T-Beam Cost Optimization by Reducing Width with Grey Wolf Convex Optimization

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Abstract-The shortcomings of the indirect design can be overcome by adopting a direct or optimal design procedure. The feature of the optimal design is that it consists of only logical decisions. In making a logical decision, one sets out the constraints and then minimizes or maximizes the objective function (which could be either cost, weight or merit function).A unique mathematical relationship between the design parameters and cost elements was formulated for simply supported Reinforced concrete beams. This is a novel approach that can easily be used to optimise the design of various types of large RC structures and also account for constraints imposed by the design standards. Particle swarm Optimization (PSO), as a robust metaheuristic, was used to solve the combinatorial optimisation arising from the structural optimisation problem. Numerical examples for certain spans of simply supported beam are presented to demonstrate the robustness and practicality of the methodology and algorithms. The results were compared to results of the same optimization problem, optimized using genetic algorithm method. In proposed approach GWO gives significant reduced cost with the help of global and local optimization. It also converges in time because of eight parameters of beam.

Keywords-*Beam,cost optimization,gwo*

I. INTRODUCTION

A. Beam

Beam is a structural member which is ordinarily set horizontally. It gives resistance to bending when burdens are connected on it. Different types of materials, for example, wood, steel, aluminum, etc. are utilized for constructing beam. Most ordinarily utilized material for beam is RCC (Reinforced Cement Concrete). RCC beam can be different types relying upon different criteria. For example, contingent upon shape, beam can be rectangular, T-beam, etc. Contingent upon reinforcement placement, beam can be two fold strengthened beam, single fortified beam, etc.

1) Beams are classified as

a) Simple Beam
b) Continuous Beam
c) Semi-Continuous Beam

a) Simple Beam-Alludes to the beam having a solitary traverse bolstered at its end without a restriction at the support. Basic beam is now and then called as just bolstered beam. Restriction implies an unbending association or harbor at the support.

b) Continuous Beam-refers to a beam with two spans with or without restraint at the two extreme ends.

c) Cantilever Beam- It is supported on one end and the other end projecting beyond the support or wall.

T-Beam-When floor slabs and beams are poured simultaneously producing a monolithic structure where the portion of the slab at both sides of the beam serves as flanges of the T-Beam. The beam below the slab serves as the web member and is sometime called stem.

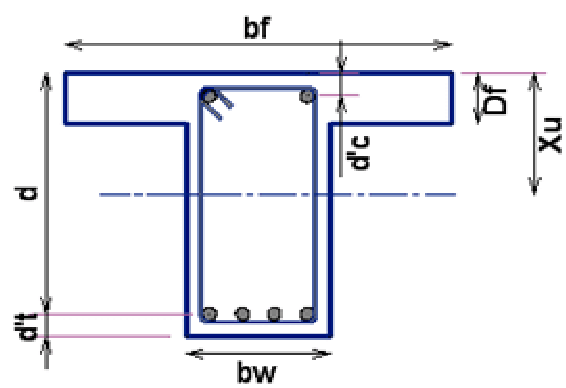

Fig 1.1 T-Beams

Singly Reinforced T-Beam Section Design

The Economic execution of a tangible structure reliant on the basic layout, the choice of materials and their optimum use. The feasibility depends on the proper analysis. Designs of Singly reinforced beam are designed by basically the following methods:

- The strain compatibility method
- The formulas method derived from the basic assumptions
- The design charts and tables method published by ISI in its publication SP 16.

