Steel Optimization in Industrial Building using Pre-Engineering Building Steel Structure

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Abstract— This In this paper, Genetic Algorithm based optimization presents for the design of portal frame according to Indian standard code. The design mainly consists of column element, Rafter element and haunched portion design. Pre engineering building have light gauge metal steel purlin, matel clading, and economic sections of column, rafter and haunched portion. In this project MAT-LAB Genetic Algorithm has been used to find the optimum design of portal frame according to "IS Code". This design aid can be used directly on structural design practice.

Key words: Genetic Algorithm, Optimization, Portal Frame, MATLAB

I. INTRODUCTION

Now a days portal frame widely applied to the construction of industrial factory buildings because of it permits the creation of buildings with large and uninterrupted span areas with light weight and easy installation. It also design in such a way that they have greater strength and rigidity that satisfy the strength and serviceability requirements. As price of material specially steel increased day by day so designer or clients always forced to reduce the section and construction time period to fight against competition. And structure engineer always interested to economize, optimize or lightening the structure section. Now a day it is possible with the help of engineering optimization techniques to find optimum solution with the help of computer application. In case of engineering optimization problem with large number of complex objective function with constrains that require global optimum solution to find. In such case the traditional methods are not guaranteed to find the global or near global solution. So where as genetic algorithm that optimize on natural phenomena of survival of the fitest and adaptation. The Genetic Algorithm optimization technique is providing reliable results as compare to other general optimization technique. GA methods are very helpful for more economical structure design and it becomes more popular now a days because of its efficiency, rapidity and the ability of using any kind of problems. Porpose of this project is to create an program with MAT-LAB to find the optimal steel portal frame design.

II. FRAME DESCRIPTION

A. *Frame Loading*

- Dead Load as per IS 875 part 1
- Live Load as per IS 875 part 2
- Wind load as per IS 875 part 3

Combination of loading and final loads are applied on frame in the form of UDL on rafter portion

B. *Frame Analysis*

Analysis of frame is done by staad pro package and various analysis results are taken for design purpose. Results of analysis for each important nodes are preserve for design some of important nodes are shown in figure below.

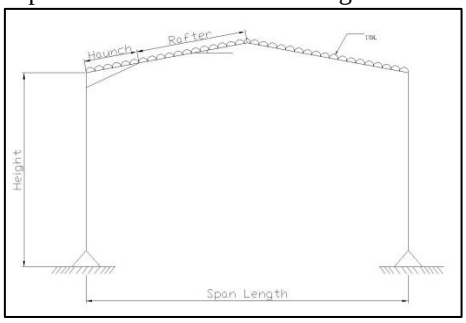

Fig. 1: Analysis of frame

Mainly frame is devided in three element Column, Rafter and Haunched portion.

The portion of haunch is again seperated by five sections and checks are provided individualy to that sections

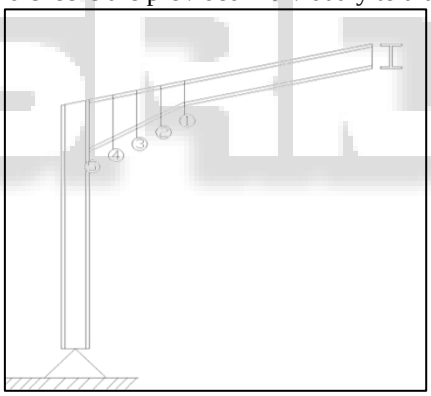

Fig. 2: Haunch

III. MEMBER CHECKS

For checking capacity of section to resist upcoming loads following checks must be require to satisfy by section.

A. *For Column Section*

1) Cross section classification
2) Compression resistance
3) Shear resistance
4) Bending Moment resistance
5) Bending and Axial for Interaction
6) Check for Biaxial bending
7) Member buckling resistance in Compression
8) Member buckling resistance in Bending
9) Member buckling resistance in Combined bending and Axial compression

B. *For Rafter and Haunched Section*

1) Cross section classification

2) Compression resistance
3) Shear resistance
4) BendingMoment resistance
5) Bending and Axial for Interaction
6) Check for Biaxial bending
7) Member buckling resistance in Compression
8) Member buckling resistance in Bending
9) Member buckling resistance in combined Bending and Axial compression
10) Web Bearing check
11) Web buckling check

IV. STRUCTURAL OPTIMIZATION

The insterst of engineer in the area of optimization for the last few years is due to availability of powerful computer tools and rapid development methods in analysis and optimization field. For adopting lighter stronger and cheaper structure industry adopts higher forms of optimization.

