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**TR** **TECHNICAL RESOURCE**

Compiled by Agricultural Engineers of the Midwest Plan Service

# Design Tables For REINFORCED CONCRETE MANURE TANKS, SLATS, & BEAMS

## TR-3

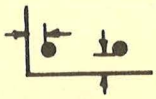
This report is intended primarily for engineers with an understanding of reinforced concrete design. While it includes design criteria and adequate reinforcing for selected sections, many essential details are not included, such as foundations, corner reinforcing, design of necessary openings in walls or lids, etc.

The design loads used in developing the tables are from ASAE R345, Design of Farm Waste Storage Tanks. Refer to the Recommendation for Additional information on location, safety features, etc.

A plan based on this publication is available from the MWPS; enclose $1.00 for Plan 74303, Liquid Manure Tanks.

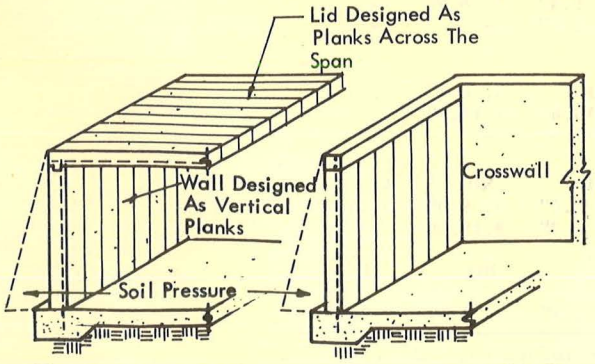
Hydrogen sulphide, $H_2S$, is given off from anaerobic waste storages. Where a tank has air over the liquids and condensation on the underside of the lid, $H_2S$ may lead to sulphuric acid, $H_2SO_4$. There is no general preventative to attack by the acid available to the farm tank designer or owner. Cement low in tri-calcium aluminate is naturally available in some areas, and has some sulphate resistance, as does Type II cement, which is apt to be available in areas with water supplies naturally high in sulphates. Specification of a high quality air-entrained concrete is perhaps the best solution available to the engineer.

Tables 1-4 list basic data for 3500 psi concrete, deformed billet steel reinforcing bars, and limiting steel placement dimensions.



**Cover**—Concrete protection over steel
cover = 1½" for #5 or smaller
cover = 2" for #6 or larger

Table 5 (page 2) gives wall designs. Table 6 (pages 3, & 4) lists top beam requirements. Tables 7 (page 5) and 8 (page 6) give lid designs. Table 9 (page 7-10) lists safe live loads for slats and beams.




**Tank With Lid** **Beam On Wall**

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**Table 1. Properties of materials**

| | | | |
|---|---|---|---|
| Concrete | | | |
| strength | $f_c'$ | 3,500 | psi |
| bending $0.45f_c'$ | $f_c$ | 1,575 | psi |
| shear $1.1f_c'^{1/2}$ beams | $v_c$ | 65 | psi |
| $2.0f_c'^{1/2}$ slabs | | 118.3 | psi |
| elasticity $(145^{1.5})(33)f_c'^{1/2}$ | $E_c$ | $3.4 \times 10^6$ | psi |
| ratio $E_s/E_c$ | n | 8.5 | |
| bond $4.8(f_c')^{1/2}$/Diam | u | 284/Diam or 500 psi max | |
| Steel | | | |
| tension | $f_s$ | 20,000 | psi |
| elasticity | $E_s$ | $29 \times 10^6$ | psi |

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**Table 2. Reinforcing steel**

| No. | Weight lb/ft | Area $in^2$ | Perimeter in. | Diam. in. | Allow. Bond psi |
|---|---|---|---|---|---|
| 3 | 0.376 | 0.11 | 1.178 | 0.375 | 500.0 |
| 4 | 0.668 | 0.20 | 1.571 | 0.500 | 500.0 |
| 5 | 1.043 | 0.31 | 1.963 | 0.625 | 454.4 |
| 6 | 1.502 | 0.44 | 2.356 | 0.750 | 378.6 |
| 7 | 2.044 | 0.60 | 2.749 | 0.875 | 324.5 |
| 8 | 2.670 | 0.79 | 3.142 | 1.000 | 284.0 |
| 9 | 3.400 | 1.00 | 3.544 | 1.128 | 251.7 |
| 10 | 4.303 | 1.27 | 3.990 | 1.270 | 223.6 |
| 11 | 5.313 | 1.56 | 4.430 | 1.410 | 201.4 |

Clear distance between bars not less than bar diameter, 1" nor 1 1/3 times max course aggregate

**Table 3. Minimum steel in walls and slabs. Temperature and shrinkage steel = 0.002bt**

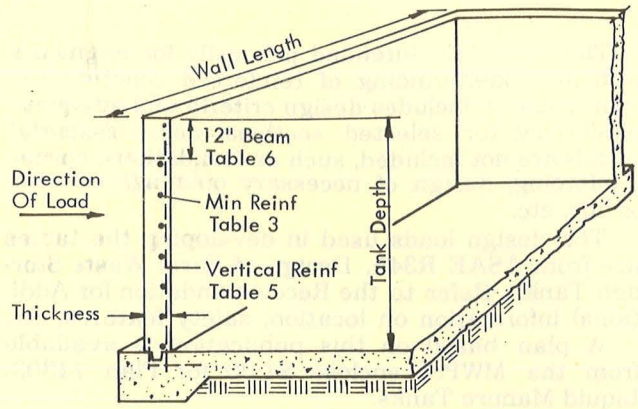
| Slab Thickness: | 4" | 5" | 6" | 7" |
|---|---|---|---|---|
| Min. $A_s$/ft | 0.096 | 0.120 | 0.144 | 0.168 |
| Bar Size | #3 | #3 | #3 | #3 |
| Bar Spacing | 13.8" | 11" | 9.2" | 7.8" |

| Slab Thickness: | 8" | 9" | 10" | 11" | 12" |
|---|---|---|---|---|---|
| Min. $A_s$/ft | 0.192 | 0.216 | 0.240 | 0.264 | 0.288 |
| Bar Size | #3 | #4 | #4 | #4 | #4 |
| Bar Spacing | 6.9" | 11.0" | 10.0" | 9.1" | 8.3" |

**Table 4. Minimum member width, inches**

| Bar | Diameter | 1 Bar | 2 Bars | 3 Bars |
|---|---|---|---|---|
| # 3 | .375" | 3.375" | 4.750" | 6.125" |
| 4 | .500 | 3.500 | 5.000 | 6.500 |
| 5 | .625 | 3.625 | 5.250 | 6.875 |
| 6 | .750 | 4.750 | 6.500 | 8.250 |
| 7 | .875 | 4.875 | 6.750 | 8.625 |
| 8 | 1.000 | 5.000 | 7.000 | 9.000 |
| 9 | 1.128 | 5.128 | 7.384 | 9.640 |
| 10 | 1.270 | 5.270 | 7.810 | 10.350 |
| 11 | 1.410 | 5.410 | 8.230 | 11.050 |

*Note: In the tables "psf/ft" is abbreviated with its demensional equivalent "pcf".*



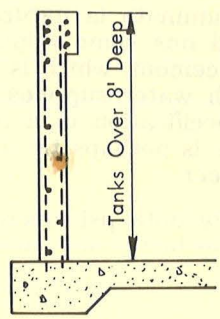

## Tank Walls

Tank walls are designed to support:

15 psf/ft inward for well-drained soil.
30 psf/ft inward for moderate drainage.
60 psf/ft inward for high water table, in both directions for partitions, and outward for walls above grade.

In addition, tanks over 8′ deep constructed where the nature of the soil or the quality of backfilling may not provide solid lateral bearing for the walls, walls should be reinforced in the outside face to resist full lateral hydraulic pressure (60 psf/ft) from stored liquid in the tank.

ASAE R345 includes a design load of 110 psf/ft for saturated fine sand. This soil type requires major modification of designs to allow for flotation, a structural floor, serious drainage and settling problems, and possible restrictions by building or other public authorities. Design elements are not included here.




