KNOWLEDGE BASED EXPERT SYSTEM

TRUSS ADVISOR

by

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ABSTRACT

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Recent successes of Applied Artificial Intelligence research in areas such as Medical Diagnostics (MYCIN), Geology (PROSPECTOR) and applied Mathematics (MACYSMA), has renewed the interest of people in several different areas in this newly emerging discipline. One area of much practical importance is the development of Expert System (ES) using the domain specific knowledge of a human expert and coding it in a form that is useable on a computer. These programs have proven themselves very effective in handling ill-structured problems. However, this process takes thousands of man hours and usually requires a team effort.

On a smaller scale, ES programs which are highly task oriented are known as Knowledge Based Expert Systems (KBES) and can be developed for use on micro computers. This process can be speeded by the use of a KBES building tool now available commercially. The objective of this report is to develop a KBES prototype with applications in Civil Engineering. One such problem within the field of Civil Engineering is the preliminary selection of a wooden truss type given the loading and other design constraints. The prototype is developed using the KBES building tool "Expert Edge" which runs on the IBM PC AT micro computer.

Tools such as "Expert Edge" relieve the developer of the task of constructing an inference mechanism. These tools offer many features to assist in the development of a KBES. Some of these features include an explanation facility, a footnoting facility and a facility for altering data or entering data in advance.

The KBES prototype in its present stage can recommend a preliminary configuration of a wooden truss for the detailed design. To demonstrate the idea the prototype is confined to triangular trusses, but the knowledge base could very easily be expanded to include various other shapes of trusses by adding more rules to it. The information contained within the knowledge base was provided by the courtesy of the Inter-Lock Steel Company, Sharon, PA.

ACKNOWLEDGEMENTS

I wish to extend my deepest gratitude to Dr. J. Alam and Professor J. F. Ritter for their time and effort in the development and review of this thesis. I also would like to thank Dr. J. D. Bakos for serving on the review committee.

I would like to dedicate this thesis to my wife Terry, her understanding and encouragement has helped a great deal in the completion of this work.

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CHAPTER I

INTRODUCTION

Artificial Intelligence (AI) is defined as "that part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics associated with intelligence in human behavior, understanding language, learning, reasoning, problem solving and so on" (1). AI research is currently sub-divided into several subject areas as shown in Figure 1.1. This figure is not the only way to divide the components of AI. Some topics may belong in more than one area.

1.1 GENERAL HISTORY

Research in AI for the most part began in the late 1940's. The first systems were attempts to create computer programs that imitated the thinking processes of the human brain (2). The key idea behind this approach was the analogy between the connection wires providing input to the central processing unit (CPU), and the nerves in the human body serving the same purpose (using the central nervous system), to provide input to the human brain. The development of these systems was eventually abandoned because the estimated size of the required computer system far exceeded the capabilities of the time. In 1955 McCarthy developed the LISP programming language. This language is considered to be best suited for programming in AI and is used extensively today. In 1956 McCarthy,

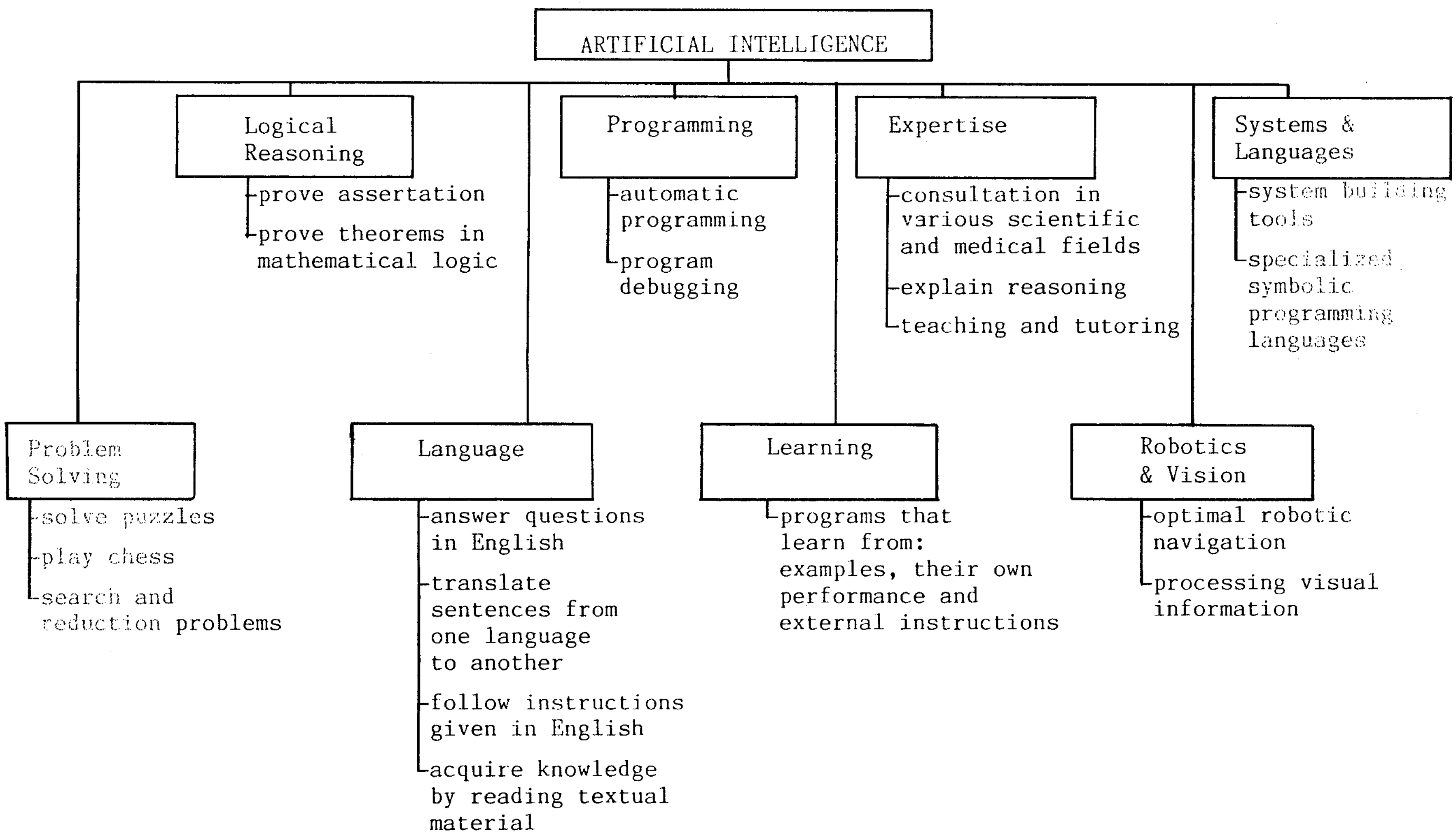


Figure 1-1 ARTIFICIAL INTELLIGENCE SPECIALIZATIONS AND AREAS OF RESEARCH PROJECTS

Minsky, Shannon and Rochester organized the first conference in AI. The goal of this conference was to blend the ideas of the various researchers and to define the path of future AI research. During the following years of research much time was spent trying to develop domain independent methods of solving problems (3). These systems were referred to as General Problem Solvers (GPS). GPS used broadly applicable techniques of heuristic search and the strategy of means end analysis. For the most part these systems did not perform well and were restricted to solving simple problems. During the 1960's the development of domain specific knowledge based systems was first introduced. This led to the successful development of Knowledge Based Expert Systems (KBES). The first of these to be developed was the DENDRAL system. Other early systems included MACSYMA, HEARSAY I and II and MYCIN (a brief review of some of these systems is provided in a later section).

Major research following this was in the development of domain independent frameworks (also referred to as KBES building tools). Examples of these general purpose building tools include EMYCIN, KAS, EXPERT, and AGE. Early KBES were developed using large mainframe computers or a special LISP machine, and involved significant man hours to build. However, recent increased microcomputer capabilities and the availability of building tools have made the construction of KBES using microcomputers possible.

1.2 PURPOSE

The purpose of this report is to review the area of KBES and to identify the current applications of this technology in the field of Civil Engineering with an emphasis on the use of micro computers. A secondary objective of this report is to review and test the expert system building tool "Expert Edge", by developing a KBES prototype.

KBES have evolved from research in Artificial Intelligence and have proven themselves very effective in handling ill-structured problems. One such problem within the field of Civil Engineering is the preliminary selection of a truss type given normal design parameters. This prototype in its present state does not attempt to rival the decisions of experts in this field, instead it was developed to demonstrate the usefulness of this technology. The information contained within the knowledge base was provided by the courtesy of the Inter-Lock Steel Company, Sharon, PA 16146.

1.3 ORGANIZATION

The remainder of this report is separated into six chapters and two appendices. Chapter two provides an overview of expert systems technology, some of the earlier developed KBES and some KBES within the field of Civil Engineering. A discussion of system building tools is presented in Chapter three, including general purpose programming languages and expert system shells. Chapter four contains an overview of the building tool (Expert Edge), used to develop the expert system prototype. In Chapter five the development of some of the rules and the decision tree used is discussed. Also included in this chapter is a discussion of some sample runs of the prototype. Chapter VI presents a summary and the conclusions of this report. Appendix A presents some of the programming considerations used in the development of the prototype. Appendix B contains a sample of a user language file listing of a KBES developed using Expert Edge.

CHAPTER II

OVERVIEW OF KNOWLEDGE BASED EXPERT SYSTEMS

Knowledge Based Expert Systems (KBES), are a class of computer programs that can advise, analyze, categorize, communicate, consult, design, diagnose, explain, explore, forcast, form concepts, identify, interpret, justify, learn, manage, monitor, plan, present, retrieve, schedule, test and tutor (4). These expert systems have demonstrated a proficiency in coping with unstructured and ill-defined problems. That is, expert systems are best suited to address problems normally thought to require human specialists or experts for their solution. Individuals whose speciality is assessing such problems, acquiring knowledge and building the KBES are referred to as Knowledge Engineers. In this report the term "expert system" shall refer to any computer system that can perform at or near the level of a human expert and the term "knowledge based expert system" shall refer to any computer system that contains knowledge of a difficult decision making situation that is useful, but hardly equivalent of a human expert. There are several basic differences between conventional programming and KBES. Conventional programming is composed of algorithms and data. KBES are composed of a knowledge base and an inference mechanism. The data base of a conventional program is numerically structured and the programs are oriented towards numerical processing. A knowledge base is symbolically structured and these programs are oriented towards symbolic reasoning. Conventional programs are sequential and batch processed whereas, KBES are highly interactive with the user. KBES can also provide explanations of its line of reasoning and of terms used by the KBES at any time during a session. This is not easily accomplished with conventional programming.

2.1 EXPERT SYSTEM COMPONENTS

Expert systems are composed of three general components, the knowledge base (static memory), the context (dynamic or working memory), and the inference mechanism (control mechanism) (5). Figure 2-1 shows the components of an ideal expert system (6). It should be noted that actual systems usually do not contain all the features shown, but one or more features are present in every system.

The knowledge base contains the encoded knowledge specific to the domain of the problem. This is usually comprised of facts, heuristic planning and problem solving rules. The context or blackboard accumulates the dynamic knowledge (intermediate results or current state), of the problem at hand. Figure 2-1 shows the blackboard can contain the three decision recorders plan, agenda and solution. Plan refers to the knowledge that describes the strategy the system will pursue for the current problem. Recording of the next action to be executed is done by the agenda (usually knowledge based rules that seem relevant to prior decisions placed on the context). The solution represents the current hypothesis and decisions the system has generated. The inference mechanism refers to the components that manipulate the context using the knowledge base. Usually the inference mechanism is provided by the programming environment and contains no domain specific knowledge (7). Any of the three modules shown in

Figure 2-1 may be contained in the inference mechanism. The schedule maintains control over the agenda and determines which pending action should be addressed next. This is performed by assigning a priority to each agenda item according to its relationship to the plan. Execution of the chosen agenda item by applying appropriate rules is controlled by the interpreter. The consistency enforcer maintains a consistent representation of the emerging solution. This is often performed by the use of certainty factors, which are assigned according to the validity of the statement.

The language processor (user interface), and the justifier are desirable but not required features. The language processor mediates information exchanges between the expert system and the user. The justifier explains the actions of the system to the user. Generally the more features included in the system the more user friendly the system is.

2.2 KNOWLEDGE REPRESENTATION

Knowledge representation techniques involve routines for manipulating the specialized data structures to make intelligent inferences. The list of these techniques include state-space search, logic, procedural representation, semantic net, production systems, special purpose representation techniques and frames (1). From this list production systems, semantic nets and frames are most commonly used in developing expert systems. However, before these are discussed, a brief review of the other methods follows. The earliest representation formalism used in AI programs was the state-space representation. The primary use for this technique was problem solving and game playing

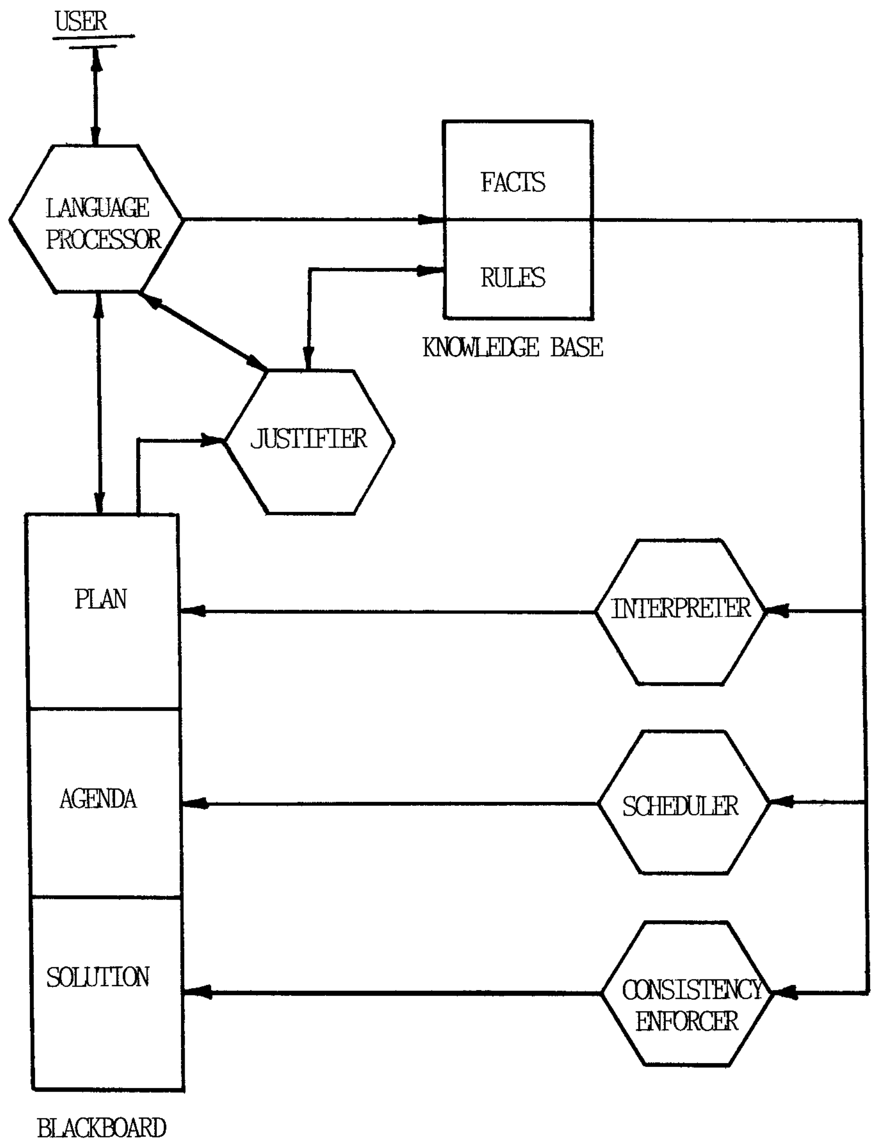


Figure 2-1 IDEAL EXPERT SYSTEM ARCHITECTURE (6)

programs. Logic is a representation method that relies on the rules of symbolic logic. The advantage of this method is that deductions are guaranteed correct to an extent that other schemes of knowledge representation cannot match. Procedural representation uses explicit control of the theorem proving process within a logic based system. A disadvantage of this technique is the difficulty in verifying and changing the procedural representations of an AI program. The special purpose representation technique involves the development of a combination of representation methods explicitly for the problem at hand. This technique is useful in large AI systems.