II. LITERATURE REVIEW

C.C. Ferreira et al In this approach, finest design of reinforced concrete T-sections in winding present optimization of the steel area and the steel localization in a T-beam under bending is performed in the current work. The expressions giving the equilibrium of a single and double reinforced T-section in the various stages introduced by the non-linear behaviour of the steel and concrete are derived ones. The final material behaviour is defined accordingly to the designs codes alike EC2 and Model Code 1990. The objective is to gain the analytical optimal design of reinforcement of a T-section in terms of the unlimited design. The established expressions are applied to examples and design abacuses are supplied. A judgment is made with the available practice technique as indicated in CEB [1]. V. Govindaraj and J. V. Ramasamy presented the optimum design of reinforced concrete regular beams using genetic algorithms as per the design deliberation of the Indian standard codes. The optimum design is such designed that it observes with all the serviceability, ductility, durability, and all other design constraints of the code. In this examine only the cross sectional dimensions of the beam are considered as design variables. An example issue is illustrated and the results are presented [2].

B. Saini et al Studied Genetically, improved artificial neural network on the basis of optimum design of single and double fortify concrete beams, research optimum design of singly and double support beams with uniformly dispersed and concentrated load has been done by compromising exact self-weight beam. On the basis of steepest descent, flexible and malleable and back-propagation learning a technique, this design is skillful has also been composed of genetically optimized artificial neural network. With the use of limit state design, the initial solution has been achieved [3]. A.B Senouci and M.S Ansari This paper is about cost optimization of composite beams using genetic algorithm. It is based on the load and confrontation factor design specification of the AISC. The cost of concrete, steel beam and sheer studs are involved in the establishment of model. In this proposed model two designs are studied to illustrate its ability in optimizing composite beam design. The outcome achieved shows that the model is able to attain cost saving. Research has also been done to analyse the effects of beam spans [4].

A.Nimtawat and P Nanakorn This paper shows that PSO algorithm for beam slab layout design distribute with measurement of the design of beam slab layout is analyzed and not algorithmic because the procedure cannot be segmented into an algorithm. In this research, the design work is written as an optimization issue, which can be solved by following suitable target and reducing functions on the basis of engineering consideration. A simple PSO used to resolve the problem of optimization. It has also been found that it is the best popular method due to its simplicity and excellent presentation. In order to employ these techniques certain coding strategy for beam slab layout is used [5]. A.C Galeb and Z.F Atiyah In this paper optimum design of supplement concrete waffle slabs dealt with the optimum design to strength concrete waffle slabs with the use of genetic algorithms. Two case studies have been explained: the first is a waffle slab with solid heads and next is the waffle slab with band beam throughout the column centre lines. The limitation involves the restrictions on measurements of the rib and limitation on the top of the slab wideness, the constraint on the areas area of steel reinforcement to gratify flexural behaviour and deliver sufficient concrete cover an the restriction on the longitudinal reinforcement o band beams. A computer program is written with the use of MATLAB to evaluate the structural investigation and design the waffle of slabs by the direct design techniques. The optimization procedure carried out by using built in genetic algorithm toolbox of matlab [6].

S.T Yousif and R.M. Najem in their study discussed the application of genetic algorithms in the cost optimization of the protected concrete beams based on the ACI standard stipulations. The resultant optimized design fulfils all the strength, serviceability, ductility, durability and all other constrains connected to design and detailing requirements. In this study the dimensions of the reinforcement steel were introduced as a variable taking into account flexural, shear and torsion influence on the beam. The forces, moments and deformations require in the Genetic algorithm constraints will be found by examines. The optimum results were calculated and then compared to the results in the previous literature [7].A.Kaveh and M.S Massoudi analyzed the Ant colony system model for cost optimization of a amalgamate floor system on the basis of load and confrontation factor design specification of AISC deals with the diverse cost of the concrete, steel bums and the shear studs need to add the cost of the structure which may be reduced on the basis of type of working in the structure [8].

A.Kaveh and A.F. Benham in their study conducted the Cost optimization of a multiple floor system using a charged system search algorithm, and deal with design optimization of special floor systems which includes multiple slab, one way waffle slab. All this is performed using the most recent meta-heuristic algorithms. The most favourable design is based on LRFD-aisc and ACI 318-05. The purpose function here is the cost function. The cost function contains cost of all the materials used and construction cost. The problem is also optimized using by enhanced Harmony search system algorithm and then compared with the output of the charged system search algorithm [9]. K.S Patil et al in their research introduced study on best possible design of reinforced detailed flat slab with the drop panel as per IS 456-2000. The total cost of columns and slab and all its elements serves as the objective function. The cost of each component includes the cost of material used, labour, and formwork. The optimization is carried out in MATLAB software using direct design method. Various grades of steel and concrete are considered for the optimization illustrations. Using Sequential unconstrained minimization technique, the Non Linear programming problem is optimally formulated [10].

