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Cost Analyis of Rc Beam Using Genetic Algorithm

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ABSTRACT

In this study we present a use of genetic algorithm applications and lay a special emphasis on use of the same as one of the most important optimization tool. Finally, some examples illustrate the effectiveness and efficiency of the genetic algorithm based optimal design. Optimization processes act as a vital part in design of structure; the main aim of optimization is to find the best manners so that a designer can figure the maximum gain from existing resources. Optimum structural design methods are able to be carried out corresponding to the design belief involved. Even today, the majority of the civil structures were designed based on allowable stress criteria as per code requirements. Nonetheless, a specific factor of safety beside ultimate collapse of the structure is used by various new processes. This study proposes a new genetic algorithm for RC beam design. A genetic algorithm model was prepared to execute the optimization of cost for singly and doubly reinforced concrete beam which was subjected to different loading conditions. The initial solution was acquired by utilizing the limit state design. Code was written in MATLAB by using genetic algorithm to obtain the optimal values.

This optimization problem is then solved by a genetic algorithm specially tailored to the problem. In the objective function, the total cost of the structure is minimized. . Cost optimization for singly and doubly reinforced beam is illustrated and plotting of various cases are shown. the total cost of beam reduces with the increase in characteristic compressive strength of concrete, while fixing the applied load and the grade of steel, beacuse the Genetic Algorithm optimizes the final cost by decreasing the dimension of section in order to find the optimal cost.

Keywords

Structural optimization, cost saving, genetic algorithm, design optimization

INTRODUCTION

Reinforced concrete structures are the structures that have substantial compressive strength as compared with the majority of different materials. When it is compared with the steel structures, it was found that the reinforced concrete

structures were more adaptable, durable, and incur comparatively less maintenance costs. They offer superior resistance for damage caused by fire and water, and have good potential for an extensive service years. Weight of a Reinforced structure comprises a chief component of the overall cost.

Cost of the material is a chief subject in case for construction and design of reinforced concrete structures. Quantity of concrete and steel reinforcement is the primary factors affecting the total cost that is needed. Hence, it is necessary to build lighter reinforced concrete structures, and should be able to fulfil the strength and serviceability requirements. The cost of formwork and labour are important along with the cost of materials. The cost of formwork is generally articulated in the form of cost per unit area, and it is complicated to compute the cost of labour. The combination of cost of labour and the cost of formwork is very widespread in order to get reasonable overall cost of construction. Therefore, for optimal usage of acquirable resources, it is necessary to minimize the overall cost of structure.

A structural design engineer needs good understanding, instinct and knowledge for formulating the capability to design robust, practical and economical structures. The standard design codes hardly give a design that can satisfy all the conditions that are given– Hence, the designer has to carry out an elite number of analysis and design cycles prior to meeting up the best solution. A better initial result decreases the number of analysis and design cycles. A set of initial solutions generated by the GA from the acceptable range for each design variable, as acquired from the intuitive design, was taken as the initial population to be optimized. For cost of structure to be minimum , the optimization process selects a group of design variables that make sure that overall cost is minimum; and is subjected to the satisfy several constraints as per IS:456-2000.

Objective of study

The objective of this study is to optimize the RC beam using genetic algorithm coding that satisfies the limitation and specifications of the IS: 456-2000.

MODEL FORMULATION

Concrete possesses extremely great compressive strength but comparatively less tensile strength. To supplement its strength, steel reinforcement is used on the part of the concrete beam that bears tensile stress. Hence, concrete beams which have been singly reinforced on the tensile face

are efficient in bearing both tension and compression. Though, concrete beams contain their own limiting moment of resistance that changes with change in specific value of depth, width, grade of concrete and grade steel.

In general, doubly reinforced beams are applied to in situations in which the cross-sectional dimensions of the beam are limited (by architectural or other circumstances) and when singly reinforced sections are not adequate in stipulations of moment-resisting capability. The existence of compression reinforcement decreases the long-term deflections caused by shrinkage. The design based on limit state and the optimization methods were done, which is subjected to satisfaction of a range of geometrical and behavioural and condition as commended by the Bureau of Indian Standards in IS: 456-2000

GENETIC ALGORITHM

Genetic algorithms are search algorithms that have been evolved from the evolution observed in nature, namely the processes of natural selection, genetics and survival of the fittest. Genetic algorithm applies these natural processes to mathematical string structures and adds \some of the artificial reasoning of search algorithms. It is a type of search paradigm that applies arbitrary selection as a tool to carry out an extremely expansive search and selection method, throughout a range of constraint limited space. Genetic algorithm was advanced as a mathematical tool at the University of Michigan, by John Holland, with the support of his peers and students. The chief goals of their research in the development of GA were:

(a) To abstract the adaptive process of natural systems and rigorously explain the same, and

(b) To formulate an artificial program or system that imbibes the essential functionalities of natural processes