2.2.1 PRODUCTION SYSTEMS

Production systems are best described by the notion of condition-action pairs, also referred to as production rules. A production rule is a statement made up of an, IF this condition holds, THEN this action is appropriate. The IF part of the rule, also referred to as the condition part or left-hand side, states the conditions that must be present for the production to be applicable. The THEN part, also referred to as the action part or right-hand side, is then taken as an appropriate action. An example of a rule that could be used to select a Howe truss is:

IF: the intended class is residential
AND: the truss is triangular
AND: the truss is symmetrical
AND: the span is greater than 30 feet
AND: the span is less than or equal to 40 feet
THEN: the recommended truss type is a Single Howe

During the execution of the production system if the IF clauses are false the system stops. On the other hand if the IF clauses are true, then the action part can be executed by the interpreter. Once this is accomplished the interpreter then determines which rule to try next.

Production systems are most often used in AI programs to represent knowledge about how an expert would perform a specific task. An example of a production system in the Civil Engineering field is SACON. It is a KBES designed to provide advice in the field of structural analysis (8). Some of the advantages of production systems include: production rules can be added, deleted, or changed independently (changing one rule can be accomplished without having direct effects on other rules), information must be encoded within a rigid structure of production rules (making the information easily understandable), and its easy adaptation to heuristic knowledge. Disadvantages of this type of representation include inefficiency of program execution and poor adaptation or flow of control in problem solving algorithms as compared to conventional programming.

2.2.2 SEMANTIC NETWORKS

This scheme of representation takes advantage of knowledge that can be grouped together because it shares a common notation. These are usually illustrated by nodes and arcs, the nodes representing objects, concepts, or situations and the arcs representing relations between them. Figure 2-2 shows how to represent a few simple facts using this method:

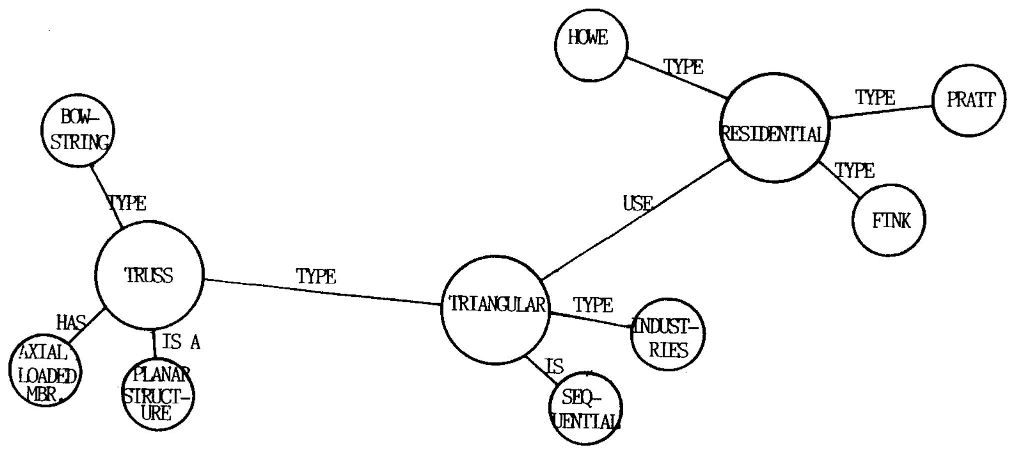


FIGURE 2-2 SEMANTIC NETWORK REPRESENTATION OF TRUSS INFORMATION

Semantic networks as a knowledge representation method are popular where it is possible to make use of the hierarchy of information. An interesting advantage of the semantic network scheme is its ability to represent knowledge about properties of objects. Some disadvantages of this scheme include computational problems when the database becomes very large, lack of ability to easily represent time dependent knowledge and difficulties in representing uncertainty of the knowledge.

2.2.3 FRAMES

Representing knowledge about the objects and events typical to specific situations is the focus of representation by frames. A frame is a description of an object that contains slots for all the information associated with the object. These slots may be stored values or expected values. One of the significant advantages of frame representation is the use of the default or inherited values. The following is an example of a frame layout:

REPRESENTATION OF A SISSOR TRUSS IN A FRAME TYPE LAYOUT

type	sissor
group	triangular
class	residential
symmetrical	yes (default)
normal use	church
roof pitch	(value)
feature	high ceiling

Frames are also being used where large amounts of knowledge is needed to perform a task. Much research is expected in this area in the coming years.

2.3 INFERENCE AND CONTROL STRATEGIES

Inference and control strategies guide the expert system as it uses facts and rules stored in its knowledge base, and information acquired from the user (9). The inference mechanism performs two important tasks. First it examines existing facts and rules, and adds new facts when possible. Second, it decides the order in which inference is made. The most common systems are either consequence-driven (backward chaining), or antecedent driven (forward chaining). The process of working backward through the rules from consequence to antecedent to consequence in search of a casual chain that will satisfy the goal is called backward chaining (4). Backward chaining systems are very efficient if the possible outcomes are known and they are reasonably small in number. A forward chaining system executes a continuous sequence of cycles terminating when a rule's action dictates a halt. These systems are useful where the goal or solution needs to be constructed or the number of possible outcomes is large.

The control portion of the inference mechanism must address two problems. First, the system must have a way to start and second the inference mechanism must resolve conflicts that occur when alternative lines of reasoning emerge. Techniques used to resolve these problems are depth-first search or breadth-first search strategy. In a depth-first search, the inference follows one path until either a goal is found or a dead end is reached. A breadth-first search looks at all nodes (rules or conclusions) on one level before going deeper. The breadth-first search will find the shortest path to the goal. However, because depth-first search has the effect of pursuing a particular path as compared to breadth-first search which appears to be jumping from topic to topic, the depth-first search is the most common technique. Figure 2-3 shows the major classifications of search and control strategies used by inference mechanism (9). In this figure the darker lines and numbered nodes refer to a path the inference mechanism would follow for a particular strategy. Because backward chaining depth-first search is the most common, a brief discussion of it is presented. This strategy attempts to follow a path from a conclusion to the rules that support it. If the inference encounters a rule it cannot prove during this process, it backtracks to a previously proven evidence and selects an alternate path (ie when rule #4 could not be proved the inference backtracks to rule #3 and then tries rule #5). This is continued until all the rules in a path are proved or no more paths exist.

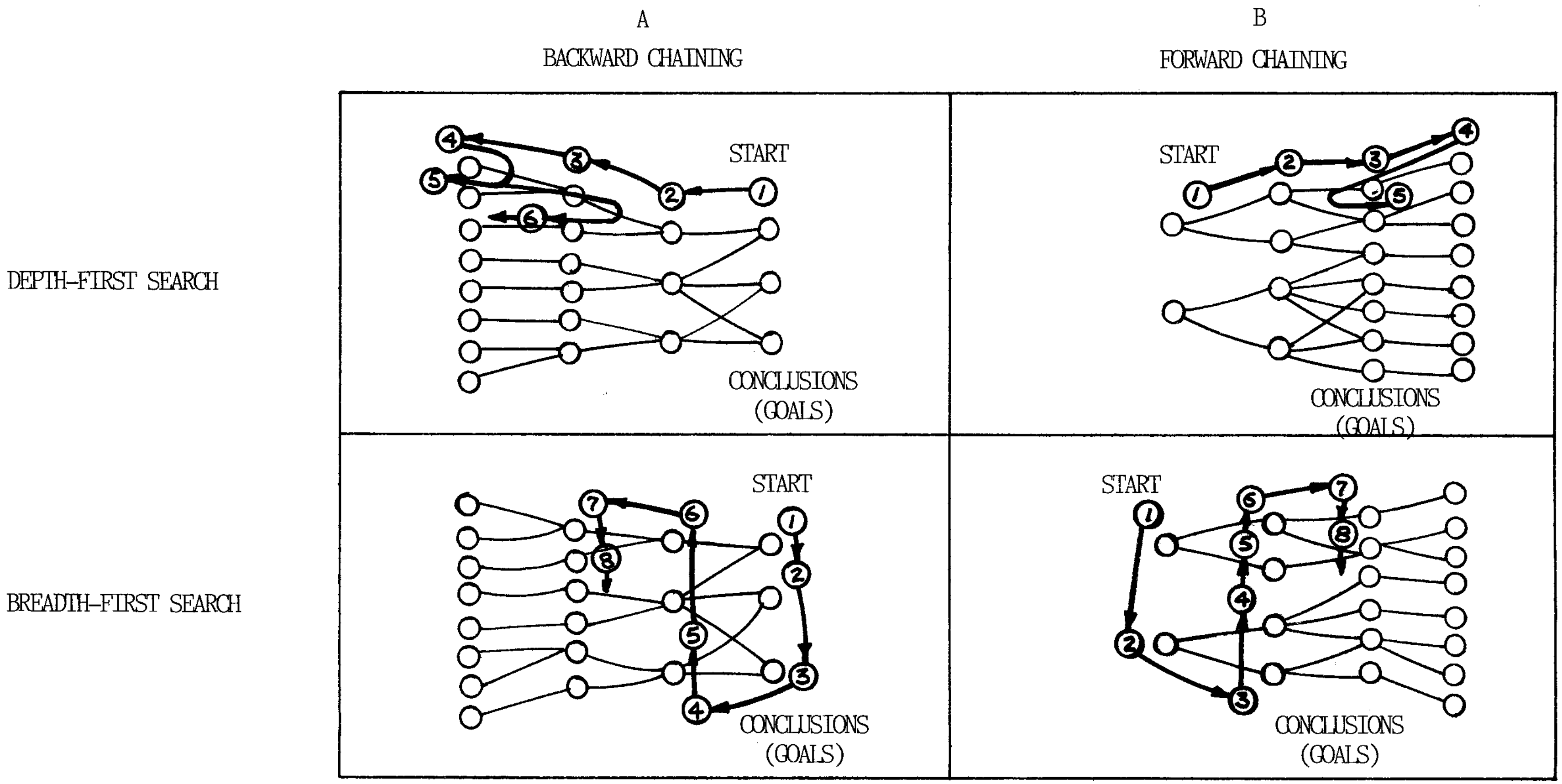


Figure 2-3 CLASSIFICATIONS OF SEARCH STRATEGIES (9)

2.4 PROCEDURE OF DEVELOPING SMALL KNOWLEDGE BASED EXPERT SYSTEMS

The purpose of this section is to review the steps involved in building a small KBES. The following list shows six steps that are recommended for this process (9):

-Selecting a tool and a commitment to a particular problem solving strategy.

-Identify the problem and analyze the information to be contained in the knowledge base.

-Design the KBES. In this step it is helpful to describe the KBES or paper and to make a flow diagram of the possible lines of reasoning.

-Develop the KBES prototype using the tool. This is best accomplished by developing a small version first to be sure it works and then gradually adding to it.

-Expand, test and revise the KBES prototype until it performs the required task.

-Maintain and update the KBES as needed.

The most significant of these steps is the first one. This is because the tool selected will play a major role in the development of the KBES (specific tools are designed to solve particular problems). The steps listed above are only a suggested method of developing a KBES. This technology lends itself to a wide variety of problems and an alternative method may be better suited to others.

2.5 EXISTING KNOWLEDGE BASED EXPERT SYSTEMS

This section contains a brief discussion of the more common early systems. These discussions only consider the development of these systems and some of the key characteristics of the systems. It does not describe the system components, knowledge representation scheme or the inference mechanism. An excellent outline of this information is presented in (10). The KBES to be discussed include: DENDRAL, MYCIN, MACSYMA, PROSPECTOR and PUFF.

DENDRAL was the first KBES to be developed and its developers are credited with the discovery of knowledge engineering. This system was developed at Stanford University in the late 1960's. DENDRAL was designed to assist experts in the field of organic chemistry in the task of identification of chemical compounds. This system was constructed using the LISP programming language. DENDRAL is currently maintained at Stanford University and has become a standard tool for chemists to determine probable molecular structures.

MYCIN is a KBES designed to diagnose certain bacterial infections and prescribe therapy. This system was developed at Stanford University in the mid 1970's. MYCIN is attributed as the first large KBES to perform at the level of a human expert. Various evaluations of this system suggested that MYCIN is as good as or better than most human experts in this field (9). This system also led to the development of the first expert system building tool (EMYCIN). Some of the features of MYCIN are its ability to provide the user with an explanation of its reasoning, the ability to work with unknown or uncertain information and the ability to easily add rules or modify reasoning. MYCIN was constructed using the LISP programming language and uses a backward-chaining control strategy. This system is maintained at a major medical center and is continually updated with state of the art medical information.

MACSYMA is a KBES used to assist in solving complex mathematical problems. This system was originally developed at MIT in the late 1960's and has been under continual development to date. MACSYMA is considered to be the most powerful program in solving complex algebraic problems with computers. It also provides closed form solutions for complex differentiation and integration problems found in calculus. This system was constructed using the LISP programming language and is currently being rewritten by its developers for use on personal computers.

PROSPECTOR is a KBES that was developed at Stanford Research Institute in the late 1970's, to aid geologists in finding the site locations of possible ore deposits (10). Like MYCIN this system was programmed in LISP and uses a backward-chaining control strategy (many consider it to be a descendant of MYCIN). However, this system differs from MYCIN in many ways, one of which is the ability of the user to volunteer information (usually at the beginning of the session). PROSPECTOR is recognized as the first KBES to achieve a major commercial success. It provided information to geologists that led to the discovery of a previously unknown large ore deposit.

PUFF is an instrument driven KBES that diagnoses the type and severity of respiratory disorders. It was developed at Stanford

University in the late 1970's using the EMYCIN building tool. The primary purpose of developing this KBES was to test the practicability of using expert system building tools and in-particular EMYCIN. The success of PUFF and this method of constructing KBES is demonstrated by the daily use of this system in several hospitals.

2.6 APPLICATIONS WITHIN CIVIL ENGINEERING

This section presents the areas of application of KBES technology within the field of Civil Engineering. Presently, several KBES are constructed to address problems in this area. However, most of these systems are confined to research projects and are not very well documented. Table 2-1 contains a list of the related KBES found during this project (10). The following is a list of some KBES designed for micro computers that are currently under development or just being completed (15):

PUMP PRO-diagnosing sewage and power plant pump problems

CHINA-designing highway noise barriers

HOWSAFE and SAFEQUAL-safety self diagnosis for contractors

DURCON-designing concrete mixes and concrete structures

(PROJECT DATA)- managing worldwide construction projects

Though these lists are not complete, they do exhibit that KBES are capable of solving complicated problems across the entire spectrum of Civil Engineering. Areas of possible application in the future may include: the evaluation of existing structures for alternate use, tutoring system for design and analysis courses and systems designed to assist in the modeling of complex engineering problems.

KBES	PROBLEM ADDRESSED	DEVELOPER/YEAR	TOOLS	RESULTS
SACON	Consultant for structural analysis using the Finite Element program MARC.	Stanford University (1978)	EMYCIN	Performance is said to match that of human expert in the domain of Structural Analysis.
HYDRO	Assist less experienced users of the HSPF watershed management system program.	Stanford Research Institute (Late 1970's)	Extension of prospector	Tested on several river basins with known characteristics and was reported to perform fairly well.
HI-RISE	Assist in the preliminary structural design of highrise buildings.	Carnegie-Mellon University (1985)	PSRL (System representation, language also developed at C-MU).	No performance data found.
CONE	Interpretes geotechnical characteristics of data from a cone penetrometer.	Carnegie-Mellon University (1985)	OPS-5	Reported to produce reasonably high performance in the area of soil analysis.
SPECON	Aids engineers in checking of structural steel elements for conformance with AISC Steel Design Specifications.	Carnegie-Mellon University (product under progress)	-	-
SPERIL	Assist in the assessment of damage to buildings after a hazardous event.	Purdue University (product under progress)	-	-

Table 2-1 KNOWLEDGE BASED EXPERT SYSTEMS WITH APPLICATIONS IN CIVIL ENGINEERING

KBES	PROBLEM ADDRESSED	DEVELOPER/YEAR	TOOLS	RESULTS
DESIGNER	Aids in the preliminary design of ships.	by Mac Callon (produced under progress).	-	-

Table 2-1 (cont.) KNOWLEDGE BASED EXPERT SYSTEMS WITH APPLICATIONS IN CIVIL ENGINEERING

CHAPTER III

BUILDING TOOLS

This chapter provides a brief discussion of various KBES building tools. The two types of tools to be considered are general purpose programming languages and expert system building tool (also referred to as expert system shells). General purpose programming languages refer to tools such as LISP, PROLOG and PASCAL. These languages are generally used by experienced programmers and can be applied to a wide variety of problems. Expert system building tools on the other hand refer to tools developed using these languages and can be applied to problems within a specific problem domain (i.e., diagnoses, consultation, etc). The latter method of development is usually the faster of the two methods. In this report the expert system building tools discussed shall be confined mostly to those used on micro computers.

