*भारतीय मानक*
*Indian Standard*

**IS 3370 (Part 4/Sec 3) : 2021**

# जलीय तरल पदार्थों को प्रतिधारित करने के लिए कंक्रीट संरचनाएँ — रीति संहिता

## भाग 4 डिजाइन तालिकाएँ

### अनुभाग 3 वृत्ताकार टैंक

*( पहला पुनरीक्षण )*

# Concrete Structures for Retaining Aqueous Liquids — Code of Practice

## Part 4 Design Tables

### Section 3 Circular tanks

*( First Revision )*

ICS 23.020.01; 91.080.40



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Cement and Concrete Sectional Committee, CED 02

## FOREWORD

This Indian Standard (Part 4/Sec 3) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

The design and construction methods in reinforced concrete and prestressed concrete structures for retaining aqueous liquids are influenced by the prevailing construction practices, the physical properties of the materials and the climatic condition. To lay down uniform requirements of structures for the retaining liquids giving due consideration to the above mentioned factors, this indian standard has been published in four parts. The other parts in the series are:

Part 1 General requirements

Part 2 Plain and reinforced concrete

Part 3 Prestressed concrete

This standard (Part 4) was first published in 1967. The present revision has been brought out with a view to keeping abreast with the rapid development in the field of structural analysis and the results available from finite element analyses of rectangular plates and tanks, and circular tanks (without prestressing), and also to bring further modifications in the light of experience gained while applying the earlier version of this standard. In this revision, the title of the standard has been modified from 'Concrete structures for storage of liquids — Code of practice: Part 4 Design tables' to 'Concrete structures for retaining aqueous liquids — Code of practice: Part 4 Design tables' for better representation of the contents of the revised standard. Furthermore, this standard (Part 4) has been trifurcated into 3 sections for giving due emphasis to each topic covered and convenience of use and handling as:

Sec 1 Plates

Sec 2 Rectangular tanks

Sec 3 Circular tanks

This Standard (Part 4/Sec 3) deals with design tables for circular tanks. The object of the design tables covered in this part is mainly to present data for ready reference to designers and as an aid to speedy design calculations. The designer has the option to adopt any established method of analysis, such as classical elastic plate analysis, finite element analysis or use of deign tables given in this standard as long as the design complies with the requirements of IS 3370 (Parts 1 to 3), and the structural adequacy and safety are ensured.

Tables relating to design of rectangular as well as cylindrical tanks have been given and by proper combination of various tables it may be possible to design different types of tanks involving many sets of conditions for rectangular and cylindrical containers built in or on ground.

In this standard it has been assumed that the design of liquid retaining structures, whether of plain, reinforced or prestressed concrete is entrusted to a qualified engineer and that the execution of the work is carried out under the direction of a qualified and experienced engineer.

The requirements of IS 456 : 2000 'Plain and reinforced concrete — Code of practice (*fourth revision*)' and IS 1343 : 2012 'Prestressed concrete — Code of practice (*second revision*)', in so far as they apply, shall be deemed to form part of this standard except where otherwise laid down in this standard.

Following are the significant modifications incorporated in this revision:

a) Title of the standard has been modified from 'Concrete structures for storage of liquids — Code of practice: Part 4 Design tables' to 'Concrete structures for retaining aqueous liquids — Code of practice: Part 4 Design tables, Section 3 Circular tanks'.
b) Coefficients of ring tension and moments have been revised and enlarged to cover wider range of loading configurations and end-restraint conditions.
c) Coefficients of shear, load and stiffness have been included for use as an aid in the design of circular reinforced concrete structures for retaining liquids.

( *Continued on third cover* )

*Indian Standard*

# CONCRETE STRUCTURES FOR RETAINING AQUEOUS LIQUIDS — CODE OF PRACTICE

## PART 4 DESIGN TABLES

Section 3 Circular tanks

*( First Revision )*

## 1 SCOPE

**1.1** This standard (Part 4/Sec 3) gives design tables of ring tension, shear, moment, load and stiffness coefficients for use as an aid in the design of circular reinforced concrete structures for retaining liquids.

**1.2** This standard does not apply to circular concrete tanks with prestressing. Specialist literature may be referred to in cases, such as the liquid retaining structures having tapered/stepped walls or resting on varying soil strata or subjected to temperature forces.

## 2 REFERENCE

The following standard contain provision, which through reference in this text constitute provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

| *IS No.* | *Title* |
|---|---|
| 456 : 2000 | Plain and reinforced concrete — Code of practice (*fourth revision*) |

## 3 CIRCULAR TANKS

### 3.1 Circular Tank Analysis Results

The coefficients of ring tension ($F_{tc}$), shear ($V_c$), moment ($M_c$), load ($P_c$) and stiffness ($K_c$) for use as an aid in the design of circular tanks with different loading configurations and end-restraint conditions (*see* **3.1.6**) obtained from finite element analyses have been tabulated in Tables 3 to 20.

**3.1.1** *Tension*

Tension in circular ring per unit height, $F_t$ (in N/m) is given by the following equation:

$F_t = F_{tc}\, wHD/2$, in case of triangular loading;

$= F_{tc}\, pD/2$, in case of rectangular loading;

$= F_{tc}\, V_a D/2H$, in case shear, $V_a$ (in N/m) is applied at top; and

$= F_{tc}\, M_a D/2H^2$, in case moment, $M_a$ (in N-m/m) is applied at base.

where

$F_{tc}$ = tension coefficient (*see* col 3 of Table 1) ;

$w$ = unit weight of liquid, N/m$^3$;

$H$ = height of loaded area of the tank, m;

$p$ = uniform rectangular loading, N/m$^2$; and

$D$ = inside diameter of the tank (in m), if impermeable lining is used, else inside diameter + wall thickness (in m).

**3.1.2** *Shear*

Shear at the base of cylindrical wall per unit height, $V$ (in N/m) is given by the following equation:

$V = V_c\, wH^2$, in case of triangular loading;

$= V_c\, pH$, in case of rectangular loading; and

$= V_c\, M_a/H$, in case moment, $M_a$ (in N-m/m) is applied at base.

where

$V_c$ = shear coefficient (*see* Table 18).

**3.1.3** *Moment*

a) Moment in cylindrical wall per unit height, $M$ (in N-m/m) is given by the following equation:

$M = M_c\, wH^3$, in case of triangular loading;

$= M_c\, pH^2$, in case of rectangular loading;

$= M_c\, V_a H$, in case shear, $V_a$ (in N/m) is applied at top; and

$= M_c\, M_a$, in case moment, $M_a$ (in N-m/m) is applied at base.

where

$M_c$ = moment coefficient (*see* col 4 of Table 1).

b) Moment in circular slab per unit height, $M$ (in N-m/m), is given by the following equation:

$M = M_c\, pD^2/4$, in case of rectangular loading; and

$= M_c\ M_a$, in case moment, $M_a$ (in N-m/m) is applied at edge.

where

$M_c$ = moment coefficient (*see* col 3 of Table 2).

**3.1.4** *Load*

Load, $P$ (in N), on centre support for a circular slab is given by the following equations:

$P = P_c\ pD^2/4$, in case of hinged and fixed support; and

$= P_c\ M_a$, in case moment, $M_a$ (N-m/m) is applied at edge.

where

$P_c$ = load coefficient (*see* Table 19).

**3.1.5** *Stiffness*

a) Stiffness, $K$ (in N), of a circular plate is given by the following equation:

$$K = K_c\ 2E_c t^3/D$$

where

$K_c$ = stiffness coefficient (*see* Table 20);

$E_c$ = Modulus of elasticity of concrete, MPa (*see* IS 456); and

$t$ = thickness of plate, mm.

b) Stiffness of cylindrical wall is given by the following equations:

Moment stiffness per unit rotation = $2\ \eta\ Z$ ;

Thrust (radial) stiffness per unit rotation = $2\ \eta^2\ Z$;

Moment stiffness per unit radial displacement = $2\ \eta^2\ Z$; and

Thrust (radial) stiffness per unit radial displacement = $4\ \eta^3\ Z$.

where

$$\eta^4 = 12\ /\ (D^2\ t^2);\ \text{and}$$

$$Z = E_c\ t^3\ /\ 12\ .$$

**3.1.6** *Loading Configurations and End-restraint Conditions*

The various loading configurations and end-restraint conditions of circular tanks for which design coefficients of tension in circular rings ($F_{tc}$) and moment ($M_c$) have been tabulated in Tables 3 to 13 are given in Table 1, and those of circular slabs for which design coefficients of moment ($M_c$) have been tabulated in Tables 14 to 17 are given in Table 2.

Additionally, the shear design coefficients ($V_c$) have been given for the shear at the base of the cylindrical wall in Table 18, load design coefficients ($P_c$) for load on centre support for circular slab in Table 19 and stiffness design coefficients ($K_c$) for cylindrical plates in Table 20.

**3.2 General Assumptions in Design**

**3.2.1** *Top Edge of Wall*

For estimating hoop tension and vertical bending moments in circular wall, the top of wall can be assumed to be free that is, without any radial or rotational restraint. This assumption is conservative and makes very little difference, except in top portion of wall where hoop tension, shear and moment are already very small.

