



OPTIMIZATION OF I-GIRDER BRIDGE USING GENETIC ALGORITHM METHOD

Engineering

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ABSTRACT

I-Girder Bridge is gaining popularity because of its serviceability, structural efficiency and economic. Hence in this study pre-stress concrete is used and optimized design is carried out for span of 30m. Loadings are taken as per IRC: 6-2012, IRC: 18-2000 and IRC: 21-2000 specifications. Genetic algorithm method is used for the optimization of I-Girder Bridge and design is carried out by limit state method. A computer programme is coded using MATLAB CSI-API software for optimization and analysis result are retrieved from Csi bridge V20 software to carry out optimization process.

KEYWORDS

I-girder, Pre-stressed, Genetic Algorithm, Csi bridge Software, MAT LAB.

1.Introduction

Bridge is a type of structure which generally provides passage over an obstacle without closing the way beneath. In present circumstances, the networking of road is being carried out by pre-stressed concrete I-girder bridge which is gaining popular because of its serviceability, superior stability, low maintenance, structural efficiency and economical. The main concept of pre-stressed concrete bridge was introduced by Freyssinet in the year 1930[1].

Pre-stressed of a concrete I-girder bridge usually involves applianc of an exterior strength to the concrete by the use of wires, strands or bars which can enhance the strength of concrete. I-girder Bridge is usually adopted for a span of 10m-30m which gives better shear resistance.

2.Need for optimization

There are numerous acceptable design for single problem design, however among all the adequate designs, one which is most economical will fulfill engineering and structural standards as well as conservative need. The demonstration of acquiring the best outcome under given condition is called optimization. Optimization means maximum benefit at a minimum cost.

In present study, structural engineering it is easy to get safe designs but it is difficult to get economic design. Hence it is necessary to go for optimum design which helps in reducing cost and saves materials because of these optimization has good scope in structural engineering. In this project the cost optimization of I-girder Bridge is carried out.

3.Analysis of I-girder Bridge

The analysis of I-girder is done by using Csi Bridge V20 software; it applies a genetic algorithm that idealizes the I-girder Bridge as a most productive bridge design package in the industry. Because it integrates modeling, analysis and design of bridge structure into a versatile and easy to use optimized tool.

4.Optimization process

The process has gain popular in many fields like structural engineering, the main reason behind that, there is vast development in technology in various fields. The preparation of all such decisions is to minimization of objective function. To find the optimal value under given set of condition, technically variables are function and condition as constraints.

4.1Genetic algorithm method

It is non-traditional search technique in the vast majority of cases it will locate the most conservative global optimum solutions. These methods begin with an arrangement of design points with available variables, it takes a shot at the vital of natural genetic and natural section. From the early arrangement of design points, new arrangements of design points are created and weaker focuses are evacuated. The essential thought of genetic algorithm was created in the year 1960 and mid-1970s, by John Holland [2], henceforth it is origination and this strategy is utilized as

an apparatus in computerized reasoning and PC programming. Along these search this idea depends on Darwin's theory of survival of fittest. Genetic algorithm gets its name so subsequently it utilizes fundamental components of common natural genetics. It works with a coding of the arrangement of feasible point as opposed to the set of generated created itself to find from an arbitrary arrangement of points instead of the set itself. It utilizes arbitrary activity in every iteration process. The flow chart of genetic algorithm illustrates the working process,



Fig 3.1 Flow chart of Genetic Algorithm Method

4.2Optimization of I-Girder Bridge

Optimizer is created on the bases of genetic algorithm programming; the issue is mechanized by composing a Computer programme in MATLAB software which is easy to use and adaptable for optimization of PSC I-Girder. Csi bridge software V20 is connected to recover the outcome from it and to do the optimization procedure.

Number of variables, constraints and maximum number of generation gap should be entered as input and also permissible stress, deflection for a grade of cement should be as per code.

Testing of optimizer

Before connecting with the design program it is important to check the optimizer to ensure that analyzer is working appropriately and in this section one of the test issue is clarified by taking a 10 bar truss problem is solved by referring literature [3], as shown in fig with dimensions, loading, and other required parameters. The assumed data are, $E = 104$ ksi (6.89 x 104 MPa), $p = 0.10$ lb/in³ (2,770 kg/m³).

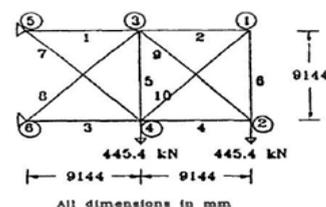


Fig.3.2 10 bar truss problem detailing

Constraints- 2	Variables- 10
Stress ± 172.5 Mpa	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10
Displacement ≤ 50.8 mm	Where, A=Area of element.

Table3.1 Comparison of result-10bar truss problem

Solution from		Elperin	S. Rajeev & C.SKrishna moorthy	Present study
Weight (N)		25,829.7	22,653.5	23,071.1
Variables	A1	200	206.4	209.2
	A2	0.645	0.645	0.645
	A3	129.0	151.6	90.32
	A4	90.32	103.2	170.9
	A5	0.645	0.645	0.64
	A6	0.645	0.645	0.64
	A7	51.61	54.8	64.54
	A8	145.1	129.0	126.3
	A9	96.7	132.2	129.4
	A10	0.645	0.645	0.645

4.3 Optimization of I-Girder Bridge.

After testing the simple problem of optimization, subsequent stage is to connect design example to optimizer, in this section the process of optimization is carried out for I-girder of span 30m, carriage width of 7.5m and M40 grade of concrete and Fe415 grade of steel is carried out and the following inputs are listed below.