Tanks over 8' deep, reinforce both faces of the walls, and both faces of the top beams

**Table 5. Reinforced concrete tank walls; vertical reinforced design; bar size and spacing, inches**

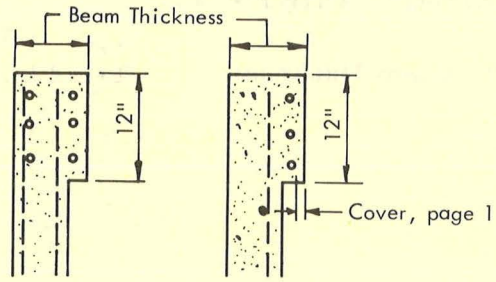
Tabulated reinforcing is vertical; minimum reinforcing (Table 3) is horizontal. See cover, page 1.

| Wall Thickness | Load, pcf | Tank Depth* 6' | 8' | 10' | 12' | 14' | 16' |
|---|---|---|---|---|---|---|---|
| | | **Bar Size and Spacing, Inches** | | | | | |
| 6" | 15 | Min | Min | Min | 4, 9.4" | 5, 8.9" | - |
| | 30 | " | " | 4, 8.2" | 7,11.2" | - | - |
| | 60 | " | 4, 8.0" | - | - | - | - |
| 8" | 15 | Min | Min | Min | Min | 4, 8.9" | 5, 9.0" |
| | 30 | " | " | " | 5,10.6 | 7,11.3" | - |
| | 60 | " | " | 5, 9.2" | 8,11.5" | - | - |
| 10" | 15 | Min | Min | Min | Min | Min | 4, 7.9" |
| | 30 | " | " | " | 4, 9.4" | 5, 9.0" | 7,10.4" |
| | 60 | " | " | 4, 8.1" | 6, 9.3" | 8,10.0" | - |
| 12" | 15 | Min | Min | Min | Min | Min | Min |
| | 30 | " | " | " | " | 5,11.2" | 6, 9.9" |
| | 60 | " | " | " | 5, 8.9" | 7, 9.9" | 9.10 7" |

* All 4' deep tanks require only minimum reinforcing, Table 3.

**Table 6. Beams at top of tank walls**

The designs assume continuous lateral support at the top and bottom of the walls. The upper 12″ of the wall may be reinforced as given in Table 6, to carry wall loads to a pilaster, partition, or end-wall. See Cover, page 1.




**Deep Tanks** **Beam Thickness**

**Bar Size**

## 6" Beam Thickness

| Tank Depth | Pcf | Wall Length 4' | 6' | 8' | 10' | 12' | 14' | 16' | 18' | 20' | 22' | 24' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4' | 15 | #3 | #3 | #3 | #3 | #3 | #3 | #3 | #4 | #4 | #4 | #5 |
| | 30 | 3 | 3 | 3 | #3 | #3 | #4 | #4 | #5 | 2#4 | 2#4 | - |
| | 60 | 3 | 3 | 3 | #4 | #5 | #5 | 2#4 | - | - | - | - |
| 6' | 15 | 3 | 3 | 3 | #3 | #3 | #3 | #4 | #4 | #5 | #5 | 2#4 |
| | 30 | 3 | 3 | 3 | #3 | #4 | #5 | #5 | 2#4 | 3#4 | - | - |
| | 60 | 3 | 3 | #4 | #5 | 2#4 | 3#4 | - | - | - | - | - |
| 8' | 15 | 3 | 3 | 3 | #3 | #3 | #4 | #4 | #5 | 2#4 | 2#4 | 3#4 |
| | 30 | 3 | 3 | 3 | #4 | #5 | #5 | 2#4 | - | - | - | - |
| | 60 | 3 | 3 | #4 | 2#4 | 3#4 | - | - | - | - | - | - |
| 10' | 15 | 3 | 3 | 3 | #3 | #4 | #4 | #5 | 2#4 | 2#4 | 3#4 | - |
| | 30 | 3 | 3 | 3 | #4 | #5 | 2#4 | - | - | - | - | - |
| | 60 | 3 | #4 | #5 | 2#4 | - | - | - | - | - | - | - |
| 12' | 15 | 3 | 3 | #3 | #3 | #4 | #5 | #5 | 2#4 | 3#4 | - | - |
| | 30 | 3 | 3 | #4 | #5 | 2#4 | 3#4 | - | - | - | - | - |
| | 60 | 3 | #4 | #5 | 3#4 | - | - | - | - | - | - | - |

## 8" Beam Thickness

| Tank Depth | Pcf | Wall Length 4' | 6' | 8' | 10' | 12' | 14' | 16' | 18' | 20' | 22' | 24' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4' | 15 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | #4 | #4 | #5 | #5 | #5 |
| | 60 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 3#4 | #8 |
| 6' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | #4 | #4 | #4 | #4 | #5 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | #4 | #5 | 2#4 | 2#4 | 3#4 |
| | 60 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | #8 | 3#5 | - |
| 8' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | #4 | #4 | #5 | #5 | #5 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #4 | 3#4 | 3#4 | #5 |
| | 60 | 4 | 4 | 4 | #5 | #5 | 3#4 | 3#4 | 4#4 | 2#7 | - | - |
| 10' | 15 | 4 | 4 | 4 | 4 | 4 | #4 | #4 | #5 | #5 | 2#4 | 2#4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 3#4 | #8 | 3#5 |
| | 60 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | #8 | - | - | - | - |
| 12' | 15 | 4 | 4 | 4 | 4 | #4 | #4 | #4 | #5 | 2#4 | 2#4 | 3#4 |
| | 30 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | #8 | 3#5 | - |
| | 60 | 4 | 4 | 4 | 2#4 | 3#4 | #8 | - | - | - | - | - |
| 14' | 15 | 4 | 4 | 4 | 4 | #4 | #4 | #5 | #5 | 2#4 | 3#4 | 3#4 |
| | 30 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 1#8 | 2#6 | - | - |
| | 60 | 4 | 4 | #5 | 2#4 | 3#4 | 2#6 | - | - | - | - | - |
| 16' | 15 | 4 | 4 | 4 | 4 | #4 | #4 | #5 | 2#4 | 3#4 | 3#4 | #8 |
| | 30 | 4 | 4 | 4 | #5 | #5 | 3#4 | 3#4 | 2#6 | 2#7 | - | - |
| | 60 | 4 | 4 | #5 | 3#4 | #8 | - | - | - | - | - | - |

**Table 6. (continued) Beams at top of tank walls**

## 10" Beam Thickness

| Tank Depth | Pcf | Wall Length 4' | 6' | 8' | 10' | 12' | 14' | 16' | 18' | 20' | 22' | 24' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4' | 15 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 |
| | 60 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 |
| 6' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 |
| | 60 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | #8 | #8 |
| 8' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 |
| | 60 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | #8 | 2#6 | 2#7 |
| 10' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 2#4 | 3#4 | #8 |
| | 60 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | #8 | 3#5 | 2#7 | 3#6 |
| 12' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | #4 | #4 | #5 | #5 | 2#4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | #8 | #8 |
| | 60 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | #8 | 2#6 | 2#7 | - | - |
| 14' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 2#4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 3#4 | #8 | 3#5 |
| | 60 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 2#6 | 2#7 | 3#6 | - | - |
| 16' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | #8 | 2#6 | 2#7 |
| | 60 | 4 | 4 | 4 | #5 | 3#4 | #8 | 3#5 | 2#7 | - | - | - |

## 12" Beam Thickness

| Tank Depth | Pcf | Wall Length 4' | 6' | 8' | 10' | 12' | 14' | 16' | 18' | 20' | 22' | 24' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4' | 15 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 | #4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 60 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 |
| 6' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 |
| | 60 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | 3#4 |
| 8' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 |
| | 60 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 3#4 | #8 | 2#6 |
| 10' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 |
| | 60 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | #8 | 2#6 | 2#7 |
| 12' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 |
| | 30 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | 3#4 |
| | 60 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | #8 | 2#6 | 2#7 | 3#6 |
| 14' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 | 3#4 | 3#4 | #8 |
| | 60 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 3#4 | #8 | #9 | #10 | #11 |
| 16' | 15 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | #5 | #5 | 2#4 |
| | 30 | 4 | 4 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | 3#4 | #8 | 2#6 |
| | 60 | 4 | 4 | 4 | #5 | 2#4 | 3#4 | #8 | 3#5 | 2#7 | #11 | - |