For design of roof slab connected to wall, continuity analysis shall be done for wall and slab joint, allowing for rotation of wall top due to liquid pressure on wall in membrane case. In absence of such an analysis at the junction, the slab can be assumed to be hinged to wall and nominal reinforcement to limit cracks may be provided in slab to resist negative moment at wall junction.

**3.2.2** *Base of Wall*

If wall base is monolithic with a slab, it acts as a diapharm and prevents the radial displacement to a negligible value. Thus, wall base can be assumed to be restrained from radial displacement. In many cases, the slab at base of wall provides rotational restrain in radial direction.

For ground supported tanks, bottom edge of wall panel may be assumed as per the following:

a) If foundation strata is rock or hard soil (corrected standard penetration '$N$' value > 30 or refusal), the rotation of wall base will be very small, and may be assumed to be fixed at bottom.
b) For soft soils in foundation ($N$ < 15), moments and shear may be taken as the algebraic sum of the one third of difference (between fixed and hinged condition) and hinged case. Moment and shear at bottom edge may be taken as average of fixed and hinged end-restraint case.
c) In cases other than covered in (a) and (b), the base provides partial restrain against rotation, and wall base may be assumed to be partially fixed that is, condition in between fixed and hinged. Design moments and shear in wall (except bottom edge) may be taken as average of fixed base and hinged base end-restraint. However, design moment and shear at bottom edge should be reduced by one third of the difference of fixed and hinged end-restraint cases from fixed end-restraint case.

**Table 1 Loading Configurations and End-restraint Conditions for Cylindrical Walls**

( *Clauses* 3.1.1, 3.1.3 *and* 3.1.6 )

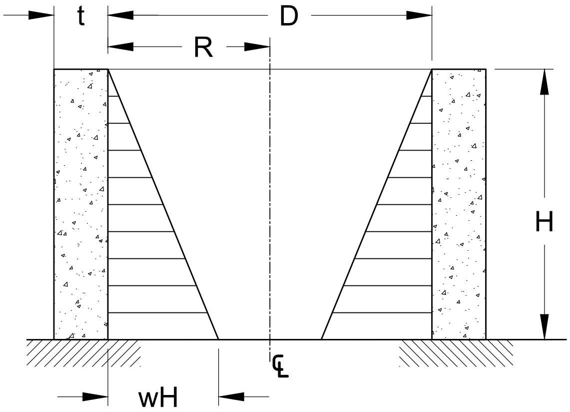
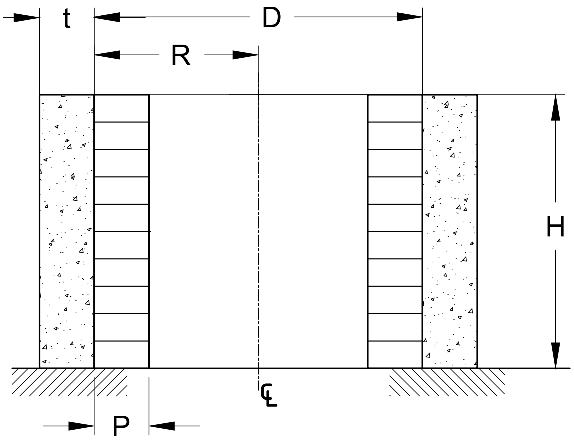
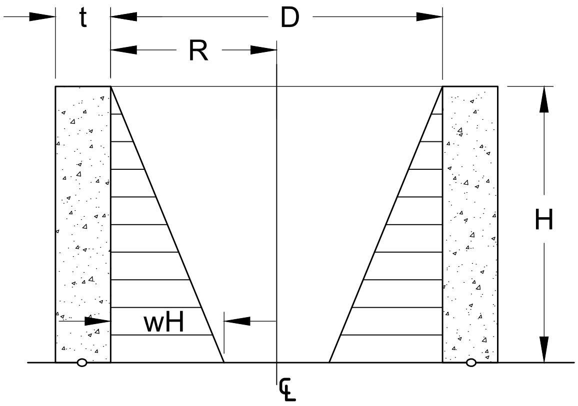
| Case | Figure | Tables of (Ref to) | |
|---|---|---|---|
| | | Ring Tension Coefficients, $F_{tc}$ | Moment Coefficients, $M_c$ |
| (1) | (2) | (3) | (4) |
| Case 1 | <br><br>a) Fixed base, free top, subjected to triangular loading | Table 3 | Table 4 |
| Case 2 | <br><br>b) Fixed base, free top, subjected to uniformly distributed loading | Table 5 | Table 6 |
| Case 3 | <br><br>c) Hinged base, free top, subjected to triangular loading | Table 7 | – |

**Table 1** *( Concluded )*

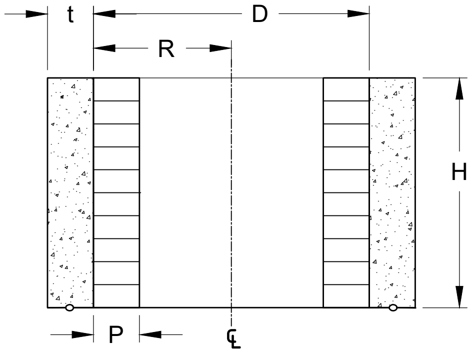
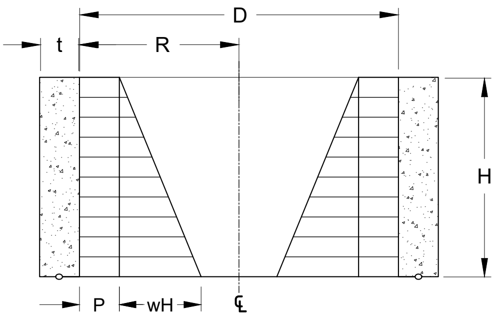
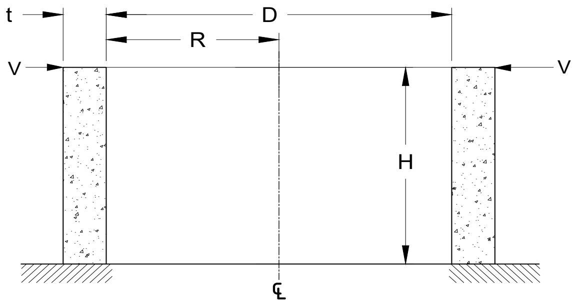
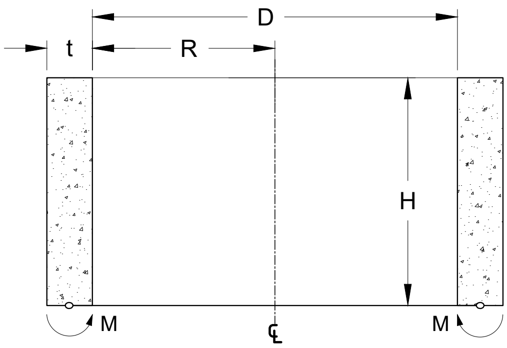
| **Case** | **Figure** | **Tables of (Ref to)** Ring Tension Coefficients, $F_{tc}$ | **Tables of (Ref to)** Moment Coefficients, $M_c$ |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| Case 4 | <br>d) Hinged base, free top, subjected to uniformly distributed loading | Table 8 | – |
| Case 5 | <br>e) Hinged base, free top, subjected to trapezoidal loading | – | Table 9 |
| Case 6 | <br>f) Fixed base, free top, shear applied at the top | Table 10 | Table 11 |
| Case 7 | <br>g) Hinged base, free top, moment applied at the base | Table 12 | Table 13 |

**Table 2 Loading Configurations and End-Restraint Conditions for Circular Slabs**

( *Clauses* 3.1.3 *and* 3.1.6 )

