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STUDY OF WATER TOWERS

THIS THESIS IS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING
IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR
THE DEGREE OF MASTER OF ENGINEERING IN
STRUCTURAL ENGINEERING DESIGN

By

Jeyaranie Sivakumar

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This thesis is submitted to the Department of Civil Engineering of the University of Moratuwa, Sri Lanka, in partial fulfillment of the requirement of the Degree of Master of Engineering in Structural Engineering Design.

Department of Civil Engineering
University of Moratuwa
Sri Lanka
September 2007

DECLARATION

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

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APPENDIX – SPECIMEN CALCULATION

A – INTZE WATER TOWER

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TABLE OF CONTENTS

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NOTATIONS

a - Radius of cylinder, ring beam.

d - Depth of ring beam.

E - Young's Modulus of Elasticity.

H_O - Horizontal force at an edge.

H_R - Radial force in a ring beam.

h - Height of water above the crown of the bottom spherical dome.

h_1 - Depth of water in the cylindrical portion of the tank.

M - Bending Moment - Subscripts s, x, & ϕ denote the meridional bending moments in the conical shell, cylindrical shell and the spherical dome respectively. Subscript θ denotes the redundant moment at an edge. Subscript O denotes the redundant moment at an edge. Subscript R denotes the radial moment in a ring beam.

N - Direct force - Subscripts s, x, & ϕ denote the meridional forces in the conical shell, cylindrical shell and the spherical dome respectively. Subscript θ denotes the hoop force.

P - Line load per unit length.

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P - Load per unit area.

Q - Shearing force -- Subscripts s, x, & ϕ denote the shearing forces in the conical shell, cylindrical shell and the spherical dome respectively.

R - Radius of a spherical dome.

s - Distance of appoint in a conical shell from the vertex of the cone.

t - Thickness of shell, ring beam.

V - Membrane rotation - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively.

v - Rotation due to edge forces and moments - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively. Subscripts H and M denote the horizontal force and redundant moment applied at an edge respectively.

x - Distance of a point from an end in a cylindrical shell.

y - Shell constant for a conical shell.

$$y = 2\sqrt[4]{\frac{12(1-\mu^2)s^2\tan^2\alpha}{t^2}}$$

α_1 - Angle made by a point in the spherical dome with its edge.

α - Angle made by a conical shell with its base circle.

β - Shell constant.

(1) $\beta = \sqrt[4]{\frac{3(1-\mu^2)a^2}{t^2}}$ *for a cylindrical shell*

(2) $\beta = \sqrt[4]{\frac{3(1-\mu^2)R^2}{t^2}}$ *for a spherical shell*

γ - Density of water.

μ - Poisson's ratio.

Δ - Membrane displacement - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively.

δ - Displacement due to edge forces and moments - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively. Subscript R denotes the ring beam. Subscripts H and M denote the horizontal force and redundant applied moment applied at an edge respectively.

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APPENDIX – SPECIMEN CALCULATION

B – CONICAL WATER TOWER

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TABLE OF CONTENTS

NOTATIONS

a	-	Radius of cylinder, ring beam.
d	-	Depth of ring beam.
E	-	Young's Modulus of Elasticity.
H_O	-	Horizontal force at an edge.
H_R	-	Radial force in a ring beam.
h	-	Height of water above the crown of the bottom spherical dome.
h_1	-	Depth of water in the cylindrical portion of the tank.
M	-	Bending Moment - Subscripts s, x, & ϕ denote the meridional bending moments in the conical shell, cylindrical shell and the spherical dome respectively. Subscript θ denotes the redundant moment at an edge. Subscript O denotes the redundant moment at an edge. Subscript R denotes the radial moment in a ring beam.
N	-	Direct force - Subscripts s, x, & ϕ denote the meridional forces in the conical shell, cylindrical shell and the spherical dome respectively. Subscript θ denotes the hoop force.
P	-	Line load per unit length.
P	-	Load per unit area.
Q	-	Shearing force -- Subscripts s, x, & ϕ denote the shearing forces in the conical shell, cylindrical shell and the spherical dome respectively.
R	-	Radius of a spherical dome.
s	-	Distance of appoint in a conical shell from the vertex of the cone.
t	-	Thickness of shell, ring beam.
V	-	Membrane rotation - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively.
v	-	Rotation due to edge forces and moments - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively. Subscripts H and M denote the horizontal force and redundant moment applied at an edge respectively.
x	-	Distance of a point from an end in a cylindrical shell.

y - Shell constant for a conical shell.

$$y = 2\sqrt[4]{\frac{12(1-\mu^2)s^2\tan^2\alpha}{t^2}}$$

α_1 - Angle made by a point in the spherical dome with its edge.

α - Angle made by a conical shell with its base circle.

β - Shell constant.

(1) $\beta = \sqrt[4]{\frac{3(1-\mu^2)a^2}{t^2}}$ *for a cylindrical shell*

(2) $\beta = \sqrt[4]{\frac{3(1-\mu^2)R^2}{t^2}}$ *for a spherical shell*

γ - Density of water.

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Δ - Membrane displacement - Subscripts c, d, b, & t denote the cylindrical shell, spherical dome and the smaller and larger ends of a truncated conical shell respectively.

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APPENDIX – SPECIMEN CALCULATION

C – CYLINDRICAL WATER TOWER

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NOTATIONS

A_n - Constant relevant to shear in brace

B_n - Constant relevant to moment in brace

d_b - Depth of brace

d_c - Diameter or side of column

E - Young's Modulus of Elasticity.

h - Height above top ring beam a which wind on container acts

H - Height of tower

L - Height of panel $= H / (N + 1)$

l - Length of brace $= D \sin \pi / n$

M_{bj} - Moment in the j^{th} brace

M_{ci} - Moment in the column n the i^{th} panel

m_i - Moment in the i^{th} panel

n - Number of columns

N - Number of braces

P_{ci} - Load on the column in the i^{th} panel

w_k - Basic wind pressure

Q_i - Shear in the i^{th} panel

S_{bj} - Shear in the j^{th} brace

S_1 - Multiplying factor relating to topology

S_2 - Multiplying factor relating to height above ground and wind braking

S_3 - Multiplying factor related to life of structure

V - Basic wind speed in m/s

w_T - Wind force on container

w_c	-	Wind force on columns in a panel
w_b	-	Wind force on brace
α	-	Shape factor for wind
θ	-	Angle between column
ψ	-	Ratio between the cylinder height to cylinder mean diameter 0.8 ~ 0.9
μ	-	Poisson's Ratio
γ	-	Weight of Water

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