Study on Effect of Diameter, Compressive Strength and Number of Ribs on the Large Concrete Monolithic Dome

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***Abstract* - This paper studies the effect of diameter, number of ribs and compressive strength on the large concrete monolithic dome. Monolithic dome structures are thin-wall reinforced concrete shell structures, capable of providing safe shelters for people in the areas with hurricanes and earthquakes. These structures use a minimum amount of material for the area to cover, they are easy to erect since no form work is required, and more importantly, they are heat efficient. Very few studies have been devoted to the case of the analysis of large concrete dome. This paper presents a study of the finite element analysis via ANSYS software for the large concrete dome and numerical percentages of the variation of ultimate loads and vertical deflection at dome apex with variation of each of those parametric has been computed**

***IndexTerms* - ANSYS, concrete, finite element method, monolithic dome, spherical shell**

I. INTRODUCTION

Dome is one of the most efficient shapes in the world since it covers the maximum volume with the minimum surface area. And today's trend is to maintain large volumes with no interrupting columns in the middle. Maintaining this with an efficient shape would be more efficient and economic. So the use of domes will help having larger volumes with no interrupting in the middle. In the recent years, thin shell structures find wide applications in many branches of technology such as space vehicle, nuclear reactor, pressure vessels, roofs of industrial building and auditoriums. From the point of view of architecture, the development of shell structure offers unexpected possibilities and opportunities for the combined realization of functional, economic and aesthetic aspects. Dome structures have been used as the cover of great spans in different modern and ancient architectural works, due to their geometric form, stiffness and self supporting condition. In recent years, large reinforced concrete domes have been used as innovative forms in the development of silos because of their great height in relation to the span that they cover. Likewise, their structural and architectural advantages have been taken advantage in residential buildings, schools and stadiums. However, the complexity of their design and construction limit their massive use around the world.

The dome is one of the most efficient and inherently stable structures by virtue of its spatial form and load-carrying mechanism. The dome, or spherical cap, is a doubly-curved shell structure; a non-developable surface that is stronger and more stable than other singly curved shell structures. In addition to the stable form, shell structures, in general, carry applied loads by an efficient mechanism known as the membrane action, as opposed to the generally less efficient bending action in framed structures. The membrane action consists of in-plane normal and shear stresses only, which enables a shell with a small thickness to absorb very large loads with relatively low in-plane stress resultants and are able to cover large spans with very small thicknesses.

II. MODELING

Concrete model adopted

In the current study, concrete material models that deal with the nonlinear three dimensional analysis of reinforced concrete members under static increasing load are considered.

Finite Element Model of Concrete

In the current study, three dimensional 8-node solid elements **(**Solid65) are used to model the concrete in ANSYS. The element has eight corner nodes, and each node has three degrees of freedom u, v and w in the x, y and z directions respectively

Model Generation

In this study the dome with large diameter (50, 70 and 100) meter is analysis with rib and without, firstly the dome is plotted and meshed using solid65 as shown in Fig.(1). The study is concerned on the effect of the ribs on the deflection of the dome. The section of the rib is taken as T- section.

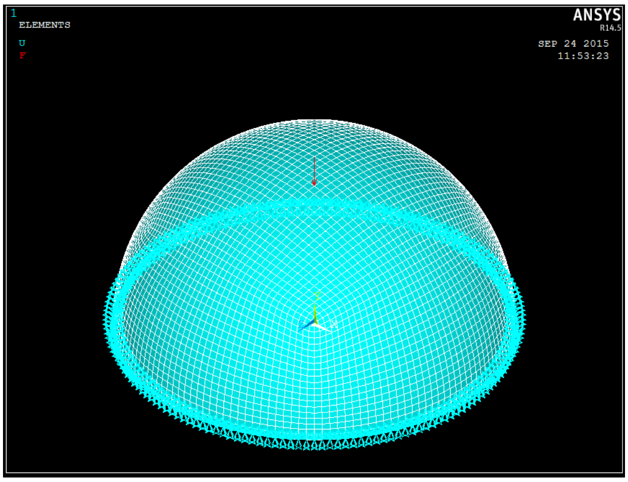

Fig.1 Dome model

III. PARAMETRIC STUDYE

Based on the present finite element model by ANSYS, a parametric study was performed to investigate the influence of several important parameters on the behavior of concrete dome. The parameters studied can be summarized as follows:

1. Diameter of dome
2. Number of ribs
3. Compressive strength of concrete.

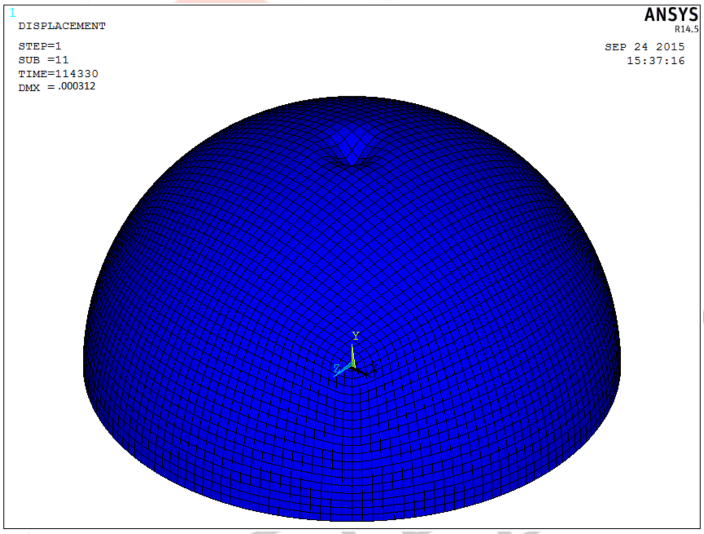

Fig.2 Deformed shape of dome

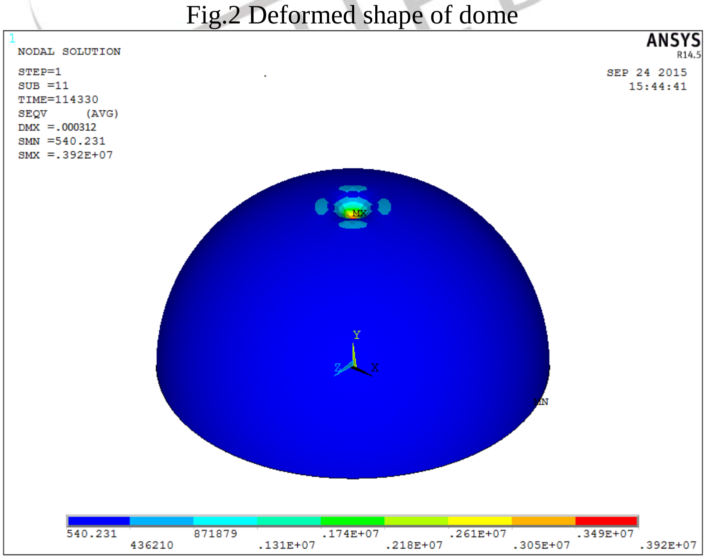

Fig.3 von mises stress

IV. DISCUSSION OF RESULTS

Effect of Diameter of Dome

The load deflection curve of concrete dome of different diametres are considered in this study. The selected values of diameters are 50m and 100m,in addition to the original diameter value,70m.Fig.(4) shows the load-deflection curve at the crown of the dome with different diameter as determined by the ANSYS model .The 50m diameter, caused a decrease in the ultimate load by about (31.2%). Similarly, the 100m diameter, caused an increase in the ultimate load by about (32.5%) relative to the original case (of 70m diameter).

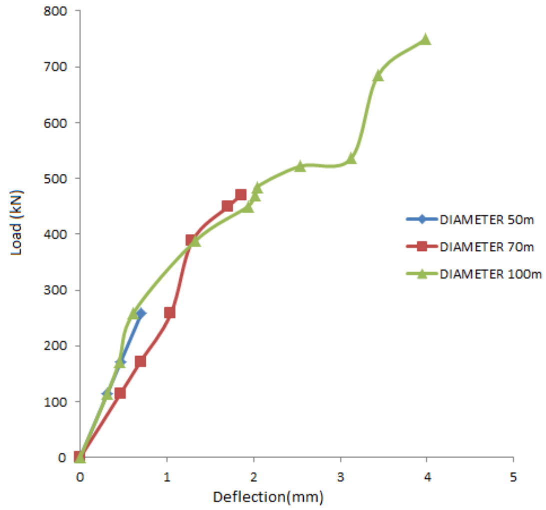

Fig. 4 Load-deflection relationships at crown showing effect of diameter value

Effect of Compressive Strength of Concrete

The load deflection curve of concrete dome of different compressive strength are considered in this study.Fig.(5) shows the load-deflection curves at the crown for un ribbed dome (case(1)) of various concrete compressive strength values. Based on the results of that analysis, the following effects have occurred relative to the load–deflection relationships for the original *f ck* value (30 MPa):

i) Using *f ck* =25 MPa for dome concrete, caused a decrease in the ultimate load by (8%).

