Design of Circular Concrete Tanks

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Load Conditions

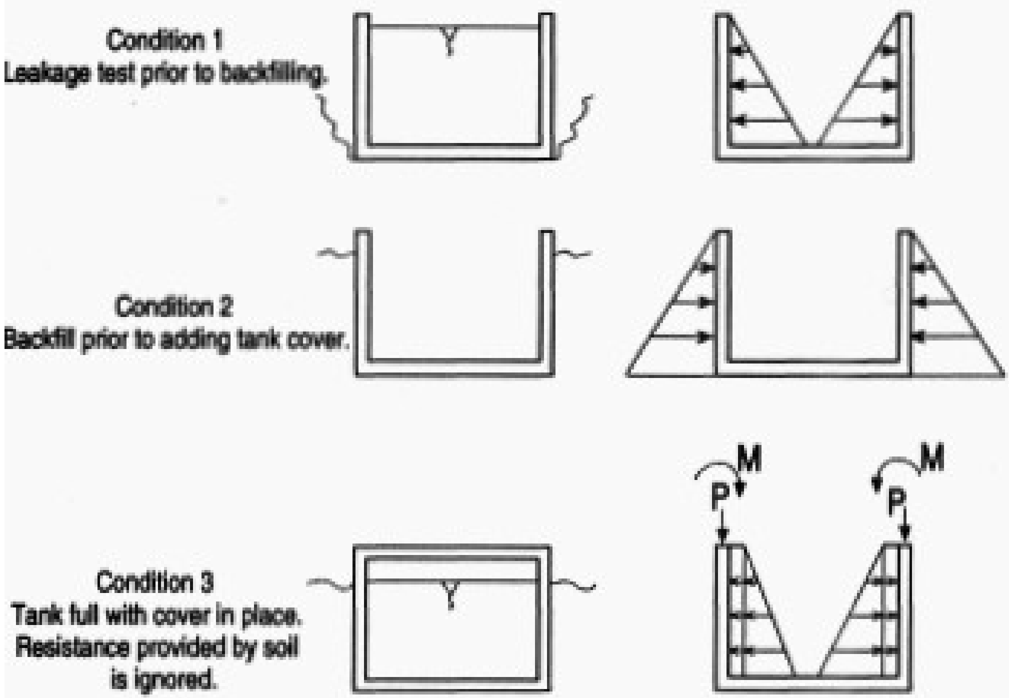

Figure 1—Possible loading conditions for a partially buried tank

Loading Conditions

- ✓ The tank may also be subjected to uplift forces from hydrostatic pressure at the bottom when empty.
- ✓ It is important to consider all possible loading conditions on the structure.
- ✓ Full effects of the soil loads and water pressure must be designed for without using them to minimize the effects of each other.
- ✓ The effects of water table must be considered for the design loading conditions.

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Strength Design Method

- **Modification 1** The load factor to be used for lateral liquid pressure, F, is taken as 1.7 rather than the value of 1.4 specified in ACI 318.

- **Modification 2** ACI 350-01 requires that the value of U be increased by using a multiplier called the sanitary coefficient. Required strength = Sanitary coefficient x U

where the sanitary coefficient equals:

1.3 for flexure
1.65 for direct tension
1.3 for shear beyond that of the capacity provided by the Concrete.

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Working Stress Design

- ACI 350-01 implies in its document that the maximum allowable stress for Grade 60 (420 mpa) reinforcing steel is 210 mpa(0.5fy).
- ACI 350 recommends the allowable stress in hoop tension for Grade 60 (420 mpa) reinforcing steel as is 140 mpa(f_y/3).

Modification according to ACI 350-06

Load Combinations according to ACI318-14

$$U = 1.4(D + F)$$

$$U = 1.2(D + F + T) + 1.6(L + H) + 0.5(Lr \ or \ S \ or \ R)$$

$$U = 1.2D + 1.6(Lr \ or \ S \ or \ R) + (1.0L \ or \ 0.8W)$$

$$U = 1.2D + 1.6W + 1.0L + 0.5(Lr \ or \ S \ or \ R)$$

$$U = 1.2D + 1.2F + 1.0E + 1.6H + 1.0L + 0.2S$$

$$U = 0.9D + 1.2F + 1.6W + 1.6H$$

$$U = 0.9D + 1.2F + 1.0E + 1.6H$$

Modification according to ACI 350-06

Load Combinations:

L = live loads, or related internal moments and force

$\boldsymbol{L_r}$ = roof live load, or related internal moments and forces

D = dead loads, or related internal moments and forces

E = load effects of earthquake, or related internal forces

R = rain load, or related internal moments and forces

S = snow load, or related internal moments and forces

H = loads due to weight and pressure of soil, water in soil, or other materials, or related internal moments and forces

