Proceedings of Narotama International Conference on Civil Engineering 2015
ISBN : 978-602-72437-2-9

Expert System for Structural Analysis and Design of Communication Tower

Tony Hartono Bagio[a*], Riyanarto Sarno[b]

[a]*Senior Lecturer, Narotama University of Surabaya, Indonesia*
[b]*Professor, Computer Science Institute Technology of Surabaya, Indonesia*

Abstract

Expert system for structural analysis and design of communication towers. The three inputs given to a tower designer are the tower height (Ht in meters) , wind velocity (V in m/second) and weight of antennae (P in kgs). Based on these inputs, the overall configuration of the tower has to fixed by the users, number of panel on the top of tower, height of top's panel, type of bracing. Parameters such as the base width, the top width, spacing of the panels, will be given on to the consultation. The IF-THEN format of the knowledge representations used to make the system "learn" the rule as it solves more problems. The obtained final results are dimensions of optimum equal angles.

Peer-review under responsibility of organizing committee of The Narotama International Conference on Civil Engineering 2015 (NICCE-2015).

Keywords: expert system; structural analysis ; design ; tower; three inputs, consultation; learn, optimun

1. Background

Tower construction process needs some activities such as planning, analyzing, designing, and constructing needing the computer analysis to be finished. This expected analysis refers to the structural analysis program using matrix method [Przemieniecki, J.S., 1968]. Beside the technical problem, the economic aspect study must be conducted such as construction budget calculation. In addition, the most important step on tower construction is decision making.

The conventional programming method is still be used on making the software for all activities. In this programming method, the sequence of program operation is pre-determined and all the detailed information is decoded. In the steel engineering construction, heuristic method is involved and it is as the training for the expert. It is still difficult to make software imitating the skill of the expert on engineering aspect. The development of Artificial Intelligence on this late decade is the part of Knowledge-based Expert System (KBES). It is has the possibility to software improvement which is related to the brain work of the expert on the designing process.

1.1 Problem

Tower, especial communication tower, has some advantages such as for AM (Modulation Amplitude) Radio Tower, FM *(Modulation Frequency) Radio Tower, and Base Transmitter Satellite (BTS). The location of tower can significantly* effect on the structure of the tower. The height of the tower is the main important data since it is the determined its function. In addition, the load from antennae is also another main parameter used to analyze the tower designing. Additionally, the complex geometry data is needed to analyze certain frame structure such as coordinate input, boundary condition, number of elements, element connectivity, and load. After the stress is found, the designing of each bar is needed to be finished.

* Corresponding author. Tel.: +62-816514425
E-mail address: tony@narotama.ac.id

1.2 Problem Boundary

Ruled-Based Expert System designed to produce the optimum steel construction profile of tower. The soil condition is assumed to be ideal and steel structure is used in this analysis. The linear elastic is the material boundary for frame structure and dominant horizontal load is wind load.

2. Design and Implementation

2.1 Structural Analysis

Coding of a frame element [Bagio, Bowles]. The horizontal load in each node of the frame can be calculated using the following equation [ANSI,1971], Steel structure design by axial load, column equations is derived by Leonhard Euler in 1759 [Salmon,1980]. The design of Tower concentrated with angel shapes is used (square profile cross section) as the main structure of the load. This can be used either as the vertical Vertical, Horizontal or Diagonal load [ASCE,1991]. Parameters for design of Structure Tower [Murdilaran (1), Murdilaran (2)] are:

- Ratio between Top width and height of Tower = 0.02 – 0.05
- Ratio between Base width and height of Tower = 0.14 – 0.20
- Ratio Diagonal members and Horizontal members = 30^o – 60^o
- Height of Panel = 4 m – 7 m

2.2 System Form

Expert System is able to classify and solve the problem. It also can form a task such as diagnosing, selecting the category, and problem solving classification. Each problem solving in different user results in the goal determination with chaining forward. In the process of activity, classification and synthesis, the problems can be found.

2.3 Knowledge Based System Development

After all of the needs is analyzed, problem solving is determined, and the extent of the problem is decided (such as the width, height minimum and maximum of tower), for further development of knowledge-based systems is done using several steps.