# Tank Lids

## Tank Lids to Support Large Tractor or Manure Wagon

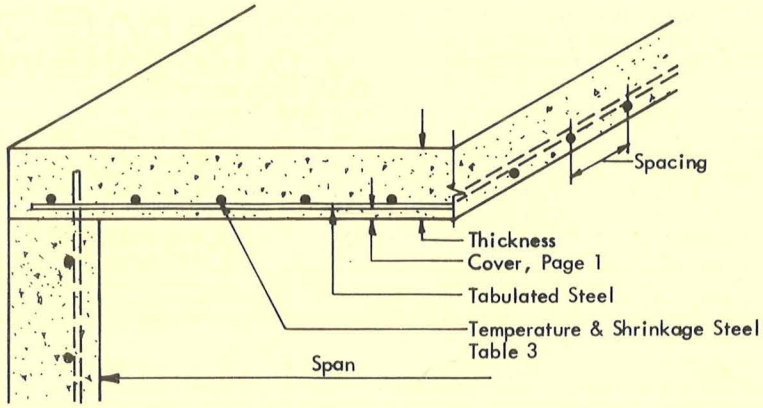



**Table 7. Heavy tank lid designs for 2-5000 lb loads 4′ o.c. plus deadweight of slabs; bar size and spacing, inches**

**Bar Size and Spacing, Inches**

| | Slab Thickness | | | | | | |
|---|---|---|---|---|---|---|---|
| Span | 6" | 7" | 8" | 9" | 10" | 11" | 12" |
| 4' | #5,11.7 | # 4,9.5 | #4,11.3 | Min | Min | Min | Min |
| 6' | 6,9.9 | 5,10.2 | 4,7.9 | # 4,9.1 | " | " | " |
| 8' | -- | 6,9.5 | 5,9.0 | 5,10.3 | # 5,11.6 | # 4,8.3 | " |
| 10' | -- | 7,10.0 | 6,8.9 | 6,10.4 | 5,8.9 | 5,9.8 | # 5,10.6 |
| 12' | -- | -- | # 7,9.7 | #7,11.2 | # 6,9.3 | # 6,10.3 | # 5,8.4 |
| 14' | -- | -- | 8,10.3 | 8,11.9 | 7,10.3 | 7,11.3 | 6,9.1 |
| 16' | -- | -- | -- | 8,9.9 | 8,11.1 | 7,9.4 | 7,10.2 |
| 18' | -- | -- | -- | 9,10.5 | 9,11.8 | 8,10.3 | 8,11.2 |
| 20' | -- | -- | -- | -- | # 9,10.1 | # 9,11.1 | # 9,12.0 |
| 22' | -- | -- | -- | -- | 10,11.0 | 10,12.0 | 9,10.3 |
| 24' | -- | -- | -- | -- | -- | 10,10.5 | 10,11.3 |

## Tank Lids With No Vehicle Traffic

Table 8 gives designs for reinforced concrete lids for tanks. Recommended loads for lids are (in addition to dead weight):

- 40 psf for human or poultry traffic
- 150 psf for livestock traffic or up to 15″ of soil cover.
- 40 psf + snow load on the ground for outdoor tanks with no vehicle traffic.

Where minimum steel is specified, use Table 3.

## Snow Zone Map

Snow Load on Ground, psf

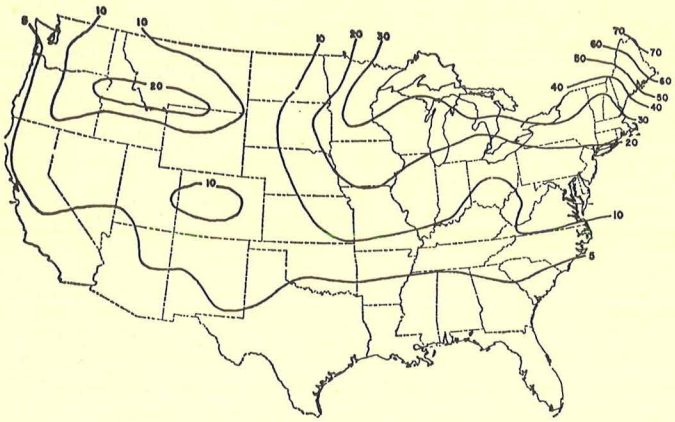


Table 8. Reinforced concrete tank lids for NO vehicle traffic; one-way slab design adequate for load listed plus dead weight of slab; bar size and spacing, inches

Bar Size and Spacing, Inches — Lid Span*

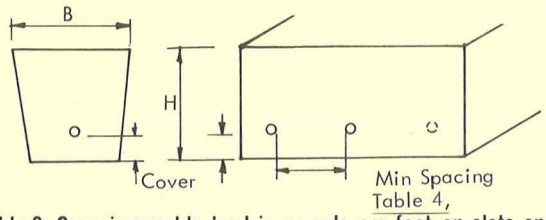
| Lid Thickness | PSF | 6' | 8' | 10' | 12' | 14' |
|---|---|---|---|---|---|---|
| 4" | 40 | 3,11.9" | 4,11.5" | 5,10.9" | - | - |
| | 50 | 3,10.7" | 4,10.3" | - | - | - |
| | 60 | 3, 9.7" | 4, 9.4" | - | - | - |
| | 70 | 3, 8.9" | 4, 8.6" | - | - | - |
| | 80 | 3, 8.2" | 5,11.7" | - | - | - |
| | 90 | 3, 7.6" | 5,10.8" | - | - | - |
| | 110 | 3, 7.1" | 5,10.1" | - | - | - |
| | 110 | 4,11.4" | | - | - | - |
| | 150 | 4, 9.1" | - | - | - | - |
| 5" | 40 | Min | 3, 8.5" | 4, 9.5" | 5, 9.8" | - |
| | 50 | " | 3, 7.7" | 4, 8.7" | 5, 9.0" | - |
| | 60 | " | 3, 7.1" | 5,11.8" | - | - |
| | 70 | " | 4,11.4" | 5,10.9" | - | - |
| | 80 | 3,10.8" | 4,10.6" | 5,10.1" | - | - |
| | 90 | 3,10.1" | 4, 9.9" | 5, 9.5" | - | - |
| | 100 | 3, 9.5" | 4, 9.3" | 5, 8.9" | - | - |
| | 110 | 3, 8.9" | 4, 8.7" | - | - | - |
| | 150 | 3, 7.2" | 5,10.6" | - | - | - |
| 6" | 40 | Min | - | 4,11.2" | 5,11.7" | 5, 8.6" |
| | 50 | " | 3, 9.2" | 4,10.3" | 5,10.7" | 6, 9.5" |
| | 60 | " | 3, 8.5" | 4, 9.5" | 5, 9.9" | - |
| | 70 | " | 3, 7.9" | 4, 8.9" | 5, 9.2" | - |
| | 80 | " | 3, 7.4" | 4, 8.3" | 5, 8.6" | - |
| | 90 | " | 3, 6.9" | 5,11.6" | 6, 9.7" | - |
| | 100 | " | 4,11.4" | 5,11.0" | 6, 9.1" | - |
| | 110 | " | 4,10.8" | 5,10.4" | 7,11.4" | - |
| | 150 | 3, 8.9" | 4, 8.8" | 5, 8.5" | - | - |
| 8" | 150 | Min | 4,11.9" | 5,11.5" | 6,10.1" | 7, 9.9" |

*All 4' wide covers require only minimum reinforcing, except 4" thickness, 150 psf = #3,11.9".

