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Optimization of Shell Structure Using Genetic Algorithm

Nrupatunga Baligar[1], Dr. R J Fernandes[2]

[1]*PG Scholor, SDM College Of Engineering and Technology, Dharwad, Karnataka, India.*

[2]*Assistant Professor SDM College of Engineering and Technology, Dharwad, Karnataka, India.*

Abstract

Shell structure are used efficiently and also economically in many fields or architecture and civil engineering. Shell roofs are made from structural skins here the shell material is thin in section relative to the other dimensions of the roof and undergoes relatively little deformation load. They are commonly used where a building interior needs to be free from intermediate walls or columns that might support a more conventional flat or pitched roof. Shells provide aesthetic view. In this paper, optimization is carried out for different grades of concrete and different chord lengths of shell. A computer program for modeling & analysis using SAP2000 is written in MATLAB software. The program is extended for optimization process using genetic algorithm method, and the results are retrieved from SAP2000 software to carry out optimization.

Keywords: Genetic Algorithm, Optimization, Chord Length, Shell Structure.

I. INTRODUCTION

Shell roofs are made from structural skins here the shell material is thin in section relative to the other dimensions of the roof and undergoes relatively little deformation load. They are commonly used where a building interior needs to be free from intermediate walls or columns that might support a more conventional flat or pitched roof, such as libraries, theaters, leisure centers, airport and so on. Shell roofs can be flat, but are typically curved, assuming a cylindrical, domed, parabolid oe ellipsoid shape. The curvature of shell structure benefits from the structural efficiency less material is generally needed compared to more traditional roofs. There are two types of shell.

Singly curved shells and doubly curved shells. The structural behavior of shells, compared to that of other type of high loads and allow covering important spaces using little material and thickness. Moreover, shells present an attractive lightness and elegance from an aesthetic point of view.

Genetic algorithm belongs to the family of evolutionary algorithms. GA is an iterative procedure that is motivated by the survival of the fittest of Darwinian theory of natural solutions and it is the method for solving both constrained and unconstrained optimization problems.

R.Reitnger & E. Ramm observed that, the optimization of structure with geometrically nonlinear behavior allowing the inclusion of instability phenomena and imperfection sensitivity in the structural design. They proposed optimization procedure is based on the methods of path following, direct computation of bifurcation and limit points and an accurate and efficient sensitivity analysis. The finite element method is used for structural analysis. J. Stegmann and E. Lund observed that, a novel method for doing material optimization of general composite laminate shell structure is presented and illustrated with three examples. The method is Discrete Material Optimization(DMO) and uses gradient information combined with mathematical programing to solve the a DMO. The applicability of the DMO method is demonstrated for fibre angle optimization of cantilever beam, and combined fibre angle and material section optimization of a four point beam bending problem and a doubly curved laminate shell. Antonio Tomas, Pascual Marti observed that, to find optimum geometrical design having an aesthetic shape similar to form initially designed for the structure. As an example, a shell based on Candela's blueprint was optimized under a state of pre dominant gravitational loads the results confirm that significant improvements in the structural behavior of the shell may be achieved with only slight changes in its form. Wu Yongliang, Wei, Wang Bin observed that, a shell is developed by python language with abacus. Finite element method is used for designing and optimizing the thickness and stiffener size of shells. Based on the experimental design a surrogate kriging model is built. Wang, Lei and Zhang, Qilin and Yang, Bin observed that, optimum designed is found which maximizes the stiffness of shell structure and an automated approach for optimizing the shape of free form surface is made. The method used in the paper is implemented into a computational model and the feasibility of the approach is demonstrated using an example.

II. MODELING AND ANALYSIS OF SHELL STRUCTURE

The analysis of shell structure is carried out by using CSI SAP2000 software

Modeling of shell structure in CSI SAP2000.