RESULT AND DISCUSSION

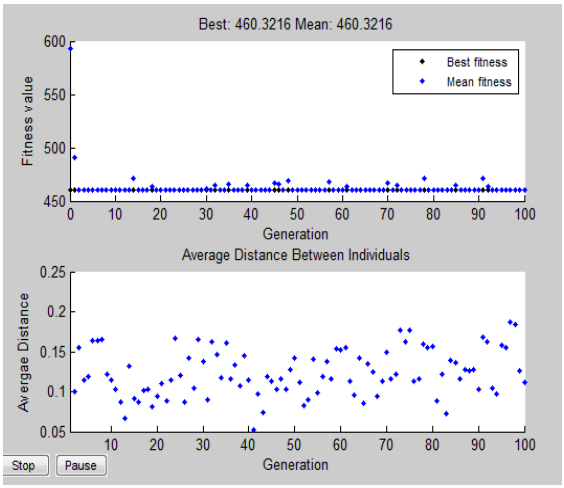
Comparison of genetic algorithm model with the Neural Network model of previous work For singly reinforced concrete beam

Comparison of cost for singly reinforced concrete beam with the Neural Network model is shown below in tabular form.

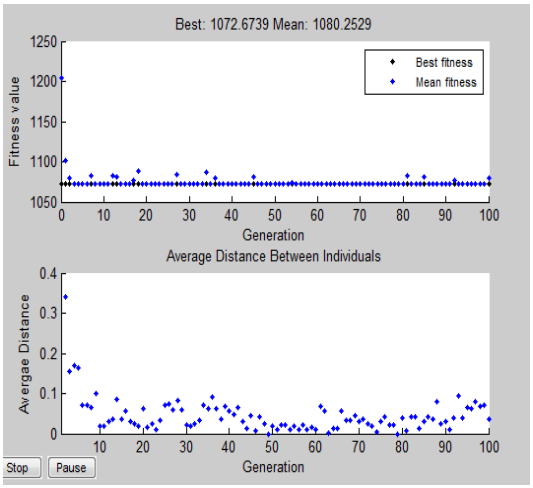
Table 1: Comparison of cost for singly reinforced beam by genetic algorithm model with Neural the Network model

INPUT	GENETIC ALGORITHM CODING			ARTIFICIAL NEURAL NETWORK TECHNIQUE			REMARKS (Cost reduction in %)
	d(mm)	p_t	Cost (Rs. /m)	d(mm)	p_t	Cost (Rs. /m)	
(1)w_u=35kN/m, l=4m, r=2.0, M25,Fe415	394.60	1.1769	460.32	401.40	1.1941	476.40	3.37
(2)w_u=65kN/m, l=6m, r=2.0, M25,Fe415	632.20	1.2015	1072.70	651.20	1.1941	1129.89	5.06
(3)w_u=50kN/m, l=6m, r=2.5, M30,Fe500	596.60	1.1239	893.50	611.10	1.1320	935.28	4.47
(4) w_u=60kN/m, l=8m, r=1.5, M30,Fe415	637.60	1.4418	1682.8	665.46	1.4329	1819.08	7.49

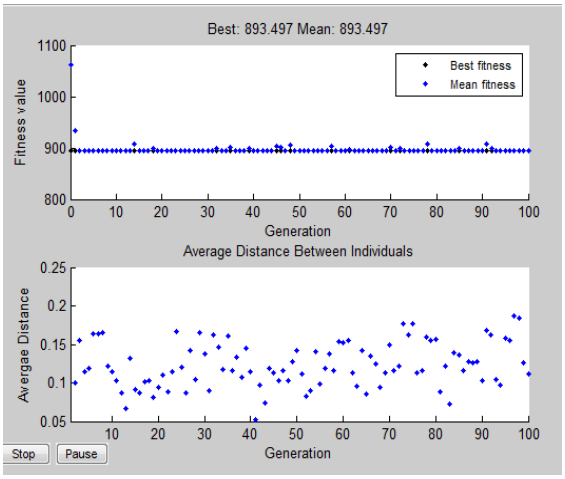
Graphs have been plotted for the above solved values