2.4 Block Diagram of Domain Expert Decision Tree

The conversion process of decision tree into IF-THEN rules is as follows:

a) Select one of the boxes from the lower end of the decision tree

b) Connect the upper node of the boxes

c) Continue until no more nodes are connected, or until another box selected

d) Repeat steps a), by selecting another box that has not been selected

e) Each node in the circle related to the premise variable IF, is all linked with AND logic

f) The knot is the premise of THEN box. Node is still connected to the box on the next lower node and is tentative conclusions. It is still the part of the IF premise together with the node that was next to it.

ISBN : 978-602-72437-2-9

Rule 10
IF LOKASI = Kota
AND LAHAN = Luas
THEN LETAK = Tanah
Rule 20
IF LOKASI = Kota
AND LAHAN = Sempit
THEN LETAK = Gedung

PROSES EXPERT SYSTEM is shown in Fig. 1. It is described the relationship of each main element.

2.5 Expert System :

User Interface : Enter the Input data consists of a High Tower , Wind Speed , Load Antenna and consultation process
Rule Base : Is a set of rules that have been stored in a rules file
Data base : Dimensional structure of the data stores, based on the data that has been entered by the user before (when there are no empty data) .
Inference Engine : Forward Chaining process required here in order to search the solution based on consultation and goal ruled base in working memory .
Output : The final results expected from the inference is a code construction where construction will be analyzed at the stage of structure analysis

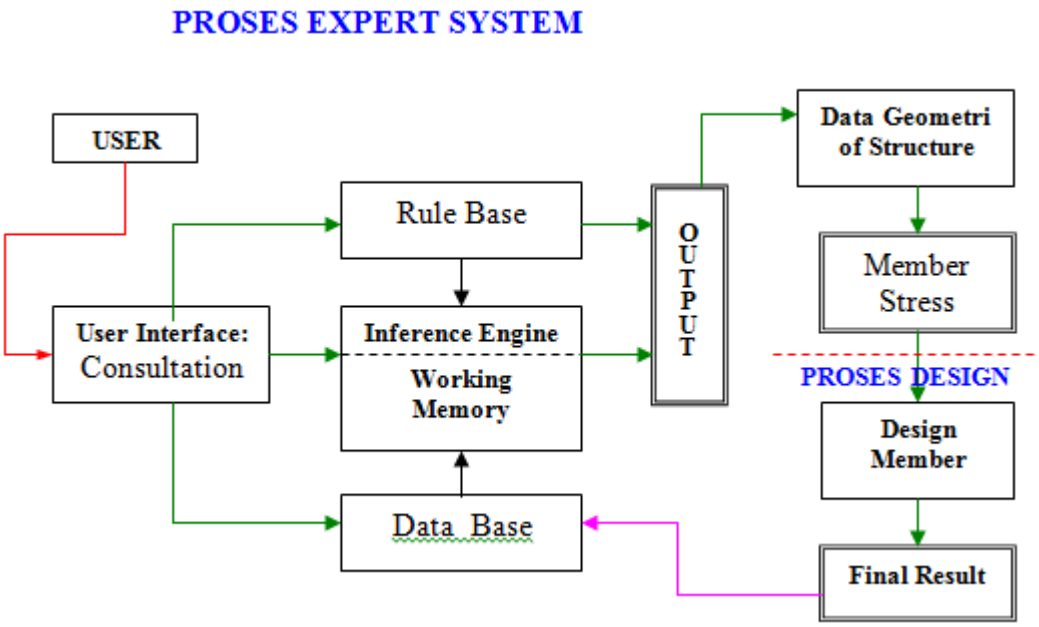

Fig. 1. Proses Expert System

2.6 Structural Analysis :

Data Geometry of Structures : Results of output will be converted to the data geometry. It is as the input from Structural Analysis
Member Stress : The process of analyzing the structure using the matrix analysis method for truss field will result in the styles for the entire trunk

2.7 Design

Design Member : Inside load for each bar is designed using the rod hit by the axial load. As preliminary design, it uses elbows profile ∟ 100 × 100 × 10 , when the results of the voltage profile of far below the voltage limit, the profile is replaced with more smaller profile, in the

other hand, if the voltage exceeds the limitation, use more larger profile than the original profile .

Final Result : The end result of the whole process, where the optimum dimension of profiles generated in addition to the data is inserted into the Data Base, in order to be recorded as additional data . So if there is an input of the same type, we do not need to make the process of Structural Analysis and Design Members (in the process of Design)

2.8 Ruled Based

Base rules are stored in a file in the form of lists, namely knowledge-based structure. In the study of knowledge and inference processes that have been represented in the form of decision tree, it is implemented in the form of rule base.

