I - 114 A FUZZY APPROACH FOR THE DECISION MAKING IN THE BRIDGE TYPE SELECTION SYSTEM

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I) Introduction

Although the design and analysis process in bridge design is an exact process, the planing and early stage of design is a comparative process that requires an input which involves with the vague function of expertise. The bridge type selection is a process that depends on expertise of experts and policy of design team. The selected bridge type have to fulfill the design conditions from viewpoint of economy, safety and serviceability and from the viewpoint of the aesthetics of the bridge. These design categories integrated in many small branches, which take the different weight on the decision of bridge types. The weight and score values of each branch category have the fuzzy nature. In our research we attempted to build a decision support system for bridge type selection based on experience of expert incorporated with production rules and a Mullti-attributes decision process with cooperation of fuzzy expertise.

II) The data related to the type selection of bridges

The selection process for bridge type, as mentioned above is a multi- criterion decision making process, in which the main input may be[2]:

(1) A plan of site showing all obstacles to be bridged, the contour lines of valleys and the desired alignment of the new traffic route. (2) Longitudinal section of ground along the axis of the bridge. (3) Required width of lanes, median, walkways, safety rail, etc. (4) Soil conditions for foundations, result of boring with a report on the geological situation and soil mechanics data. (5) Local condition like accessibility for transport of equipment, available materials, available industry standard. (6) Landscape conditions and landscape existing scenes, open or flat land, bridge is in town or in country side. (7) Environmental conditions, floods, high and low tide level, temperature,...

III)Procedure of the system

The data to the selection process of bridge's type are input by input devices to computer such as keyboard, scanner, digitizer, mouse, etc. Theknowledge based for the decision can be divided in many rules' sets according to the attributes.

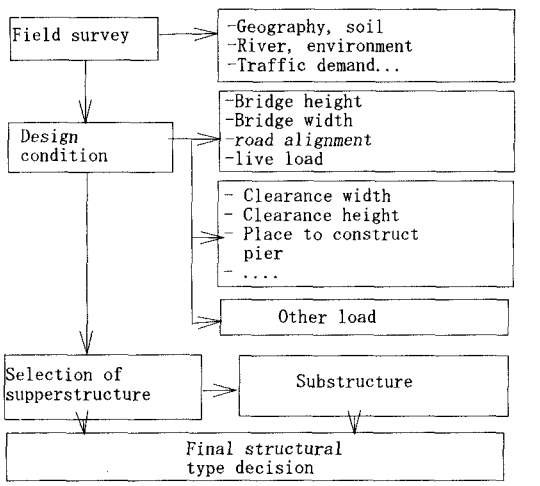

Fig. 1: Bridge design condition

a) Acquisition of knowledge

Bases on the input criterion for bridge types an interview has been conducted to a number of experts. The weight w_i of each criterion like the width of river, difficulty of soil condition, clearance, geography, landscape, etc. is obtained

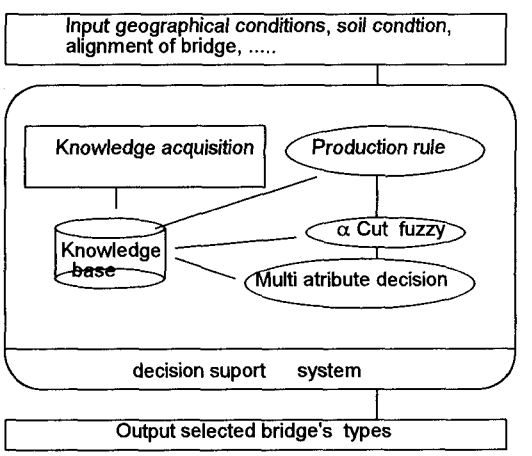

Fig. 2: System flow

the fuzzy pattern "most important", "very important", "important", "not very important", "absolutely not important", which is transferred later to the fuzzy number. Also the system consists of the selection and decision module, in which we are mapping the expert knowledge about the suitability of bridge type and condition in fuzzy membership. The second step is eliminating unsuitable bridge types to the practical conditions. The third step is bridge type selection using the multi attribute order.

b) Mapping the fitness into membership function

The fitness of the each data's type to various types of bridge shows a nonlinear and the boundary is not clearly, that why we used a fuzzy mapping to describe this fitness. The membership function is a mapping from the set of belonging X to [0,1] , that is : $X \subset [0, 1]$

The relations between environment conditions, landscape, technical conditions to various types of bridge are following the same principle. These data are collected from two sources: from experiences of experts and tenical standards. We consider the criterion of graphical condition, soil condition, required clearance dimension.

c) The α- cut Principle

We can demand the membership value greater than some threshold α, $\alpha \in]0,1]$. The bridge types which do not satisfied the condition are eliminated case by case if the membership is smaller than α. The ordinary set of such elements is the α-cut A_α of A [1]. The characteristic equation is as following:

$$A_\alpha = \{ x \in X,\ \mu_A(x) \geq \alpha \} \qquad (1)$$

The set A_α contains only the bridge types, which satisfy the conditions.

d) Multi attribute decision making and ordering

By Multi Attribute Decision Making and ordering under fuzzy environment, we need to define a mapping function to transform the Multi-dimensional vector to a scale, that is to define

$$y_i = f(x) = f(x_i) = f (x_{i,1}, x_{i,2},...,x_{i,m}), \qquad (2)$$

which can be compared in linear scale.

i are the candidates of bridge type i = (1,..., n) and m are number of the attributes .

We have:

$$y_i = f(x) = \sum_{j=1}^{m} w_j . x_j \qquad 0 \leq w \leq 1 \qquad (3)$$

Where w_j's are weights of each attribute, j's are the attribute j = 1,...,m.

$$Y = X . W \qquad (4)$$

And the ordering now is based on the value of y_i. The best choice x^* (or the most suitable type to a given condition) will be:

$$x^* \text{ if } f(x^*) = \max f(x_i) \qquad (5)$$

In our system the design attributes are input data for design such as bridge length, clearance dimension, foundations, location, the environment and landscape condition, which the weigh and score is taking from expert interview and standard.

IV) Conclusion

Most engineering design tasks have to deal with incomplete and vague knowledge. The bridge's planner and designer in practice have to make the decision on selection of bridge types based on experiences and such kind of decision usually has been done by very senior experts. Most of young and novice engineers, which have little knowledge, are very difficult to participate in this kind of decision processes. Some research has been done in the field of KBES, GIS; and the result are systems, that are very useful from many perspectives such as economy, maintenance, analysis, landscape. However none of them tried to solve the problems of presentation of the vagueness and linguistic inputs and knowledge and the method to deal with them . This research was carried to aim the development of a system to aid the novice engineering by bridge type selection and gain some basic knowledge in the primary design. A new method was applied to overcome the difficulty in dealing with vaguer, linguistic and sometime incomplete information. To achieve the goal the fuzzy Alpha-cut and fuzzy Multi attribute ordering was used in a knowledge based system.

Literature:

1) Dubois, Prage, Fuzzy set Theory and Application Academic Press 1986.

2) Fritz Leonhard, Aesthetics und Gestalt ; Deutsche Verlag: Anstalt 1982 GmbH, Stuttgart.

3) Nishino et al. A practical system for selecting type of bridges crossing river. JSCE Journal, April 1990

4)Japan Road Association: Road Bridge specifications (in Japanese)