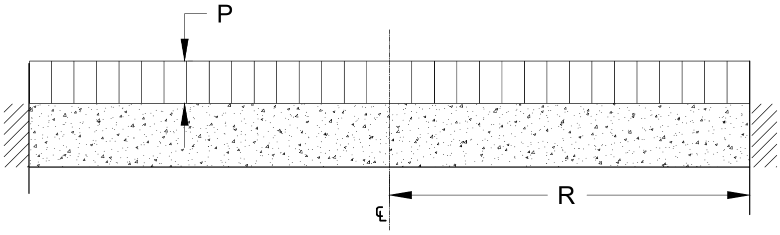
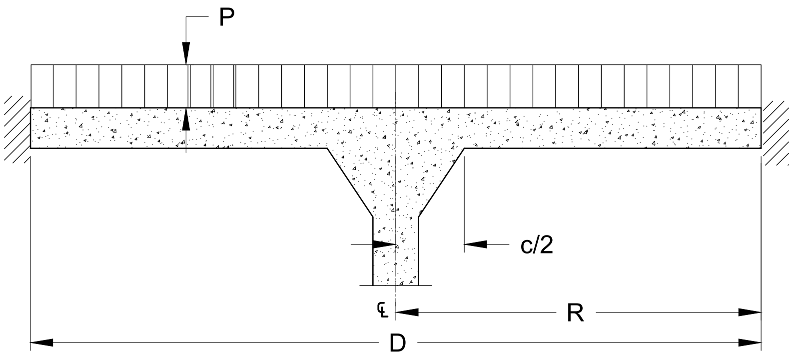
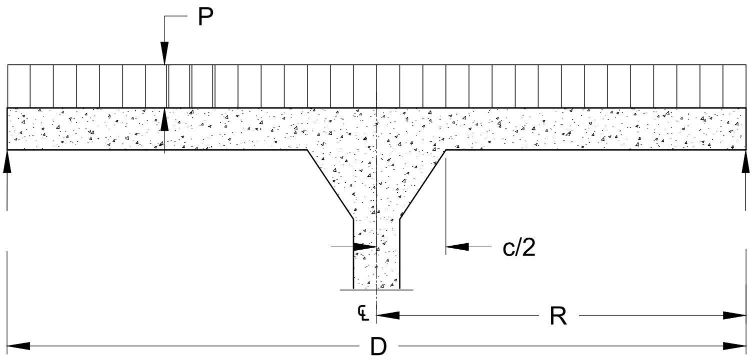
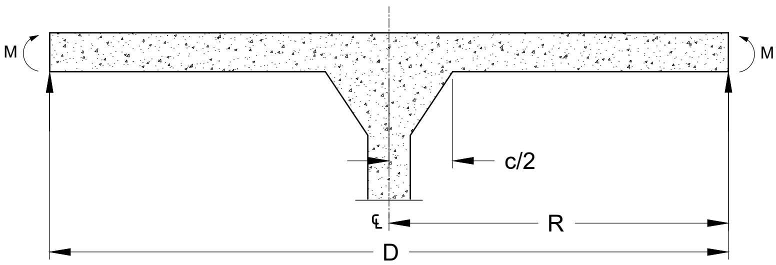
| Case | Figure | Tables of Moment Coefficients, $M_c$ (Ref to) |
|---|---|---|
| (1) | (2) | (3) |
| Case 8 | <br>a) Fixed base, without centre support, subjected to uniformly distributed loading | Table 14 |
| Case 9 | <br>b) Fixed base, with centre support, subjected to uniformly distributed loading | Table 15 |
| Case 10 | <br>c) Hinged base, with centre support, subjected to uniformly distributed loading | Table 16 |
| Case 11 | <br>d) Hinged base, with centre support, subjected to moment at edge | Table 17 |

**Table 3 Ring Tension Coefficients for Case 1 Arrangement**

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 3A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0*H* | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* |
| 0.4 | +0.149 | +0.134 | +0.120 | +0.101 | +0.082 | +0.066 | +0.049 | +0.029 | +0.014 | +0.004 |
| 0.8 | +0.263 | +0.239 | +0.215 | +0.190 | +0.160 | +0.130 | +0.096 | +0.063 | +0.034 | +0.010 |
| 1.2 | +0.283 | +0.271 | +0.254 | +0.234 | +0.209 | +0.180 | +0.142 | +0.099 | +0.054 | +0.016 |
| 1.6 | +0.265 | +0.268 | +0.268 | +0.266 | +0.250 | +0.226 | +0.185 | +0.134 | +0.075 | +0.023 |
| 2.0 | +0.234 | +0.251 | +0.273 | +0.285 | +0.285 | +0.274 | +0.232 | +0.172 | +0.104 | +0.031 |
| 3.0 | +0.134 | +0.203 | +0.267 | +0.322 | +0.357 | +0.362 | +0.330 | +0.262 | +0.157 | +0.052 |
| 4.0 | +0.067 | +0.164 | +0.256 | +0.339 | +0.403 | +0.429 | +0.409 | +0.334 | +0.210 | +0.073 |
| 5.0 | +0.025 | +0.137 | +0.245 | +0.346 | +0.428 | +0.477 | +0.469 | +0.398 | +0.259 | +0.092 |
| 6.0 | +0.018 | +0.119 | +0.234 | +0.344 | +0.441 | +0.504 | +0.514 | +0.447 | +0.301 | +0.112 |
| 8.0 | -0.011 | +0.104 | +0.218 | +0.335 | +0.443 | +0.534 | +0.575 | +0.530 | +0.381 | +0.151 |
| 10.0 | -0.011 | +0.098 | +0.208 | +0.323 | +0.437 | +0.542 | +0.608 | +0.589 | +0.440 | +0.179 |
| 12.0 | -0.005 | +0.097 | +0.202 | +0.312 | +0.429 | +0.543 | +0.628 | +0.633 | +0.494 | +0.211 |
| 14.0 | -0.002 | +0.098 | +0.200 | +0.306 | +0.420 | +0.539 | +0.639 | +0.666 | +0.541 | +0.241 |
| 16.0 | 0.000 | +0.099 | +0.199 | +0.304 | +0.412 | +0.531 | +0.641 | +0.687 | +0.582 | +0.265 |

**Table 3A Supplementary Ring Tension Coefficients for Case 1 Arrangement**

( *Tables* 1 and 3, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 ) | | | | |
|---|---|---|---|---|---|
| | 0.75*H* | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* |
| 20 | +0.716 | +0.654 | +0.520 | +0.325 | +0.115 |
| 24 | +0.746 | +0.702 | +0.577 | +0.372 | +0.137 |
| 32 | +0.782 | +0.768 | +0.663 | +0.459 | +0.182 |
| 40 | +0.800 | +0.805 | +0.731 | +0.530 | +0.217 |
| 48 | +0.791 | +0.828 | +0.785 | +0.593 | +0.254 |
| 56 | +0.763 | +0.838 | +0.824 | +0.636 | +0.285 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

**Table 4 Moment Coefficients for Case 1 Arrangement**

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 4A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* | 1.0*H* |
| 0.4 | +.000 5 | +.001 4 | +.002 1 | +.000 7 | -.004 2 | -.015 0 | -.030 2 | -.052 9 | -.081 6 | -.120 5 |
| 0.8 | +.001 1 | +.003 7 | +.006 3 | +.008 0 | +.007 0 | +.002 3 | -.006 8 | -.022 4 | -0.46 5 | -.079 5 |
| 1.2 | +.001 2 | +.004 2 | +.007 7 | +.010 3 | +.011 2 | +.009 0 | +.002 2 | -.010 8 | -.031 1 | -.060 2 |
| 1.6 | +.001 1 | +.004 1 | +.007 5 | +.010 7 | +.012 1 | +.011 1 | +.005 8 | -.005 1 | -.023 2 | -.050 5 |
| 2.0 | +.001 0 | +.003 5 | +.006 8 | +.009 9 | +.012 0 | +.011 5 | +.007 5 | -.002 1 | -.018 5 | -.043 6 |
| 3.0 | +.000 6 | +.002 4 | +.004 7 | +.007 1 | +.009 0 | +.009 7 | +.007 7 | +.001 2 | -.011 9 | -.033 3 |
| 4.0 | +.000 3 | +.001 5 | +.002 8 | +.004 7 | +.006 6 | +.007 7 | +.006 9 | +.002 3 | -.008 0 | -.026 8 |
| 5.0 | +.000 2 | +.000 8 | +.001 6 | +.002 8 | +.004 6 | +.005 9 | +.005 9 | +.002 8 | -.005 8 | -.022 2 |
| 6.0 | +.000 1 | +.000 3 | +.000 8 | +.001 9 | +.003 2 | +.004 6 | +.005 1 | +.002 9 | -.004 1 | -.018 7 |
| 8.0 | .000 0 | +.000 1 | +.000 2 | +.000 8 | +.001 6 | +.002 8 | +.003 8 | +.002 9 | -.002 2 | -.014 6 |
| 10.0 | .000 0 | .000 0 | +.000 1 | +.000 4 | +.000 7 | +.001 9 | +.002 9 | +.002 8 | -.001 2 | -.012 2 |
| 12.0 | .000 0 | -.000 0 | +.000 1 | +.000 2 | +.000 3 | +.001 3 | +.002 3 | +.002 6 | -.000 5 | -.010 4 |
| 14.0 | .000 0 | .000 0 | .000 0 | .000 0 | +.000 1 | +.000 8 | +.001 9 | +.002 3 | -.000 1 | -.009 0 |
| 16.0 | .000 0 | .000 0 | -.000 1 | -.000 2 | -.000 1 | +.000 4 | +.001 3 | +.001 9 | +.000 1 | -.007 9 |

**Table 4A Supplementary Moment Coefficients for Case 1 Arrangement**

( *Tables* 1 and 4, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 ) | | | | |
|---|---|---|---|---|---|
| | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* | 1.00*H* |
| 20 | +.001 5 | +.001 4 | +.000 5 | -.001 8 | -.006 3 |
| 24 | +.001 2 | +.001 2 | +.000 7 | -.001 3 | -.005 3 |
| 32 | +.000 7 | +.000 9 | +.000 7 | -.000 8 | -.004 0 |
| 40 | +.000 2 | +.000 5 | +.000 6 | -.000 5 | -.003 2 |
| 48 | .000 0 | +.000 1 | +.000 6 | -.000 3 | -.002 6 |
| 56 | .000 0 | .000 0 | +.000 4 | -.000 1 | -.002 3 |

