"ANALYSIS OF RIBBED SHELLS"

A THESIS
Submitted to
The Faculty of Engineering
Ain Shams University

For the Degree of
MASTER OF SCIENCE
in Structural Engineering

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1976

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بسم الله الرحمن الرحيم

A C K N O W L E D G E M E N T

The author cannot adequately acknowledge his dept of gratitude to his supervisor Prof. Dr. Saafan A. Saafan.

The author wishes to express his sincere gratitude to his supervisor Dr. Ahmed A. Korashy for the guidance, encouragement and efforts offered by him.

The author is deeply indepted to Dr. Mahmoud El-Banna for his valuable and useful suggestions.

Thanks are due to Engineers; Fakhry Abul-Ela and Mostafa K. M. Zidan, Asst. Lecturer, Structural Engineering Dept., Ain-Shams University, for kind assistance.

Thanks for the computer staff centres of Ain-Shams and Cairo Universities, for their help.

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LIST OF SYMBOLS

The following symbols are used in the present thesis.
Other symbols not listed below are defined wherever used.

E = Young's modulus of elasticity.

I = moment of inertia.

N_x, N_y = normal forces developed per unit area in x , y directions.(t/m)

N_{xy} = Shearing force developed per unit area.(t/m)

M_x, M_y = Bending moments.(kg m/m)

M_{xy} = Torsional moment.(kg m/m)

Q_x, Q_y = Shearing forces.(t/m)

u,v,w = Deformations in x , y , z directions.(m.m.)

ν = Poisson's ratio

F = Stress function.

r , t = Change of curvature.

s = Torsional change of curvature.

INTRODUCTION

Shells belong to the class of stressed-skin structures which by virtue of their geometry and small flexural rigidity tend to carry applied loads primarily by direct stresses lying in their plane accompanied by some bending.

Shells possess such many useful properties arising from their elastic nature as :

- By suitable design they can be made to support heavy loads even if they were very thin.

- They have light weight as compared with other structures. This is a substantial factor where economy in the materials is essential.

The theory of shells forms a part of the theory of elasticity concerned with the study of the deformation of elastic bodies under the influence of given loads. For this purpose it will be assumed that the material of the shell is isotropic and obeys Hook's law and that the displacements at a point are small in comparison with the thickness of the shell.

With increasing spans, both in longitudinal and transversal directions, the danger of buckling of the thin shell membrane becomes an important design factor . Similarly the radial deflection can no longer be ignored due to the flattening of the shell are, which is particularly a serious matter in the case of end bays and single shells.

In order to increase the rigidity of the shell structure, also to avoid the bad effect of the concentrated loads on the shell, small stiffening ribs are introduced, either in the transverse or longitudinal pattern. Exceptionally large shells may be stiffened by a system of ribs at right angles to each other. They may be set parallel to the axis of the shell or along the diagonals. The ribs are placed either below the soffit of the shell slab or above it. Since both systems have their disadvantages, it is rather pointless to set the shell in line with their centroids, although theoritically it may be the most correct way. With ribs projecting below the shell membrane, the unbroken ceiling would be desirable. On the other hand, ribs above the shell surface create difficulties in water proofing.

Most of the early analysis of ribbed shells were done for ribbed domes and cylinders by various methods. In this thesis, analysis of double curved shell is the main object.

The present work is concerned with the stress distribution of the ribbed shallow double curved shells. (The shell is called shallow if the ratio between the rise and the side length is less than 1/10). The object is to investigate the effect of stiffeners on the stress distribution and the vertical deformations.

Now the problem of ribbed shell is treated in this thesis by using two methods of analysis :

The first : is the variational method, which is derived for the first time in this thesis. The basic differential equations which govern the behaviour of the ribbed shallow shells under any case of loading can be reduced to a pair of homogeneous equations involving a stress function (F) and the vertical displacement (w). These equations can then be linearly combined to emanate the proper solution.

The second; is the finite element method. In this method the construction consists of an assemblage of elements fitting together in a continuous and close approximation to the shape of the actual shell. The state of stresses in each element is assumed to be a combination of membrane and bending stresses, constant through the thickness of the element and bending stresses varying linearly through the thickness.

Two programs have been used through the analysis.

In conclusion, it must be emphasized that this work intends to give a new presentation of the particular application to the analysis of ribbed shells.

Solution of such shells need a great effort especially in the development of the methods of analysis, studying the convergence of the various shell and ribbed shells solution, preparing the computer programs, ...etc.

CHAPTER (I)

REVIEW OF PREVIOUS WORK .

1-1 : Shell Analysis :

Shell analysis means the estimation of the internal stresses caused by the external loads.

There are two main theories for this estimation :

a) Classical Membrane Theory :-

A shell which carries loads entirely by direct stresses lying in its plane is known as membrane. For membrane action to be possible, the shell must be thin.

In the membrane theory, the shell is idealized as a membrane incapable of resisting bending stresses.

This theory provides the solution of such problems depending on the condition of static equilibrium (6 , 20).

Membrane theory doesn't give a complete solution for the different types of shells, because it neglects the effect of the bending stresses, especially near the boundaries. Thus it is not sufficient to solve all shell problems as :-

1) The effect of a non-uniform or concentrated load.

2) The sudden change of geometry, curvature and shell thickness.

3) The variety of boundary conditions of the shell.

For these reasons, the classical membrane theory cannot be used to solve the ribbed shell problem.

b) <u>Approximate Bending Theory</u> :-

In this theory the external loads are carried by the membrane and the bending stresses.

The following assumptions are considered :-

1) The straight fibers which are perpendicular to the middle surface before deformation remain as such after deformation and do not change their length.

2) The normal stresses acting on planes parallel to the middle surface may be neglected in comparison with the other stresses.

Here two bending theories are mentioned as follows :-