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Expert System for the Selection of Bridge Superstructures using Fuzzy Inference System

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Abstract: In the present research the expert system is designed for the selection of bridge superstructures of river crossing bridges with the aim to overcome the practical problems faced during the selection of bridge types. Selection of bridge superstructure is one of the complex processes with lot of fuzziness. Among all the techniques like neural network, fuzzy logic, linear system and differential equation, fuzzy logic is faster and cheaper. Hence in the present research, system is designed using Fuzzy Inference System (FIS) in MATrix Laboratory and the knowledge in the knowledge base of an expert system is built using the data collected from Fuzzy Delphi Method (FDM) and Fuzzy Analytical Hierarchy Process (FAHP).

Key Words: Fuzzy Logic, Expert System, FIS, FDM, FAHP.

I. Introduction

Selection of Bridge Super Structure for river crossing bridges is one of the complex decisions to be taken by Bridge Engineers as it involves a very sophisticated research considering the geotechnical and geological aspects, social and economic conditions, material availability, environmental conditions, and other technical aspects. Decision may not only rely on any single person, it is a collective decision to be taken by a group of experts in various fields of bridge engineering. As most of the times decision would be crisp and ambiguous, with the aim to handle this crispness, an Expert system in the present research is developed using Fuzzy rules. FDM and FAHP are used to collect the expert opinions; Fuzzy Rules is used for Knowledge Representation of the system. System is trained by the collective experts' knowledge using the above mentioned knowledge representation technique and it takes the decision in a similar way, like how human expert does. Expert system consists of 4 major components and each component of the expert system is developed in MATLAB environment.

II. Factors influencing the selection

The factors, influencing the selection of bridge superstructure are collected using fuzzy Delphi method through set of interviews with the experts from the field of bridge engineering. Fuzzy analytical hierarchy process gives the weightages of selected factors. The list of factors influencing the selection of bridge superstructure as obtained from FDM is as listed below.

• Span length	• Lighter weight
• Faster construction	• Time saving
• Built operate transfer projects where speed in construction is crucial	• For Urban Flyovers/ Elevated road Projects
• Least obstruction to traffic	• For construction across wide and deep valleys
• Tall piers	• Uninterrupted passage of traffic and navigation

Table 1 List of influential factors

III. Methodology

In the present research Expert system consists of 4 major components. User Interface, Knowledge Base, Inference Engine, Output Facility. Flow chart showing various components of an expert system is as shown in figure 1.

The expert system interacts with the outside environment through user interface component. To make the system user friendly, graphical user interface is designed in the present system. Knowledge required for building knowledge base is acquired from textbooks and experts and is represented using fuzzy rules. System inference is drawn using fuzzy inference system. Fuzzy inference is the actual process of mapping from a given input to an output using fuzzy logic. There are two approaches to make a fuzzy inference system called Mamdani and Sugeno.

Mamdani allows the experts to describe in more human like manner. Hence in the present research due to its wide acceptance for capturing expert knowledge, Mamdani fuzzy inference system is used.

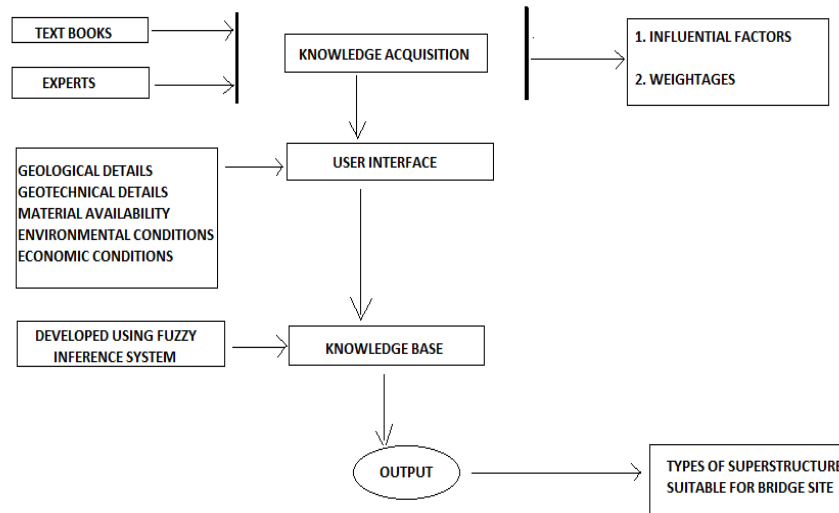


Figure 1 Flowchart showing bridge superstructure selection system

The membership function of a fuzzy set is an indicator function in classical sets. There are several membership functions which can be chosen for any specific problem depending on the input and output attributes. In the present research triangular membership function is designed from the capacity of humans through intelligence and understanding. Membership functions used for the input and output attributes is as shown below. ‘Yes’, ‘No’, and ‘Partial’ and ‘different span lengths’ are the membership functions for the input attributes. ‘Reject’, ‘partial’, and ‘select’ and ‘mf1(b/w 0 and 0.4)’, ‘mf2(b/w 0.4 and 0.6)’ and ‘mf3(b/w 0.6 and 1)’ are used as a membership functions for the output attributes.