NOTES

**1** Positive sign indicates tension in the outside.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

**Table 5 Ring Tension Coefficients for Case 2 Arrangement**

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 5A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0*H* | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* |
| 0.4 | +0.582 | +0.505 | +0.431 | +0.353 | +0.277 | +0.206 | +0.145 | +0.092 | +0.046 | +0.013 |
| 0.8 | +1.052 | +0.921 | +0.796 | +0.669 | +0.542 | +0.415 | +0.289 | +0.179 | +0.089 | +0.024 |
| 1.2 | +1.218 | +1.078 | +0.946 | +0.808 | +0.665 | +0.519 | +0.378 | +0.246 | +0.127 | +0.034 |
| 1.6 | +1.257 | +1.141 | +1.009 | +0.881 | +0.742 | +0.600 | +0.449 | +0.294 | +0.153 | +0.045 |
| 2.0 | +1.253 | +1.144 | +1.041 | +0.929 | +0.806 | +0.667 | +0.514 | +0.345 | +0.186 | +0.055 |
| 3.0 | +1.160 | +1.112 | +1.061 | +0.998 | +0.912 | +0.796 | +0.646 | +0.459 | +0.258 | +0.081 |
| 4.0 | +1.085 | +1.073 | +1.057 | +1.029 | +0.977 | +0.887 | +0.746 | +0.553 | +0.322 | +0.105 |
| 5.0 | +1.037 | +1.044 | +1.047 | +1.042 | +1.015 | +0.949 | +0.825 | +0.629 | +0.379 | +0.128 |
| 6.0 | +1.010 | +1.024 | +1.038 | +1.045 | +1.034 | +0.986 | +0.879 | +0.694 | +0.430 | +0.149 |
| 8.0 | +0.989 | +1.005 | +1.022 | +1.036 | +1.044 | +1.026 | +0.953 | +0.788 | +0.519 | +0.189 |
| 10.0 | +0.989 | +0.998 | +1.010 | +1.023 | +1.039 | +1.040 | +0.996 | +0.859 | +0.591 | +0.226 |
| 12.0 | +0.994 | +0.997 | +1.003 | +1.014 | +1.031 | +1.043 | +1.022 | +0.911 | +0.652 | +0.262 |
| 14.0 | +0.997 | 0.998 | +1.000 | +1.007 | +1.022 | +1.040 | +1.035 | +0.949 | +0.705 | +0.294 |
| 16.0 | +1.000 | 0.999 | +0.999 | +1.003 | +1.015 | +1.032 | +1.040 | +0.975 | +0.750 | +0.321 |

**Table 5A Supplementary Ring Tension Coefficients for Case 2 Arrangement**

( *Tables* 1 and 5, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 ) | | | | |
|---|---|---|---|---|---|
| | 0.75*H* | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* |
| 20 | +0.949 | +0.825 | +0.629 | +0.379 | +0.128 |
| 24 | +0.986 | +0.879 | +0.694 | +0.430 | +0.149 |
| 32 | +1.026 | +0.953 | +0.788 | +0.519 | +0.189 |
| 40 | +1.040 | +0.996 | +0.859 | +0.591 | +0.226 |
| 48 | +1.043 | +1.022 | +0.911 | +0.652 | +0.262 |
| 56 | +1.040 | +1.035 | +0.949 | +0.705 | +0.294 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

**Table 6 Moment Coefficients for Case 2 Arrangement**

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2$/Dt | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 6A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* | 1.0*H* |
| 0.4 | -.002 3 | -.009 3 | -.022 7 | -.043 9 | -.071 0 | -.101 8 | -.145 5 | -.200 0 | -.259 3 | -.331 0 |
| 0.8 | .000 0 | -.000 6 | -.002 5 | -.008 3 | -.018 5 | -.036 2 | -.059 4 | -.091 7 | -.132 5 | -.183 5 |
| 1.2 | +.000 8 | +.002 6 | +.003 7 | +.002 9 | -.000 9 | -.008 9 | -.022 7 | -.046 8 | -.081 5 | -.117 8 |
| 1.6 | +.001 1 | +.003 6 | +.006 2 | +.007 7 | +.006 8 | +.001 1 | -.009 3 | -.026 7 | -.052 9 | -.087 6 |
| 2.0 | +.001 0 | +.003 6 | .006 6 | +.008 8 | +.008 9 | +.005 9 | -.001 9 | -.016 7 | -.038 9 | -.071 9 |
| 3.0 | +.000 7 | +.002 6 | +.005 1 | +.007 4 | +.009 1 | +.008 3 | -.004 2 | -005 3 | -.022 3 | -.048 3 |
| 4.0 | +.000 4 | +.001 5 | +.003 3 | +.005 2 | +.006 8 | +.007 5 | -.005 3 | -.001 3 | -.014 5 | -.036 5 |
| 5.0 | +.000 2 | +.000 8 | +.001 9 | +.003 5 | +.005 1 | +.006 1 | -.005 2 | +.000 7 | -.010 1 | -.029 3 |
| 6.0 | +.000 1 | +.000 4 | +.001 1 | +.002 2 | +.003 6 | +.004 9 | -.004 8 | +.001 7 | -.007 3 | -.024 2 |
| 8.0 | .000 0 | +.000 1 | +.000 3 | +.000 8 | +.001 8 | +.003 1 | -.003 8 | +.002 4 | -.004 0 | -.018 4 |
| 10.0 | .000 0 | -.000 1 | .000 0 | +.000 2 | +.000 9 | +.002 1 | +.003 0 | +.002 6 | -.002 2 | -.014 7 |
| 12.0 | .000 0 | .000 0 | -.000 1 | .000 0 | +.000 4 | +.001 4 | +.002 4 | +.002 2 | -.001 2 | -.012 3 |
| 14.0 | .000 0 | .000 0 | .000 0 | .000 0 | +.000 2 | +.001 0 | +.001 8 | +.002 1 | -.000 7 | -.010 5 |
| 16.0 | .000 0 | .000 0 | .000 0 | -.000 1 | +.000 1 | +.000 6 | +.001 2 | +.002 0 | -.000 5 | -.009 1 |

**Table 6A Supplementary Moment Coefficients for Case 2 Arrangement**

( *Tables* 1 and 6, *Clauses* 3.1 *and* 3.1.6 )

| $H^2$/Dt | Coefficients at Point ( *see* Notes 1 and 2 ) | | | | |
|---|---|---|---|---|---|
| | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* | 1.00*H* |
| 20 | +.001 5 | +.001 3 | +.000 2 | -.002 4 | -.007 3 |
| 24 | +.001 2 | +.001 2 | +.000 4 | -.001 8 | -.006 1 |
| 32 | +.000 8 | +.000 9 | +.000 6 | -.001 0 | -.004 6 |
| 40 | +.000 5 | +.000 7 | +.000 7 | -.000 5 | -.003 7 |
| 48 | +.000 4 | +.000 6 | +.000 6 | -.000 3 | -.003 1 |
| 56 | +.000 2 | +.000 4 | +.000 5 | -.000 1 | -.002 6 |

NOTES

**1** Positive sign indicates tension in the outside.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

**Table 7 Ring Tension Coefficients for Case 3 Arrangement**

(*Table* 1*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 7A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0*H* | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* |
| 0.4 | +0.474 | +0.440 | +0.395 | +0.352 | +0.308 | +0.264 | +0.215 | +0.165 | +0.111 | +0.057 |
| 0.8 | +0.423 | +0.402 | +0.381 | +0.358 | +0.330 | +0.297 | +0.249 | +0.202 | +0.145 | +0.076 |
| 1.2 | +.0350 | +0.355 | +0.361 | +0.362 | +0.358 | +0.343 | +0.309 | +0.256 | +0.186 | +0.098 |
| 1.6 | +0.271 | +0.303 | +0.341 | +0.369 | +0.385 | +0.385 | +0.362 | +0.314 | +0.233 | +0.124 |
| 2.0 | +0.205 | +0.260 | +0.321 | +0.373 | +0.411 | +0.434 | +0.419 | +0.369 | +0.280 | +0.151 |
| 3.0 | +0.074 | +0.179 | +0.281 | +0.375 | +0.449 | +0.506 | +0.519 | +0.479 | +0.375 | +0.210 |
| 4.0 | +0.017 | +0.137 | +0.253 | +0.367 | +0.469 | +0.545 | +0.579 | +0.553 | +0.447 | +0.256 |
| 5.0 | -0.008 | +0.114 | +0.235 | +0.356 | +0.469 | +0.563 | +0.617 | +0.606 | +0.503 | +0.294 |
| 6.0 | -0.011 | +0.103 | +0.223 | +0.343 | +0.463 | +0.566 | +0.639 | +0.643 | +0.547 | +0.327 |
| 8.0 | -0.015 | +.0.96 | +0.208 | +0.324 | +0.443 | +0.564 | +0.661 | +0.697 | +0.621 | +0.386 |
| 10.0 | -0.008 | +0.095 | +0.200 | +0.311 | +0.428 | +0.552 | +0.666 | +0.730 | +0.678 | +0.433 |
| 12.0 | -0.002 | +0.097 | +0.197 | +0.302 | +0.417 | +0.541 | +0.664 | +0.750 | +0.720 | +0.477 |
| 14.0 | 0.000 | +0.096 | +0.197 | +0.299 | +0.408 | +0.531 | +0.659 | +0.761 | +0.752 | +0.513 |
| 16.0 | +0.002 | +0.100 | +0.198 | +0.299 | +0.403 | +0.521 | +0.650 | +0.764 | +0.776 | +0.536 |