Lid Span*

| Lid Thickness | PSF | 14' | 16' | 18' | 20' | 22' | 24' |
|---|---|---|---|---|---|---|---|
| 8" | 40 | 5,10.6" | 6,10.3" | 7,10.8" | 8,11.2" | - | - |
| | 50 | 5, 9.9" | 6, 9.6" | 7,10.1" | 8,10.5" | - | - |
| | 60 | 5, 9.3" | 6, 9.0" | 7, 9.4" | - | - | - |
| | 70 | 5, 8.7" | 7,11.2" | 8,11.4" | - | - | - |
| | 80 | 6,10.4" | 7,10.6" | 8,10.7" | - | - | - |
| | 90 | 6, 9.8" | 7,10.0" | 8,10.1" | - | - | - |
| | 100 | 6, 9.3" | 7, 9.5" | 9,11.9" | - | - | - |
| | 110 | 6, 8.9" | 8,11.6" | - | - | - | - |
| | 150 | 7, 9.9" | - | - | - | - | - |
| 10" | 40 | 4, 7.9" | 5, 9.2" | 6, 9.5" | 7,10.3" | 8,10.9" | 9,11.4" |
| | 50 | 5,11.3" | 5, 8.7" | 6, 8.9" | 7, 9.7" | 8,10.3" | 9,10.7" |
| | 60 | 5,10.7" | 6,10.7" | 7,11.3" | 8,11.8" | 8, 9.7" | 9,10.1" |
| | 70 | 5,10.2" | 6,10.1" | 7,10.7" | 8,11.1" | 9,11.4" | 10,11.9" |
| | 80 | 5, 9.6" | 6, 9.6" | 7,10.1" | 8,10.6" | 9,10.9" | 10,11.3" |
| | 90 | 5, 9.2" | 6, 9.2" | 7, 9.7" | 8,10.1" | 9,10.3" | - |
| | 100 | 5, 8.8" | 6, 8.7" | 7, 9.2" | 9,11.9" | 9, 9.9" | - |
| | 110 | 5, 8.4" | 7,11.2" | 8,11.4" | 9,11.4" | 10,11.7" | - |
| | 150 | 6, 9.3" | 7, 9.5" | 8, 9.7" | 9, 9.7" | - | - |
| 12" | 40 | Min | 5,10.1" | 6,10.5" | 7,11.4" | 7, 9.4" | 8,10.2" |
| | 50 | 4, 8.2" | 5, 9.5" | 6,10.0" | 7,10.8" | 8,11.6" | 8, 9.7" |
| | 60 | 4, 7.8" | 5, 9.1" | 6, 9.5" | 7,10.3" | 8,11.0" | 9,11.5" |
| | 70 | 5,11.3" | 5, 8.6" | 6, 9.0" | 7, 9.8" | 8,10.5" | 9,10.9" |
| | 80 | 5,10.8" | 6,10.9" | 7,11.6" | 7, 9.4" | 8,10.0" | 9,10.5" |
| | 90 | 5,10.3" | 6,10.5" | 7,11.1" | 8,11.6" | 9,11.9" | 9,10.0" |
| | 100 | 5, 9.9" | 6,10.0" | 7,10.6" | 8,11.1" | 9,11.4" | 10,11.9" |
| | 110 | 5, 9.5" | 6, 9.6" | 7,10.2" | 8,10.7" | 9,11.0" | 10,11.5" |
| | 150 | 6,10.9" | 7,11.2" | 8,11.4" | 9,11.5" | 10,11.8" | 10, 9.9" |

Table 9 lists the safe superimposable load on concrete slats and beams.




Slats up to 6" x 7.5" and 16' long are reinforced with one bar (page 7). Beams are reinforced with 2 bars (page 8, part of page 9) or with 3 bars (pages 9 and 10).