3.1 GENERAL PURPOSE PROGRAMMING LANGUAGES

Many programming languages are used for AI programs, among them are: LISP, PROLOG, PASCAL, C, BASIC, FORTRAN and OPS-5. Because the two most suited and most common languages for AI programming are LISP and PROLOG, only these will be discussed. LISP stands for LISt Processing language. This language was created by John McCarthy in the late 1950's, and is based on Lamda Calculus. spite of few vendors promoting it and the lack of software support, this language has remained very popular. LISP has two data structures, atoms and lists (13). An atom is an element that cannot be divided any further and is either a number or a name. A list is made up of atoms or other lists. The following is a sample of some atoms and a list:

atoms:

5

John

dog

add

sum

list:

(this list contains five atoms)

Some of the attributes of this language include no essential difference between the data and the programs, one LISP program can be used as another LISP program's data. The data and programs are both represented as list, and lists can be nested one within another (9). Some of the criticisms of LISP are its lack of standardization (there is currently a variety of incompatible dialects of LISP available), its inefficiency (LISP programs require high amounts of CPU time and consume a great deal of memory), and its availability (each different dialect is available on only a small number of machines).

PROLOG, which stands for PROgramming language for LOGic, was developed in 1972 by A. Colmerauer and P. Roussel (9). This language is closest to a true logical computer programming language because of the implementation of a simplified version of predicate calculus in it. PROLOG, like LISP is designed for symbolic computation rather than numerical calculations. This language contains features that make it easy to write programs that manipulate logical expressions. In a sense these programs are controlled logical deductions. To program in PROLOG the following steps are carried out: specify facts about the objects and relationships, and ask questions about the objects and relationships. An example of this is

facts: grandfather (George, Terry)
grandfather (George, Mike)
grandfather (George, Tim)
then ask:
?-grandfather (George, Tim)
PROLOG would reply:
yes

The significant advantage of PROLOG is its availability for both main frame and personal computers and a built in inference mechanism based upon the resolution theorem by Kowakski (14).

3.2 EXPERT SYSTEM BUILDING TOOLS (SHELLS)

An expert system building tool or expert system shell (the former referring to mainframe computer tools and the latter referring to micro computer tools), can be thought of as the framework for building a knowledge base and control structure. These tools include an inference mechanism capable of interconnecting facts supplied by the expert or user of the tool in the form of rules for a specific problem. This frees the expert or user of the tool from the task of programming the knowledge representation and the inference mechanism. This in turn allows more time to be spent on the knowledge acquisition necessary to solve the problem at hand. This is a very attractive feature in the sense that it facilitates a quicker development of KBES by a non-computer specialist.

EMYCIN was the first expert system building tool to be developed. This tool was developed at Stanford University in the mid 1970's. It is a domain-independent version of MYCIN and was created by removing the knowledge from MYCIN. Other tools that have been developed in a similar manner are: KAS developed from PROSPECTOR, EXPERT developed from CASNET and AGE developed from HEARSAY II.

The early tools were developed primarily for use on mainframe computers, but in recent years research has expanded their range to personal computers. As mentioned earlier these tools are usually referred to as expert system shells. For a summary of the common shells available for personal computers refer to Table 3-1 (9). Expert system shells used on personal computers are normally confined to about 400 rules. Disadvantages of these tools include: poor portability (that is, tools developed by suppliers usually only run on their machines), and each tool is especially designed to perform a particular type of problem solving (it is a waste of time to try to develop a KBES using an unsuitable tool). Also, expert system building tools have a smaller range of applications than the general purpose programming languages. However these tools are designed to facilitate the rapid development of KBES within a specific class of problems (i.e.,diagnosing, identification, forecasting, selecting, etc).

EXPERT SYSTEM SHELLS	IMPLEMENTATION	USER INTERFACE	APPLICATIONS	SUPPORT
EXPERT/EASE	IBM PC (128k) DEC Rainbow Victor 9000	Prompted Menu Screen	Small Knowledge Systems	Manual
INSIGHT	PASCAL IBM PC (128k) DEC Rainbow Victor 9000	Prompted Menu Screen (how, why, explain) Knowledge Base created w/word processing software, the compiled	Small Knowledge Systems	Manual
M1	PROLOG IBM PC (192k)	Explanation (how & why) Trace (and panels) Knowledge Base created w/word processing software	Demonstration Systems	4-day course, Manual, Library of simple systems phone-in-user support
ADVISE LANGUAGE /X	PASCAL APPLE II	Line oriented Knowledge Base created w/regular word processor software	Used by DEC to develop a small classroom assignment program	---
ES/P	PROLOG IBM PC (128k)	Explanation (how, why, expain) Prompted-menu Screen Knowledge Base created w/word processor the compiled	Small Knowledge System	Manual
EXSYS	IBM PC (256k) or compatible	Explanation (how, why, explain)	Small Knowledge System	Manual (Company Printout)
EXPERT EDGE	IBM PC (256k) or compatible	Prompted Menu Screen Knowledge Base created w/word processing software then compiled	Small Knowledge Systems	Manual phone-in-user support

Table 3-1 (cont.) A PARTIAL LIST OF KNOWLEDGE BASED EXPERT SYSTEM SHELLS

EXPERT SYSTEM SHELLS	DISTRIBUTOR (Manufactors)	INTRODUCED (COST)	CONSULTATION PARADIGN	FEATURES
EXPERT/EASE	Expert software Int.	1983 ($2,000)	Example driven	Example (one rule) Decision tree algorithm
INSIGHT	Level 5 Research	1984 ($95)	Diagnosis/ Prescription	If-Then rules (+/- 400) Forward & Backward chaining certainty factors
M1	Teknowledge Inc.	1984 ($12,500) includes all material (entry cost $2,000)	Diagnosis/ Prescription	If-Then rules (+/- 200) variable rules certain-ty factors, Backwards chaining depth first modus ponens
ADVISE LANGUAGE /X	J. Reiter, S. Barth, and A. Paterson	---	Diagnosis/ Prescription	If-Then rules Forward chaining Bayesian probability propagation
ES/P ADVISOR	Expert System International	1984 ($1,895)	Automated text (diagnosis/ prescription	If-Then rules Backward chaining depth first resolution
EXSYS	Exsys Inc.	($295)	Diagnosis Indentification	If-Then rules Forward & Backward chaining probability certainty factors
EXPERT EDGE	Human Edge Software Corporation	1984 ($495)	Diagnosis/ Prescription	If-Then rules Backward chaining probability and certainty factors

Table 3-1 A PARTIAL LIST OF AVAILABLE KNOWLEDGE BASED EXPERT SYSTEM SHELLS

CHAPTER IV

OVERVIEW OF EXPERT EDGE

Expert edge (also known as TESS),is an expert system building tool designed to assist in the development of consulting or diagnostic types of KBES (11). It is distributed by the Human Edge Software Corporation in the United States and by the Helix Expert System Ltd. in the United Kingdom. Expert Edge is written in the C programming language and runs on the IBM Personal Computer, PC XT or PC AT. It requires a dual drive system and 256K bytes of RAM, however, 512K is recommended to take full advantage of Expert Edge. The program is supplemented with a very useful manual and a customer support phone service. The Expert Edge program includes three disks, the Expert Edge Runtime Version Disk.

Expert Edge offers several features that make the construction and understanding of a KBES much easier. A list of some of the key features includes:

-Rule based representation of knowledge

-Rules are easily entered (Expert Edge prompts the user to enter rules step by step).

-Interfaces with other IBM software (DIF, SYLK, WKS and MEM formats are supported for data entry)

-KBES rules can include equations and comparators (i.e., is less than)

-Passwords can be installed to protect the resulting KBES

-Automatic question generation facility (if not supplied by the knowledge engineer)

-KBES can be automatically demonstrated

-Runtime version of Expert Edge is available for the builder to distribute the KBES

-Special user language (knowledge base may be altered or created using a word processor)

-Knowledge bases can be automatically checked for redundant and conflicting rules

-Lines of reasoning can be traced during an advisor session for easy debugging of the knowledge base

-Bayesian statistics are used to handle probabilities

-Certainty factors or crisp reasoning is available

-Format control (screens, windows, color, probability, data format, and numeric punctuation can be altered easily)

This chapter reviews some of these features in more depth, that is, the ones that are used frequently in constructing the prototype.

4.1 SYSTEM ENVIRONMENT

The user interface is based on the monitor divided into six windows. These windows simultaneously display several pieces of information. This information includes conclusions reached, user progress, questions, answer, main menu, system status data and error messages. A seventh window (displays HELP messages), is only viewed when the user presses the F4 key (on the computer keyboard). The help message can be the information entered by the knowledge engineer or default text. This text is designed to provide instant help to explain any question asked by the system.

The main menu mentioned above contains four commands. These commands and their subsequent subcommands are shown in Figure 4-1 (11). The Advise command runs any KBES that is currently loaded. Learn enters the user into a mode where a system can be constructed, amended, or reviewed. The Change commands allows the user to alter various parameters of the KBES. These include the system parameters (i.e.,probability control), windows (i.e., background color), and messages (i.e.,restore default messages). The Disk command is used to perform actions such as reading a stored KBES, writing the current KBES and reviewing the directory. Moving down in Figure 4-1 is accomplished by positioning the cursor on the first letter (typing the first letter) of the appropriate choice and pressing the enter key. To move up in Figure 4-1 hit the ESC key. This menu provides an easy method of maneuvering the particular comand required, however, it becomes tedious and time consuming.

Though not utilized by this author to its full extent, Expert Edge offers a special user language to build or modify the knowledge base with a word processor. This method of constructing a KBES is reported to be faster than the use of the menu technique and presents the structure of the knowledge base in a much more concise and clearer fashion (12).

4.2 RULES

Knowledge bases created using Expert Edge consist of names, rules and evidence. Names can have values that are non-numeric, numeric, constant, variable and the result of an equation. Rules are used by the resulting KBES to arrive at conclusions. These rules consist of a conclusion and optional evidence (that leads to the conclusion). Conclusions are broken into two or more parts corresponding to a subject, verb, and

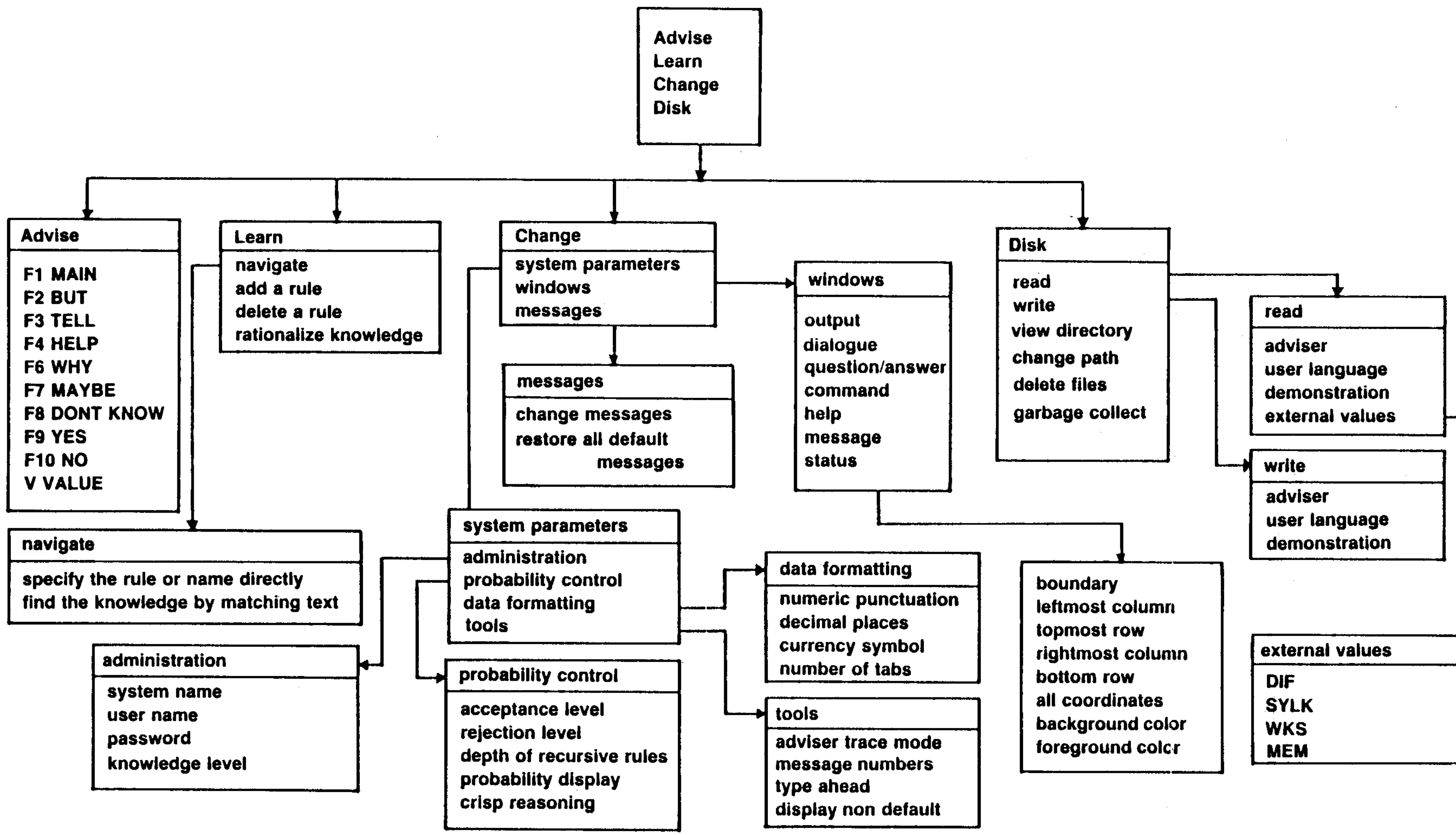


Figure 4-1 EXPERT EDGE MENU STRUCTURE (11)

optional objects. The evidence is displayed after IF/AND prompts and is broken down in the same manner as the conclusions. An example of a rule that could be used to select a sissor truss is:

```
sissor truss:selected   IF  class:is:residential
                        AND  use:is:church
                        AND  a high ceiling:is:desired
```

Rule may also be supplemented with help text, questions and answer, these will be explained in more depth in a later section.

Rules are connected (or linked), to other rules in two ways. One method is by matching parts of the rules. In this method a rule can be used to prove the evidence of another rule. An example of rules that are connected in this manner could be:

```
residential:recommended   IF  span:is less than:50
                          AND  use:is:family housing
                          AND type:is:advised

(is linked to)
single fink:advised       IF span:is less than:30
```

Notice that the verb (advise), in the evidence of the first rule and conclusion of the second rule is identical. This is required to link the two rules.