**Table 7A Supplementary Ring Tension Coefficients for Case 3 Arrangement**

( *Tables* 1 and 7*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1 and 2 ) | | | | |
|---|---|---|---|---|---|
| | 0.75*H* | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* |
| 20 | +0.812 | +0.817 | +0.756 | +0.603 | +0.344 |
| 24 | +0.816 | +0.839 | +0.793 | +0.647 | +0.377 |
| 32 | +0.814 | +0.861 | +0.847 | +0.721 | +0.436 |
| 40 | +0.802 | +0.866 | +0.880 | +0.778 | +0.483 |
| 48 | +0.791 | +0.864 | +0.900 | +0.820 | +0.527 |
| 56 | +0.781 | +0.859 | +0.911 | +0.852 | +0.563 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

**Table 8 Ring Tension Coefficients for Case 4 Arrangement**

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2$/Dt | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 8A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0*H* | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* |
| 0.4 | +1.474 | +1.340 | +1.195 | +1.052 | +0.908 | +0.764 | +0.615 | 0.465 | +0.311 | +0.154 |
| 0.8 | +1.423 | +1.302 | +1.181 | +1.058 | +0.930 | +0.797 | +0.649 | +0.502 | +0.345 | +0.166 |
| 1.2 | +1.350 | +1.255 | +1.161 | +1.062 | +0.958 | +0.843 | +0.709 | +0.556 | +0.385 | +0.198 |
| 1.6 | +1.271 | +1.203 | +1.141 | +1.069 | +0.985 | +0.885 | +0.756 | +0.614 | +0.433 | +0.224 |
| 2.0 | +1.205 | +1.160 | +1.121 | +1.073 | +0.011 | +0.934 | +0.819 | +0.669 | +0.480 | +0.251 |
| 3.0 | +1.074 | +1.079 | +1.081 | +1.075 | +1.049 | +1.006 | +0.919 | +0.779 | +0.575 | +0.310 |
| 4.0 | +1.017 | +1.037 | +1.053 | +1.067 | +1.069 | +1.045 | +0.979 | +0.853 | +0.647 | +0.356 |
| 5.0 | +0.992 | +1.014 | +1.035 | +1.056 | +1.069 | +1.062 | +1.017 | +0.906 | +0.703 | +0.394 |
| 6.0 | +0.989 | +1.003 | +1.023 | +1.043 | +1.063 | +1.066 | +1.039 | +0.943 | +0.747 | +0.427 |
| 8.0 | +0.985 | +0.996 | +1.008 | +1.024 | +1.043 | +1.064 | +1.061 | +0.997 | +0.821 | +1.486 |
| 10.0 | +0.992 | +0.995 | +1.000 | +1.011 | +1.028 | +1.052 | +1.066 | +1.030 | +0.878 | +0.533 |
| 12.0 | +0.998 | +0.997 | +0.997 | +1.002 | +1.017 | +1.041 | +1.064 | +1.050 | +0.920 | +0.577 |
| 14.0 | +1.000 | +0.998 | +0.997 | +0.999 | +1.008 | +1.031 | +1.059 | +1.060 | +0.952 | +0.613 |
| 16.0 | +1.002 | +1.000 | +0.998 | +0.999 | +1.003 | +1.021 | +1.050 | +1.064 | +0.976 | +0.636 |

**Table 8A Supplementary Ring Tension Coefficients for Case 4 Arrangement**

( *Tables* 1 and 8, *Clauses* 3.1 *and* 3.1.6 )

| $H^2$/Dt | Coefficients at Point (*see* Notes 1 and 2) | | | | |
|---|---|---|---|---|---|
| | 0.75*H* | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* |
| 20 | +1.062 | +1.017 | +0.906 | +0.703 | +0.394 |
| 24 | +1.066 | +1.039 | +0.943 | +0.747 | +0.427 |
| 32 | +0.064 | +1.061 | +0.997 | +0.821 | +0.486 |
| 40 | +1.052 | +1.066 | +1.030 | +0.878 | +0.533 |
| 48 | +1.041 | +1.064 | +1.050 | +0.920 | +0.577 |
| 56 | +1.021 | +1.059 | +1.061 | +0.613 | +0.613 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

## Table 9 Moment Coefficients for Case 5 Arrangement

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2$/Dt | Coefficients at Point ( *see* Notes 1 and 2 at the end of Table 9A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* | 1.0*H* |
| 0.4 | +.002 0 | +.007 2 | +.015 1 | +.023 0 | +.030 1 | +.034 8 | +.035 7 | +.031 2 | +.019 7 | 0 |
| 0.8 | +.001 9 | +.006 4 | +.013 3 | +.020 7 | +.027 1 | +.031 9 | +.032 9 | +.028 2 | +.018 7 | 0 |
| 1.2 | +.001 6 | +.005 8 | +.011 1 | +.017 7 | +.023 7 | +.028 0 | +.029 6 | +.026 3 | +.017 1 | 0 |
| 1.6 | +.001 2 | +.004 4 | +.009 1 | +.014 5 | +.019 5 | +.023 6 | +.025 5 | +.023 2 | +.015 5 | 0 |
| 2.0 | +.000 9 | +.003 3 | +.007 3 | +.011 4 | +.015 8 | +.019 9 | +.021 9 | +.020 5 | +.014 5 | 0 |
| 3.0 | +.000 4 | +.001 8 | +.004 0 | +.006 3 | +.009 2 | +.012 7 | +.015 2 | +.15 3 | +.011 1 | 0 |
| 4.0 | +.000 1 | +.000 7 | +.001 6 | +.003 3 | +.005 7 | +.008 3 | +.010 9 | +.011 8 | +.009 2 | 0 |
| 5.0 | .000 0 | +.000 1 | +.000 6 | +.001 6 | +.003 4 | +.005 7 | +.008 0 | +.009 4 | +.007 8 | 0 |
| 6.0 | .000 0 | .000 0 | +.000 2 | +.000 8 | +.001 9 | +.003 9 | +.006 2 | +.007 8 | +.006 8 | 0 |
| 8.0 | .000 0 | .000 0 | -.000 2 | .000 0 | +.000 7 | +.002 0 | +.003 8 | +.005 7 | +.005 4 | 0 |
| 10.0 | .000 0 | .000 0 | -.000 2 | -.000 1 | +.000 2 | +.001 1 | +.002 5 | +.004 3 | +.004 5 | 0 |
| 12.0 | .000 0 | .000 0 | -.000 1 | -.000 2 | .000 0 | +.000 5 | +.001 7 | +.003 2 | +.003 9 | 0 |
| 14.0 | .000 0 | .000 0 | -.000 1 | -.000 1 | -.000 1 | .000 0 | +.001 2 | +.002 6 | +.003 3 | 0 |
| 16.0 | .000 0 | .000 0 | .000 0 | -.000 1 | .000 2 | -.000 4 | +.000 8 | +.002 2 | +.002 9 | 0 |

## Table 9A Supplementary Moment Coefficients for Case 5 Arrangement

( *Tables* 1 and 9, *Clauses* 3.1 *and* 3.1.6 )

| $H^2$/Dt | Coefficients at Point (*see* Notes 1 and 2) | | | | |
|---|---|---|---|---|---|
| | 0.75*H* | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* |
| 20 | +.000 8 | +.001 4 | +.002 0 | +.002 4 | +.002 0 |
| 24 | +.000 5 | +.001 0 | +.001 5 | +.002 0 | +.001 7 |
| 32 | .000 0 | +.000 5 | +.000 9 | +.001 4 | +.001 3 |
| 40 | .000 0 | +.000 3 | +.000 6 | +.001 1 | +.001 1 |
| 48 | .000 0 | +.000 1 | +.000 4 | +.000 8 | +.001 0 |
| 56 | .000 0 | .000 0 | +.000 3 | +.000 7 | +.000 8 |

NOTES

**1** Positive sign indicates tension in the outside.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank.

**Table 10 Ring Tension Coefficients for Case 6 Arrangement**

( *Table* 1*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1, 2 and 3 at the end of Table 10A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0*H* | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* |
| 0.4 | -1.57 | -1.32 | -1.08 | -0.86 | -0.65 | -0.47 | -0.31 | -0.18 | -0.08 | -0.02 |
| 0.8 | -3.09 | -2.55 | -2.04 | -1.57 | -1.15 | -0.80 | -0.51 | -0.28 | -0.13 | -0.03 |
| 1.2 | -3.95 | -3.17 | -2.44 | -1.79 | -1.25 | -0.81 | -0.48 | -0.25 | -0.10 | -0.02 |
| 1.6 | -4.57 | -3.54 | -2.60 | -1.80 | -1.17 | -0.69 | -0.36 | -0.16 | -0.05 | -0.01 |
| 2.0 | -5.12 | -3.83 | -2.68 | -1.74 | -1.02 | -0.52 | -0.21 | -0.05 | +0.01 | +0.01 |
| 3.0 | -6.32 | -4.37 | -2.70 | -1.43 | -0.58 | -0.02 | +0.15 | +0.19 | +0.13 | +0.04 |
| 4.0 | -7.34 | -4.73 | -2.60 | -1.10 | -0.19 | +0.26 | +0.38 | +0.33 | +0.19 | +0.06 |
| 5.0 | -8.22 | -4.99 | -2.45 | -0.79 | +0.11 | +0.47 | +0.50 | +0.37 | +0.20 | +0.06 |
| 6.0 | -9.02 | -5.17 | -2.27 | -0.50 | +0.34 | +0.59 | +0.53 | +0.35 | +0.17 | +0.01 |
| 8.0 | -10.42 | -5.36 | -1.85 | -0.02 | +0.63 | +0.66 | +0.46 | +0.24 | +0.09 | +0.01 |
| 10.0 | -11.67 | -5.43 | -1.43 | +0.38 | +0.78 | +0.62 | +0.33 | +0.12 | +0.02 | 0.00 |
| 12.0 | -12.76 | -5.41 | -1.03 | +0.63 | +0.83 | +0.52 | +0.21 | +0.04 | -0.02 | 0.00 |
| 14.0 | -13.77 | -5.34 | -0.68 | +0.80 | +0.81 | +0.42 | +0.13 | 0.00 | -0.03 | -0.01 |
| 16.0 | -14.74 | -5.22 | -0.33 | +0.96 | +0.76 | +0.32 | +0.05 | -0.04 | -0.05 | -0.02 |