- 1) No of variables -6
- 2) No of constraints -2

a) Stress $-\frac{\text{stress}}{\text{allowable stress}} - 1 < 0$

b) Deflection $-\frac{\text{total deflection}}{\text{permissible deflection}} - 1 < 0$

Variable Limits	X1 (m)	X2 (m)	X3 (m)	X4 (m)	X5 (m)	X6 (No.)
Lower	2	0.8	0.2	0.4	0.2	2
Upper	3	1.5	0.4	0.6	0.4	3

Where,

- X1=Over all depth of I-girder in meter.
- X2=Breadth of top flange in meter.
- X3=Depth of top flange in meter.
- X4= Breadth of bottom flange in meter.
- X5= Depth of bottom flange in meter.
- X6= No. of internal girder.

5.Results and Discussion

The obtained results are studied with the variety of parameters, 5.1 Parametric study on effect of change in grade of concrete

Table 4.1 Cost of I-girder for various grade of concrete for 30m span.

Sl No.	Grade of concrete	Optimum design variable						Cost (Lakhs)	
		Weight (KN)	X1 (m)	X2 (m)	X3 (m)	X4 (m)	X5 (m)		X6 (No.)
1	M40	427.2	2	0.94	0.2	0.6	0.2	2	Rs.5.55
2	M45	427.0	2	0.89	0.2	0.43	0.2	2	Rs.5.94
3	M50	421.3	2	0.8	0.21	0.41	0.21	2	Rs.6.18
4	M55	418.4	2	0.87	0.2	0.45	0.2	2	Rs.6.51
5	M60	415.4	2	0.75	0.2	0.45	0.2	2	Rs.6.75

- M40 grade of concrete is cost effective and satisfy all checks in design.

5.2 Parametric study on effect of change in I-girder span for M₄₀ grade of concrete.

Table 4.2 Optimum design variable for different span of M₄₀ grade concrete

Sl No.	Span (m)	Optimum design variable						
		Weight (KN)	X1 (m)	X2 (m)	X3 (m)	X4 (m)	X5 (m)	X6 (No.)
1	10	216.5	2.06	0.85	0.20	0.4	0.20	2
2	20	376.1	2.2	0.89	.24	0.46	0.24	2
3	30	427.2	2	0.94	0.2	0.6	0.2	2

- Increase in the span of girder, results increase in the weight of girder.

5.3 Optimum cost and variables of I-girder

Table 4.3 Optimum cost and variables for span 30m and M40 grade of concrete.

Initial Variables							
Weight (KN)	X1 (m)	X2 (m)	X3 (m)	X4 (m)	X5 (m)	X6 (No.)	Cost (lakhs)
452.4	1.8	1.2	0.25	0.5	0.25	2	Rs.6.15
Optimum Variables							
427.2	2	0.94	0.2	0.6	0.2	2	Rs.5.55

- It can be seen that weight of I-girder Bridge is decreased from 452.47KN to 427.24KN.
- The cost of girder decreased from Rs.6.15 Lakhs to Rs. 5.55 Lakhs, i.e. Rs. 60,000 reduced in optimization

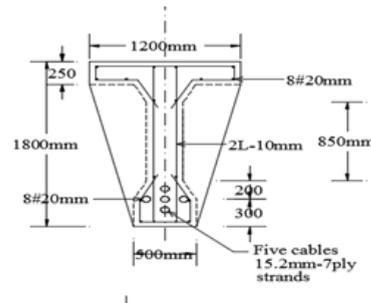


Fig.4.1 Before optimization Reinforcement section

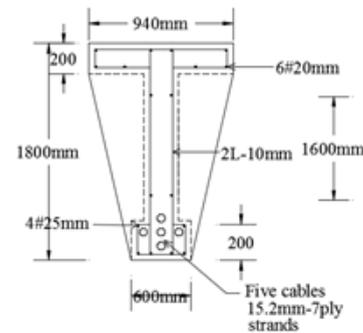


Fig.4.2 After optimization Reinforcement section

Table 4.4 Variation in pre-stressing force and No. of tendons.

Span (m)	Grade of concrete	Pre-stressing force (KN)	No of strands 15.2mm (5tendons)
Before optimization			
30	M40	7172.27	8
After optimization			
30	M40	6738.90	7

After optimization, design of PSC I- Girder Bridge using optimum section values is carried out and the following results are obtained,

- The pre stressing force decreased from 7172.27KN to 6738.90KN.
- The no. of tendons also decreased from 8nos to 7nos.

6.CONCLUSION

Under the scope of the present study, following conclusions can be made:

1. Genetic algorithm can be adequately applied for the optimization of I-girder.
2. The obtained design by the optimization is more economical than the existing design.
3. Optimum web width remains nearly constant irrespective of girder span and concrete strength.
4. The present optimization problem of 6 number design variables and 2 number constraints is easily solved by Genetic Algorithm.
5. The pre-stressing force is reduced for optimized section compared to the initial section.

2.Recommendations for Further Studies

It is recommended that the study can be extended further in the following fields:

- Study can be extended to various carriage width as per IRC.
- Study can be carried out for different types of loads as per IRC.
- Study can be carried out for different types of bridges.
- Study can be carried out for span length greater than 30m.

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