III. PROPOSED METHODOLOGY

In section result o the proposed work is presented in Comparison between PSO Algorithm and Grey Wolf Optimisation.

In this section the results for the cost optimisation of a simply supported beam for both genetic algorithm method and particle swarm optimisation would be compared.

Comparison for optimum cost of 4m span.

TABLE 1. Comparison for optimum cost of 4m span

Sno.	Parameter - Load, depth of flange, fck, fy,	Particle Swarm Optimisation Method	Grey Wolf Optimisation Method
1	40,100,20,415	5930	4432
2	40,100,20,500	6452	4412
3	40,200,20,415	8788	7110
4	40,200,20,500	8620	6992
5	60,100,25,415	7485	7116
6	60,100,25,500	7390	6957
7	60,200,25,415	8815	7117
8	60,200,25,500	8720	6996

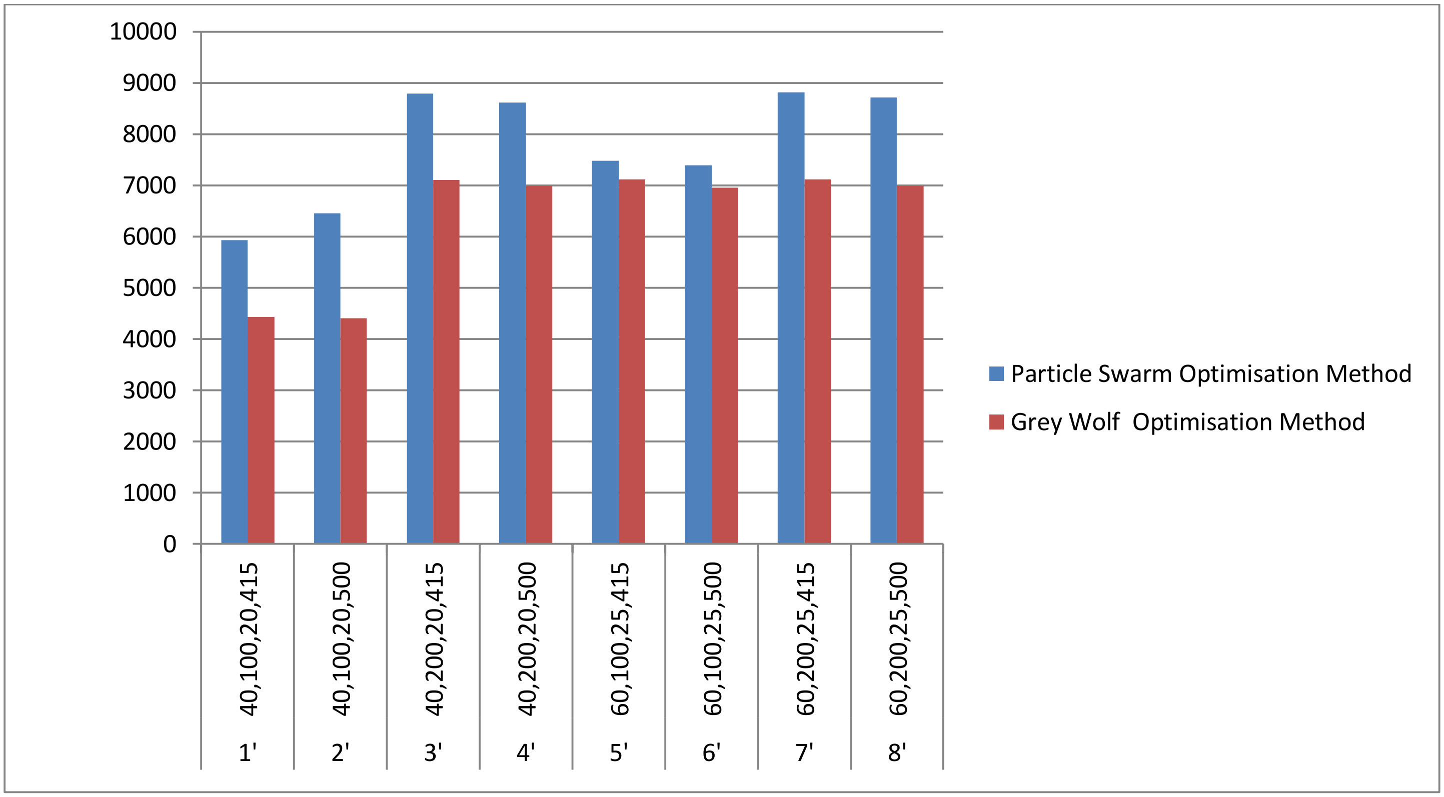

Fig 1.2 Comparison for optimum cost of 4m span

Comparison for optimum cost of 8m span

TABLE 2: Comparison for optimum cost of 8m span

Sr No.	Parameter - Load, depth of flange, fck, fy,	Particle Swarm Optimisation Method	Grey Wolf Optimisation Method
1	40,100,20,415	8892	6648
2	40,100,20,500	9684	6618
3	40,200,20,415	16232	12022
4	40,200,20,500	15192	11639
5	60,100,25,415	14312	10278