**Table 10A Supplementary Ring Tension Coefficients for Case 6 Arrangement**

( *Tables* 1 and 10*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point (*see* Notes 1, 2 and 3) | | | | |
|---|---|---|---|---|---|
| | 0.00H | 0.05H | 0.10H | 0.15H | 0.20H |
| 20 | -16.44 | -9.98 | -4.90 | -1.59 | +0.22 |
| 24 | -18.04 | -10.34 | -4.54 | -1.00 | +0.68 |
| 32 | -20.84 | -10.72 | -3.70 | -0.04 | +1.26 |
| 40 | -23.34 | 10.86 | -2.86 | +0.72 | +1.56 |
| 48 | -25.52 | -10.82 | -2.06 | +1.26 | +1.66 |
| 56 | -27.54 | -10.68 | -1.36 | +1.60 | +1.62 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank, when shear is applied at the top and vice-versa, when shear is applied at the base with fixed top.

**3** Shear applied inward is positive and outward is negative.

**Table 11 Moment Coefficients for Case 6 Arrangement**

( *Table* 1, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1, 2 and 3 at the end of Table 11A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* | 1.0*H* |
| 0.4 | +0.093 | +0.172 | +0.240 | +0.300 | +0.354 | +0.402 | +0.448 | +0.492 | +0.535 | +0.578 |
| 0.8 | +0.085 | +0.145 | +0.185 | +0.208 | +0.220 | +0.224 | +0.223 | +0.219 | +0.214 | +0.208 |
| 1.2 | +0.082 | +0.132 | +0.157 | +0.164 | +0.159 | +0.145 | +0.127 | +0.106 | +0.084 | +0.062 |
| 1.6 | +0.079 | +0.122 | +0.139 | +0.138 | +0.125 | +0.105 | +0.081 | +0.056 | +0.030 | +0.004 |
| 2.0 | +0.077 | +0.115 | +0.126 | +0.119 | +0.103 | +0.080 | +0.056 | +0.031 | +0.006 | -0.019 |
| 3.0 | +0.072 | +0.100 | +0.100 | +0.086 | +0.066 | +0.044 | +0.025 | +0.006 | -0.010 | -0.024 |
| 4.0 | +0.068 | +0.088 | +0.081 | +0.063 | +0.043 | +0.025 | +0.010 | -0.001 | -0.010 | -0.019 |
| 5.0 | +0.064 | +0.078 | +0.067 | +0.047 | +0.028 | +0.013 | +0.003 | -0.003 | -0.007 | -0.011 |
| 6.0 | +0.062 | +0.070 | +0.056 | +0.036 | +0.018 | +0.006 | 0.000 | -0.003 | -0.005 | -0.006 |
| 8.0 | +0.057 | +0.058 | +0.041 | +0.021 | +0.007 | 0.000 | -0.002 | -0.003 | -0.002 | -0.001 |
| 10.0 | +0.053 | +0.049 | +0.029 | +0.012 | +0.002 | -0.002 | -0.002 | -0.002 | -0.001 | 0.000 |
| 12.0 | +0.049 | +0.042 | +0.022 | +0.007 | +0.000 | -0.002 | -0.002 | -0.001 | 0.000 | 0.000 |
| 14.0 | +0.046 | +0.036 | +0.017 | +0.004 | -0.001 | -0.002 | -0.001 | -0.001 | 0.000 | 0.000 |
| 16.0 | +0.044 | +0.031 | +0.012 | +0.001 | -0.002 | -0.002 | -0.001 | 0.000 | 0.000 | 0.000 |

**Table 11A Supplementary Moment Coefficients for Case 6 Arrangement**

( *Tables* 1 and 11, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point (*see* Notes 1, 2 and 3) | | | | |
|---|---|---|---|---|---|
| | 0.05*H* | 0.10*H* | 0.15*H* | 0.20*H* | 0.25*H* |
| 20 | +0.032 | +0.039 | +0.033 | +0.023 | +0.014 |
| 24 | +0.031 | +0.035 | +0.028 | +0.018 | +0.009 |
| 32 | +0.028 | +0.029 | +0.020 | +0.011 | +0.004 |
| 40 | +0.026 | +0.025 | +0.015 | +0.006 | +0.001 |
| 48 | +0.024 | +0.021 | +0.011 | +0.003 | 0.000 |
| 56 | +0.023 | +0.018 | +0.008 | +0.002 | 0.000 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank, when shear is applied at the top and vice-versa, when shear is applied at the base with fixed top.

**3** Shear applied inward is positive and outward is negative.

## Table 12 Ring Tension Coefficients for Case 7 Arrangement

( *Table* 1*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1, 2 and 3 at the end of Table 12A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.0*H* | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* |
| 0.4 | +2.70 | +2.50 | +2.30 | +2.12 | +1.91 | +1.69 | +1.41 | +1.13 | +0.80 | +0.44 |
| 0.8 | +2.02 | +2.06 | +2.10 | +2.14 | +2.10 | +2.02 | +1.95 | +1.75 | +1.39 | +0.80 |
| 1.2 | +1.06 | +1.42 | +1.79 | +2.03 | +2.46 | +2.65 | +2.80 | +2.60 | +2.22 | +1.37 |
| 1.6 | +0.12 | +0.79 | +1.43 | +2.04 | +2.72 | +3.25 | +3.56 | +3.59 | +3.13 | +2.01 |
| 2.0 | -0.68 | +0.22 | +1.10 | +2.02 | +2.90 | +3.69 | +4.30 | +4.54 | +4.08 | +2.75 |
| 3.0 | -1.78 | -0.71 | +0.43 | +1.60 | +2.95 | +4.29 | +5.66 | +6.58 | +6.55 | +4.73 |
| 4.0 | -1.87 | -1.00 | -0.08 | +1.04 | +2.47 | +4.31 | +6.34 | +8.19 | +8.82 | +6.81 |
| 5.0 | -1.54 | -1.03 | -0.42 | +0.45 | +1.86 | +3.93 | +6.60 | +9.41 | +11.03 | +9.02 |
| 6.0 | -1.04 | -0.86 | -0.59 | -0.05 | +1.21 | +3.34 | +6.54 | +10.28 | +13.08 | +11.41 |
| 8.0 | -0.24 | -0.53 | -0.73 | -0.67 | -0.02 | +2.05 | +5.87 | +11.32 | +16.52 | +16.06 |
| 10.0 | +0.21 | -0.23 | -0.64 | -0.94 | -0.73 | +0.82 | +4.79 | +11.63 | +19.48 | +20.87 |
| 12.0 | +0.32 | -0.05 | -0.46 | -0.96 | -1.15 | -0.18 | +3.52 | +11.27 | +21.80 | +25.73 |
| 14.0 | +0.26 | +0.04 | -0.28 | -0.76 | -1.29 | -0.87 | +2.29 | +10.55 | +23.50 | +30.34 |
| 16.0 | +0.22 | +0.07 | -0.08 | -0.64 | -1.28 | -1.30 | +1.12 | +9.67 | +24.53 | +34.65 |

## Table 12A Supplementary Ring Tension Coefficients for Case 7 Arrangement

( *Tables* 1 and 12*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point (*see* Notes 1, 2 and 3) | | | | |
|---|---|---|---|---|---|
| | 0.75*H* | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* |
| 20 | +15.30 | +25.9 | +36.9 | +43.3 | +35.3 |
| 24 | +13.20 | +25.9 | +40.7 | +51.8 | +45. |
| 32 | +8.10 | +23.2 | +45.9 | +65.4 | +63.6 |
| 40 | +3.28 | +19.2 | +46.5 | +77.9 | +83.5 |
| 48 | -0.70 | +14.1 | +45.1 | +87.2 | +103.0 |
| 56 | -3.40 | +9.2 | +42.2 | +94.0 | +121.0 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank, when moment is applied at the base and vice-versa, when moment is applied at the top with hinged top.