The other method of linking rules is through the use of a name tree. This method consists of grouping specific names under general names. Figure 4-2 shows how a name tree could be used in developing this prototype:

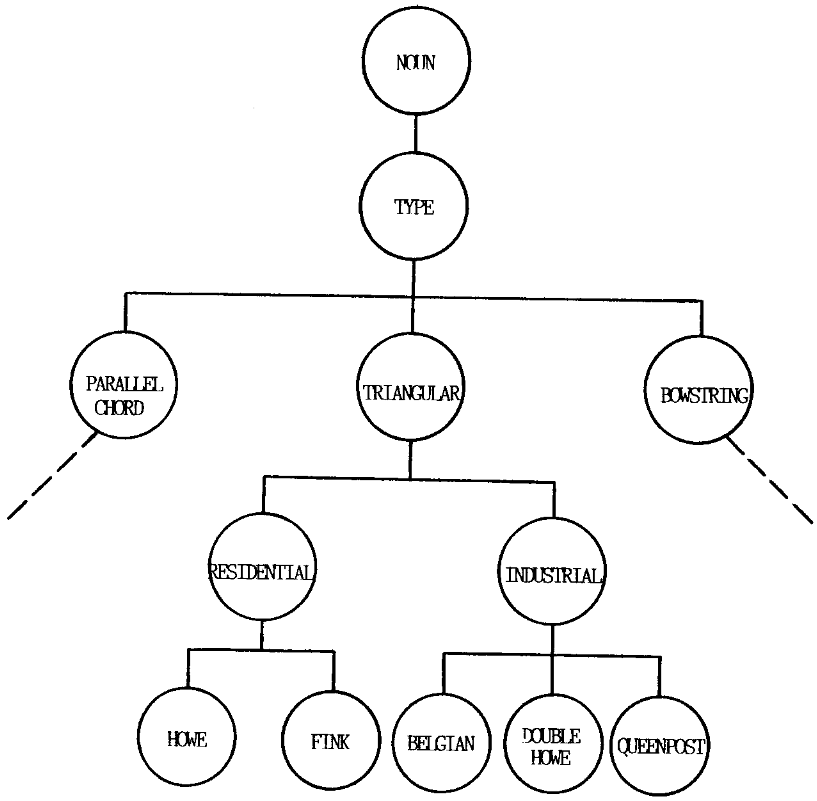


FIGURE 4-2 SAMPLE NAME TREE FOR TRUSS INFORMATION

Expert Edge offers the feature of specifying three types of rules. These include inquiry rules, answer rules and menu rules. An inquiry rule provides the starting point of the KBES. At least one rule of this type is required in a KBES, and only the top rule of the KBES should be an inquiry rule. The question text of this rule will be displayed at the beginning of the session in a menu form and is selected to start the session. Answer rules are used to display conclusions as they are proved by the KBES. At least one rule of this type is also required in all systems. A menu rule displays its evidence as a list of options. The program only attempts to prove rules that follow from the option selected. This type of rule is particularly useful in branching the knowledge base into separate lines of reasoning.

An example of how part of the name tree shown earlier could be represented using a menu rule is:

```
configuration:suggested   IF  triangular:selected
                          ANSWER  triangular
                          AND  bowstring:selected
                          ANSWER  bowstring
                          AND  parallel chord:selected
                          ANSWER  parallel chord
QUESTION  What type of truss do you wish to use?
```

Rules within the KBES may be any combination of the above types, but if the rule is used only to provide intermediate conclusions then no type need be specified.

Evidence is an optional statement that is used to prove the conclusion of a rule. The evidence is displayed after an IF/AND prompt, and should be broken into two or more parts corresponding to a subject, verb and optional objects. Expert Edge offers many features for the development of evidence. The most useful of these are comparators, numeric name values and identities. An example of evidence containing comparators was shown in the rule linking example (span:is less than:50). The comparators available include:"is less than", "is greater than", "is equal to", "is less than or equal to" and "is greater than or equal to". There are three types of numeric names available. These are constants (value is held permanently in the knowledge base), variables (KBES asks for the value directly), and equations (values calculated from other variables and/or constants). An identity of a name is another name with an identical value or meaning.

4.3 TEXT INFORMATION

Expert Edge offers the knowledge engineer a variety of methods to supplement the KBES with useful messages. These include help, questions and answers. Help text can be entered for conclusions and evidence, and is used to provide the user with additional information about the current rule. This information usually takes the form of definitions of terms. Questions are used by the system to obtain information from the user during the session. Answer text should be entered for the conclusion of a rule, when the rule has been identified as an answer type rule. Answer text is also used to form the list of options for a menu rule. Text information can be entered by the knowledge engineer or default text supplied by Expert Edge.

4.4 OTHER SYSTEM FEATURES

Expert Edge contains an explanation facility referred to as the WHY function. This function permits the user to trace backward through the chain of reasoning. When prompted this function displays the conclusion and evidence used to reach the conclusion.

The user of a KBES created with Expert Edge can enter footnote like messages to justify answers. To enter messages such as this the user must enter the BUT function. When the message is completed the user may continue to answer questions.

Expert Edge can also handle probabilities (or certainty factors) when answering questions. This is performed by moving the cursor along a horizontal scale to the appropriate value and hitting the enter key. The values of 100 (yes), 50 (maybe) and 0 (no) may be entered directly. A known value may be entered by using the value heading. An example of how 87 can be entered this way is:

press v

then enter 8 and 7

If the user wishes to ignore a question, Expert Edge accommodates this with a don't know answer. Crisp reasoning is also available to the knowledge engineer. This is useful if the answer to the questions will be only in terms of 100/0 (true or false).

TELL is a function that allows the user or knowledge engineer to alter answers, enter known answers in advance, perform a what if examination and ignore remaining questions. This function is particularly useful in checking and debugging prototypes. The process of wading through questions to check a solution path can be avoided using TELL and entering known data. To check other possible solution paths, enter TELL and alter existing answers. This is considerably faster than restarting the system. The TELL function is a valuable asset to this tool and should not be overlooked by the knowledge engineer or the user of a KBES.

4.5 SUMMARY

Expert Edge is an excellent KBES building tool, especially for problems of the following types: categorizing, consulting, diagnosing and forecasting. This system offers many programming aids to assist the knowledge engineer and the user. Among them are the ability to easily alter the screen format, the ability to handle probability of solutions, the ability to perform mathematical calculations and the ability to add several types of helpful texts.

One drawback that was found with this system was its inability to handle higher mathematical calculations such as square roots and trigonometrical functions. However, this can be overcome by developing a library of special mathematical functions and incorporating them into an empty advisor. Expert Edge is accompanied by a user manual that leads the user through several demonstrations to explain the features of the tool. The manual also includes discussions of these features and several examples are presented to demonstrate the use of these features. In addition to this, Expert Edge offers a customer phone service support, but it was not found to be of much help.

CHAPTER V

PROTOTYPE DEVELOPMENT

The prototype developed in this report addresses the area of wood truss design. The design process of wood trusses involves three major steps (16). First is the gathering of information such as the span, pitch, spacing, material, etc. Following this is the selection of feasible geometrical configurations. This is followed by analysis of the truss (determining all member axial forces). For the development of this prototype it is assumed that information concerning the first step is available. Further research in KBES technology could lead to the linking of a prototype such as the one in this report to an analysis program. This would assist in the third step of the design. The second step is where the prototype becomes useful, the recommendation of a suitable geometrical truss configuration. In the following sections the scope of the prototype, the decision tree, the development of some of the rules contained within the KBES and some sample problems are presented.

5.1 SCOPE

This prototype was developed to assist in recommending feasible wood truss geometries. For simplicity, this prototype was confined to:

- allowable stress increase of 15%
- truss spacing of 24 inches on centers
- design loads of 30 psf on the top chord and 10 psf on the bottom chord

-pitches of 3 to 12 and 4 to 12

-lumber species of No. 1 Southern Pine KD, Dense No. 1 Southern Pine KD and Dense No. 2 Southern Pine KD

-top and bottom chord must be of the same species

-top and bottom chord lumber sizes of 2 x 4 or 2 x 6

-spans between 10 and about 50 feet (depending on the type of lateral support)

-seven truss geometries refer to Figure 5-1

This figure does not contain all available trusses but does contain the most commonly used. Other factors being equal, economy is the prime consideration and therefore the truss geometry with fewer members or fewer members in compression is recommended (compression members often require more bracing).

5.2 RULE DEVELOPMENT

The rules used in the prototype were developed by organizing the available information into a hierarchial form, then creating rules to maneuver through the branches of the decision tree. The best way to explain the rules in the prototype is to follow one of the lines of reasoning. Figure 5-2 shows the rules required to recommend a Fink type truss. The first rule the user encounters is an inquiry rule. This rule is used to start the KBES and to select the preferred design loads (for now 30 psf top chord and 10 psf bottom chord). It is linked to rule "pi", which is used to determine the desired pitch (3 to 12 or 4 to 12). This rule is a menu type rule (recall from Chapter III that if the 3 to 12 pitch is selected, all knowledge concerning 4 to 12 pitch will be ignored). This rule is linked to the rule used to determine the species (or type) of

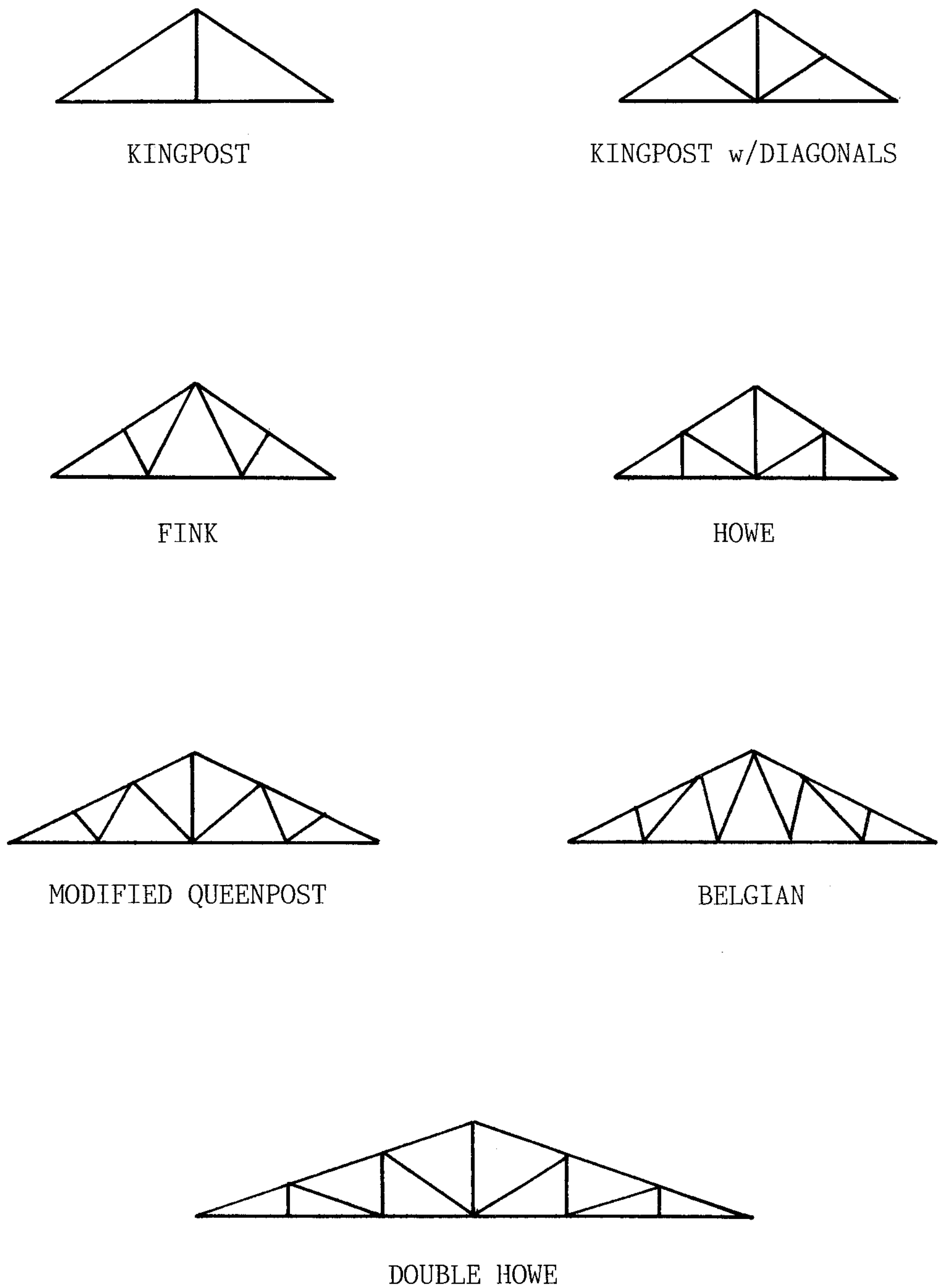


Figure 5-1 TRUSS GEOMETRIES CONTAINED IN KNOWLEDGE BASE

```
RULE         c1
RULETYPE     ENQUIRY
CONCLUSION   loading 1  ! suggested
QUESTION     LOADING 1 (30 psf top chord and 10 psf b
             ottom chord).
ANSWER       t
PRB NO EVD   100
          IF pitch ! selected
QUESTION     What value of pitch would you like?
PRB IF CON   100
PRB IFN CON  0


RULE         p1
RULETYPE     MENU
CONCLUSION   pitch ! selected
QUESTION     What value of pitch would you like?
PRB NO EVD   100
          IF three to twelve ! desired
ANSWER       3 to 12
PRB IF CON   100
PRB IFN CON  0
         AND four to twelve ! desired
ANSWER       4 to 12
PRB IF CON   100
PRB IFN CON  0


RULE         ty
RULETYPE     MENU
CONCLUSION   type  ! desired
QUESTION     What species of lumber would you like?
PRB NO EVD   100
          IF No 2 SP KD ! advised
ANSWER       #2 southern pine (kd)
PRB IF CON   100
PRB IFN CON  0
         AND No 2 DEN SP KD ! advised
ANSWER       #2 dense southern pine (kd)
PRB IF CON   100
PRB IFN CON  0
         AND No 1 SP KD ! advised
ANSWER       #1 southern pine (kd)
PRB IF CON   100
PRB IFN CON  0
         AND No 1 DEN SP KD ! advised
ANSWER       #1 dense southern pine (kd)
PRB IF CON   100
PRB IFN CON  0


RULE         br1
RULETYPE     MENU
CONCLUSION   lateral support  ! advised
QUESTION     Which would you rather provide?
PRB NO EVD   100
          IF lateral bracing  ! recommended
ANSWER       continuous lateral bracing
PRB IF CON   100
PRB IFN CON  0
         AND web material ! recommended
ANSWER       more web material
PRB IF CON   100
PRB IFN CON  0
         AND reduced pannel length ! recommended
QUESTION     reduced pannel length of the bottom chor
             d
PRB IF CON   100
PRB IFN CON  0


RULE         w13a
RULETYPE     ANSWER
CONCLUSION   fink1 ! recommended
ANSWER       A FINK truss is recommended.
PRB NO EVD   100
          IF span ! is greater than or equal to ! 16
PRB IF CON   100
PRB IFN CON  0
         AND span ! is less than or equal to ! 27
PRB IF CON   100
PRB IFN CON  0
         AND bottom chord size ! is equal to ! 4
PRB IF CON   100
PRB IFN CON  0
         AND top chord size ! is equal to ! 4
PRB IF CON   100
PRB IFN CON  0
```

Figure 5-2 RULES REQUIRED TO RECOMMEND A FINK TRUSS lumber desired. It is also a menu type rule. The species the user may select from are: No. 1 Southern Pine KD, Dense No. 1 Southern Pine KD, No. 2 Southern Pine KD and Dense No. 2 Southern Pine KD (For this explanation No. 2 Southern Pine KD will be followed). This rule is linked to the rule used to determine the type of lateral support preferred. The three choices are continuous lateral bracing, more web material and reduced panel length of the bottom chord. Continuous lateral bracing refers to bracing provided at the midpoints of the compression members and perpendicular to the plane of the truss. More web material refers to truss geometries that have shorter compression members. However, as the name indicates, these usually require more web material. The third choice is to reduce the panel length of the bottom chords. Table 5-1 shows the trusses that are grouped below these three categories. For this explanation the more web material branch will followed. The next rule is an answer rule. As mentioned earlier, the answer is only produced if all the evidence is true. In this case the span would have to be greater than or equal to 15 feet, less than or equal to 27 feet, bottom chord lumber of 2 x 4. If these conditions are met the answer is displayed (A FINK truss is recommended), in the dialogue window. It is important to note that there are several other lines of reasoning that would produce the same recommendations.

	CONTINUOUS LATERAL BRACING	MORE WEB MATERIAL	REDUCED PANEL LENGTH OF BOTTOM CHORD
	Kingpost	Kingpost	Kingpost
TRUSS	Kingpost with Diagonals	Fink	Howe
	Modified Queenpost	Belgian	Double Howe

Table 5-1 TYPES OF LATERAL SUPPORT AND RESPECTIVE TRUSSES.