IV. RESULTS AND DISCUSSION

The expert system designed in the present work selects the best bridge superstructure for the existing site conditions. The sample rule view of the inference system is as shown in figure 2. The sample output of an expert system shown in figure 3 gives the certainty factor of the superstructure types, which is a clear indication of the suitability of the bridge superstructure for the existing site conditions. The expert system is designed for various flexible and rigid conditions in which the system performs its work even in the absence of certain inputs. The current system is designed to respond well to the various situations outside their range of expertise by including the self awareness in the system. It offers solution to the substantial uncertainties which otherwise requires expert consultation by imitating the decision making capability of the experts. The expert system is validated to the existing bridge sites located in Palakkad(D), Kerala(S), India. The expert system designed in the present research serves the purpose.

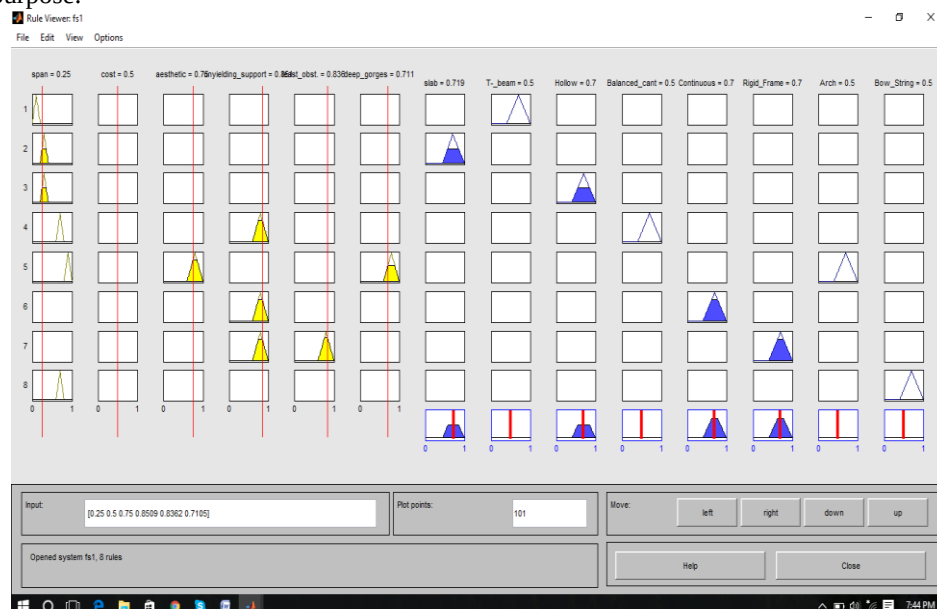


Figure 2 Rule View of Inference Editor 1

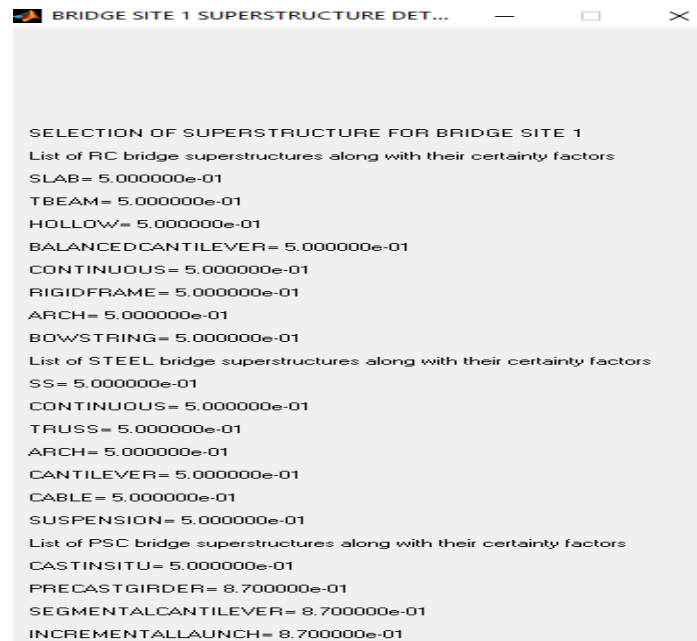


Figure 3 Expert system output screen

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