**3** Moment applied at an edge is positive when it causes outward rotation at that edge.

**Table 13 Moment Coefficients for Case 7 Arrangement**

( *Table 1, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point ( *see* Notes 1, 2 and 3 at the end of Table 13A ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.1*H* | 0.2*H* | 0.3*H* | 0.4*H* | 0.5*H* | 0.6*H* | 0.7*H* | 0.8*H* | 0.9*H* | 1.0*H* |
| 0.4 | +0.013 | +0.051 | +0.109 | +0.196 | +0.296 | +0.414 | +0.547 | +0.692 | +0.843 | +1.000 |
| 0.8 | +0.009 | +0.040 | +0.090 | +0.164 | +0.253 | +0.375 | +0.503 | +0.659 | +0.824 | +1.000 |
| 1.2 | +0.006 | +0.027 | +0.063 | +0.125 | +0.206 | +0.316 | +0.454 | +0.616 | +0.802 | +1.000 |
| 1.6 | +0.003 | +0.011 | +0.035 | +0.078 | +0.152 | +0.253 | +0.393 | +0.570 | +0.775 | +1.000 |
| 2.0 | -0.002 | -0.002 | +0.012 | +0.034 | 0.096 | +0.193 | +0.340 | +0.519 | +0.748 | +1.000 |
| 3.0 | -0.007 | -0.022 | -0.030 | -0.029 | +0.010 | +0.087 | +0.227 | +0.426 | +0.692 | +1.000 |
| 4.0 | -0.008 | -0.026 | -0.044 | -0.051 | -0.034 | +0.023 | +0.150 | +0.354 | +0.645 | +1.000 |
| 5.0 | -0.007 | -0.024 | -0.045 | -0.061 | -0.057 | -0.015 | +0.095 | +0.296 | +0.606 | +1.000 |
| 6.0 | -0.005 | -0.018 | -0.040 | -0.058 | -0.065 | -0.037 | +0.057 | +0.252 | +0.572 | +1.000 |
| 8.0 | -0.001 | -0.009 | -0.022 | -0.044 | -0.068 | -0.062 | +0.002 | +0.178 | +0515 | +1.000 |
| 10.0 | 0.000 | -0.002 | -0.009 | -0.028 | -0.053 | -0.067 | -0.031 | +0.123 | +0.467 | +1.000 |
| 12.0 | 0.000 | 0.000 | -0.003 | -0.016 | -0.040 | -0.064 | -0.049 | +0.081 | +0.424 | +1.000 |
| 14.0 | 0.000 | 0.000 | 0.000 | -0.008 | -0.029 | -0.059 | -0.060 | +0.048 | +0.387 | +1.000 |
| 16.0 | 0.000 | 0.000 | +0.002 | -0.003 | -0.021 | -0.051 | -0.066 | +0.025 | +0.354 | +1.000 |

**Table 13A Moment Coefficients for Case 7 Arrangement**

( *Tables* 1 and 13*, Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point (*see* Notes 1, 2 and 3) | | | | |
|---|---|---|---|---|---|
| | 0.80*H* | 0.85*H* | 0.90*H* | 0.95*H* | 1.00*H* |
| 20 | -0.015 | +0.095 | +0.296 | +0.606 | +1.000 |
| 24 | -0.037 | +0.057 | +0.250 | +0.572 | +1.000 |
| 32 | -0.062 | +0.002 | +0.178 | +0.515 | +1.000 |
| 40 | -0.067 | -0.031 | +0.123 | +0.467 | +1.000 |
| 48 | -0.064 | -0.049 | +0.081 | +0.424 | +1.000 |
| 56 | -0.059 | -0.060 | +0.048 | +0.387 | +1.000 |

NOTES

**1** Positive sign indicates tension.

**2** The point, 0.0 *H* denotes the top of the tank and the point, 1.0 *H* denotes the base of the tank, when moment is applied at the base and vice-versa, when moment is applied at the top with hinged top.

**3** Moment applied at an edge is positive when it causes outward rotation at that edge.

**Table 14 Moment Coefficients for Circular Slabs for Case 8 Arrangement**

( *Table* 2, *Clauses* 3.1 *and* 3.1.6 )

| Coefficients at Point ( *see* Note ) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **0.00R** | **0.10R** | **0.20R** | **0.30R** | **0.40R** | **0.50R** | **0.60R** | **0.70R** | **0.80R** | **0.90R** | **1.00R** |
| **Radial Moments, $M_r$** | | | | | | | | | | |
| +0.0625 | +0.0606 | +0.0550 | +0.0456 | +0.0325 | +0.0156 | -0.0050 | -0.0294 | -0.0575 | -0.0894 | -0.1250 |
| **Tangential Moments, $M_t$** | | | | | | | | | | |
| +0.0625 | +0.0619 | +0.0600 | +0.0569 | +0.0525 | +0.0469 | +0.0400 | +0.0319 | +0.0225 | -0.0119 | 0 |

NOTE — Positive sign indicates compression in surface loaded

**Table 15 Moment Coefficients for Circular Slabs for Case 9 Arrangement**

( *Table* 2, *Clauses* 3.1 *and* 3.1.6 )

| Coefficients at Point ( *see* Note ) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **c/D** | **0.05R** | **0.10R** | **0.15R** | **0.20R** | **0.25R** | **0.30R** | **0.40R** | **0.50R** | **0.60R** | **0.70R** | **0.80R** | **0.90R** | **1.00R** |
| **Radial Moments, $M_r$** | | | | | | | | | | | | | |
| 0.05 | -0.2100 | -0.0729 | -0.0275 | -0.0026 | +0.0133 | +0.0238 | +0.0342 | +0.0347 | +0.0277 | +0.0142 | -0.0049 | -0.0294 | -0.0589 |
| 0.10 | | -0.1433 | -0.0624 | -0.0239 | -0.0011 | +0.0136 | +0.0290 | +0.0326 | +0.0276 | +0.0158 | -0.0021 | -0.0255 | -0.0541 |
| 0.15 | | | -0.1089 | -0.0521 | -0.0200 | +0.0002 | +0.0220 | +0.0293 | +0.0269 | +0.0169 | +0.0006 | -0.0216 | -0.0490 |
| 0.20 | | | | -0.0862 | -0.0429 | -0.0161 | +0.0133 | +0.0249 | +0.0254 | +0.0176 | +0.0029 | -0.0178 | -0.0441 |
| 0.25 | | | | | -0.0698 | -0.0351 | +0.0029 | +0.0194 | +0.0231 | +0.0177 | +0.0049 | -0.0143 | -0.0393 |
| **Tangential Moments, $M_t$** | | | | | | | | | | | | | |
| 0.05 | -0.0417 | -0.0700 | -0.0541 | -0.0381 | -0.0251 | -0.0145 | +0.0002 | +0.0085 | +0.0118 | +0.0109 | +0.0065 | -0.0003 | -0.0119 |
| 0.10 | | -0.0287 | -0.0421 | -0.0354 | -0.0258 | -0.0168 | -0.0027 | +0.0059 | +0.0099 | +0.0098 | +0.0061 | -0.0009 | -0.0108 |
| 0.15 | | | -0.0218 | -0.0284 | -0.0243 | -0.0177 | -0.0051 | +0.0031 | +0.0080 | +0.0086 | +0.0057 | -0.0006 | -0.0098 |
| 0.20 | | | | -0.0172 | -0.0203 | -0.0171 | -0.0070 | +0.0013 | +0.0063 | +0.0075 | +0.0052 | -0.0003 | -0.0088 |
| 0.25 | | | | | -0.0140 | -0.0150 | -0.0083 | -0.0005 | +0.0046 | +0.0064 | +0.0048 | 0.0000 | -0.0078 |

NOTE — Positive sign indicates compression in surface loaded.

**Table 16 Moment Coefficients for Circular Slabs for Case 10 Arrangement**

( *Table* 2, *Clauses* 3.1 *and* 3.1.6 )

| c/D | Coefficients at Point ( *see* Note ) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.05R | 0.10R | 0.15R | 0.20R | 0.25R | 0.30R | 0.40R | 0.50R | 0.60R | 0.70R | 0.80R | 0.90R | 1.0R |
| | Radial Moments, $M_r$ | | | | | | | | | | | | |
| 0.05 | -0.3658 | -0.1388 | -0.0640 | -0.0221 | +0.0058 | +0.0255 | +0.0501 | +0.0614 | +0.0629 | +0.0566 | +0.0437 | +0.0247 | 0 |
| 0.10 | | -0.2487 | -0.1180 | -0.0557 | -0.0176 | +0.0081 | +0.0391 | +0.0539 | +0.0578 | +0.0532 | +0.0416 | +0.0237 | 0 |
| 0.15 | | | -0.1869 | -0.0977 | -0.0467 | -0.0135 | +0.0258 | +0.0451 | +0.0518 | +0.0494 | +0.0393 | +0.0226 | 0 |
| 0.20 | | | | -0.1465 | -0.0800 | -0.0381 | +0.0109 | +0.0352 | +0.0452 | +0.0451 | +0.0368 | +0.0215 | 0 |
| 0.25 | | | | | -0.1172 | -0.0645 | +0.0055 | +0.0245 | +0.0381 | +0.0404 | +0.0340 | +0.0200 | 0 |
| | Tangential Moments, $M_t$ | | | | | | | | | | | | |
| 0.05 | -0.0731 | -0.1277 | -0.1040 | -0.0786 | -0.0569 | -0.0391 | -0.0121 | +0.0061 | +0.0175 | +0.0234 | +0.0251 | +0.0228 | +0.0168 |
| 0.10 | | -0.0498 | -0.0768 | -0.0684 | -0.0539 | -0.0394 | -0.0153 | +0.0020 | +0.0134 | +0.0197 | +0.0218 | +0.0199 | +0.0145 |
| 0.15 | | | -0.0374 | -0.0516 | -0.0470 | -0.0375 | -0.0175 | -0.0014 | +0.0097 | +0.0163 | +0.0186 | +0.0172 | +0.0123 |
| 0.20 | | | | -0.0293 | -0.0367 | -0.0333 | -0.0184 | -0.0042 | +0.0065 | +0.0132 | +0.0158 | +0.0148 | +0.0103 |
| 0.25 | | | | | -0.0234 | -0.0263 | -0.0184 | -0.0062 | +0.0038 | +0.0103 | +0.0132 | +0.0122 | +0.0085 |

NOTE — Positive sign indicates compression in surface loaded.

