/N ---N
FOR THIS HEIGHT AND NUMBER OF STAGES, YOU HAD BETTER SELECT 5, 6, 8 OR 9 FEET.
INPUT WIDTH IN FEET ---8.0
TOP SHELL PLATE WIDTH = +0.2400000E+01 M
OTHER SHELL PLATE WIDTH = +0.2800000E+01 M
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Fig. 2 Sample of a display screen

4. Summary

An attempt is described to develop an "expert system" for the design support of an oil storage tank with special attention paid to the pursuit of generic techniques for structural design support.

Although a great majority of the past expert systems are more oriented toward developing better inference mechanisms and used Prolog only for symbolic manipulations, numerical data and their processing are no less or rather more important than symbolic manipulation as far as structural design is concerned. Therefore, Prolog and Fortran have been linked together in our system to facilitate both symbolic and numerical data processing. This permits the full utilization of the existing large wealth of Fortran packages. And further the use of Prolog as a kind of Macro and the introduction of flag and its identifier make this system quite flexible and useful enough both for skilled and poor experienced designers.

Although the extent and the amount of knowledge implemented is quite limited from the standpoint of immediate applications to practical design, it may be safely asserted that Prolog, or Prolog/KR which couples Prolog and Lisp together to be more exact, seems to be one of the most promising tools for this purpose and that the techniques developed herein would help to develop an "expert system" for the design support of other kinds of structures.

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