DESIGN OF COST EFFECTIVE COMPOSITE REINFORCED BRICK WORK-FERRO CEMENT WATER TANKS

THESIS SUBMITED TO THE DEPARTMENT OF CIVIL ENGINEERING IN FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF ENGINEERING

BY
R.A.T.N.RANAWAKA

SUPERVISED BY
DR. S.M.A.NANAYAKKARA

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MORATUWA
SRI LANKA
FEBRUARY 2003

DECLARATION

I herewith declare that the work included in the thesis in part or whole, has not been submitted for any other academic qualification at any institution.

08/01/04
Date

R.A.T.N.Ranawaka

Certified by

.....
Date

.....
Dr. S.M.A.Nanayakkara
(Supervisor)

ABSTRACT

In Sri Lanka, the most of the farmers are in dry rural areas and due to lack of water they can't cultivate in an effective manner. Therefore, there is a great need of designing and constructing of water tanks for rainwater harvesting purposes. This research was carried out to formulate design and construction of water tanks by using low cost materials with easy methods of construction and sufficient strength. Then water tanks can be constructed as fully underground, partially under ground as well as above ground, tanks.

Since Sri Lanka is developing country and these tanks are going to be constructed in the rural area, the construction method should be cost effective as well as simple. Ferro-cement is low cost material and it does not require some formwork like in concrete. And also it does not require skilled workers and supervision and also the maintenance is very much easy.

The design is based on analytical results obtain from a computer programme. An experimental investigation was carried out to find the properties of the construction materials required for the design. The computer programme had been already developed for the two types of water tanks, which are cylindrical tanks with spherical roof and flat bottom and cylindrical tanks with spherical roof and spherical bottom. This computer programme was further developed to analise the cylindrical tank with conical roof and spherical bottom. All the tank types can be analyzed using this software for fully under ground, partially under ground and above ground tanks. The linear elastic theory of shells is used to develop this programme.

The optimum dimensions for the water tanks, which gives the highest strength can be found by using the computer programme. It was found that there are three main parameters, which influence to the combined stress in the tank. The main parameters are, limiting angle of the spherical roof, limiting angle of the spherical bottom and radius of cylindrical tanks. The sensitivity analysis was carried out by varying only

one parameter at a time while keeping all the others constant. The analysis was done for all the load cases.

According to the results of the parametric study, optimum tank shape was selected for $25m^3$ capacity tank. The structural design was carried out for the optimum tank shape. A construction process is also presented for the selected tank shape.

ACKNOWLEDGEMENT

I am indebted to my supervisor Dr. S.M.A.Nanayakkara for his devotion, guidance, support and encouragement given to me in order to make my MSc. Degree a success.

I would like to extended my gratitude and appreciation towards;

Vice Chancellor, Dean Faculty of Engineering, the Senate Research Committee of Moratuwa University and the Asian Development Bank, Prof. (Mrs) N. Ratnayake, (Director Postgraduate Studies), Prof. A.K.W.Jayawardana (Head of the Department of Civil Engineering), Dr. G.W.Kodikara (Former Head of the Department of Civil Engineering), Dr. S.A.S. kulathilake (Research Coordinator of the Department of Civil Engineering), Dr.(Mrs.) P.Hettiarachchi (Senior Lecturer of the Department of Civil Engineering) and all the other staff members of the Postgraduate Department of their role in conducting the work related to my MSc. Degree.

All the staff members of the computer lab, construction materials lab, structural testing lab, mechanics of materials lab and the workshop of the Department of Civil Engineering for their assistance and provided necessary facilities in order to carry out the research work.

All the research assistance in the Department of Civil Engineering for the support given to me in various ways.

Finally, I would like to thank all those who provided their assistance, support and guidance to the success of this research project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

NOTATIONS

Φ - Angle between the central axis of the conical shell and axis which is perpendicular to the middle surface of the conical shell at the consideration point.

θ - Angle between any define two lines in the base.

α_o - Angle between the base and the angular surface.

R_0 - Maximum radius of the conical shell (Radius at base)

R - Distance from any point on the middle surface to the axis of rotation along the normal to the middle surface.

X - Sloping distance measured from the apex of the conical shell.

L - The maximum sloping length of the conical shell.

L - Vertical height

El - Vertical height of the opening conical shell from its base.

N_x - Normal inplane force in the meridian direction

N_θ - Normal inplane force in the hoop direction

M_Φ - Bending moment in the meridian direction

M_θ - Bending moment in the hoop direction

Q - Transverse shear

K - Shell constant

Δ - Horizontal displacement

β - Rotations at the boundaries

H - Edge restraining horizontal force

μ - Poisons ratio

d - Depth of ring beam

E - Modulus of elasticity

h - Height of the cylinder

M - Edge restraining moment

t - Thickness of the shell