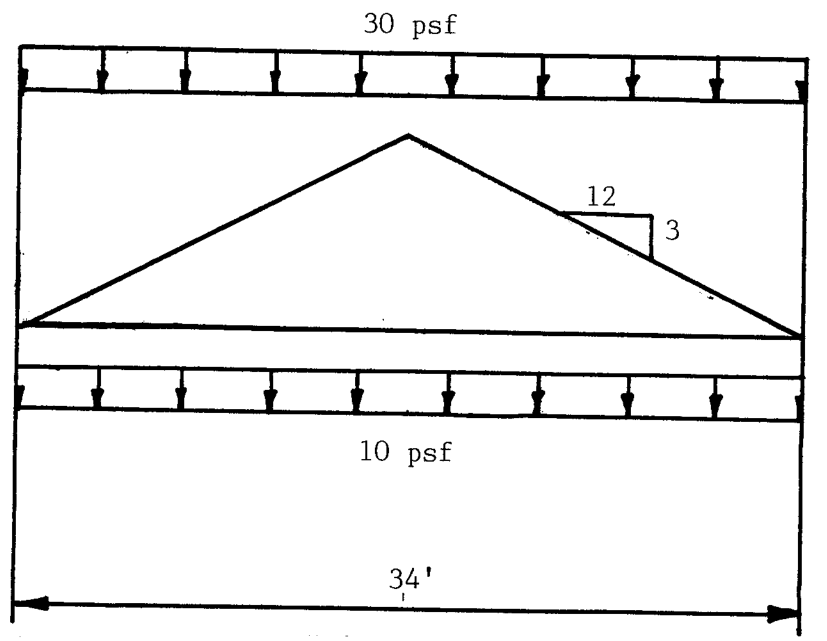
5.3 SAMPLE RUNS

This section contains some sample runs of the prototype. These samples are run by selecting the Advisor option from the main menu, then answering the questions the prototype presents. The first example is a consultation that recommends a Modified Queenpost geometry. The second consultation recommends a Fink geometry and also demonstrates the use of the WHY function. The third sample run recommends a Double Howe geometry. However, at first no recommendation could be obtained with the information provided. Following this, the TELL function was entered and the information was modified such that a conclusion could be reached.

5.3.1 SAMPLE 1

The dialogue of the first consultation is presented below. Figure 5-3 shows the freebody diagram used for the input data. Given this data, very little time was required for the prototype to reach the conclusion that a Modified Queenpost geometry is recommended. The text that is underlined is the questions the prototype presents to the user. The text following the dash marks are the input data. The information contained in the brackets shows the conclusion the prototype has recommended.

Spacing = 24" c/c
ASI = 1.15



Try: No. 2 Southern Pine KD lumber
2 x 6 top chord
2 x 6 bottom chord
(lateral bracing preferred)

Figure 5-3 INPUT DATA FOR SAMPLE 1

```
            LOADING 1 (30 psf top chord and 10 psf bottom chord).

The acceptance level is currently 70
- It is  100   percent certain that A MODIFIED QUEENPOST truss is recommended.
```

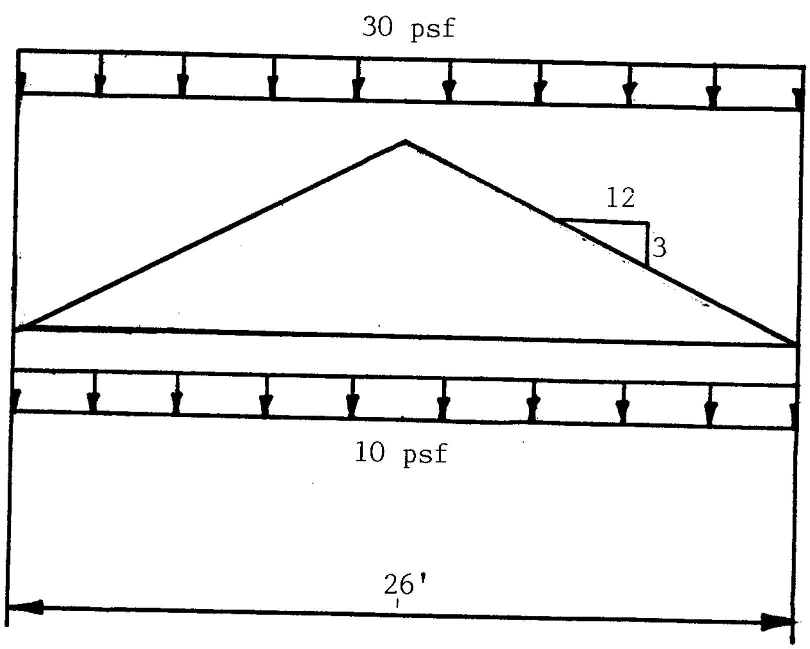
```
      LOADING 1 (30 psf top chord and
10 psf bottom chord).

The acceptance level is currently 70
What value of pitch would you like? -
3 to 12
What species of lumber would you like?
 - #2 southern pine (kd)
Which would you rather provide? -
continuous lateral bracing
What is the length of the BOTTOM
CHORD in feet?- 34.00
BOTTOM CHORD size 2x? - 6.00
TOP CHORD size is 2x?- 6.00
- It is  100   percent certain that A
MODIFIED QUEENPOST truss is
recommended.
```

5.3.2 SAMPLE 2

This session demonstrates the WHY function and its use. Figure 5-4 shows the freebody diagram of the input data. With this data the prototype recommends a Fink geometry. The information following the recommendation is what appears in the dialogue window when the WHY function is activated (pressing F6 on the computer keyboard). As mentioned earlier, this function backtracks through the inference to justify its recommendations. The messages presented are default messages contained within the Expert Edge building tool.

Spacing = 24" c/c
ASI = 1.15



Try: No. 1 Southern Pine KD lumber
2 x 4 top chord
2 x 6 bottom chord
(more web material preferred)

Figure 5-4 INPUT DATA FOR SAMPLE 2

LOADING 1 (30 psf top chord and 10 psf bottom chord).

The acceptance level is currently 70
- It is 100 percent certain that A FINK truss is recommended.

LOADING 1 (30 psf top chord and
10 psf bottom chord).

The acceptance level is currently 70
- It is 100 percent certain that A
FINK truss is recommended.

LOADING 1 (30 psf top chord and
10 psf bottom chord).

The acceptance level is currently 70
What value of pitch would you like? -
3 to 12
What species of lumber would you like?
- #1 southern pine (kd)
Which would you rather provide? -
more web material
What is the length of the BOTTOM
CHORD in feet?- 26.00
BOTTOM CHORD size 2x? - 6.00
TOP CHORD size is 2x?- 4.00
- It is 100 percent certain that A
FINK truss is recommended.

LOADING 1 (30 psf top chord and 10 psf bottom chord).

The acceptance level is currently 70
- It is 100 percent certain that A FINK truss is recommended.

I found that
.A FINK truss is recommended. (100 %)
by checking whether
.span is greater than or equal to 17 .(100 %)
.span is less than 30 .(100 %)
.bottom chord size is equal to 6 .(100 %)
.top chord size is equal to 4 .(100 %)

I found that
.lateral support3 advised . (100 %)
by checking whether
.more web material(100 %)

I found that
.type desired . (100 %)
by checking whether
.#1 southern pine (kd)(100 %)

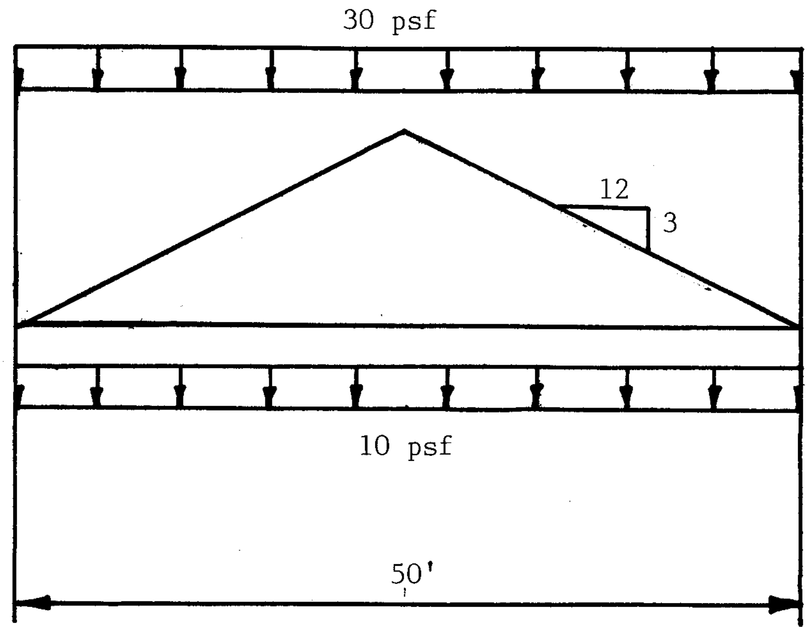
I found that
.pitch selected . (100 %)
by checking whether
.3 to 12(100 %)

The message shown above the dashed line is presented when the F6 (WHY) key is pressed. This message is the conclusion and evidence of the answer rule the session proved. The next message is obtained by pressing the F6 key again. This is the rule that preceded the answer rule. The next two messages are obtained in the same manner and represents other rules used to prove the conclusion.

5.3.3 SAMPLE 3

This session recommends a truss geometry for the information shown in Figure 5-5. Based on that information the prototype at first could not make a recommendation (no conclusion could be reached). To obtain a recommendation the TELL function was entered and then the "modify an answer", branch (boxed text in printout). The top chord lumber was then changed from 2 x 4 to 2 x 6. After this change was completed and the Advise Mode was entered the prototype recommended a Double Howe geometry. Other changes may have been tried such as the species of lumber or the type of lateral support.

Spacing = 24" c/c
ASI = 1.15



Try: No. 1 Dense Southern Pine KD lumber
2 x 4 top chord
2 x 6 bottom chord
(reduced panel length of the bottom chord preferred)

Figure 5-5 INPUT DATA FOR SAMPLE 3.

LOADING 1 (30 psf top chord and 10 psf bottom chord).

The acceptance level is currently 70
What value of pitch would you like? —
3 to 12
What species of lumber would you like?
— #1 dense southern pine (kd)
Which would you rather provide? —
reduced pannel length of the bottom
chord
What is the length of the BOTTOM
CHORD in feet?— 50.00
BOTTOM CHORD size 2x? — 6.00
TOP CHORD size is 2x?— 4.00

.Change acceptance level.
.Call Tell.
.Finish Advise session.

.Clear all questions.
.Provide answers.
.Modify answers.
.Ignore remaining questions.
.Determine question type.
.Switch on levels.
.Tell Tools.

LOADING 1 (30 psf top chord and 10 psf bottom chord).

The acceptance level is currently 70
TOP CHORD size is 2x?— 6.00
— It is 100 percent certain that a
DOUBLE HOWE truss is recommended.

CHAPTER VI

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

The main objectives of this report were to review the current technology of KBES and their applications in the domain of Civil Engineering. An additional objective was to review and test the applicability of the expert system building tool Expert Edge in developing a prototype KBES using a micro computer. The prototype developed in this report can recommend the geometry for a wooden truss. The word geometry here refers to the configuration of the web material. It took approximately four weeks to develop this prototype. This was accomplished through a sequence of adding more rules at different levels in the decision tree of the preliminary KBES. This process of development gradually increased the complexity of the prototype and made it more versatile. The end product is a prototype that contains approximately three hundred rules and in its present stage can assist in the preliminary selection of a wooden truss type.

- -allowable stress increase of 15%
- -truss spacing of 24 inches or centers
- -design loads of 30 psf on the top chord and 10 psf on the bottom chord
- -pitches of 3 to 12 and 4 to 12
- -lumber species of No. 1 Southern Pine KD, Dense No. 1 Southern Pine KD, No. 2 Southern Pine KD and Dense No. 2 Southern Pine KD

-top and bottom chord must be of the same species

-top and bottom chord lumber sizes of 2 x 4 or 2 x 6

-scans between 10 and about 50 feet (depending on the type of lateral support)

-seven truss geometries (see Figure 5-1)

These limitations were based on information provided by Inter-Lock Steel Company and (17). However, if needed any of these areas could be expanded easily and with little time involved.

Further work on this prototype should include a default that would produce a recommended lateral support type and possibly the species and size of the top and bottom chord lumber. This improvement could be accomplished by the use of certainty factors.

6.2 CONCLUSION

KBES have a place in the domain of Civil Engineering, especially in the area of structural design. One such problem involves selecting a suitable geometry of a truss prior to analysis. The building tool used for the development of this prototype was Expert Edge. This building tool is very useful, but like most of the KBES building tools for micro computers on the market today it seemed to be oriented towards business applications rather than engineering. There are building tools available that are oriented towards engineering applications, two such tools are INSIGHT II (an updated version of INSIGHT I) and EXSYS (13). However, because a building tool such as this was used in the development, a suitable prototype was constructed without any significant programming and was completed in a relatively short period of time. This conclusion in itself shows that micro computer applications of KBES technology offer an inexpensive alternative for small consulting systems.

APPENDIX A

PROGRAMMING CONSIDERATIONS

A-1 RULES

Rules used in the Expert Edge building tool are statements that consist of a conclusion and optional evidence that is used to prove the the conclusion (11). The following is an example of a rule contained within the prototype.

```
RULE            b13a
RULETYPE        ANSWER
CONCLUSION      belgian  | recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
             IF span | is greater than | 27
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 32
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
```

A rule such as this is entered using the "Learn" command from the main menu. The following steps are required to add a rule such as this one to the knowledge base.

1. Select the "Learn" command from the main menu.

2. Select the "add a rule" option from the nest menu (navigate, add a rule, delete a rule, rationalize knowledge).

3. Enter the conclusion (the program prompts for the subject to

be entered first). For this example the conclusion is Belgian (type Belgian and press the return key).

4. Next enter the verb (Expert Edge also prompts for this). The verb used in this rule is recommended.

5. Following this Expert Edge prompts for the first objective to be entered. The conclusion of this rule does not have an objective, therefore just press the return key.

6. The program now prompts the user to enter the evidence if there is any. The example rule contains four pieces of evidence. These are entered one at a time in a manner similar to entering the conclusion (steps 3, 4 and 5). The following entries provide the evidence for this rule:

-span

-is greater than

-27

-span

-is less than

-32

-bottom chord size

-is equal to

-4

-top chord size

-is equal to

-4

7. The program continues to prompt the user for evidence until the return key is pressed twice. When this is done the program displays the message ****END OF RULE**** in the output window.

8. Probabilities associated with the conclusion and evidence would be entered following this. However, the prototype was developed using the crisp reasoning feature and truss. These steps were omitted.

9. Expert Edge now displays a menu for editing or entering associated text for the evidence (questions, answers and help). To enter this text select the option desired and press the return key. The program then prompts for the text to be entered. To leave this menu press the ESC key. Since no text is associated with any of the evidence in this example the ESC key was hit four times.

10. The program now asks the user for the name of the rule. The name of the example rule is bl3a.

11. Expert Edge then displays a menu of rule types. To enter the type select the appropriate type from the menu and press the return key. To escape from this menu press the ESC key. The rule in the example was an answer type rule.

12. The last information the program seeks from the user is the text associated with the conclusion. This is entered similar to text for the evidence (step 9). In this example the text "A BELGIAN truss is recommended" is the answer to be displayed if the rule is proved to be true.

Following this step press Fl to return to the main menu or ESC to return to the Learn menu.

A-2 DECISION TREE

The decision tree is a method of organizing names, so that specific names are grouped under general names. Figure A-1 shows the decision tree used to develop the prototype. This figure shows the paths an inference may follow to produce a conclusion. The formation of this tree is based on information provided by the Inter Lock Steel Company and (17). The placement of the nodes (or names), is accomplished using the "Learn" command from the main menu. The following is an example of the commands to enter and place the name "pitch".

Commands Form Main Menu To Enter A Name

-Learn (menu selection)

-Navigate (menu selection)

-Specify The Rule or Name Directly (menu selection)

-Pitch (typed input)

-Look More Closely (menu selection)

-Position In The Tree (menu selection)

-Sideways (menu selection)

-Noun (menu selection)

-Downward (menu selection)

-Loading 1 (menu selection)

-**ADD** (menu selection)

This example assumes that the name "pitch" has not been placed previously in the tree.