F = loads due to weight and pressures of fluids with well-defined densities and controllable maximum heights, or related internal moments and forces

Modification according to ACI 350-06

Durability Factor

Required strength environmental durability factor (S_d).

$$S_d = \frac{\phi f_y}{\gamma f_s} \geq 1.0$$

$$where: \quad \gamma = \frac{\text{factored load}}{\text{unfactored load}}$$

$$\text{Required Strength} = S_d \cdot \text{factored load} = S_d \cdot U$$

f_s is the permissible tensile stress in reinforcement

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Modification according to ACI 350-06

➢ **Strength reduction factor ϕ shall be as follows:**

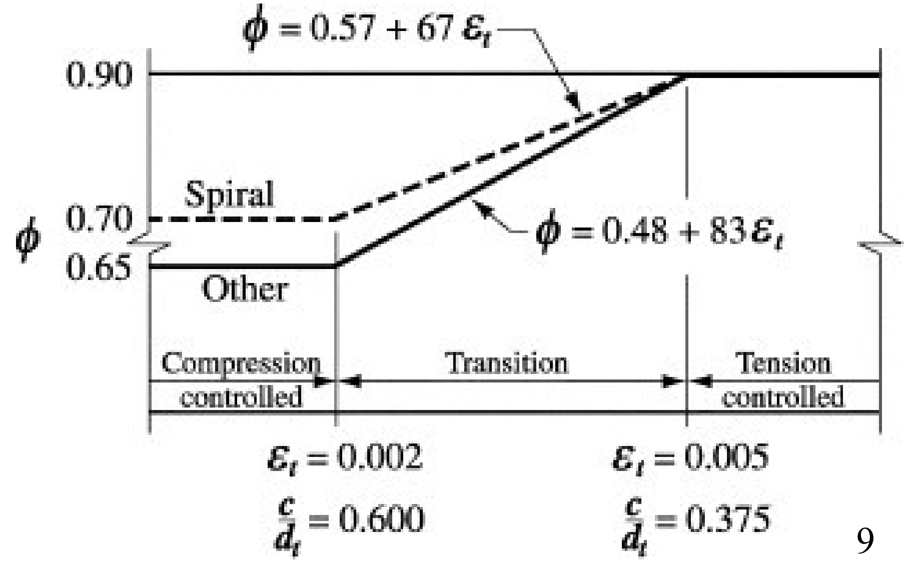
✓Tension-controlled sections ϕ=0.90

✓Compression-controlled sections,

- ❖Members with spiral reinforcement ϕ=0.70
- ❖Other reinforced members ϕ=0.65

✓Shear and torsion ϕ=0.75

✓Bearing on concrete ϕ=0.65



Modification according to ACI 350-06

Permissible Stresses

- **Direct and hoop tensile stresses**

  Normal environmental exposures

  f_s = 20 ksi (138 Mpa ≅ 140Mpa)

  Severe environmental exposures

  f_s = 17 ksi (117 Mpa ≅ 120Mpa)

- **Shear stress carried by shear reinforcement**

  Normal environmental exposures

  fs = 24 ksi (165 Mpa)

  Severe environmental exposures

  fs = 20 ksi (138 Mpa ≅ 140Mpa)

Modification according to ACI 350-06

Shear Stress

Shear stress carried by the shear reinforcing is defined as the excess shear strength required in addition to the design shear strength provided by the concrete ϕVc

$$\phi V_s \geq S_d \left(V_u - \phi V_c \right)$$

Modification according to ACI 350-06

Permissible Stresses

- **Flexural stress**

  Normal environmental exposures

$$f_{s,max} = \frac{320}{\beta\sqrt{s^2 + 4\left(2 + d_b/2\right)^2}} \geq 20\text{ksi}(\cong 140\text{Mpa}) \text{ for one way members}$$

$$\geq 24\text{ksi}(165\text{Mpa}) \text{for two way members.}$$

The following simplified equation can be used

$$f_{s,max} = \frac{320}{\beta\sqrt{s^2 + 25}}$$

where: $\beta = \dfrac{h-c}{d-c}$

$\beta = 1.2$ for h $\geq$ 16 in (40cm).

$\beta = 1.35$ for h < 16 in (40cm).