Elections to the rule base knowledge were later based on the following reasons:

a) Development of an expert system using a rule based

b) Availability of the expert system based on widely rule based. Allowing the engineer knowledge to emphasize the critical phase in the development of expert systems is the acquisition of knowledge

c) Rule represents the knowledge based in the form of a relatively which is more naturally, so the time spent is relatively fast .

d) Rule based is relatively easy to be modified , such as the addition , deletion or modification of the rule based.

e) Validating the contents of the rule base system is relatively easier (completeness and consistency) .

Representation of rule based utilization is implemented in the form of clauses which are divided into: Question Clause and Clause Rule.

2.9 Question Clause

Question clause is used to identify the obtained facts by asking the user directly on value facts. This fact is a basic fact.

Question Clause Structure:

EXAMPLE:

```
ASK     LOKASI  : Where is the location of the tower?
CHOICE  LOKASI  : City, Village
ASK     LAHAN   : Wide area of building tower location ?
CHOICE  LAHAN   : larger, smaller
ASK     LETAK   : Where is the tower existed?
CHOICE  LETAK   : Building, field
ASK     TANAH   : The soil used in the area of tower building?
CHOICE  TANAH   : hard, soft
```

2.10 Rule Clause

Rule clause is used to represent knowledge based on the chosen method. This clause is used to derive the necessary facts which are broadly described as follows:

The following example is the structure of the knowledge based that has previously been designed using a decision tree and decision table.

```
Rule  10
IF  LOKASI    =     City
AND  LAHAN    =     Wide area
```

ISBN : 978-602-72437-2-9

THEN LETAK = In fields
Rule 20
IF LOKASI = City
AND LAHAN = Smaller area
THEN LETAK = Building

3. Forward Algorithm Chaining

a) Define variables with initial conditions = ruledbf by going to top, all status = N (. F. = false), let the stackdbf be empty
b) Check on stackdbf, it is present or absent,
c) Check at stackdbf. When there are no question arises of vardbf [based on VARIF value from step a)], then go to step e).
d) If there is a question(s) at then go to step f).
e) Push into stackdbf
f) Skip the Ruledbf for the next record
g) Check KODEIF (ruledbf)
h) When KODEIF = T (= THEN) do step e).
i) When KODEIF = I (= IF) or A (= AND), then do step f). and so forth until EOF (End Of File =) is found
j) When EOF () =. T. process is complete

4. Program Operation

Fig 2. Describes an implementation of the using program. The image of "button" (on the bottom row has four choices Button, namely: Begin, Rule, Change and Analysis.

Begin : Initiating the program on the preliminary conditions, especially for the file of stack.dbf. The previous data which is in stack.dbf will completely zap . (Removed all) then stack.dbf will be empty.

Rule : It will be shown some rules that exist in the database, from the smallest number rule (number 10) , up to the maximum number .

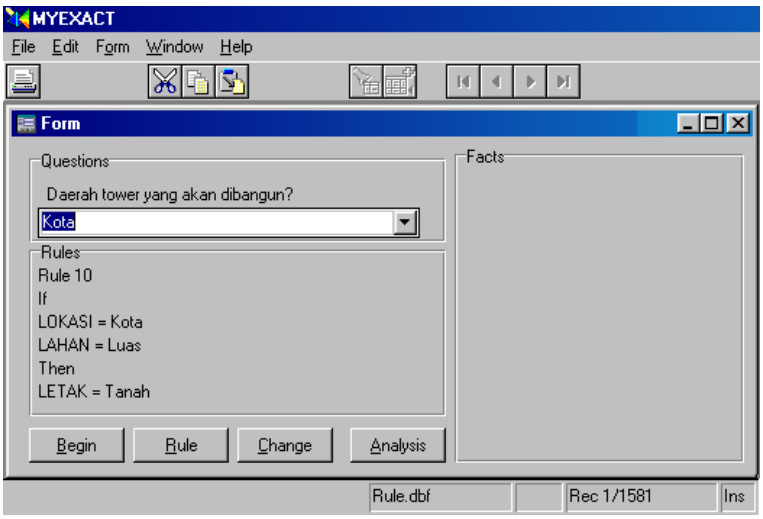

Fig. 2. Operating Program

Change: when clicking this button, then the inference process will be processing. It will happen with the condition that begins with rule number 10. Any questions can be directly selected the

answer, by clicking directly vertical - bar which is right under the question in the form of Data Combo. The changes will appear on the Facts when we are pressing the button where the management of rule result is located. Data Facts section will change continuously, until the Rule on the left is empty, and then the process Change stopped.