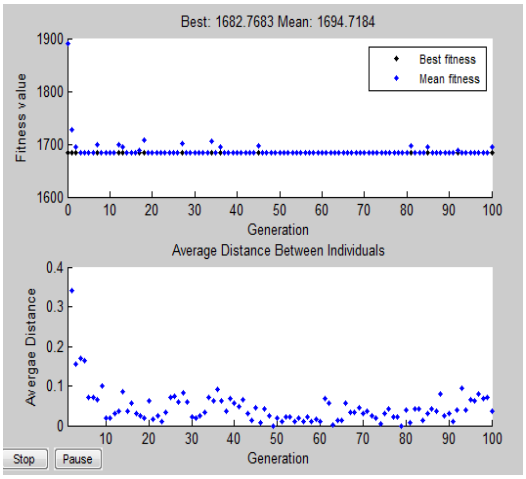
(a)Problem 1



(b) Problem 2



(c)Problem 3



(d) Problem 4

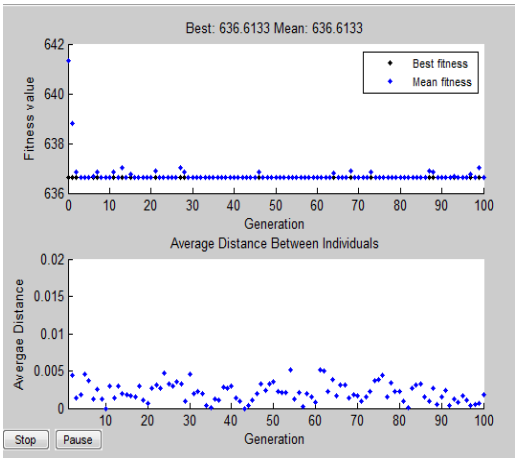
For doubly reinforced concrete beam:

Comparison of cost for doubly reinforced concrete beam with the Neural Network model is shown below in tabular form.

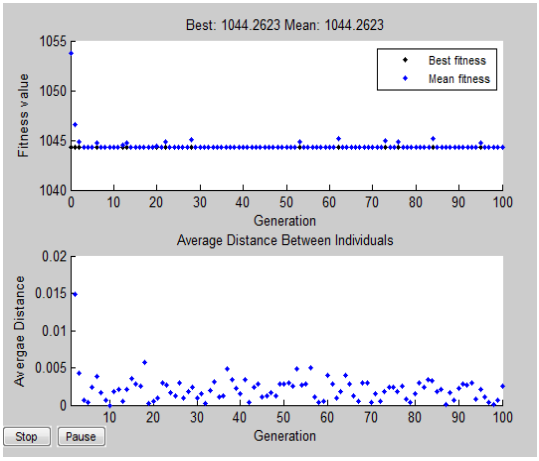
Table 5.6: Comparison of cost for doubly reinforced beam by genetic algorithm model with Neural Network model

INPUT	GENETIC ALGORITHM CODING			ARTIFICIAL NEURAL NETWORK TECHNIQUE			REMARKS (cost reduction in %)
	p_t	p_c	Cost (Rs. /m)	p_t	p_c	Cost (Rs. /m)	
(1)w_u=30kN/m, l=6m, r=2.5, D=545.16mm M25,Fe415	1.339	0.1441	636.61	1.1991	0.0539	677.22	5.99
(2)w_u=50kN/m, l=6m, r=1.5, D=512.75mm M30,Fe500	1.3599	0.2497	1044.30	1.1726	0.0436	1092.84	4.44
(3)w_u=70KN/m, l=4m, r=1.5, D=426.53mm M30,Fe500	1.5340	0.4741	790.70	1.4706	0.0402	815.18	3.00

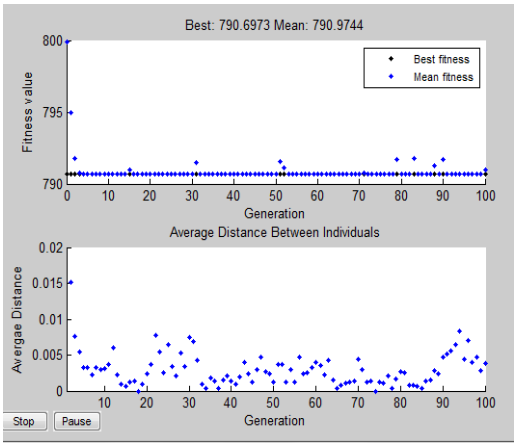
Graphs have been plotted for the above solved values



(a)Problem 1



(b) Problem 2



(c)Problem 3

Discussion:

The optimal cost of singly and doubly reinforced concrete beams by Genetic Algorithm model was compared with the optimal cost by Neural Network considered from one of the previous works and it was found that the former technique showed a considerable fall in total optimal cost. The resulting optimal designs shows cost savings of up to 5.1% for singly reinforced concrete beam and 4.48% for doubly reinforced concrete beam when compared with the literature considered for comparison.

CONCLUSIONS

A genetic algorithm model was prepared to execute the optimization of cost for singly and doubly reinforced concrete beam which was subjected to different loading conditions. The initial solution was acquired by utilizing the limit state design. Code was written in MATLAB by using genetic algorithm to obtain the optimal values.

Following conclusions were inferred from this study:

1. Reduction in cost was negligible due to change above certain values of mutation rate, number of generations and population size for singly and doubly reinforced concrete beam.
2. The total cost of beam reduces with the increase in characteristic compressive strength of concrete, while fixing the applied load and the grade of steel, beacuse the Genetic Algorithm optimizes the final cost by decreasing the dimension of section in order to find the optimal cost.
3. The total cost increases with the increase in grade of steel, while fixing the applied load and compressive strength of concrete.
4. On comparison with an earlier literature related to cost optimization of reinforced beams, it was concluded that there was cost reduction of 5.1% for singly reinforced concrete beam and in case of doubly reinforced concrete beams cost reduction of 4.48% was acquired by genetic algorithm model.

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