Ⅳ-145 FUZZY SET APPROACH IN PLANNING AND DESIGN OF OVERPASS BRIDGES ON EXPRESSWAY

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<I> Introduction

In Japan today many overpasses has been built and are going to be build. To have an optimal multicriteria decision making in planning and design of overpasses is the aim of this study. In this report the authors try to solve the uncertainties in decision making process for design of plural overpasses on the highway. The characteristics of decision making process are multicriteria, multiparticipants and vagueness(fuzziness). By means of Fuzzy set approach in evaluating and finding the most favorable (or least objective) alternative on the dimensions of overpasseses is the object of this study.

<II> Theory

Fuzzy set theory was first addressed by Zahdeh in 1965. At the present Fuzzy set theory has been applied in many theoretical researches and practical production process. Fung and Fu (1975) proposed a new approach to arrived group consensus. They argued that "rational aggregation possessing is possible if and only if the interpersonal comparison of membership function are permitted and that the approaches to comparisons can be theoretically pessimistic , optimistic or mixed." The fuzzy group decision making consists of three steps. [2]

[Step 1]: Let X be a set of concurrent pattern (alternative), m is the number of individual, the preference pattern of criterion j is presented by L-Fuzzy set A_j on X. $U_{Aj}(X_i)$is fuzzy membership denoted the degree of preference of action or alternative X_i (i =1,2 ,...,n) by individual j.

[Step 2]: Aggregate the individuals into a representative of groups.

[Step 3]: Choose an action or alternative that has the highest membership in the aggregate.

The aggregate proposed by Fung and Fu (1975)[2] is to be a rational aggregate and the theorem is as follows:

Let L and * the preference measure system and its binary operation. L and * satisfied the law of independent, idempotent,commutative, associative and nondecreasingness , then the possible and only possible choice of rational aggregation * are,

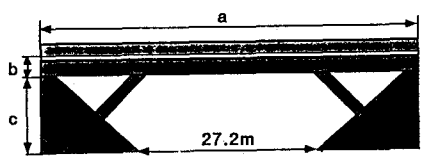
- pessimistic approach: a*b = min(a,b),for all a,b ∈ L;
- optimistic approach: a*b = max(a,b),for all a,b ∈ L; (1)
- mixed approach : There exist at least one point α, such that a*b = max(a,b), all a<= α, all b<= α, a*b = min(a,b), all a>= α, all b>= α,

where α is the acceptability of an objective or attribute, which is some arbitrary fixed threshold point L. The problem here is to take the acceptability of the object into consideration with the weight of criterion and the favor score of the objective.

By a pessimistic approach the best alternative is X^* satisfied the equation:

$D(X^*)= \mathrm{Max}[\min (U_{Aj}(X_i))^{Wj}]$ with W_j is the weight of criterion j. (2)

<III> Experiment



PROFILE OF OVERPASS

A) *Creation of animation images* : Simulated video images was created using a CG animation technique, superimpose into existent recorded scenes of highway. (The video scenes was taken from a car with constant velocity at 100km/hr.).

B)*Collection of data:* After creating animation video images, the video was played for 10 people(subjects). In the questionnaire the subject must fill, as if he or she is driving a car running toward on the highway with

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overpasses.The psychological senses like oppressiveness, complicatedness, stableness and favorableness are the criterions and various combinations of design factors. In the questionnaire the subjects were asked about the impression of each alternative, important and acceptability of criterions. Typical questionnaire was ranking like in folowing: Complicatedness ranks: Very complicate (VC), complicate(C),Not complicate(N),easy (E),Very easy(VE).

Similarly with the senses of oppressiveness, stable and favorableness.

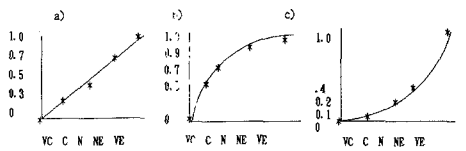

Fig. 3. Mapping fuzzy pattern by a)linear, b)convex parabola, c)parabolare

The important, acceptability of criterion was asked after ranking like following: Very importance, importance, moderate, less importance, not importance

c)*Assign the individual:* By analyzing a fuzzy pattern was used, we using here 3 sets of pattern:

linear:0,0.3,0.5,0.7,1 correspond to (VC,C,N,NE,VE);

parabola: 0,0.1,0.2,0.4,1 or convex parabola 0,0.5,0.7,0.9,1 to assign to the membership $U_{Aj}(X_i)$ of alternative X_i to attribute A_j and the individual weighing of attribute W_j. For example the individual weight vector = (0.7,0.3,1,0.5) correspondent to the 4 psychological senses. And individual grade of membership $U_{Aj}(X_i)$ in our experiment is a matrix order[15,4].

d)*Aggregate group matrix* Using the score of W_j to calculate a threshold (we using here after median of W_j^k of k individuals ,called MW_j[4]) . Using unequation (1) we calculate the aggregate membership $GU_{Aj}(X_i)$

if $[U_{Aj}(X_i)]^k < MW_j$ for all individuals k then $GU_{Aj}(X_i) = \max[U_{Aj}(X_i)]$
if $[U_{Aj}(X_i)]^k > MW_j$ for all individuals k then $GU_{Aj}(X_i) = \min[U_{Aj}(X_i)]$
if $[U_{Aj}(X_i)]^k > MW_j$ for at least one individual k and
$[U_{Aj}(X_i)]^k < MW_j$ for at least one k then $GU_{Aj}(X_i) = MW_j$;

Using a C program we obtain for the linear cases the group matrix $GU_{Aj}(X_i)$.

e)*Making decision*: From equation (2) we obtain the best alternatives by replace the aggregate $GU_{Aj}(X_i)$ instead of $U_{Aj}(X_i)$. $D(X^*)$.The result was obtained by the alternatives A5,A6,A7,A12,A14, where A5,A6 corespondent to the maximum clearance: The clearance height c= 11m and 13m, the overpass length a=51.2-52.2m. A7 is the alternative with maximal slender(b=0.4m) and A12 and A14 indicate an interval between overpasses by 200m to 300m. The results is also true with the experiences of aesthetical bridges designer.

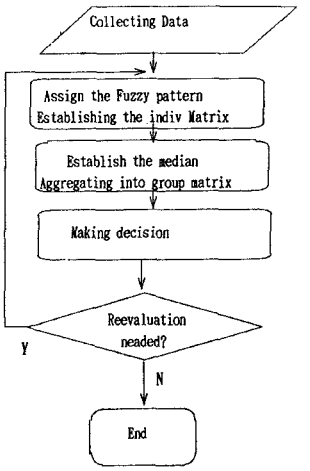

Fig 2. Flowchart of the proccess

<IV> Some Conclusions

Applying the fuzzy group in decision making the problem of vagueness and uncertainly was solve in an easy and programmable way. Practice showed that in many cases problems can not be solve or complicated to solve with conventional two and multivalue logic, with fuzzy set describing method and fuzzy operation may be the best way especially in expert and decision support systems.

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