Analysis : if the consultation process has been completed (with marked Rules if the board is empty. If without a data rule then the inference process ends), when clicking this button, the process of structural analysis to calculate the steel profiles will be done.

5. Evaluation Design

The design of each bar is the final stage of the process. In this process the data input process does not be used since the restrictions is used an angled profile. This angled profile is where the initial trial profile data elbow made uniform by wearing profiles ∟ size 100 × 100 × 10

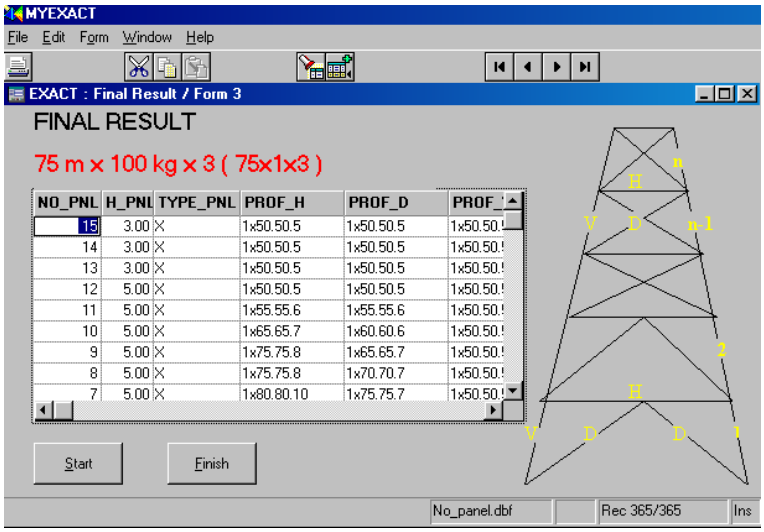

Fig. 3. Final Result

6. Conclusion

Expert system can solve the complex problem which cannot be solved using conventional programming. The calculation of steel tower construction is derived with focused questions. It is possible to add the based ruled in the increasing of time by user friendly editing and adding. It does not need to start from the beginning. There are some limits used in this program such as the high of tower and width of tower. It is limited in order to make the user will not get the unprincipled problems.

7. Acknowledgements

The research was funded by the Competitive Grant, Higher Education 2012 and 2013. (Hibah Bersaing, Dirjen Dikti, 2012 and 2013).

8. References

[1] ASCE, “Guide for Design of : Steel Transmission Towers”, American Society of Civil Engineers, 1971

[2] ANSI TIA/EIA-222F, “Structural Standards for Steel Antenna Towers and Antenna Supporting Structures”, 1991

[3] Bagio, Tony Hartono, and Hwat, Cheng Hong, “Program Komputer untuk Elastic Plane Frame menggunakan Large Deflection Theory”, Tugas Akhir, Fakultas Teknik Jurusan Teknik Sipil UK. Petra., 1987

ISBN : 978-602-72437-2-9

[4] Bowles,J.E., and Silabaan, P., "Disain Baja Konstruksi (Structural Steel Design)", Penerbit Airlangga, 1984

[5] Murlidharan, T.I., Aravind, H.B., Suryakumar, G.V., and Raman, N.V., "Expert Tower Analysis and Design System (EXTASY), Part (I) : Architecture and Heuristic", Journal of Computing in Civil Engineering, Vol 5. No. 2, April 1991

[6] Murlidharan, T.I., Aravind, H.B., Suryakumar, G.V., and Raman, N.V., "Expert Tower Analysis and Design System (ESTASY), Part (II) : Search Strategies and Learning", Journal of Computing in Civil Engineering, Vol 5. No. 2, April 1991

[7] Przemieniecki, J.S., "Theory of Matrix Structural Analysis",McGraw-Hill, Inc., New York, 1968

[8] Salmon, Charles G., and Johnson, John E., "Steel Structures: Design and Behavior , Second Edition ", Harper & Row, Publishers, New York, 1980

This page is intentionally left blank