**Table 17 Moment Coefficients for Circular Slabs for Case 11 Arrangement**

( *Table* 2, *Clauses* 3.1 *and* 3.1.6 )

| | Coefficients at Point ( *see* Note ) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **c/D** | **0.05R** | **0.10R** | **0.15R** | **0.20R** | **0.25R** | **0.30R** | **0.40R** | **0.50R** | **0.60R** | **0.70R** | **0.80R** | **0.90R** | **1.00R** |
| | | | | | | **Radial Moments, $M_r$** | | | | | | | |
| 0.05 | -2.650 | -1.121 | -0.622 | -0.333 | -0.129 | +0.029 | +0.268 | +0.450 | +0.596 | +0.718 | +0.824 | +0.917 | +1.000 |
| 0.10 | | -1.950 | -1.026 | -0.584 | -0.305 | -0.103 | +0.187 | +0.394 | +0.558 | +0.692 | +0.808 | +0.909 | +1.000 |
| 0.15 | | | -1.594 | -0.930 | -0.545 | -0.280 | +0.078 | +0.323 | +0.510 | +0.663 | +0.790 | +0.900 | +1.000 |
| 0.20 | | | | -1.366 | -0.842 | -0.499 | -0.057 | +0.236 | +0.451 | +0.624 | +0.768 | +0.891 | +1.000 |
| 0.25 | | | | | -1.204 | -0.765 | -0.216 | +0.130 | +0.392 | +0.577 | +0.740 | +0.880 | +1.000 |
| | | | | | | **Tangential Moments, $M_t$** | | | | | | | |
| 0.05 | -0.530 | -0.980 | -0.847 | -0.688 | -0.544 | -0.418 | -0.211 | -0.042 | +0.095 | +0.212 | +0.314 | +0.405 | +0.486 |
| 0.10 | | -0.388 | -0.641 | -0.608 | -0.518 | -0.419 | -0.233 | -0.072 | +0.066 | +0.185 | +0.290 | +0.384 | +0.469 |
| 0.15 | | | -0.319 | -0.472 | -0.463 | -0.404 | -0.251 | -0.100 | +0.035 | +0.157 | +0.263 | +0.363 | +0.451 |
| 0.20 | | | | -0.272 | -0.372 | -0.368 | -0.261 | -0.123 | +0.007 | +0.129 | +0.240 | +0.340 | +0.433 |
| 0.25 | | | | | -0.239 | -0.305 | -0.259 | -0.145 | -0.020 | +0.099 | +0.214 | +0.320 | +0.414 |

NOTE — Positive sign indicates compression in surface loaded.

**Table 18 Shear Coefficients at the Base of Cylindrical Wall**

( *Table* 2, *Clauses* 3.1 *and* 3.1.6 )

| $H^2/Dt$ | Coefficients at Point (*see* Note ) | | | |
|---|---|---|---|---|
| | Triangular Load, Fixed Base | Rectangular Load, Fixed Base | Triangular or Rectangular Load, Hinged Base | Moment at Edge |
| 0.4 | +0.436 | +0.755 | +0.245 | -1.58 |
| 0.8 | +0.374 | +0.552 | +0.234 | -1.75 |
| 1.2 | +0.339 | +0.460 | +0.220 | -2.00 |
| 1.6 | +0.317 | +0.407 | +0.204 | -2.28 |
| 2.0 | +0.299 | +0.370 | +0.189 | -2.57 |
| 3.0 | +0.262 | +0.310 | +0.158 | -3.18 |
| 4.0 | +0.236 | +0.271 | +0.137 | -3.68 |
| 5.0 | +0.213 | +0.243 | +0.121 | -4.10 |
| 6.0 | +0.197 | +0.222 | +0.110 | -4.49 |
| 8.0 | +0.174 | +0.193 | +0.096 | -5.18 |
| 10.0 | +0.158 | +0.172 | +0.087 | -5.81 |
| 12.0 | +0.145 | +0.158 | +0.079 | -6.38 |
| 14.0 | +0.135 | +0.147 | +0.073 | -6.88 |
| 16.0 | +0.0127 | +0.137 | +0.068 | -7.38 |
| 20.0 | +0.114 | +0.122 | +0.062 | -8.20 |
| 24.0 | +0.102 | +0.111 | +0.055 | -8.94 |
| 32.0 | +0.089 | +0.096 | +0.048 | -10.36 |
| 40.0 | +0.080 | +0.086 | +0.043 | -10.62 |
| 48.0 | +0.072 | +0.079 | +0.039 | -12.76 |
| 56.0 | +0.067 | +0.074 | +0.036 | -13.76 |

NOTE — Positive sign indicates shear acting inward.

**Table 19 Load Coefficients for Load on Centre Support for Circular Slab**

( *Clauses* 3.1.4 *and* 3.1.6 )

| c/D | 0.005 | 0.10 | 0.15 | 0.20 | 0.25 |
|---|---|---|---|---|---|
| Hinged | 1.320 | 1.387 | 1.463 | 1.542 | 1.625 |
| Fixed | 0.839 | 0.919 | 1.007 | 1.101 | 1.200 |
| Moment at edge | 8.16 | 8.66 | 9.29 | 9.99 | 10.81 |

**Table 20 Stiffness Coefficients for Stiffness of Circular Plates**

( *Clauses* 3.1.5 *and* 3.1.6 )

| c/D | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 |
|---|---|---|---|---|---|
| With centre support | 0.290 | 0.309 | 0.3332 | 0.358 | 0.387 |
| Without centre support | 0.104 | 0.104 | 0.104 | 0.104 | 0.104 |

# ANNEX A

( *Foreword* )

## COMMITTEE COMPOSITION

Cement and Concrete Sectional Committee, CED 02

| *Organization* | *Representative(s)* |
|---|---|
| In Personal Capacity (*Grace Villa, Kadamankulam P.O., Thiruvalla 689 583*) | Shri Jose Kurian (***Chairman***) |
| ACC Ltd, Mumbai | Shri Rajesh J. Modi<br>Dr Manish V. Karandikar (*Alternate*) |
| Ambuja Cements Limited, Ahmedabad | Shri Umesh P. Soni<br>Shri Sukuru Ramarao (*Alternate*) |
| Atomic Energy Regulatory Board, Mumbai | Shri L. R. Bishnoi<br>Shri Sourav Acharya (*Alternate*) |
| Builders' Association of India, Mumbai | Shri Sushanta Kumar Basu<br>Shri D. R. Sekor (*Alternate*) |
| Building Materials & Technology Promotion Council, New Delhi | Shri C. N. Jha |
| Cement Manufacturers' Association, Noida | Dr V. Ramachandra<br>Ms Shashwati Ghosh (*Alternate*) |
| Central Public Works Department, New Delhi | Shri D. K. Garg<br>Shri Naveen Kumar Bansal (*Alternate*) |
| Central Soil and Materials Research Station, New Delhi | Director<br>Shri U. S. Vidyarthi (*Alternate*) |
| Central Water Commission, New Delhi | Director (CMDD) (N&W)<br>Deputy Director (CMDD) (NW&S) (*Alternate*) |
| Conmat Technolgies Pvt Ltd, Kolkata | Dr A. K. Chatterjee<br>Dr Subrato Chowdhury (*Alternate*) |
| Construction Chemical Manufacturers' Association, Mumbai | Shri Samir Surlaker<br>Shri Nilotpol Kar (*Alternate*) |
| CSIR – Central Building Research Institute, Roorkee | Shri S. K. Singh<br>Shri Subhash Gurram (*Alternate*) |
| CSIR – Central Road Research Institute, New Delhi | Dr Rakesh Kumar<br>Dr V. V. L. Kanta Rao (*Alternate*) |
| CSIR – Structural Engineering Research Centre, Chennai | Dr K. Ramanjaneyulu<br>Dr P. Srinivasan (*Alternate*) |
| Delhi Development Authority, New Delhi | Shri Laxman Singh<br>Shri Vijay Shankar (*Alternate*) |
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( *Continued from second cover* )

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The composition of the Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 `Rules for rounding off numerical values ( *revised* )'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard

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