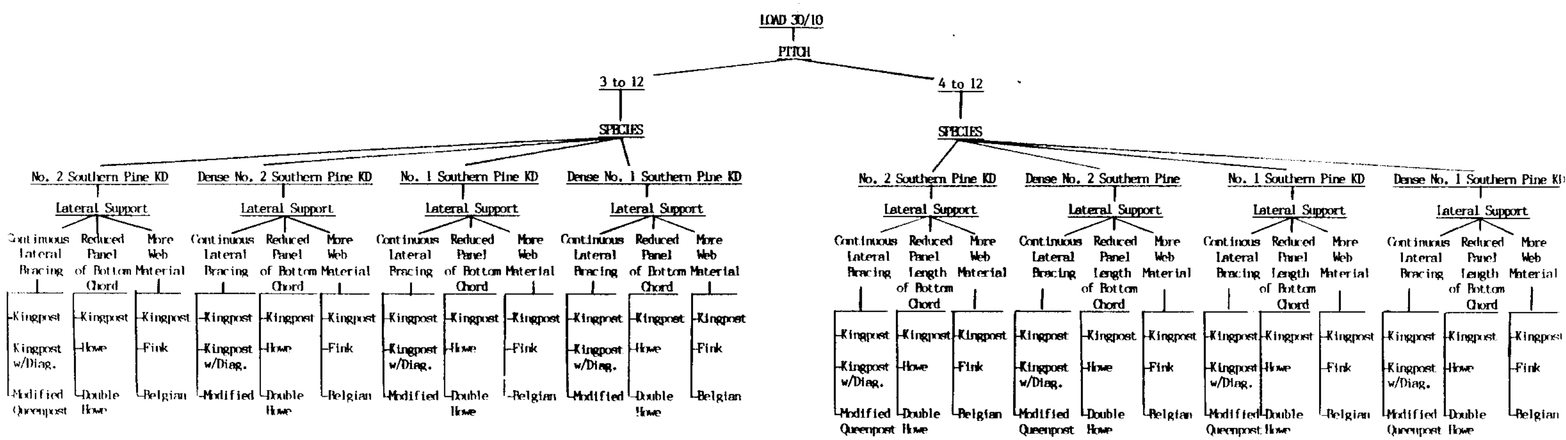


Figure A-1 DECISION TREE USED TO DEVELOP THE PROTOTYPE

APPENDIX B

USER LANGUAGE FILE LISTING

```
NAME          double howe2
SUPERSET      reduced pannel length2

NAME          43
SUPERSET      constant
VALUE         43.00

NAME          kingpost24
SUPERSET      web material24

NAME          lateral bracing34
SUPERSET      lateral support34

NAME          53
SUPERSET      constant
VALUE         53.00

NAME          24
SUPERSET      constant
VALUE         24.00

NAME          lateral support44
SUPERSET      No 1 DEN SP KD4

NAME          kingpost24b
SUPERSET      reduced panel length24

NAME          three to twelve
SUPERSET      pitch

NAME          lateral bracing44
SUPERSET      lateral support44

NAME          34
SUPERSET      constant
VALUE         34.00

NAME          kingpost44
SUPERSET      web material44

NAME          3
SUPERSET      constant
VALUE         3.00

NAME          kingpost w diag2
SUPERSET      lateral bracing2

NAME          kingpost w diag1
SUPERSET      lateral bracing

NAME          kingpost w diag4
SUPERSET      lateral bracing4

NAME          kingpost w diag3
SUPERSET      lateral bracing3

NAME          44
SUPERSET      constant
VALUE         44.00

NAME          4
SUPERSET      constant
VALUE         4.00

NAME          web material24
SUPERSET      lateral support24

NAME          mod queenpost2
SUPERSET      lateral bracing2

NAME          mod queenpost1
SUPERSET      lateral bracing
```

```
NAME         No 1 SP KD
SUPERSET     type

NAME         kingpost44b
SUPERSET     reduced panel length44

NAME         mod queenpost4
SUPERSET     lateral bracing4

NAME         25
SUPERSET     constant
VALUE        25.00

NAME         mod queenpost3
SUPERSET     lateral bracing3

NAME         web material34
SUPERSET     No 1 SP KD4

NAME         No 2 SP KD
SUPERSET     type

NAME         fink1
SUPERSET     web material

NAME         6
SUPERSET     constant
VALUE        6.00

NAME         reduced panel length34
SUPERSET     No 1 SP KD4

NAME         35
SUPERSET     constant
VALUE        35.00

NAME         kingpost34b
SUPERSET     reduced panel length34

NAME         fink2
SUPERSET     web material2

NAME         45
SUPERSET     constant
VALUE        45.00

NAME         fink3
SUPERSET     web material3

NAME         16
SUPERSET     constant
VALUE        16.00

NAME         span
SUPERSET     constant
MINIMUM      10.00
MAXIMUM      100.00
QUESTION     What is the length of the BOTTOM CHORD i
             n feet?

NAME         fink4
SUPERSET     web material4

NAME         type
SUPERSET     three to twelve

NAME         26
SUPERSET     constant
VALUE        26.00
```

```
NAME        bottom chord size
SUPERSET    constant
MINIMUM     4.00
MAXIMUM     6.00
QUESTION    BOTTOM CHORD size 2x?

NAME        36
SUPERSET    constant
VALUE       36.00

NAME        46
SUPERSET    constant
VALUE       46.00

NAME        17
SUPERSET    constant
VALUE       17.00

NAME        56
SUPERSET    constant
VALUE       56.00

NAME        27
SUPERSET    constant
VALUE       27.00

NAME        belgian1
SUPERSET    web material

NAME        belgian2
SUPERSET    web material2

NAME        belgian3
SUPERSET    web material3

NAME        web lumber
SUPERSET    lateral support

NAME        37
SUPERSET    constant
VALUE       37.00

NAME        belgian4
SUPERSET    web material4

NAME        No 1 DEN SP KD4
SUPERSET    spec

NAME        No 1 DEN SP KD
SUPERSET    type

NAME        web material44
SUPERSET    lateral support44

NAME        No 2 DEN SP KD4
SUPERSET    spec

NAME        No 2 DEN SP KD
SUPERSET    type

NAME        18
SUPERSET    constant
VALUE       18.00

NAME        web material
SUPERSET    lateral support

NAME        spec
SUPERSET    four to twelve
```

```
NAME            web material2
SUPERSET        lateral support2

NAME            57
SUPERSET        constant
VALUE           57.00

NAME            web material3
SUPERSET        lateral support3

NAME            28
SUPERSET        constant
VALUE           28.00

NAME            kingpost1
SUPERSET        web material

NAME            40
SUPERSET        constant
VALUE           40.00

NAME            kingpost2
SUPERSET        web material2

NAME            lateral bracing2
SUPERSET        lateral support2

NAME            lateral bracing
SUPERSET        lateral support

NAME            web material4
SUPERSET        lateral support4

NAME            kingpost3
SUPERSET        web material3

NAME            lateral bracing4
SUPERSET        lateral support4

NAME            top chord length
SUPERSET        constant
MINIMUM         10.00
MAXIMUM         80.00
QUESTION        What is the length of the TOP CHORD in f
                eet?

NAME            kingpost4
SUPERSET        web material4

NAME            lateral bracing3
SUPERSET        lateral support3

NAME            30
SUPERSET        constant
VALUE           30.00

NAME            lateral bracing14
SUPERSET        lateral support14

NAME            38
SUPERSET        constant
VALUE           38.00

NAME            50
SUPERSET        constant
VALUE           50.00

NAME            No 1 SP KD4
SUPERSET        spec
```

```
NAME        top chord size
SUPERSET    constant
MINIMUM     4.00
MAXIMUM     6.00
QUESTION    TOP CHORD size is 2x?

NAME        48
SUPERSET    constant
VALUE       48.00

NAME        web material14
SUPERSET    lateral support14

NAME        31
SUPERSET    constant
VALUE       31.00

NAME        No 2 SP KD4
SUPERSET    spec

NAME        reduced panel length44
SUPERSET    lateral support44

NAME        29
SUPERSET    constant
VALUE       29.00

NAME        41
SUPERSET    constant
VALUE       41.00

NAME        39
SUPERSET    constant
VALUE       39.00

NAME        pitch
SUPERSET    loading 1
QUESTION    What is the vertical component of the ro
            of slope(ie. 3,4,5,6)?

NAME        loading 1
SUPERSET    noun

NAME        22
SUPERSET    constant
VALUE       22.00

NAME        loading 2
SUPERSET    noun

NAME        reduced pannel length
SUPERSET    lateral support

NAME        reduced pannel length4
SUPERSET    lateral support4

NAME        kingpost14a
SUPERSET    lateral bracing14

NAME        reduced panel length14
SUPERSET    lateral support14

NAME        49
SUPERSET    constant
VALUE       49.00

NAME        kingpost34a
SUPERSET    lateral bracing34

NAME        reduced pannel length3
SUPERSET    lateral support3
```

