I —44

STUDY ON SELECTION OF BRIDGE TYPE USING EXPERT SYSTEM

Toyohashi Univ.of Tech. Student ○ Leelawat Chartchai
Member Kuribayashi Eiichi
Member Niiro Tadashi

1.INTRODUCTION

The selection of a specfic type of bridge to cross a river,ravine or highway is not an automatic determination. Many factors,such as fitness for purpose,method of construction,appearance and cost,must be considered before a final decision is made.Consequently,designer must perform a detailed investigation of those factors until sufficient data is available.The purpose of this paper is to describe an application of Expert System(ES) in selection of bridges and applying fuzzy set theory in ranking of alternatives.

2.EXPERT SYSTEM FOR SELECTION OF BRIDGE TYPES

In this paper,the expert system is written in Prolog,and designed for selecting a type of bridge,which refer only to intermediate range (say,20 - 200 m).and not relevant to cable stayed or long-span suspension bridge.The step of selection is shown in fig.1.For the evaluation method, the authors use a technique of fuzzy decisionmaking to rank the alternatives which refer to superstructure and substructure .

3.RANKING OF ALTERNATIVES USING FUZZY SET

If let $A_1,\ldots,A_m$ be the set of m alternatives and a set of n criteria $(x_1,x_2,\ldots,x_n)$, the merit of alternative A_i according to the criterion j is denoted by the rating r_{ij}The relative importance of each criterion is denoted by a weight w_j.(see in table.1)Then alternative A_i receives the weighted average rating.

$$\bar{r}_i = \sum_{j=1}^{n} w_j r_{ij} \Big/ \sum_{j=1}^{n} w_j$$

This average rating now induces an ordering of the alternatives $A_1,\ldots,A_m$.However,if rating and weight are characterised by the small amount of precise information and the predominant uncertainty.Rating and weight can at most be described in term such as 'good','fair', 'unimportant',etc. In such case, the uncertainty may be represented by using fuzzy set.The concept of using fuzzy set theory in this paper appears in the work of Baas and Kwakernaak[1] and also by Yueen-Yee M. Cheng and Bayliss McInnis[2].Due to[1],fuzzy rating to criterion x_j of alternative A_i,characterised by membership function $\mu_{R_{ij}}(r_{ij})$ where $r_{ij} \in R$ And a relative importance of criteion x_j will be a fuzzy variable as well,characterised by $\mu_{w_j}(w_j)$where $w_j \in R$.All membership function take values in the closed interval [0,1],all fuzzy set are normal,and all support set are finite.

Table 1 Rating and Weight

	Weight	Ratings for Alternative 1	Ratings for Alternative 2	Ratings for Alternative m
Criteria 1	w_1	r_{11}	r_{21} ···	r_{m1}
Criteria 2	w_2	r_{12}	r_{22} ···	r_{m2}
.	.	.	.	.
.	.	.	.	.
Criteria n	w_n	r_{1n}	r_{2n} ···	r_{mn}

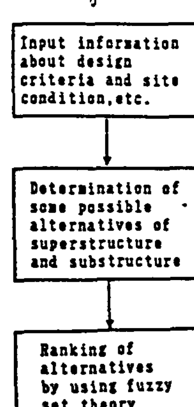

Fig.1

Consider the function $g_i(z_i)$: $R^{2n} \to R$ defined by

$$g_i(z_i) = \sum_{j=1}^{n} w_j r_{ij} / \sum_{j=1}^{n} w_j$$

where $z_i = (w_1, \ldots, w_n, r_{i1}, \ldots, r_{in})$.
Define the membership function μ_{z_i} by

$$\mu_z(z_i) = [\bigwedge_{j=1}^{n} \mu_w(w_j)] \wedge [\bigwedge_{j=1}^{n} \mu_r(r_{ij})]$$

through the mapping $g_i: R^{2n} \to R$ the fuzzy set Z_i induces a fuzzy set R_i with membership function.

$$\mu_R(\bar{r}_i) = \sup_{z_i : g_i(z_i) = \bar{r}_i} \mu_z(z_i), \quad \bar{r}_i \in R$$

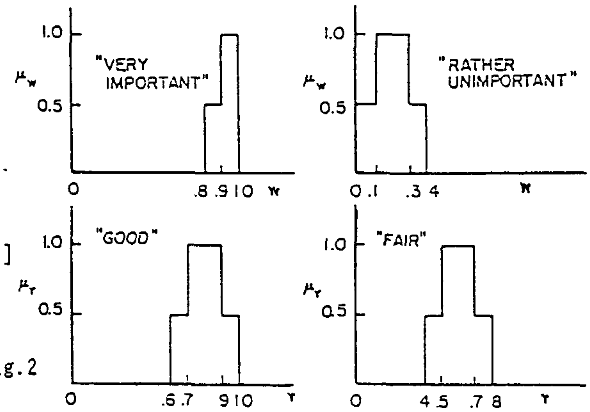

Fig.2

This membership function characterises the final rating of alternative A_i. Hence, we consider ranking the alternative by meansof the centroid of the area under the final rating graph. Some of membership functions are shown in fig.2

4.EXAMPLE OF APPLICATION

In this example,we apply an expert system for selecting possible type of bridge at the site of Hachinohe bridge [3],which is a 3 span continuous orthotropic deck bridge, erected by large block erection with floating crane and lift up machine.And using steel pile and pneumatic cassion for pier foundation in left and right side span,respectivesly. The output of the expert system gives in lists of possible type of bridges, erection method and foundation method which are ranked as shown in fig.3.We can see that the continuous PC box girder bridge has the highest ranking, followed by the orthotropic deck bridge and continuous truss bridge.and for the erection method, we find that the steel structure has only one method of construction and foundation method,we obtain the same solution as given in [3].

5.CONCLUSIONS

The author believe that a technique presented in this paper is suitable for evaluation of selecting a type of bridge. However,an expert system still needs a further development in progress.

Rank of bridges and erection method

*continuous pc box girder bridge (.92)
-- precast block cantilever erection (.82)
-- cast in place cantilever erection (.82)
-- movable scaffolding erection (.69)
*orthotropic deck bridge (.60)
-- large block erection with floating crane (.78)
-- large block erection with flat topped barge (.78)
*continuous truss bridge (.58)
-- large block erection with floating crane (.78)
-- large block erection with flat topped barge (.78)

Ranking of foundation method at left-side span

*steel pile (.74)
*pneumatic cassion (.72)
*open cassion (.69)
*reverse pile (.59)
*all casing pile (.54)
*pc pile (.53)

Ranking of foundation method at right-side span

*pneumatic cassion (.74)
*open cassion (.68)
*steel pile (.64)
*all casing pile (.60)
*pc pile (.57)
*spread foundation (.53)

Fig.3

REFERENCE

1.S.M.Baas and H.Kwakernaak,"Rating and ranking of multiple-aspect alternative using fuzzy sets",Automatic,vol.13,pp.47-58,1977.
2.Yuen-Yee M.Cheng and Bayliss Mcinnis,"An algorithm for multiple attribute,multiple alternative decision problems based on fuzzy set with application to medical diagnosis",IEEE Transactions on Systems,Man and Cybernetics,Vol.smc-10,No.10,1980.
3.H.Tatemori,"Design and construction of Hachinohe bridge",Bridge and foundation,Vol.9,No.2,1975.