UNIVERSITI TEKNOLOGI MARA

NUMERICAL OPTIMIZATION OF ELEVATED THIN REINFORCED CONCRETE SHELL STRUCTURES SUBJECTED TO EXTREME LOADING

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ABSTRACT

The potential of shell structures as elevated raft foundations to support extreme loads is investigated by exploring the influence of their shape on load-carrying capacity. Traditionally used mainly for roofing, the distribution of compression forces in shell structures has been underutilized in building construction. To address this issue, the research develops and analyses thin shell models as exposed foundations under extreme loading, employing the Finite Element Analysis (FEA) method. The shape optimization process involves minimizing the maximum displacement using the gradient descent algorithm. Additionally, the study designs the reinforced concrete and checks the proposed dimensions for structural adequacy. Ten different shell models with various geometries are proposed and analysed, using LUSAS software and FEA to evaluate the maximum stresses and displacement. Among these models, three demonstrate feasible results, while seven exceed the yield strength of the material used. The best model, Model 3, and a control model, Model 1, undergo further optimization to determine the optimum volume and thickness through the gradient method. Reinforcement details are calculated to ensure the models meet structural integrity requirements. The study's outcomes highlight the potential of shell structures as elevated raft foundations, providing engineers with valuable references for future implementations. The research expands the current knowledge in this area, shedding light on the benefits of utilizing shell structures for extreme load support. By bridging the gap between the traditional use of shell structures and their versatility in different applications, this study contributes to the advancement of engineering practices in the field of foundation design and load-bearing structures.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Shell can be categorized as a thin shell when it satisfied the criterion of the ratio thickness over curvature radius, max(h/R) < 1/20 (Makwana et al., 2021). Thin shell is defined by the middle surfaces, which is located in between of the outer and inner shell of edge, $\frac{h}{2}$ as in Figure 1.1.

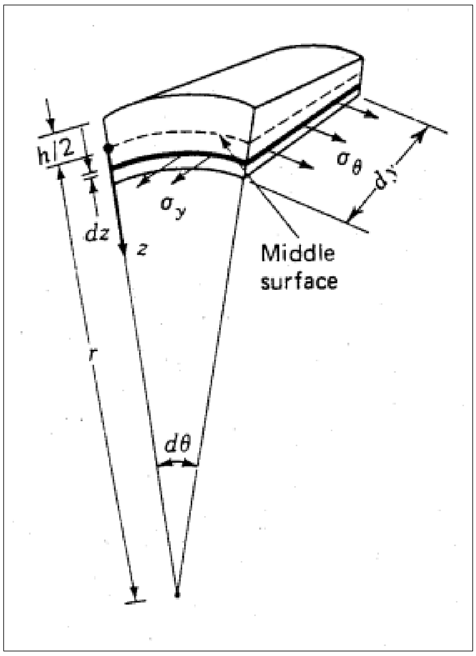

Figure 1.1: Thin Shells' Surface Cross Section.
(Makwana et al., 2021)

Shell structures have several advantages that explain their widespread use in engineering, including their efficient load-carrying behaviour, high level of strength and structural integrity, impressive strength-to-weight ratio, high stiffness, and ability to contain space. This ratio is commonly used to gauge the efficiency of a structural component, with shell structures outperforming other structural systems of the same span and overall dimensions. Additionally, shell structures have significant aesthetic value and are frequently utilized in a variety of architectural designs. Shell surfaces are commonly categorized according to their Gaussian curvatures. In the case of a three-dimensional surface, the Gaussian curvature is obtained by multiplying the highest and