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MULTICRITERIA FUZZY OPTIMISATION OF STRUCTURAL SYSTEMS

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There are a number of different characteristic objectives which in practical structural design problem designers have to consider. Each objective is evaluated relative to the other objective functions being considered. Conflicts can arise between these objectives, for example, economy versus safety and functionality. Moreover, the value of each objective function has to obtain client and/or general consent, as well as satisfy the designer's preferences and design emphases. Furthermore, relative evaluations of these objectives have some fuzziness. Therefore, designers are always faced with determining a best-compromise solution by evaluating each different characteristic objective relative to the others being considered, whilst satisfying the design requirements. This optimum decision-making problem can be recognised as a multicriteria optimum design problem with fuzziness.

This study proposes an efficient and systematic multicriteria fuzzy optimum design method which can deal with multiobjectives, fuzziness in the decision-making, design emphases, designer's preferences and so on. The proposed design method is developed using suboptimisation, introduction of measure membership functions and fuzzy decision-making techniques. Each objective function is suboptimised first for all discrete sets of common design variables and design parameters. To make the relative evaluation of suboptimised data of objective functions rationality and systematically, and involving the fuzziness in the decision-making process and design emphases, the measure membership functions are introduced for all objective functions. The membership functions of the suboptimised objective functions are determined simply using the corresponding measure membership functions as datum. A hybrid decision-making process is developed combining the weighted operator method, comparison processes of maximum membership values and backward interpolation processes for the determination of the global optimum solution.

The proposed design method is applied to a large-scale prestressed concrete bridge system in which the two primary objectives to be considered are the total expected cost after an earthquake and the aesthetics of the bridge system. The total expected cost is calculated as the sum of the suboptimized total construction cost of the bridge system and the expected losses caused by collapse of bridge system due to an earthquake. The expected losses are assumed to be calculated as a product of certain amount of social losses, which is the sum of the cost of demolition after collapse and all other expenses directly or indirectly involve due to the failure of the bridge system, and failure probability of the bridge system. Since the failure probability of the bridge system is affected so much by the safety parameter used in the design of substructures, the safety parameter is dealt with as the design parameter, while the span ratio and web height are dealt with as the common design variables. The bridge system is suboptimized on the total construction cost at discrete combinations of span ratio web height and safety parameter. The measure membership function of total expected cost is introduced by inspecting the total expected cost at all discrete combinations of span ratio, web height and the safety parameter. The membership values of total expected cost are determined simply using the measure membership function as datum. The measure membership function of aesthetic of the bridge system and the membership values for every discrete span ratio and web height are introduced by comparing the aesthetics of corresponding perspectives of the bridge system relatively.