NAME	kingpost24a
SUPERSET	lateral bracing24
NAME	kingpost14
SUPERSET	web material14
NAME	32
SUPERSET	constant
VALUE	32.00
NAME	reduced pannel length2
SUPERSET	lateral support2
NAME	lateral support14
SUPERSET	No 2 SP KD4
NAME	lateral support
SUPERSET	No 2 SP KD
NAME	lateral support2
SUPERSET	No 2 DEN SP KD
NAME	lateral support3
SUPERSET	No 1 SP KD
NAME	kingpost1b
SUPERSET	reduced pannel length
NAME	kingpost1a
SUPERSET	lateral bracing
NAME	kingpost2a
SUPERSET	lateral bracing2
NAME	lateral support4
SUPERSET	No 1 DEN SP KD
NAME	kingpost2b
SUPERSET	reduced pannel length2
NAME	kingpost3a
SUPERSET	lateral bracing3
NAME	42
SUPERSET	constant
VALUE	42.00
NAME	kingpost3b
SUPERSET	reduced pannel length3
NAME	kingpost4a
SUPERSET	lateral bracing4
NAME	kingpost4b
SUPERSET	reduced pannel length4
NAME	kingpost34
SUPERSET	web material34
NAME	howe1
SUPERSET	reduced pannel length
NAME	23
SUPERSET	constant
VALUE	23.00
NAME	kingpost44a
SUPERSET	lateral bracing44
NAME	reduced panel length24
SUPERSET	lateral support24

```
NAME          kingpost14b
SUPERSET      reduced panel length14

NAME          howe2
SUPERSET      reduced pannel length2

NAME          lateral support24
SUPERSET      No 2 DEN SP KD4

NAME          33
SUPERSET      constant
VALUE         33.00

NAME          howe3
SUPERSET      reduced pannel length3

NAME          lateral support34
SUPERSET      No 1 SP KD4

NAME          double howe1
SUPERSET      reduced pannel length

NAME          double howe4
SUPERSET      reduced pannel length4

NAME          four to twelve
SUPERSET      pitch

NAME          lateral bracing24
SUPERSET      lateral support24

NAME          double howe3
SUPERSET      reduced pannel length3

NAME          howe4
SUPERSET      reduced pannel length4


RULE          o1
RULETYPE      ENQUIRY
CONCLUSION    loading 1   | suggested
QUESTION      LOADING 1 (30 psf top chord and 10 psf b
              ottom chord).
ANSWER        t
PRB NO EVD    100
           IF pitch | selected
QUESTION      What value of pitch would you like?
PRB IF CON    100
PRB IFN CON   0


RULE          pi
RULETYPE      MENU
CONCLUSION    pitch | selected
QUESTION      What value of pitch would you like?
PRB NO EVD    100
           IF three to twelve | desired
ANSWER        3 to 12
PRB IF CON    100
PRB IFN CON   0
          AND four to twelve | desired
ANSWER        4 to 12
PRB IF CON    100
PRB IFN CON   0
```

```
RULE          ty
RULETYPE      MENU
CONCLUSION    type  ! desired
QUESTION      What species of lumber would you like?
PRB NO EVD    100
           IF No 2 SP KD ! advised
ANSWER        #2 southern pine (kd)
PRB IF CON    100
PRB IFN CON   0
          AND No 2 DEN SP KD ! advised
ANSWER        #2 dense southern pine (kd)
PRB IF CON    100
PRB IFN CON   0
          AND No 1 SP KD ! advised
ANSWER        #1 southern pine (kd)
PRB IF CON    100
PRB IFN CON   0
          AND No 1 DEN SP KD ! advised
ANSWER        #1 dense southern pine (kd)
PRB IF CON    100
PRB IFN CON   0


RULE          sp
RULETYPE      MENU
CONCLUSION    spec ! desired
QUESTION      What species of lumber would you like?
PRB NO EVD    100
           IF No 2 SP KD4 ! advised
ANSWER        #2 southern pine (kd)
PRB IF CON    100
PRB IFN CON   0
          AND No 2 DEN SP KD4 ! advised
ANSWER        #2 dense southern pine (kd)
PRB IF CON    100
PRB IFN CON   0
          AND No 1 SP KD4 ! advised
ANSWER        #1 southern pine (kd)
PRB IF CON    100
PRB IFN CON   0
          AND No 1 DEN SP KD4 ! advised
ANSWER        #1 dense southern pine (kd)
PRB IF CON    100
PRB IFN CON   0


RULE          br4
RULETYPE      MENU
CONCLUSION    lateral support4 ! advised
QUESTION      Which would you rather provide?
PRB NO EVD    100
           IF lateral bracing4 ! recommended
ANSWER        continuous lateral bracing
PRB IF CON    100
PRB IFN CON   0
          AND web material4 ! recommended
ANSWER        more web material
PRB IF CON    100
PRB IFN CON   0
          AND reduced pannel length4 ! recommended
ANSWER        reduced pannel length of the bottom chor
              d
PRB IF CON    100
PRB IFN CON   0
```

```
RULE           br2
RULETYPE       MENU
CONCLUSION     lateral support2 ! advised
QUESTION       Which would you rather provide?
PRB NO EVD     100
            IF lateral bracing2 ! recommended
ANSWER         continuous lateral bracing
PRB IF CON     100
PRB IFN CON    0
           AND web material2 ! recommended
ANSWER         more web material
PRB IF CON     100
PRB IFN CON    0
           AND reduced pannel length2 ! recommended
QUESTION       reduced pannel length of the bottom chor
               d
PRB IF CON     100
PRB IFN CON    0


RULE           br1
RULETYPE       MENU
CONCLUSION     lateral support  ! advised
QUESTION       Which would you rather provide?
PRB NO EVD     100
            IF lateral bracing  ! recommended
ANSWER         continuous lateral bracing
PRB IF CON     100
PRB IFN CON    0
           AND web material ! recommended
ANSWER         more web material
PRB IF CON     100
PRB IFN CON    0
           AND reduced pannel length ! recommended
QUESTION       reduced pannel length of the bottom chor
               d
PRB IF CON     100
PRB IFN CON    0


RULE           br3
RULETYPE       MENU
CONCLUSION     lateral support3 ! advised
QUESTION       Which would you rather provide?
PRB NO EVD     100
            IF lateral bracing3 ! recommended
ANSWER         continuous lateral bracing
PRB IF CON     100
PRB IFN CON    0
           AND web material3 ! recommended
ANSWER         more web material
PRB IF CON     100
PRB IFN CON    0
           AND reduced pannel length3 ! recommended
QUESTION       reduced pannel length of the bottom chor
               d
PRB IF CON     100
PRB IFN CON    0
```

```
RULE          br14
RULETYPE      MENU
CONCLUSION    lateral support14 | advised
QUESTION      Which would you rather provide?
PRB NO EVD    100
           IF lateral bracing14 | recommended
ANSWER        continuous lateral bracing
PRB IF CON    100
PRB IFN CON   0
          AND web material14 | recommended
ANSWER        more web material
PRB IF CON    100
PRB IFN CON   0
          AND reduced panel length14 | recommended
ANSWER        reduced panel length of the bottom chord
PRB IF CON    100
PRB IFN CON   0


RULE          br24
RULETYPE      MENU
CONCLUSION    lateral support24 | advised
QUESTION      Which would you rather provide?
PRB NO EVD    100
           IF lateral bracing24 | recommended
ANSWER        continuous lateral bracing
PRB IF CON    100
PRB IFN CON   0
          AND web material24 | recommended
PRB IF CON    100
PRB IFN CON   0
          AND reduced panel length24 | recommended
PRB IF CON    100
PRB IFN CON   0


RULE          br44
RULETYPE      MENU
CONCLUSION    lateral support44 | advised
QUESTION      Which would you rather provide?
PRB NO EVD    100
           IF lateral bracing44 | recommended
ANSWER        continuous lateral bracing
PRB IF CON    100
PRB IFN CON   0
          AND web material44 | recommended
ANSWER        more web material
PRB IF CON    100
PRB IFN CON   0
          AND reduced panel length44 | recommended
ANSWER        reduced panel length of the bottom chord
PRB IF CON    100
PRB IFN CON   0
```

```
RULE         br34
RULETYPE     MENU
CONCLUSION   lateral support34 | advised
QUESTION     Which would you rather provide?
PRB NO EVD   100
          IF lateral bracing34 | recommended
ANSWER       continuous lateral bracing
PRB IF CON   100
PRB IFN CON  0
         AND web material34 | recommended
ANSWER       more web material
PRB IF CON   100
PRB IFN CON  0
         AND reduced panel length34 | recommended
ANSWER       reduced panel length of the bottom chord
PRB IF CON   100
PRB IFN CON  0


RULE         h23c
RULETYPE     ANSWER
CONCLUSION   howe2 | recommended
ANSWER       A SINGLE HOWE truss is recommended.
PRB NO EVD   100
          IF span | is greater than | 24
PRB IF CON   100
PRB IFN CON  0
         AND span | is less than or equal to | 42
PRB IF CON   100
PRB IFN CON  0
         AND bottom chord size | is equal to | 4
PRB IF CON   100
PRB IFN CON  0
         AND top chord size | is equal to | 6
PRB IF CON   100
PRB IFN CON  0


RULE         h23d
RULETYPE     ANSWER
CONCLUSION   howe2 | recommended
ANSWER       A SINGLE HOWE truss is recommended.
PRB NO EVD   100
          IF span | is greater than | 24
PRB IF CON   100
PRB IFN CON  0
         AND span | is less than or equal to | 42
PRB IF CON   100
PRB IFN CON  0
         AND bottom chord size | is equal to | 6
PRB IF CON   100
PRB IFN CON  0
         AND top chord size | is equal to | 6
PRB IF CON   100
PRB IFN CON  0
```

```
RULE          h23a
RULETYPE      ANSWER
CONCLUSION    howe2 ¦ recommended
ANSWER        A SINGLE HOWE truss is recommended.
PRB NO EVD    100
           IF span ¦ is greater than or equal to ¦ 17
PRB IF CON    100
PRB IFN CON   0
          AND span ¦ is less than ¦ 29
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0


RULE          h23b
RULETYPE      ANSWER
CONCLUSION    howe2 ¦ recommended
ANSWER        A SINGLE HOWE truss is recommended.
PRB NO EVD    100
           IF span ¦ is greater than or equal to ¦ 17
PRB IF CON    100
PRB IFN CON   0
          AND span ¦ is less than or equal to ¦ 29
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0


RULE          m23a
RULETYPE      ANSWER
CONCLUSION    mod queenpost2 ¦ recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span ¦ is greater than ¦ 24
PRB IF CON    100
PRB IFN CON   0
          AND span ¦ is less than ¦ 35
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
```

```
RULE          m23b
RULETYPE      ANSWER
CONCLUSION    mod queenpost2 | recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span | is greater than | 24
PRB IF CON    100
PRB IFN CON   0
          AND span | is less than or equal to | 35
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0


RULE          m23c
RULETYPE      ANSWER
CONCLUSION    mod queenpost2 | recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span | is less than or equal to | 45
PRB IF CON    100
PRB IFN CON   0
          AND span | is greater than | 33
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          m23d
RULETYPE      ANSWER
CONCLUSION    mod queenpost2 | recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span | is less than or equal to | 45
PRB IF CON    100
PRB IFN CON   0
          AND span | is greater than | 33
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
```

```
RULE            dh23a
RULETYPE        ANSWER
CONCLUSION      double howe2 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
             IF span | is greater than or equal to | 29
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than or equal to | 34
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            dh23b
RULETYPE        ANSWER
CONCLUSION      double howe2 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
             IF span | is greater than | 29
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 35
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            dh23c
RULETYPE        ANSWER
CONCLUSION      double howe2 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
             IF span | is greater than | 42
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than or equal to | 50
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
```

```
RULE           dh23d
RULETYPE       ANSWER
CONCLUSION     double howe2 | recommended
ANSWER         A DOUBLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than | 42
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 50
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           dh13c
RULETYPE       ANSWER
CONCLUSION     double howe1 | recommended
ANSWER         A DOUBLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than or equal to | 40
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than | 44
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           dh13d
RULETYPE       ANSWER
CONCLUSION     double howe1 | recommended
ANSWER         A DOUBLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than | 40
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than | 44
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE            dh13b
RULETYPE        ANSWER
CONCLUSION      double howe1 ¦ recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
            IF  span ¦ is greater than ¦ 27
PRB IF CON      100
PRB IFN CON     0
           AND  span ¦ is less than or equal to ¦ 32
PRB IF CON      100
PRB IFN CON     0
           AND  bottom chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
           AND  top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            dh13a
RULETYPE        ANSWER
CONCLUSION      double howe1 ¦ recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
            IF  span ¦ is greater than or equal to ¦ 27
PRB IF CON      100
PRB IFN CON     0
           AND  span ¦ is less than ¦ 32
PRB IF CON      100
PRB IFN CON     0
           AND  bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
           AND  top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            b33a
RULETYPE        ANSWER
CONCLUSION      belgian3 ¦ recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
            IF  span ¦ is greater than or equal to ¦ 30
PRB IF CON      100
PRB IFN CON     0
           AND  span ¦ is less than or equal to ¦ 35
PRB IF CON      100
PRB IFN CON     0
           AND  bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
           AND  top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
```

```
RULE            b33c
RULETYPE        ANSWER
CONCLUSION      belgian3 | recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
             IF span | is greater than or equal to | 44
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 53
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0


RULE            b33d
RULETYPE        ANSWER
CONCLUSION      belgian3 | recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
             IF span | is greater than or equal to | 44
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than or equal to | 53
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0


RULE            b33b
RULETYPE        ANSWER
CONCLUSION      belgian3 | recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
             IF span | is greater than or equal to | 30
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 36
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
```

```
RULE           h33b
RULETYPE       ANSWER
CONCLUSION     howe3 | recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than or equal to | 17
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 29
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           h33a
RULETYPE       ANSWER
CONCLUSION     howe3 | recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than or equal to | 17
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 29
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           h33c
RULETYPE       ANSWER
CONCLUSION     howe3 | recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than or equal to | 25
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 43
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE            h33d
RULETYPE        ANSWER
CONCLUSION      howe3 | recommended
ANSWER          A SINGLE HOWE truss is recommended.
PRB NO EVD      100
             IF span | is greater than or equal to | 25
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 44
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
```

```
RULE            dh33d
RULETYPE        ANSWER
CONCLUSION      double howe3 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
             IF span | is greater than or equal to | 44
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 53
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
```

```
RULE            dh33b
RULETYPE        ANSWER
CONCLUSION      double howe3 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
             IF span | is greater than | 29
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than | 36
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
```

```
RULE           dh33a
RULETYPE       ANSWER
CONCLUSION     double howe3 ! recommended
ANSWER         A DOUBLE HOWE truss is recommended.
PRB NO EVD     100
            IF span ! is greater than ! 29
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than or equal to ! 35
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0


RULE           dh33c
RULETYPE       ANSWER
CONCLUSION     double howe3 ! recommended
ANSWER         A DOUBLE HOWE truss is recommended.
PRB NO EVD     100
            IF span ! is greater than ! 43
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than ! 53
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0


RULE           w43d
RULETYPE       ANSWER
CONCLUSION     fink4 ! recommended
ANSWER         A FINK truss is recommended.
PRB NO EVD     100
            IF span ! is greater than ! 26
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than or equal to ! 46
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           w43a
RULETYPE       ANSWER
CONCLUSION     fink4 ! recommended
ANSWER         A FINK truss is recommended.
PRB NO EVD     100
            IF span ! is greater than or equal to ! 18
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than or equal to ! 31
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0


RULE           w43b
RULETYPE       ANSWER
CONCLUSION     fink4 ! recommended
ANSWER         A FINK truss is recommended.
PRB NO EVD     100
            IF span ! is greater than or equal to ! 18
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than or equal to ! 31
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0


RULE           w43c
RULETYPE       ANSWER
CONCLUSION     fink4 ! recommended
ANSWER         A FINK truss is recommended.
PRB NO EVD     100
            IF span ! is greater than ! 26
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than ! 46
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE            m43a
RULETYPE        ANSWER
CONCLUSION      mod queenpost4 | recommended
ANSWER          A MODIFIED QUEENPOST truss is recommende
                d.
PRB NO EVD      100
             IF span | is greater than | 27
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than or equal to | 38
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            m43d
RULETYPE        ANSWER
CONCLUSION      mod queenpost4 | recommended
ANSWER          A MODIFIED QUEENPOST truss is recommende
                d.
PRB NO EVD      100
             IF span | is less than or equal to | 56
PRB IF CON      100
PRB IFN CON     0
            AND span | is greater than | 40
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0


RULE            m43b
RULETYPE        ANSWER
CONCLUSION      mod queenpost4 | recommended
ANSWER          A MODIFIED QUEENPOST truss is recommende
                d.
PRB NO EVD      100
             IF span | is greater than | 27
PRB IF CON      100
PRB IFN CON     0
            AND span | is less than or equal to | 38
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
```

```
RULE            m43c
RULETYPE        ANSWER
CONCLUSION      mod queenpost4 | recommended
ANSWER          A MODIFIED QUEENPOST truss is recommende
                d.
PRB NO EVD      100
            IF  span | is less than or equal to | 56
PRB IF CON      100
PRB IFN CON     0
           AND  span | is greater than | 40
PRB IF CON      100
PRB IFN CON     0
           AND  bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
           AND  top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0


RULE            dh43b
RULETYPE        ANSWER
CONCLUSION      double howe4 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
            IF  span | is greater than | 31
PRB IF CON      100
PRB IFN CON     0
           AND  span | is less than | 38
PRB IF CON      100
PRB IFN CON     0
           AND  bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
           AND  top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            dh43a
RULETYPE        ANSWER
CONCLUSION      double howe4 | recommended
ANSWER          A DOUBLE HOWE truss is recommended.
PRB NO EVD      100
            IF  span | is greater than | 31
PRB IF CON      100
PRB IFN CON     0
           AND  span | is less than | 38
PRB IF CON      100
PRB IFN CON     0
           AND  bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
           AND  top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
```

```
RULE          dh43c
RULETYPE      ANSWER
CONCLUSION    double howe4 ¦ recommended
ANSWER        A DOUBLE HOWE truss is recommended.
PRB NO EVD    100
           IF span ¦ is greater than or equal to ¦ 46
PRB IF CON    100
PRB IFN CON   0
          AND span ¦ is less than ¦ 56
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0


RULE          dh43d
RULETYPE      ANSWER
CONCLUSION    double howe4 ¦ recommended
ANSWER        A DOUBLE HOWE truss is recommended.
PRB NO EVD    100
           IF span ¦ is greater than or equal to ¦ 46
PRB IF CON    100
PRB IFN CON   0
          AND span ¦ is less than or equal to ¦ 56
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0


RULE          d23a
RULETYPE      ANSWER
CONCLUSION    kingpost w diag2 ¦ recommended
ANSWER        A KINGPOST WITH DIAGONALS truss is recom
              mended.
PRB NO EVD    100
           IF span ¦ is greater than or equal to ¦ 17
PRB IF CON    100
PRB IFN CON   0
          AND span ¦ is less than or equal to ¦ 24
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
```

```
RULE           d23b
RULETYPE       ANSWER
CONCLUSION     kingpost w diag2 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than or equal to | 17
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 24
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           d23c
RULETYPE       ANSWER
CONCLUSION     kingpost w diag2 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than | 24
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 33
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           d23d
RULETYPE       ANSWER
CONCLUSION     kingpost w diag2 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than | 24
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 33
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           k23aa
RULETYPE       ANSWER
CONCLUSION     kingpost2 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 17
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k23ba
RULETYPE       ANSWER
CONCLUSION     kingpost2 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 17
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k23ca
RULETYPE       ANSWER
CONCLUSION     kingpost2 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 24
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k23da
RULETYPE       ANSWER
CONCLUSION     kingpost2 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 24
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE          k23ab
RULETYPE      ANSWER
CONCLUSION    kingpost2b ¦ recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
           IF span ¦ is less than ¦ 17
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0


RULE          k23bb
RULETYPE      ANSWER
CONCLUSION    kingpost2b ¦ recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
           IF span ¦ is less than ¦ 17
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0


RULE          k23cb
RULETYPE      ANSWER
CONCLUSION    kingpost2b ¦ recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
           IF span ¦ is less than or equal to ¦ 24
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0


RULE          k23db
RULETYPE      ANSWER
CONCLUSION    kingpost2b ¦ recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
           IF span ¦ is less than or equal to ¦ 24
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
```

```
RULE            w13a
RULETYPE        ANSWER
CONCLUSION      fink1 ¦ recommended
ANSWER          A FINK truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than or equal to ¦ 16
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than or equal to ¦ 27
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            w13c
RULETYPE        ANSWER
CONCLUSION      fink1 ¦ recommended
ANSWER          A FINK truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than or equal to ¦ 23
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than ¦ 38
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0


RULE            w13d
RULETYPE        ANSWER
CONCLUSION      fink1 ¦ recommended
ANSWER          A FINK truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than or equal to ¦ 23
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than ¦ 38
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
```

```
RULE           w13b
RULETYPE       ANSWER
CONCLUSION     fink1 ! recommended
ANSWER         A FINK truss is recommended.
PRB NO EVD     100
           IF  span ! is greater than or equal to ! 16
PRB IF CON     100
PRB IFN CON    0
          AND  span ! is less than or equal to ! 27
PRB IF CON     100
PRB IFN CON    0
          AND  bottom chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
          AND  top chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0


RULE           b13c
RULETYPE       ANSWER
CONCLUSION     belgian1 ! recommended
ANSWER         A BELGIAN truss is recommended.
PRB NO EVD     100
           IF  span ! is greater than or equal to ! 38
PRB IF CON     100
PRB IFN CON    0
          AND  span ! is less than or equal to ! 42
PRB IF CON     100
PRB IFN CON    0
          AND  bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
          AND  top chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0


RULE           b13d
RULETYPE       ANSWER
CONCLUSION     belgian1 ! recommended
ANSWER         A BELGIAN truss is recommended.
PRB NO EVD     100
           IF  span ! is greater than or equal to ! 38
PRB IF CON     100
PRB IFN CON    0
          AND  span ! is less than or equal to ! 42
PRB IF CON     100
PRB IFN CON    0
          AND  bottom chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
          AND  top chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE            b13a
RULETYPE        ANSWER
CONCLUSION      belgian1 ¦ recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than ¦ 27
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than ¦ 32
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            b13b
RULETYPE        ANSWER
CONCLUSION      belgian1 ¦ recommended
ANSWER          A BELGIAN truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than ¦ 27
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than or equal to ¦ 32
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            d13a
RULETYPE        ANSWER
CONCLUSION      kingpost w diag1 ¦ recommended
ANSWER          A KINGPOST WITH DIAGONALS truss is recom
                mended.
PRB NO EVD      100
             IF span ¦ is greater than or equal to ¦ 16
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than or equal to ¦ 22
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
```

```
RULE           d13b
RULETYPE       ANSWER
CONCLUSION     kingpost w diag1 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than or equal to | 16
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 22
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           d13c
RULETYPE       ANSWER
CONCLUSION     kingpost w diag1 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than or equal to | 23
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 30
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           d13d
RULETYPE       ANSWER
CONCLUSION     kingpost w diag1 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than or equal to | 23
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 30
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           h13a
RULETYPE       ANSWER
CONCLUSION     howe1 ! recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span ! is greater than or equal to ! 16
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than ! 27
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0


RULE           h13b
RULETYPE       ANSWER
CONCLUSION     howe1 ! recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span ! is greater than or equal to ! 16
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than or equal to ! 27
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0


RULE           h13c
RULETYPE       ANSWER
CONCLUSION     howe1 ! recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span ! is greater than or equal to ! 23
PRB IF CON     100
PRB IFN CON    0
           AND span ! is less than ! 40
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ! is equal to ! 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ! is equal to ! 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           h13d
RULETYPE       ANSWER
CONCLUSION     howe1 ¦ recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span ¦ is greater than or equal to ¦ 23
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than or equal to ¦ 40
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0


RULE           k33a
RULETYPE       ANSWER
CONCLUSION     kingpost3a ¦ recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span ¦ is less than ¦ 17
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0


RULE           k33b
RULETYPE       ANSWER
CONCLUSION     kingpost3a ¦ recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span ¦ is less than ¦ 17
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0


RULE           k33c
RULETYPE       ANSWER
CONCLUSION     kingpost3a ¦ recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span ¦ is less than ¦ 25
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE          k33d
RULETYPE      ANSWER
CONCLUSION    kingpost3a ! recommended
ANSWER        A KINGPOST truss is recommended
PRB NO EVD    100
           IF span ! is less than ! 25
PRB IF CON    100
PRB IFN CON 0
          AND bottom chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON 0
          AND top chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON 0


RULE          w33a
RULETYPE      ANSWER
CONCLUSION    fink3 ! recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
           IF span ! is greater than or equal to ! 17
PRB IF CON    100
PRB IFN CON 0
          AND span ! is less than ! 30
PRB IF CON    100
PRB IFN CON 0
          AND bottom chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON 0
          AND top chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON 0


RULE          w33b
RULETYPE      ANSWER
CONCLUSION    fink3 ! recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
           IF span ! is greater than or equal to ! 17
PRB IF CON    100
PRB IFN CON 0
          AND span ! is less than ! 30
PRB IF CON    100
PRB IFN CON 0
          AND bottom chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON 0
          AND top chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON 0
```

```
RULE          w33c
RULETYPE      ANSWER
CONCLUSION    fink3 ! recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
          IF  span ! is greater than or equal to ! 25
PRB IF CON    100
PRB IFN CON   0
         AND  span ! is less than ! 44
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON   0


RULE          w33d
RULETYPE      ANSWER
CONCLUSION    fink3 ! recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
          IF  span ! is greater than or equal to ! 25
PRB IF CON    100
PRB IFN CON   0
         AND  span ! is less than ! 44
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON   0


RULE          k33aa
RULETYPE      ANSWER
CONCLUSION    kingpost3 ! recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
          IF  span ! is less than ! 17
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON   0


RULE          k33ba
RULETYPE      ANSWER
CONCLUSION    kingpost3 ! recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
          IF  span ! is less than ! 17
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ! is equal to ! 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ! is equal to ! 4
PRB IF CON    100
PRB IFN CON   0
```

```
RULE           k33ca
RULETYPE       ANSWER
CONCLUSION     kingpost3 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 25
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k33da
RULETYPE       ANSWER
CONCLUSION     kingpost3 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 25
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           d33a
RULETYPE       ANSWER
CONCLUSION     kingpost w diag3 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than or equal to | 17
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than | 25
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           d33b
RULETYPE       ANSWER
CONCLUSION     kingpost w diag3 ¦ recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span ¦ is greater than or equal to ¦ 17
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than ¦ 25
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0


RULE           d33c
RULETYPE       ANSWER
CONCLUSION     kingpost w diag3 ¦ recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span ¦ is greater than or equal to ¦ 25
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than ¦ 37
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0


RULE           d33d
RULETYPE       ANSWER
CONCLUSION     kingpost w diag3 ¦ recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span ¦ is greater than or equal to ¦ 25
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than ¦ 37
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           m33a
RULETYPE       ANSWER
CONCLUSION     mod queenpost3 | recommended
ANSWER         A MODIFIED QUEENPOST truss is recommende
               d.
PRB NO EVD     100
            IF span | is greater than or equal to | 25
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 35
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           m33b
RULETYPE       ANSWER
CONCLUSION     mod queenpost3 | recommended
ANSWER         A MODIFIED QUEENPOST truss is recommende
               d.
PRB NO EVD     100
            IF span | is greater than or equal to | 25
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 35
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           m33c
RULETYPE       ANSWER
CONCLUSION     mod queenpost3 | recommended
ANSWER         A MODIFIED QUEENPOST truss is recommende
               d.
PRB NO EVD     100
            IF span | is less than or equal to | 53
PRB IF CON     100
PRB IFN CON    0
           AND span | is greater than or equal to | 37
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           m33d
RULETYPE       ANSWER
CONCLUSION     mod queenpost3 | recommended
ANSWER         A MODIFIED QUEENPOST truss is recommende
               d.
PRB NO EVD     100
            IF span | is less than or equal to | 53
PRB IF CON     100
PRB IFN CON    0
           AND span | is greater than or equal to | 37
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k43a
RULETYPE       ANSWER
CONCLUSION     kingpost4a | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 18
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k43b
RULETYPE       ANSWER
CONCLUSION     kingpost4a | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 18
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k43c
RULETYPE       ANSWER
CONCLUSION     kingpost4a | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 26
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