**Table 9. Superimposable load in pounds per foot on slats and beams**

**1 Bar per beam**

Span, ft
Bar Size
Load, lb/ft

| SPAN / B H | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | NO. 3 | | | | | | | NO. 4 | | | | | | | NO. 5 | | | | |
| 3.0 | 73 | 26 | 9 | 1 | 0 | 0 | 0 | 80 | 29 | 11 | 2 | 0 | 0 | 0 | 80 | 29 | 11 | 2 | 0 | 0 | 0 |
| 3.5 | 130 | 33 | 22 | 9 | 2 | 0 | 0 | 152 | 59 | 27 | 12 | 4 | 0 | 0 | 159 | 63 | 29 | 13 | 5 | 0 | 0 |
| 4.0 | 170 | 66 | 30 | 13 | 4 | 0 | 0 | 240 | 97 | 46 | 24 | 12 | 4 | 0 | 258 | 106 | 52 | 27 | 14 | 6 | 1 |
| 4.5 | 211 | 83 | 39 | 18 | 7 | 0 | 0 | 339 | 142 | 72 | 39 | 22 | 11 | 4 | 331 | 156 | 80 | 44 | 25 | 14 | 6 |
| 5.0 | 252 | 100 | 48 | 23 | 10 | 2 | 0 | 402 | 188 | 97 | 55 | 32 | 18 | 9 | 394 | 214 | 111 | 64 | 38 | 23 | 12 |
| 5.5 | 293 | 118 | 56 | 28 | 13 | 3 | 0 | 466 | 220 | 114 | 65 | 38 | 22 | 12 | 457 | 278 | 147 | 86 | 53 | 33 | 20 |
| 6.0 | 334 | 135 | 65 | 33 | 15 | 5 | 0 | 529 | 253 | 131 | 75 | 45 | 26 | 14 | 521 | 339 | 186 | 110 | 69 | 44 | 28 |
| 6.5 | 375 | 152 | 74 | 38 | 18 | 6 | 0 | 592 | 285 | 149 | 86 | 51 | 31 | 17 | 584 | 380 | 228 | 136 | 86 | 57 | 37 |
| 7.0 | 417 | 169 | 83 | 43 | 21 | 8 | 0 | 655 | 318 | 166 | 96 | 58 | 35 | 20 | 647 | 422 | 263 | 158 | 101 | 67 | 44 |
| 7.5 | 459 | 187 | 92 | 48 | 24 | 9 | 0 | 718 | 350 | 184 | 107 | 65 | 39 | 23 | 710 | 463 | 290 | 175 | 112 | 74 | 50 |
| 5 | | | | | | | | | | | | | | | | | | | | | |
| 3.0 | 85 | 29 | 10 | 1 | 0 | 0 | 0 | 94 | 32 | 12 | 2 | 0 | 0 | 0 | 95 | 32 | 12 | 2 | 0 | 0 | 0 |
| 3.5 | 128 | 29 | 19 | 5 | 0 | 0 | 0 | 177 | 69 | 31 | 13 | 4 | 0 | 0 | 188 | 74 | 34 | 15 | 5 | 0 | 0 |
| 4.0 | 168 | 63 | 27 | 10 | 0 | 0 | 0 | 279 | 113 | 42 | 27 | 13 | 4 | 0 | 303 | 123 | 60 | 31 | 15 | 6 | 0 |
| 4.5 | 209 | 80 | 35 | 14 | 3 | 0 | 0 | 376 | 154 | 77 | 41 | 21 | 10 | 2 | 414 | 182 | 92 | 51 | 28 | 15 | 6 |
| 5.0 | 249 | 97 | 43 | 18 | 5 | 0 | 0 | 450 | 186 | 93 | 51 | 27 | 13 | 4 | 493 | 249 | 129 | 73 | 43 | 25 | 13 |
| 5.5 | 290 | 113 | 52 | 23 | 7 | 0 | 0 | 525 | 218 | 110 | 61 | 33 | 17 | 7 | 572 | 323 | 170 | 99 | 60 | 37 | 21 |
| 6.0 | 331 | 130 | 60 | 27 | 10 | 0 | 0 | 600 | 250 | 127 | 70 | 40 | 21 | 9 | 651 | 388 | 205 | 120 | 74 | 46 | 28 |
| 6.5 | 372 | 147 | 68 | 32 | 12 | 0 | 0 | 676 | 282 | 144 | 80 | 46 | 25 | 11 | 730 | 438 | 232 | 137 | 85 | 53 | 33 |
| 7.0 | 414 | 164 | 77 | 36 | 14 | 1 | 0 | 752 | 314 | 161 | 90 | 52 | 29 | 14 | 808 | 489 | 259 | 153 | 96 | 61 | 38 |
| 7.5 | 455 | 181 | 85 | 41 | 17 | 2 | 0 | 828 | 347 | 178 | 101 | 58 | 33 | 16 | 887 | 539 | 287 | 170 | 106 | 68 | 43 |
| 6 | | | | | | | | | | | | | | | | | | | | | |
| 3.0 | 86 | 28 | 8 | 0 | 0 | 0 | 0 | 106 | 29 | 13 | 1 | 0 | 0 | 0 | 109 | 29 | 13 | 2 | 0 | 0 | 0 |
| 3.5 | 126 | 44 | 15 | 2 | 0 | 0 | 0 | 201 | 26 | 34 | 14 | 3 | 0 | 0 | 215 | 83 | 38 | 16 | 5 | 0 | 0 |
| 4.0 | 166 | 60 | 23 | 6 | 0 | 0 | 0 | 302 | 120 | 38 | 28 | 12 | 2 | 0 | 345 | 140 | 38 | 35 | 17 | 6 | 0 |
| 4.5 | 206 | 76 | 31 | 10 | 0 | 0 | 0 | 375 | 152 | 73 | 37 | 17 | 5 | 0 | 497 | 206 | 104 | 51 | 31 | 15 | 5 |
| 5.0 | 246 | 93 | 39 | 14 | 0 | 0 | 0 | 450 | 183 | 90 | 46 | 23 | 9 | 0 | 592 | 281 | 145 | 48 | 47 | 27 | 13 |
| 5.5 | 287 | 109 | 47 | 18 | 2 | 0 | 0 | 525 | 215 | 106 | 56 | 29 | 12 | 1 | 686 | 336 | 174 | 99 | 59 | 34 | 18 |
| 6.0 | 328 | 125 | 55 | 22 | 4 | 0 | 0 | 600 | 246 | 123 | 65 | 34 | 15 | 3 | 781 | 386 | 201 | 116 | 69 | 41 | 23 |
| 6.5 | 369 | 142 | 63 | 26 | 6 | 0 | 0 | 675 | 278 | 139 | 75 | 40 | 19 | 5 | 876 | 436 | 228 | 132 | 79 | 48 | 27 |
| 7.0 | 410 | 158 | 71 | 30 | 8 | 0 | 0 | 751 | 310 | 156 | 84 | 46 | 22 | 7 | 970 | 486 | 255 | 148 | 90 | 55 | 32 |
| 7.5 | 451 | 175 | 79 | 34 | 10 | 0 | 0 | 827 | 342 | 173 | 94 | 51 | 26 | 9 | 1065 | 537 | 282 | 164 | 100 | 62 | 36 |
| 5 | | | NO. 6 | | | | | | | NO. 7 | | | | | | | NO. 8 | | | | |
| 3.0 | 16 | 1 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.5 | 90 | 29 | 9 | 0 | 0 | 0 | 0 | 84 | 27 | 7 | 0 | 0 | 0 | 0 | 76 | 24 | 6 | 0 | 0 | 0 | 0 |
| 4.0 | 188 | 72 | 32 | 13 | 3 | 0 | 0 | 186 | 71 | 31 | 13 | 2 | 0 | 0 | 181 | 69 | 30 | 12 | 2 | 0 | 0 |
| 4.5 | 314 | 127 | 61 | 31 | 14 | 4 | 0 | 313 | 129 | 62 | 32 | 15 | 5 | 0 | 302 | 128 | 62 | 32 | 15 | 5 | 0 |
| 5.0 | 402 | 191 | 96 | 53 | 29 | 14 | 5 | 391 | 198 | 100 | 55 | 30 | 16 | 6 | 381 | 201 | 102 | 56 | 31 | 16 | 6 |
| 5.5 | 480 | 265 | 137 | 78 | 45 | 26 | 13 | 470 | 279 | 144 | 82 | 49 | 28 | 15 | 460 | 287 | 149 | 85 | 51 | 30 | 16 |
| 6.0 | 559 | 348 | 183 | 106 | 64 | 39 | 23 | 549 | 356 | 194 | 113 | 69 | 43 | 26 | 539 | 349 | 202 | 119 | 73 | 46 | 28 |
| 6.5 | 638 | 414 | 233 | 137 | 85 | 54 | 33 | 628 | 408 | 249 | 148 | 93 | 59 | 38 | 618 | 401 | 262 | 156 | 98 | 63 | 41 |
| 7.0 | 717 | 466 | 287 | 171 | 108 | 70 | 45 | 707 | 459 | 310 | 185 | 118 | 77 | 51 | 697 | 453 | 327 | 196 | 126 | 83 | 55 |
| 7.5 | 796 | 518 | 346 | 208 | 133 | 87 | 58 | 786 | 511 | 374 | 226 | 145 | 97 | 65 | 775 | 504 | 369 | 241 | 156 | 104 | 71 |
| 6 | | | | | | | | | | | | | | | | | | | | | |
| 3.0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.5 | 103 | 26 | 10 | 0 | 0 | 0 | 0 | 97 | 26 | 8 | 0 | 0 | 0 | 0 | 89 | 26 | 6 | 0 | 0 | 0 | 0 |
| 4.0 | 216 | 83 | 36 | 14 | 2 | 0 | 0 | 215 | 82 | 35 | 14 | 2 | 0 | 0 | 210 | 80 | 34 | 13 | 2 | 0 | 0 |
| 4.5 | 359 | 144 | 69 | 34 | 15 | 4 | 0 | 367 | 148 | 71 | 36 | 16 | 5 | 0 | 363 | 148 | 71 | 36 | 16 | 5 | 0 |
| 5.0 | 482 | 217 | 109 | 48 | 31 | 15 | 4 | 470 | 227 | 114 | 62 | 34 | 17 | 6 | 458 | 232 | 117 | 64 | 35 | 18 | 6 |
| 5.5 | 577 | 301 | 155 | 87 | 50 | 28 | 14 | 564 | 318 | 164 | 93 | 54 | 31 | 16 | 552 | 329 | 170 | 97 | 57 | 33 | 17 |
| 6.0 | 671 | 395 | 206 | 119 | 58 | 43 | 24 | 659 | 421 | 221 | 128 | 78 | 47 | 28 | 647 | 419 | 231 | 135 | 82 | 51 | 30 |
| 6.5 | 766 | 497 | 262 | 154 | 95 | 59 | 36 | 754 | 489 | 283 | 167 | 104 | 66 | 41 | 741 | 481 | 299 | 177 | 111 | 71 | 45 |
| 7.0 | 860 | 559 | 324 | 192 | 120 | 68 | 49 | 848 | 551 | 351 | 209 | 132 | 86 | 56 | 836 | 543 | 372 | 223 | 142 | 93 | 61 |
| 7.5 | 955 | 622 | 364 | 216 | 136 | 88 | 57 | 943 | 613 | 424 | 255 | 163 | 108 | 72 | 931 | 605 | 443 | 273 | 176 | 117 | 79 |
| 6 | | | NO. 9 | | | | | | | NO. 10 | | | | | | | NO. 11 | | | | |
| 3.0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.5 | 79 | 23 | 4 | 0 | 0 | 0 | 0 | 67 | 18 | 1 | 0 | 0 | 0 | 0 | 55 | 13 | 0 | 0 | 0 | 0 | 0 |
| 4.0 | 200 | 75 | 32 | 11 | 0 | 0 | 0 | 186 | 69 | 28 | 9 | 0 | 0 | 0 | 171 | 62 | 24 | 7 | 0 | 0 | 0 |
| 4.5 | 350 | 145 | 70 | 35 | 16 | 4 | 0 | 337 | 140 | 67 | 33 | 14 | 3 | 0 | 323 | 133 | 63 | 30 | 13 | 2 | 0 |
| 5.0 | 445 | 232 | 117 | 64 | 35 | 18 | 6 | 431 | 229 | 116 | 63 | 34 | 17 | 6 | 418 | 223 | 112 | 61 | 33 | 16 | 5 |
| 5.5 | 540 | 334 | 173 | 99 | 58 | 34 | 18 | 526 | 335 | 174 | 99 | 59 | 34 | 18 | 512 | 330 | 172 | 98 | 58 | 34 | 18 |
| 6.0 | 634 | 411 | 237 | 139 | 85 | 53 | 32 | 620 | 401 | 241 | 141 | 87 | 54 | 33 | 607 | 392 | 241 | 141 | 87 | 54 | 33 |
| 6.5 | 729 | 473 | 309 | 183 | 115 | 74 | 48 | 715 | 464 | 316 | 188 | 119 | 77 | 49 | 701 | 454 | 319 | 190 | 120 | 78 | 50 |
| 7.0 | 824 | 535 | 387 | 233 | 149 | 98 | 65 | 810 | 526 | 384 | 240 | 154 | 102 | 68 | 796 | 517 | 377 | 244 | 157 | 104 | 70 |
| 7.5 | 918 | 597 | 436 | 286 | 185 | 124 | 84 | 904 | 588 | 429 | 297 | 192 | 129 | 88 | 891 | 579 | 423 | 304 | 197 | 133 | 91 |