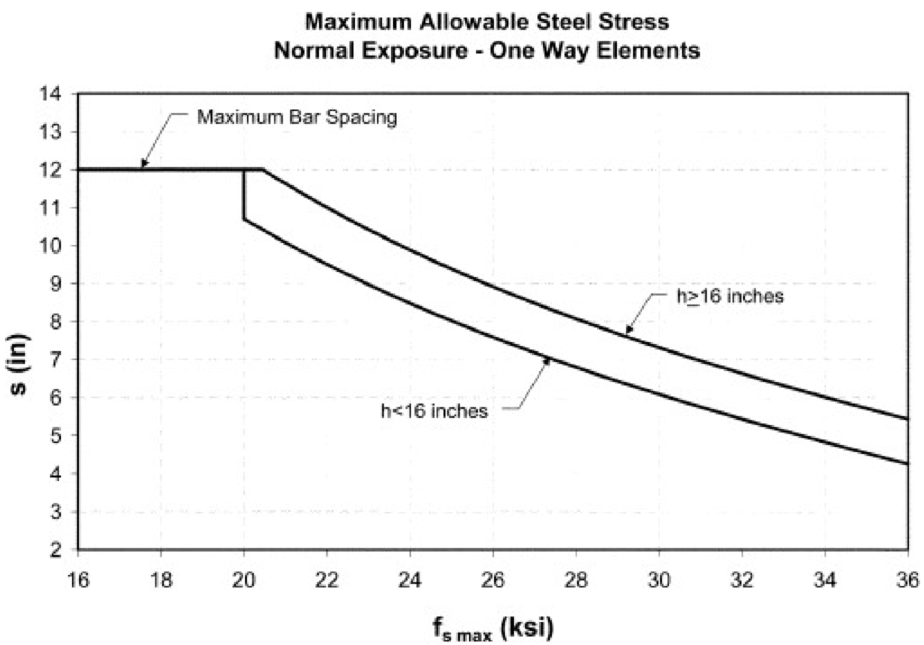
s = center-to-center spacing of deformed bars

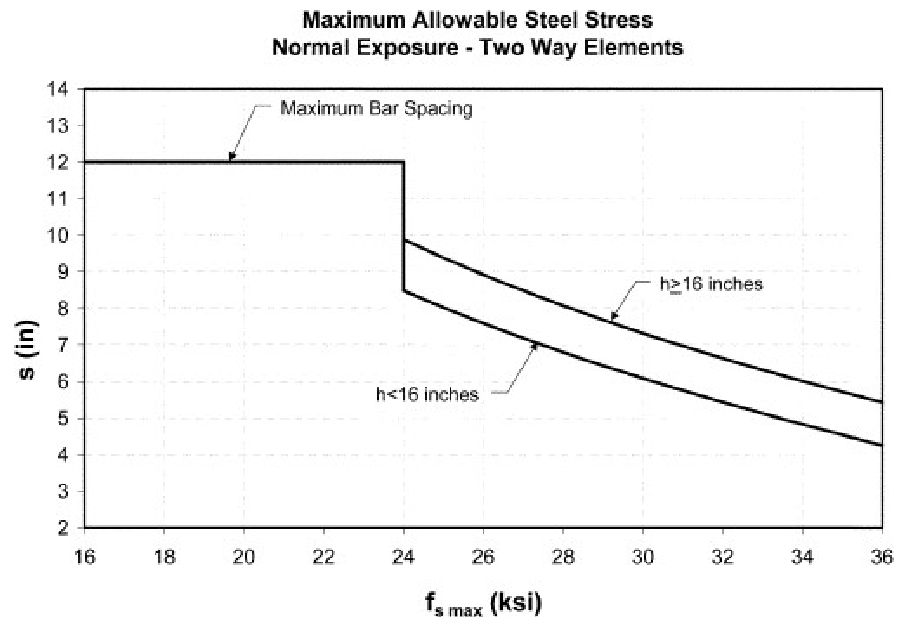
Modification according to ACI 350-06

Permissible Stresses

- **Flexural stress**

  Normal environmental exposures





Modification according to ACI 350-06

Permissible Stresses

- **Flexural stress**

  Severe environmental exposures

$$f_{s,\max} = \frac{260}{\beta\sqrt{s^2 + 4\left(2 + d_b/2\right)^2}} \geq 17\text{ksi}(\cong 120\text{Mpa}) \text{ for one way members}$$

$$\geq 20\text{ksi}(\cong 140\text{Mpa}) \text{ for two way members.}$$

The following simplified equation can be used

$$f_{s,\max} = \frac{260}{\beta\sqrt{s^2 + 25}}$$

s = center-to-center spacing of deformed bars

Modification according to ACI 350-06

Permissible Stresses

- **Flexural stress**

  Severe environmental exposures