6	60,100,25,500	12630	8980
7	60,200,25,415	16820	12098
8	60,200,25,500	15822	11890

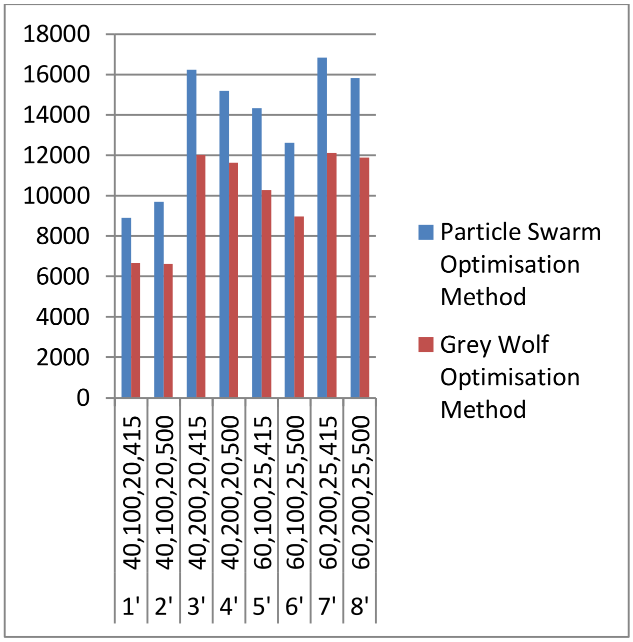

Fig 1.3 Comparison for optimum cost of 8m span

IV. CONCLUSION

In the comparitive study of optimization of a simply supported T-Beam by Particle swarm optimisation technique and Grey Wolf optimisation technique, the following conclusions can be made:

A. For a simply supported Reinforced concrete T-beam of span 4m, on an average Grey Wolf optimisation showed a **10.2%** decreased cost or it can be said **10.6%** better optimisation then Particle swarm optimisation method.

B. For a simply supported Reinforced concrete T-beam of span 8m, on an average Grey Wolf optimisation showed a **15.6%** decreased cost or it can be said **15.6%** better optimisation then Particle swarm optimisation method.

C. Grey Wolf optimisation method proved better in this study owing to its nature of optimising parameters both locally and globally.

D. It is not always true that a better grade of concrete or steel would result in lesser cost for a structural member.

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