Table 9. (continued) Superimposable load in pounds per foot on slats and beams

## 2 Bars per beam

| SPAN | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B H | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | NO. | 3 | | | | | | NO. | 4 | | | | | | NO. | 5 | | | |
| 6.0 | 671 | 278 | 140 | 77 | 42 | 21 | 8 | 793 | 509 | 270 | 160 | 100 | 64 | 40 | 781 | 509 | 306 | 183 | 116 | 75 | 49 |
| 7.0 | 838 | 349 | 178 | 98 | 55 | 29 | 13 | 982 | 640 | 341 | 203 | 128 | 83 | 53 | 970 | 633 | 452 | 274 | 177 | 119 | 81 |
| 8.0 | 1005 | 420 | 215 | 120 | 69 | 38 | 17 | 1172 | 765 | 412 | 247 | 156 | 102 | 67 | 1159 | 757 | 555 | 378 | 248 | 169 | 118 |
| 9.0 | 1173 | 491 | 252 | 142 | 82 | 46 | 22 | 1361 | 889 | 484 | 290 | 185 | 121 | 80 | 1349 | 881 | 647 | 463 | 305 | 210 | 148 |
| 10.0 | 1342 | 563 | 290 | 164 | 95 | 54 | 27 | 1550 | 1013 | 556 | 334 | 214 | 141 | 94 | 1538 | 1005 | 739 | 533 | 352 | 242 | 171 |
| 11.0 | 1511 | 635 | 328 | 186 | 109 | 62 | 32 | 1739 | 1137 | 629 | 378 | 242 | 161 | 107 | 1727 | 1129 | 830 | 604 | 399 | 276 | 195 |
| 12.0 | 1681 | 707 | 366 | 208 | 122 | 71 | 37 | 1929 | 1262 | 701 | 423 | 271 | 180 | 121 | 1916 | 1253 | 922 | 675 | 446 | 309 | 219 |
| 13.0 | 1851 | 779 | 404 | 230 | 136 | 79 | 42 | 2118 | 1386 | 774 | 467 | 301 | 200 | 135 | 2106 | 1378 | 1014 | 746 | 494 | 342 | 244 |
| 14.0 | 2021 | 851 | 442 | 252 | 149 | 87 | 47 | 2307 | 1510 | 847 | 512 | 330 | 220 | 148 | 2295 | 1502 | 1105 | 817 | 542 | 376 | 268 |
| 15.0 | 2192 | 924 | 480 | 275 | 163 | 96 | 52 | 2496 | 1634 | 921 | 557 | 359 | 240 | 162 | 2484 | 1626 | 1197 | 889 | 590 | 409 | 292 |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 670 | 274 | 136 | 72 | 37 | 16 | 2 | 926 | 508 | 267 | 156 | 95 | 59 | 35 | 911 | 593 | 340 | 202 | 128 | 82 | 53 |
| 7.0 | 837 | 344 | 172 | 92 | 49 | 23 | 6 | 1146 | 638 | 337 | 198 | 122 | 77 | 47 | 1132 | 738 | 501 | 303 | 195 | 130 | 88 |
| 8.0 | 1004 | 415 | 209 | 113 | 61 | 30 | 10 | 1367 | 769 | 408 | 241 | 150 | 95 | 60 | 1353 | 883 | 640 | 389 | 253 | 171 | 118 |
| 9.0 | 1172 | 485 | 245 | 134 | 74 | 37 | 14 | 1588 | 901 | 479 | 284 | 178 | 114 | 72 | 1574 | 1028 | 752 | 458 | 299 | 203 | 140 |
| 10.0 | 1340 | 556 | 282 | 155 | 86 | 45 | 18 | 1809 | 1034 | 551 | 327 | 206 | 132 | 85 | 1794 | 1173 | 862 | 528 | 345 | 235 | 163 |
| 11.0 | 1509 | 628 | 319 | 176 | 99 | 52 | 22 | 2029 | 1167 | 622 | 370 | 234 | 151 | 97 | 2015 | 1318 | 969 | 598 | 392 | 267 | 186 |
| 12.0 | 1678 | 699 | 356 | 198 | 111 | 59 | 26 | 2250 | 1300 | 694 | 414 | 262 | 170 | 110 | 2236 | 1462 | 1076 | 668 | 438 | 300 | 210 |
| 13.0 | 1848 | 770 | 393 | 219 | 124 | 67 | 30 | 2471 | 1434 | 767 | 458 | 290 | 189 | 123 | 2457 | 1607 | 1183 | 739 | 485 | 332 | 233 |
| 14.0 | 2017 | 842 | 430 | 240 | 137 | 74 | 34 | 2692 | 1568 | 839 | 502 | 318 | 208 | 136 | 2677 | 1752 | 1289 | 810 | 532 | 365 | 256 |
| 15.0 | 2188 | 914 | 468 | 261 | 149 | 82 | 38 | 2912 | 1703 | 912 | 545 | 347 | 227 | 149 | 2898 | 1897 | 1396 | 881 | 579 | 398 | 280 |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 668 | 270 | 131 | 66 | 31 | 10 | 0 | 1058 | 506 | 263 | 151 | 90 | 53 | 29 | 1042 | 678 | 372 | 220 | 138 | 62 | 57 |
| 7.0 | 834 | 339 | 166 | 86 | 42 | 16 | 0 | 1310 | 636 | 333 | 193 | 117 | 71 | 41 | 1294 | 844 | 526 | 316 | 202 | 134 | 69 |
| 8.0 | 1001 | 409 | 202 | 106 | 54 | 22 | 2 | 1562 | 767 | 403 | 235 | 143 | 88 | 52 | 1546 | 1009 | 637 | 384 | 247 | 165 | 111 |
| 9.0 | 1168 | 479 | 238 | 126 | 65 | 29 | 5 | 1815 | 898 | 473 | 277 | 170 | 106 | 64 | 1798 | 1175 | 749 | 453 | 292 | 196 | 133 |
| 10.0 | 1336 | 549 | 274 | 146 | 77 | 35 | 8 | 2067 | 1030 | 544 | 319 | 197 | 124 | 76 | 2051 | 1340 | 861 | 522 | 338 | 227 | 155 |
| 11.0 | 1505 | 620 | 310 | 166 | 89 | 42 | 11 | 2319 | 1163 | 615 | 362 | 224 | 141 | 87 | 2303 | 1506 | 974 | 592 | 384 | 258 | 177 |
| 12.0 | 1673 | 690 | 346 | 187 | 100 | 48 | 14 | 2572 | 1296 | 687 | 405 | 252 | 159 | 99 | 2555 | 1671 | 1087 | 661 | 430 | 290 | 199 |
| 13.0 | 1842 | 761 | 382 | 207 | 112 | 54 | 17 | 2824 | 1429 | 758 | 448 | 279 | 177 | 111 | 2808 | 1837 | 1201 | 731 | 476 | 322 | 222 |
| 14.0 | 2012 | 832 | 419 | 227 | 124 | 61 | 20 | 3076 | 1563 | 830 | 491 | 306 | 195 | 123 | 3060 | 2002 | 1315 | 801 | 522 | 354 | 244 |
| 15.0 | 2181 | 902 | 455 | 248 | 135 | 67 | 23 | 3329 | 1696 | 901 | 534 | 334 | 213 | 135 | 3312 | 2168 | 1429 | 871 | 568 | 386 | 267 |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 666 | 266 | 126 | 61 | 26 | 4 | 0 | 1190 | 503 | 259 | 146 | 85 | 48 | 24 | 1172 | 756 | 401 | 237 | 148 | 56 | 59 |
| 7.0 | 831 | 334 | 160 | 80 | 36 | 10 | 0 | 1474 | 633 | 328 | 187 | 111 | 64 | 34 | 1456 | 949 | 523 | 312 | 197 | 128 | 83 |
| 8.0 | 998 | 403 | 195 | 99 | 46 | 15 | 0 | 1758 | 763 | 398 | 228 | 136 | 81 | 45 | 1739 | 1135 | 633 | 379 | 241 | 158 | 104 |
| 9.0 | 1165 | 472 | 230 | 118 | 57 | 20 | 0 | 2042 | 894 | 467 | 270 | 162 | 98 | 56 | 2023 | 1322 | 745 | 447 | 286 | 188 | 125 |
| 10.0 | 1332 | 542 | 265 | 137 | 68 | 26 | 0 | 2325 | 1026 | 537 | 311 | 189 | 115 | 66 | 2307 | 1508 | 857 | 516 | 330 | 219 | 146 |
| 11.0 | 1500 | 611 | 300 | 156 | 78 | 31 | 0 | 2609 | 1158 | 608 | 353 | 215 | 131 | 77 | 2591 | 1694 | 969 | 584 | 375 | 249 | 168 |
| 12.0 | 1668 | 681 | 336 | 176 | 89 | 36 | 3 | 2893 | 1290 | 678 | 395 | 241 | 148 | 88 | 2875 | 1880 | 1082 | 653 | 420 | 280 | 189 |
| 13.0 | 1836 | 751 | 371 | 195 | 100 | 42 | 5 | 3177 | 1423 | 749 | 437 | 268 | 165 | 99 | 3159 | 2067 | 1195 | 722 | 466 | 311 | 211 |
| 14.0 | 2005 | 821 | 406 | 214 | 110 | 47 | 7 | 3461 | 1556 | 820 | 479 | 294 | 182 | 110 | 3443 | 2253 | 1308 | 792 | 511 | 342 | 232 |