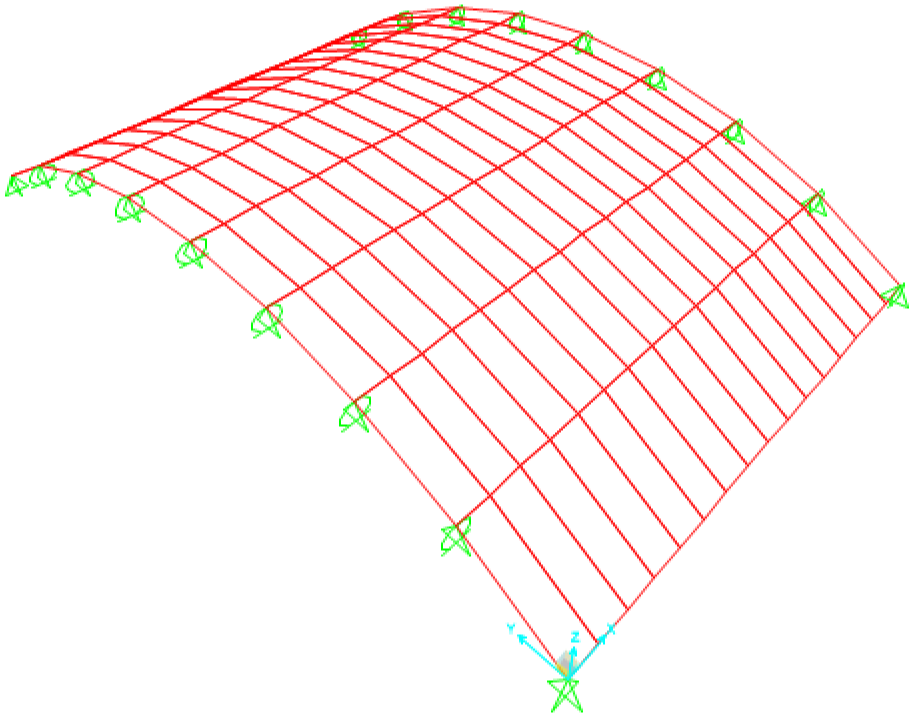

Fig 1. Shell structure model

Data used for the above modeling is as follows.

Grade of concrete: M30.

Chord width: 8 meters

Length: 8 meters

Semi central angle (T): 30 to 45 degrees

No. of divisions: 8

Radius = $\frac{chord\ width}{2*\sin(T)}$

III. RESULT

In this chapter study on process of optimization of shell structure for length 8m with different chord lengths(8,9,10,11,12 m), and M30 grade of concrete is carried out and keeping the length and chord length 8m for different grades of concrete(M20,M25,M30 and M40) made and the following inputs are listed below and the results obtained for the same are as follows.

1) Objective function= Minimization of weight for the shell structure
2) No of variables: 2 (X1 and X2)

3) No of constraints : 2

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

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

Allowable stress for M30 concrete=30N/mm^2

Permissible deflection =Span/360

4) No of individuals per subpopulation : 20 to 100

5) Maximal number of generations: 20 to 100

6) Generation gap: 0.8

7) Lower limit of variable

X1-30degree

X2-75mm

8) Upper limit of variables

X1-45degree

X2-200mm

X1 and X2 are semi central angle and thickness of shell respectively.

Table 1: The optimum results obtained for different chord lengths and M30 grade of concrete

Chord length(m)	Weight(KN)	X1(degrees)	X2(m)
8	12.72999	44	0.075
9	15.84069	43	0.08333
10	19.36084	43	0.091667
11	21.29692	43	0.091667
12	27.21909	41	0.108333

Table 2: The optimum results obtained for chord length 8m and different grades of concrete

Chord length (m)	**Grade of concrete**	**Weight(KN)**	**X1(degrees)**	**X2(m)**
8	M20	10.94152	32	0.141667
8	M25	12.44091	38	0.141667
8	M30	12.72999	44	0.075
8	M40	14.13795	30	0.15

IV. CONCLUSION

In this work, genetic algorithm is successfully applied for optimization of cylindrical shells without edge beams. Optimization is carried out for different chord length and different grade of concretes. Optimum value of weight of the shell structure is determined for above defined parameters. In this present work, optimization of shell structure is carried out by applying uniformly distributed loads throughout the shell structure.

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