Major form of optimization of structure is its self weight and it is associated with overall cost of building. Before few decades it wasn't possible to find globle or nearly blobal solution for complex engineering problems because of unavailability of computers but now it is possible easily.

Structural optimization means to find the best structure that can transfer a certain loads in space to a fix support. The structure is best which is use the material in the most economical way. But the optimization result doesn't refer to the lightest weight but it can also refer to many variables e.g. more buckling resistance, more stiffer. So it should fulfill some structural, constructional and manufacturing types of requirements.

In optimization objective function followed by some of constrains. Constrain can be stress, displacement or geometry. The structural optimization consist of objective function and variables

Objective function is the main formulation that needed to be minimised or maximization.

Constrains: Design constraints are restrictions that must be satisfied to produce an acceptable design.

V. GENETIC ALGORITHM OPTIMIZATION

Genetic Algorithm is an important method in which problems are characterized by mixed continuous discrete variable dand discontinuous and nonconvex design spaces. Genetic Algorithm become popular now a days due to requirements of finding a fast and an effective method to solve wide type of optimization problems.

One of the most important base of Genetic Algorithm is Darwin's principle for the natural evolutions that is "survival of fittest". Genetic Algorithm handle group of solutions in every cycle instead of a single one and find fitest one among them. In each iteration the population is upgraded through three important operations that selection, crossover and mutation for creation of new fitter generation.
Selection: It is the first operation of GA to be applied to the population. It is simple idea of picking the good individuals and put them in a mating pool in selection picking an above average string, duplicate it and insert it again in the mating pool.

- Crossover: The idea of crossover method is based on randomisation. In crossover method taking two string from the mating pool cut them at certain point and finally switching the cut portions,
- Mutation: The aim of mutation is to introduce genetic diversity into the population. This operation is responcible for fine tuning capabilities of the system. It can be applied to a single or multiple chromosome.

VI. METHODOLOGY

A. Objective Function

Prelimnary requirement of optimization is to minimise the cross section and ultimatly member weight so objective function or Minimizer is

$$= \sum(Agn \times Wn \times Ln)$$

Subjected to:

1) $N/Nd \leq 1.0$
2) $V/Vd \leq 1.0$
3) $Mx/Mdx \leq 1.0$, $My/Mdy \leq 1.0$
4) $Mdx/Mndx \leq 1.0$, $Mdy/Mndy \leq 1.0$
5) $(my/Mndy)^{\alpha 1} + (Mx/Mndx)^{\alpha 2}$
6) $P/Pdx \leq 1.0$, $P/Pdy \leq 1.0$
7) $M/Mltd \leq 1.0$
8) $(P/Pdy)+[(ky.cmy.My)/Mdy]+kLT(Mx/Mdx) \leq 1.0$,$(P/Pdz) + [(0.6\ ky.cmy.My)/Mdy] + [(kx.cmx.Mx) / Mdx] \leq 1.0$

B. Result Output

Output result provides optimum section at each important nodes which are of following section properties at important nodes.

Element	Length (mm)	Bf (mm)	tf(mm)	tw(mm)	H (mm)	Ag(mm^2)	Weight Kg.
Column	L						
Rafter	L						
Haunched	L						
Total Weight of frame							

Table 1: Shows calcution for Optimum section

After calcution number of section provide by the output result that can be used in sequatia manner.

VII. CONCLUSION

Using Genetic Algorithm programe to Optimize the portal frame design has lot of advantages like fast convergence, Convinient and Precise calculation. For design of frame with various codal constraints optimal result can be obtain to give economic design. By the uses of Genetic Algorithm optimization the considerable saving in weight and cost of Pre-Engineering Building frame is obtain.

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