| 15.0 | 2173 | 891 | 442 | 234 | 121 | 53 | 9 | 3745 | 1689 | 891 | 521 | 321 | 200 | 121 | 3726 | 2439 | 1422 | 861 | 557 | 373 | 254 |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 663 | 261 | 120 | 55 | 20 | 0 | 0 | 1201 | 500 | 255 | 141 | 80 | 43 | 18 | 1302 | 776 | 410 | 240 | 149 | 50 | 57 |
| 7.0 | 828 | 329 | 154 | 73 | 29 | 3 | 0 | 1504 | 629 | 323 | 181 | 104 | 58 | 28 | 1617 | 978 | 519 | 307 | 192 | 122 | 77 |
| 8.0 | 994 | 397 | 188 | 91 | 39 | 7 | 0 | 1808 | 759 | 392 | 222 | 129 | 74 | 38 | 1933 | 1181 | 629 | 374 | 235 | 151 | 97 |
| 9.0 | 1160 | 465 | 222 | 110 | 48 | 12 | 0 | 2114 | 889 | 461 | 262 | 154 | 89 | 47 | 2248 | 1386 | 740 | 441 | 279 | 181 | 117 |
| 10.0 | 1326 | 534 | 256 | 128 | 58 | 16 | 0 | 2421 | 1020 | 530 | 303 | 180 | 105 | 57 | 2564 | 1591 | 851 | 509 | 322 | 210 | 137 |
| 11.0 | 1494 | 602 | 291 | 146 | 68 | 20 | 0 | 2729 | 1152 | 599 | 344 | 205 | 121 | 67 | 2879 | 1798 | 963 | 577 | 367 | 240 | 158 |
| 12.0 | 1661 | 671 | 325 | 165 | 77 | 25 | 0 | 3038 | 1283 | 669 | 385 | 230 | 137 | 77 | 3194 | 2005 | 1075 | 645 | 411 | 270 | 178 |
| 13.0 | 1829 | 740 | 359 | 183 | 87 | 29 | 0 | 3348 | 1415 | 739 | 426 | 256 | 153 | 87 | 3510 | 2213 | 1188 | 713 | 455 | 300 | 199 |
| 14.0 | 1997 | 809 | 394 | 201 | 97 | 34 | 0 | 3658 | 1548 | 809 | 467 | 282 | 170 | 97 | 3825 | 2421 | 1300 | 782 | 500 | 330 | 220 |
| 15.0 | 2165 | 878 | 428 | 220 | 107 | 38 | 0 | 3968 | 1680 | 879 | 508 | 307 | 186 | 107 | 4141 | 2630 | 1413 | 850 | 545 | 360 | 240 |
| 7 | | | NO. | 6 | | | | | | NO. | 7 | | | | | | NO. | 8 | | | |
| 6.0 | 783 | 508 | 286 | 168 | 103 | 65 | 40 | 769 | 498 | 300 | 177 | 110 | 69 | 43 | 755 | 489 | 309 | 183 | 114 | 72 | 45 |
| 7.0 | 1004 | 653 | 452 | 271 | 173 | 114 | 76 | 990 | 643 | 470 | 290 | 186 | 124 | 83 | 975 | 634 | 463 | 304 | 196 | 131 | 88 |
| 8.0 | 1225 | 798 | 584 | 392 | 255 | 173 | 119 | 1210 | 788 | 577 | 423 | 277 | 188 | 131 | 1196 | 779 | 570 | 445 | 293 | 201 | 140 |
| 9.0 | 1445 | 942 | 691 | 530 | 349 | 239 | 168 | 1431 | 933 | 684 | 534 | 380 | 262 | 186 | 1417 | 923 | 677 | 529 | 406 | 281 | 200 |
| 10.0 | 1666 | 1087 | 798 | 624 | 452 | 314 | 224 | 1652 | 1078 | 791 | 619 | 495 | 345 | 248 | 1638 | 1068 | 784 | 613 | 499 | 372 | 268 |
| 11.0 | 1887 | 1232 | 905 | 708 | 534 | 372 | 267 | 1873 | 1223 | 898 | 703 | 573 | 436 | 316 | 1859 | 1213 | 891 | 697 | 568 | 472 | 343 |
| 12.0 | 2108 | 1377 | 1012 | 792 | 602 | 420 | 302 | 2094 | 1368 | 1005 | 787 | 642 | 535 | 390 | 2079 | 1358 | 997 | 781 | 637 | 534 | 425 |
| 13.0 | 2329 | 1522 | 1119 | 877 | 671 | 468 | 337 | 2314 | 1512 | 1111 | 871 | 710 | 596 | 470 | 2300 | 1503 | 1104 | 865 | 706 | 592 | 506 |
| 14.0 | 2549 | 1667 | 1225 | 961 | 739 | 517 | 373 | 2535 | 1657 | 1218 | 955 | 779 | 654 | 530 | 2521 | 1648 | 1211 | 949 | 775 | 650 | 556 |
| 15.0 | 2770 | 1812 | 1332 | 1045 | 808 | 566 | 408 | 2756 | 1802 | 1325 | 1039 | 848 | 712 | 580 | 2742 | 1793 | 1318 | 1033 | 844 | 708 | 606 |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 895 | 581 | 314 | 183 | 113 | 62 | 42 | 879 | 570 | 331 | 195 | 120 | 76 | 46 | 863 | 559 | 343 | 202 | 125 | 79 | 49 |
| 7.0 | 1147 | 746 | 495 | 297 | 189 | 124 | 81 | 1131 | 735 | 530 | 319 | 204 | 135 | 90 | 1115 | 724 | 529 | 335 | 215 | 143 | 96 |
| 8.0 | 1400 | 912 | 668 | 429 | 278 | 187 | 128 | 1383 | 901 | 659 | 465 | 303 | 205 | 142 | 1367 | 890 | 651 | 493 | 323 | 220 | 153 |
| 9.0 | 1652 | 1077 | 790 | 578 | 379 | 260 | 182 | 1636 | 1066 | 782 | 611 | 416 | 286 | 202 | 1619 | 1055 | 773 | 604 | 446 | 308 | 219 |
| 10.0 | 1904 | 1243 | 912 | 699 | 461 | 317 | 224 | 1888 | 1232 | 904 | 707 | 541 | 376 | 269 | 1872 | 1221 | 896 | 700 | 570 | 407 | 293 |
| 11.0 | 2157 | 1408 | 1034 | 799 | 528 | 364 | 258 | 2140 | 1397 | 1026 | 803 | 654 | 475 | 343 | 2124 | 1387 | 1018 | 797 | 649 | 516 | 374 |
| 12.0 | 2409 | 1574 | 1156 | 899 | 595 | 412 | 293 | 2393 | 1563 | 1148 | 899 | 733 | 580 | 421 | 2376 | 1552 | 1140 | 893 | 728 | 610 | 463 |
| 13.0 | 2661 | 1739 | 1278 | 1001 | 663 | 459 | 327 | 2645 | 1728 | 1270 | 995 | 812 | 647 | 471 | 2629 | 1718 | 1262 | 989 | 807 | 676 | 559 |
| 14.0 | 2914 | 1905 | 1401 | 1098 | 731 | 507 | 362 | 2897 | 1894 | 1392 | 1091 | 891 | 714 | 520 | 2881 | 1883 | 1384 | 1085 | 885 | 743 | 636 |
| 15.0 | 3166 | 2070 | 1523 | 1194 | 799 | 555 | 397 | 3150 | 2060 | 1515 | 1188 | 970 | 782 | 570 | 3133 | 2049 | 1506 | 1181 | 964 | 809 | 693 |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1007 | 648 | 340 | 198 | 121 | 56 | 44 | 989 | 641 | 361 | 211 | 130 | 81 | 49 | 970 | 629 | 375 | 220 | 136 | 86 | 53 |
| 7.0 | 1291 | 839 | 536 | 320 | 203 | 132 | 62 | 1273 | 827 | 576 | 346 | 221 | 145 | 96 | 1254 | 815 | 595 | 365 | 234 | 155 | 104 |
| 8.0 | 1575 | 1026 | 751 | 463 | 299 | 201 | 137 | 1556 | 1013 | 742 | 503 | 327 | 221 | 152 | 1538 | 1001 | 733 | 536 | 350 | 238 | 165 |
| 9.0 | 1859 | 1212 | 889 | 595 | 388 | 263 | 183 | 1840 | 1200 | 879 | 683 | 449 | 308 | 217 | 1822 | 1187 | 870 | 680 | 483 | 333 | 236 |
| 10.0 | 2142 | 1398 | 1026 | 694 | 454 | 310 | 216 | 2124 | 1386 | 1017 | 795 | 584 | 405 | 289 | 2106 | 1374 | 1008 | 788 | 632 | 440 | 316 |
| 11.0 | 2426 | 1584 | 1163 | 793 | 521 | 356 | 249 | 2408 | 1572 | 1154 | 903 | 725 | 507 | 364 | 2390 | 1560 | 1145 | 896 | 730 | 558 | 404 |
| 12.0 | 2710 | 1771 | 1301 | 894 | 587 | 403 | 283 | 2692 | 1758 | 1292 | 1012 | 818 | 573 | 413 | 2674 | 1746 | 1283 | 1004 | 819 | 685 | 499 |
| 13.0 | 2994 | 1957 | 1438 | 994 | 654 | 450 | 317 | 2976 | 1945 | 1429 | 1120 | 912 | 639 | 462 | 2957 | 1932 | 1420 | 1112 | 907 | 761 | 602 |
| 14.0 | 3278 | 2143 | 1576 | 1095 | 722 | 497 | 351 | 3260 | 2131 | 1567 | 1228 | 1002 | 706 | 511 | 3241 | 2119 | 1557 | 1221 | 996 | 836 | 695 |
| 15.0 | 3562 | 2329 | 1713 | 1196 | 789 | 544 | 385 | 3543 | 2317 | 1704 | 1336 | 1091 | 772 | 560 | 3525 | 2305 | 1695 | 1329 | 1085 | 910 | 762 |