ii) The increase of *f ck* value to 35 MPa, caused an increase in the ultimate load by (10%).

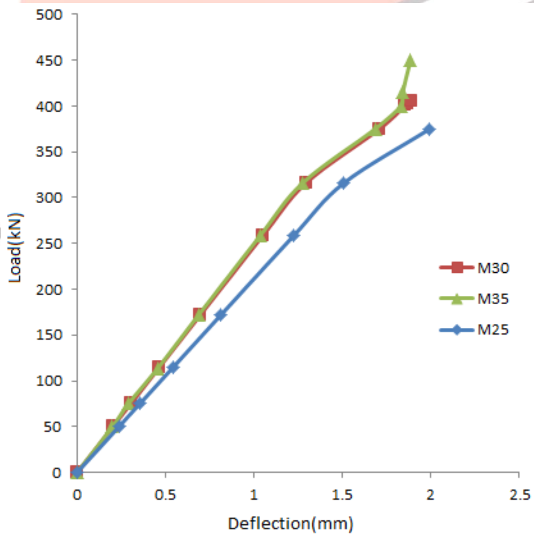

Fig. 5 Load-deflection relationships at crown showing effect of compressive strength of concrete

Effect of Number of Ribs

Three monolithic domes with different numbers of ribs have been considered to study this effect on the load-deflection relationships. Fig.(6) shows the load-deflection curves at the crowns of three ribbed monolithic domes of different numbers of ribs. The selected numbers are 0 (without ribs), 2 and 4 ribs. With respect to the original number of ribs; two; the removal of ribs, caused a 21.2% decrease in the ultimate load. On the other hand, increasing the number of ribs to four ,cased a 25% increase in the ultimate load.

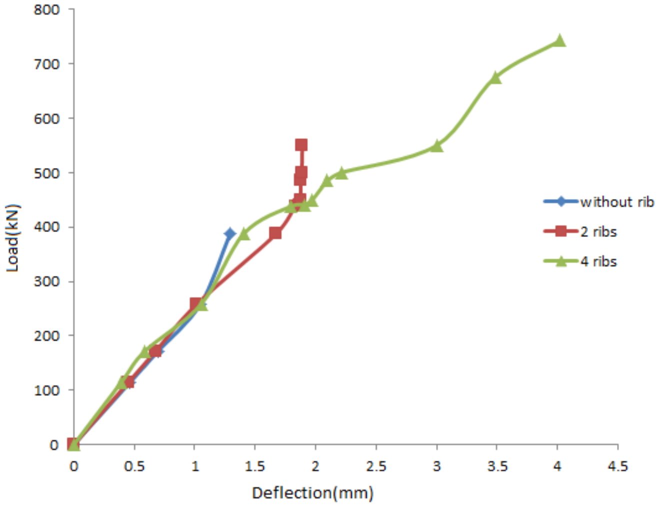

Fig. 6 Load-deflection relationships at crown showing effect of number of ribs.

V. CONCLUSIONS

The present finite element analysis shown that the increasing of dome diameter from 70-100 m causes increasing in ultimate load capacity by about 32.5%. The decreasing of dome diameter from 70-50 m causes decreasing in ultimate load capacity by about 31.2%.

Increasing of concrete compressive strength *f ck* from 30 MPa to 35 MPa, cause to increase in ultimate load capacity by about10% . The decreasing of concrete compressive strength *f ck* from 30 MPa to 25 MPa, cause to decrease in ultimate load capacity by about8%.

Increasing the numbers of axisymmtric meridional ribs from two to four in the dome, causes increasing in ultimate load capacity by about 25%. The removal of the two original meridional ribs in the dome , cause to decrease in all ultimate load capacity with 21.2% .

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