```
RULE          k43d
RULETYPE      ANSWER
CONCLUSION    kingpost4a | recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
          IF  span | is less than or equal to | 26
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          b43a
RULETYPE      ANSWER
CONCLUSION    belgian4 | recommended
ANSWER        A BELGIAN truss is recommended.
PRB NO EVD    100
          IF  span | is greater than | 31
PRB IF CON    100
PRB IFN CON   0
         AND  span | is less than | 38
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0


RULE          b43b
RULETYPE      ANSWER
CONCLUSION    belgian4 | recommended
ANSWER        A BELGIAN truss is recommended.
PRB NO EVD    100
          IF  span | is greater than | 31
PRB IF CON    100
PRB IFN CON   0
         AND  span | is less than or equal to | 38
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
```

```
RULE          b43c
RULETYPE      ANSWER
CONCLUSION    belgian4 | recommended
ANSWER        A BELGIAN truss is recommended.
PRB NO EVD    100
           IF span | is greater than or equal to | 46
PRB IF CON    100
PRB IFN CON   0
          AND span | is less than or equal to | 56
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          b43d
RULETYPE      ANSWER
CONCLUSION    belgian4 | recommended
ANSWER        A BELGIAN truss is recommended.
PRB NO EVD    100
           IF span | is greater than | 46
PRB IF CON    100
PRB IFN CON   0
          AND span | is less than or equal to | 56
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          k43aa
RULETYPE      ANSWER
CONCLUSION    kingpost4 | recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
           IF span | is less than | 18
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0


RULE          k43ba
RULETYPE      ANSWER
CONCLUSION    kingpost4 | recommended
ANSWER        A KINGPOST truss is recommended.
PRB NO EVD    100
           IF span | is less than | 18
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
```

```
RULE           k43ca
RULETYPE       ANSWER
CONCLUSION     kingpost4 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 26
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k43da
RULETYPE       ANSWER
CONCLUSION     kingpost4 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 26
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           d43a
RULETYPE       ANSWER
CONCLUSION     kingpost w diag4 | recommended
ANSWER         A KINGPOST WITH DIAGONALS truss is recom
               mended.
PRB NO EVD     100
            IF span | is greater than or equal to | 18
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than or equal to | 27
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
```

```
RULE          d43b
RULETYPE      ANSWER
CONCLUSION    kingpost w diag4 ¦ recommended
ANSWER        A KINGPOST WITH DIAGONALS truss is recom
              mended.
PRB NO EVD    100
          IF  span ¦ is greater than or equal to ¦ 18
PRB IF CON    100
PRB IFN CON   0
         AND  span ¦ is less than or equal to ¦ 27
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0


RULE          d43c
RULETYPE      ANSWER
CONCLUSION    kingpost w diag4 ¦ recommended
ANSWER        A KINGPOST WITH DIAGONALS truss is recom
              mended.
PRB NO EVD    100
          IF  span ¦ is greater than ¦ 26
PRB IF CON    100
PRB IFN CON   0
         AND  span ¦ is less than or equal to ¦ 40
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ¦ is equal to ¦ 4
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0


RULE          d43d
RULETYPE      ANSWER
CONCLUSION    kingpost w diag4 ¦ recommended
ANSWER        A KINGPOST WITH DIAGONALS truss is recom
              mended.
PRB NO EVD    100
          IF  span ¦ is greater than ¦ 26
PRB IF CON    100
PRB IFN CON   0
         AND  span ¦ is less than or equal to ¦ 40
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size ¦ is equal to ¦ 6
PRB IF CON    100
PRB IFN CON   0
```

```
RULE            h43a
RULETYPE        ANSWER
CONCLUSION      howe4 ¦ recommended
ANSWER          A SINGLE HOWE truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than or equal to ¦ 18
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than or equal to ¦ 31
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            h43b
RULETYPE        ANSWER
CONCLUSION      howe4 ¦ recommended
ANSWER          A SINGLE HOWE truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than or equal to ¦ 18
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than or equal to ¦ 31
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0


RULE            h43c
RULETYPE        ANSWER
CONCLUSION      howe4 ¦ recommended
ANSWER          A SINGLE HOWE truss is recommended.
PRB NO EVD      100
             IF span ¦ is greater than ¦ 26
PRB IF CON      100
PRB IFN CON     0
            AND span ¦ is less than ¦ 46
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
```

```
RULE           h43d
RULETYPE       ANSWER
CONCLUSION     howe4 | recommended
ANSWER         A SINGLE HOWE truss is recommended.
PRB NO EVD     100
            IF span | is greater than | 26
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than | 46
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           b23a
RULETYPE       ANSWER
CONCLUSION     belgian2 | recommended
ANSWER         A BELGIAN truss is recommended.
PRB NO EVD     100
            IF span | is greater than | 29
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than | 35
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           b23b
RULETYPE       ANSWER
CONCLUSION     belgian2 | recommended
ANSWER         A BELGIAN truss is recommended.
PRB NO EVD     100
            IF span | is greater than | 29
PRB IF CON     100
PRB IFN CON    0
           AND span | is less than | 35
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
```

```
RULE           b23c
RULETYPE       ANSWER
CONCLUSION     belgian2 ¦ recommended
ANSWER         A BELGIAN truss is recommended.
PRB NO EVD     100
            IF span ¦ is greater than ¦ 42
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than or equal to ¦ 48
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0


RULE           b23d
RULETYPE       ANSWER
CONCLUSION     belgian2 ¦ recommended
ANSWER         A BELGIAN truss is recommended.
PRB NO EVD     100
            IF span ¦ is greater than ¦ 42
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than or equal to ¦ 48
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0


RULE           w23a
RULETYPE       ANSWER
CONCLUSION     fink2 ¦ recommended
ANSWER         A FINK truss is recommended.
PRB NO EVD     100
            IF span ¦ is greater than or equal to ¦ 17
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than or equal to ¦ 29
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
```

```
RULE          w23b
RULETYPE      ANSWER
CONCLUSION    fink2 | recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
          IF  span | is greater than or equal to | 17
PRB IF CON    100
PRB IFN CON   0
         AND  span | is less than or equal to | 29
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0


RULE          w23c
RULETYPE      ANSWER
CONCLUSION    fink2 | recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
          IF  span | is greater than | 24
PRB IF CON    100
PRB IFN CON   0
         AND  span | is less than or equal to | 42
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          w23d
RULETYPE      ANSWER
CONCLUSION    fink2 | recommended
ANSWER        A FINK truss is recommended.
PRB NO EVD    100
          IF  span | is greater than | 24
PRB IF CON    100
PRB IFN CON   0
         AND  span | is less than or equal to | 42
PRB IF CON    100
PRB IFN CON   0
         AND  bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
         AND  top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
```

```
RULE            k23a
RULETYPE        ANSWER
CONCLUSION      kingpost2a | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than | 17
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            k23b
RULETYPE        ANSWER
CONCLUSION      kingpost2a | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than | 17
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            k23c
RULETYPE        ANSWER
CONCLUSION      kingpost2a | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than or equal to | 24
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0


RULE            k23d
RULETYPE        ANSWER
CONCLUSION      kingpost2a | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than or equal to | 24
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
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```
RULE           k13a
RULETYPE       ANSWER
CONCLUSION     kingpost1a | recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span | is less than | 16
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k13b
RULETYPE       ANSWER
CONCLUSION     kingpost1a | recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span | is less than | 16
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k13c
RULETYPE       ANSWER
CONCLUSION     kingpost1a | recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span | is less than | 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k13d
RULETYPE       ANSWER
CONCLUSION     kingpost1a | recommended
ANSWER         A KINGPOST truss is recommended
PRB NO EVD     100
            IF span | is less than | 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
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RULE          m13c
RULETYPE      ANSWER
CONCLUSION    mod queenpost1 | recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span | is less than | 40
PRB IF CON    100
PRB IFN CON   0
          AND span | is greater than | 30
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          m13d
RULETYPE      ANSWER
CONCLUSION    mod queenpost1 | recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span | is less than | 40
PRB IF CON    100
PRB IFN CON   0
          AND span | is greater than | 30
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 6
PRB IF CON    100
PRB IFN CON   0


RULE          m13a
RULETYPE      ANSWER
CONCLUSION    mod queenpost1 | recommended
ANSWER        A MODIFIED QUEENPOST truss is recommende
              d.
PRB NO EVD    100
           IF span | is greater than | 22
PRB IF CON    100
PRB IFN CON   0
          AND span | is less than or equal to | 31
PRB IF CON    100
PRB IFN CON   0
          AND bottom chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
          AND top chord size | is equal to | 4
PRB IF CON    100
PRB IFN CON   0
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RULE           m13b
RULETYPE       ANSWER
CONCLUSION     mod queenpost1 ¦ recommended
ANSWER         A MODIFIED QUEENPOST truss is recommende
               d.
PRB NO EVD     100
            IF span ¦ is greater than ¦ 22
PRB IF CON     100
PRB IFN CON    0
           AND span ¦ is less than or equal to ¦ 31
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0


RULE           k13aa
RULETYPE       ANSWER
CONCLUSION     kingpost1 ¦ recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span ¦ is less than ¦ 16
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0


RULE           k13ba
RULETYPE       ANSWER
CONCLUSION     kingpost1 ¦ recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span ¦ is less than ¦ 16
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0


RULE           k13ca
RULETYPE       ANSWER
CONCLUSION     kingpost1 ¦ recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span ¦ is less than ¦ 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size ¦ is equal to ¦ 6
PRB IF CON     100
PRB IFN CON    0
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RULE           k13da
RULETYPE       ANSWER
CONCLUSION     kingpost1 | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k43ab
RULETYPE       ANSWER
CONCLUSION     kingpost4b | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 18
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k43bb
RULETYPE       ANSWER
CONCLUSION     kingpost4b | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 18
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k43cb
RULETYPE       ANSWER
CONCLUSION     kingpost4b | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 26
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0

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RULE            k43db
RULETYPE        ANSWER
CONCLUSION      kingpost4b | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than or equal to | 26
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0


RULE            k33ab
RULETYPE        ANSWER
CONCLUSION      kingpost3b | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than | 17
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            k33bb
RULETYPE        ANSWER
CONCLUSION      kingpost3b | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than | 17
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0


RULE            k33cb
RULETYPE        ANSWER
CONCLUSION      kingpost3b | recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span | is less than | 25
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size | is equal to | 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size | is equal to | 6
PRB IF CON      100
PRB IFN CON     0
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RULE            k33db
RULETYPE        ANSWER
CONCLUSION      kingpost3b ¦ recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span ¦ is less than ¦ 25
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
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RULE            k13ab
RULETYPE        ANSWER
CONCLUSION      kingpost1b ¦ recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span ¦ is less than ¦ 16
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
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RULE            k13bb
RULETYPE        ANSWER
CONCLUSION      kingpost1b ¦ recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span ¦ is less than ¦ 16
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
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RULE            k13cb
RULETYPE        ANSWER
CONCLUSION      kingpost1b ¦ recommended
ANSWER          A KINGPOST truss is recommended.
PRB NO EVD      100
             IF span ¦ is less than ¦ 23
PRB IF CON      100
PRB IFN CON     0
            AND bottom chord size ¦ is equal to ¦ 4
PRB IF CON      100
PRB IFN CON     0
            AND top chord size ¦ is equal to ¦ 6
PRB IF CON      100
PRB IFN CON     0
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RULE           k13db
RULETYPE       ANSWER
CONCLUSION     kingpost1b | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than | 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k14b
RULETYPE       ANSWER
CONCLUSION     kingpost14a | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 16
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0


RULE           k14c
RULETYPE       ANSWER
CONCLUSION     kingpost14a | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 4
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0


RULE           k14d
RULETYPE       ANSWER
CONCLUSION     kingpost14a | recommended
ANSWER         A KINGPOST truss is recommended.
PRB NO EVD     100
            IF span | is less than or equal to | 23
PRB IF CON     100
PRB IFN CON    0
           AND bottom chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
           AND top chord size | is equal to | 6
PRB IF CON     100
PRB IFN CON    0
```

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