Table 9. (continued) Superimposable load in pounds per foot on slats and beams

## 2 Bars per beam

| SPAN B H | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NO. 6 | | | | | | | NO. 7 | | | | | | | NO. 8 | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1119 | 697 | 366 | 212 | 129 | 50 | 46 | 1099 | 712 | 389 | 227 | 139 | 50 | 52 | 1078 | 699 | 405 | 238 | 146 | 92 | 56 |
| 7.0 | 1434 | 933 | 575 | 343 | 217 | 140 | 55 | 1414 | 919 | 620 | 371 | 236 | 155 | 102 | 1394 | 906 | 654 | 393 | 252 | 166 | 111 |
| 8.0 | 1750 | 1140 | 813 | 492 | 317 | 211 | 143 | 1729 | 1126 | 824 | 540 | 351 | 236 | 162 | 1709 | 1113 | 814 | 577 | 376 | 255 | 176 |
| 9.0 | 2065 | 1347 | 972 | 589 | 382 | 256 | 175 | 2045 | 1333 | 977 | 732 | 481 | 329 | 231 | 2024 | 1319 | 967 | 755 | 519 | 357 | 252 |
| 10.0 | 2381 | 1554 | 1132 | 688 | 447 | 302 | 208 | 2360 | 1540 | 1130 | 884 | 625 | 433 | 308 | 2340 | 1526 | 1120 | 876 | 678 | 471 | 337 |
| 11.0 | 2696 | 1760 | 1292 | 787 | 513 | 348 | 240 | 2676 | 1747 | 1283 | 1004 | 719 | 499 | 356 | 2655 | 1733 | 1272 | 996 | 811 | 597 | 431 |
| 12.0 | 3011 | 1967 | 1445 | 887 | 579 | 393 | 273 | 2991 | 1954 | 1435 | 1124 | 812 | 564 | 404 | 2971 | 1940 | 1425 | 1116 | 910 | 733 | 533 |
| 13.0 | 3327 | 2174 | 1598 | 987 | 645 | 440 | 306 | 3306 | 2161 | 1588 | 1244 | 905 | 630 | 452 | 3286 | 2147 | 1578 | 1236 | 1008 | 846 | 620 |
| 14.0 | 3642 | 2381 | 1751 | 1087 | 712 | 486 | 339 | 3622 | 2368 | 1741 | 1364 | 998 | 696 | 500 | 3601 | 2354 | 1730 | 1356 | 1107 | 929 | 686 |
| 15.0 | 3957 | 2588 | 1903 | 1188 | 779 | 532 | 372 | 3937 | 2575 | 1893 | 1485 | 1092 | 762 | 548 | 3917 | 2561 | 1883 | 1476 | 1205 | 1012 | 752 |
| | NO. 9 | | | | | | | NO. 10 | | | | | | | NO. 11 | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 846 | 548 | 348 | 205 | 128 | 81 | 51 | 827 | 535 | 349 | 206 | 128 | 81 | 51 | | | | | | | |
| 7.0 | 1098 | 713 | 521 | 346 | 223 | 149 | 101 | 1080 | 701 | 512 | 353 | 228 | 152 | 103 | | | | | | | |
| 8.0 | 1351 | 879 | 643 | 502 | 337 | 230 | 161 | 1332 | 867 | 634 | 494 | 348 | 239 | 168 | | | | | | | |
| 9.0 | 1603 | 1044 | 765 | 598 | 468 | 325 | 231 | 1584 | 1032 | 756 | 590 | 480 | 339 | 243 | | | | | | | |
| 10.0 | 1855 | 1210 | 887 | 694 | 565 | 431 | 311 | 1837 | 1198 | 878 | 686 | 559 | 452 | 328 | | | | | | | |
| 11.0 | 2107 | 1375 | 1009 | 790 | 643 | 539 | 399 | 2089 | 1363 | 1000 | 782 | 637 | 534 | 422 | | | | | | | |
| 12.0 | 2360 | 1541 | 1132 | 886 | 722 | 605 | 495 | 2341 | 1529 | 1122 | 879 | 716 | 600 | 513 | | | | | | | |
| 13.0 | 2612 | 1707 | 1254 | 982 | 801 | 672 | 575 | 2594 | 1694 | 1245 | 975 | 795 | 666 | 570 | | | | | | | |
| 14.0 | 2864 | 1872 | 1376 | 1078 | 880 | 738 | 632 | 2846 | 1860 | 1367 | 1071 | 874 | 733 | 627 | | | | | | | |
| 15.0 | 3117 | 2038 | 1498 | 1174 | 959 | 804 | 689 | 3098 | 2025 | 1489 | 1167 | 952 | 799 | 684 | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 952 | 616 | 381 | 225 | 139 | 88 | 54 | 931 | 602 | 384 | 226 | 140 | 89 | 55 | 910 | 589 | 382 | 225 | 139 | 88 | 55 |
| 7.0 | 1236 | 803 | 586 | 378 | 243 | 162 | 109 | 1215 | 789 | 576 | 387 | 249 | 166 | 112 | 1194 | 775 | 565 | 391 | 252 | 168 | 114 |
| 8.0 | 1519 | 989 | 723 | 560 | 367 | 250 | 174 | 1499 | 975 | 713 | 556 | 380 | 260 | 182 | 1478 | 961 | 703 | 548 | 389 | 266 | 187 |
| 9.0 | 1803 | 1175 | 861 | 672 | 509 | 352 | 251 | 1782 | 1161 | 850 | 664 | 532 | 369 | 264 | 1762 | 1147 | 840 | 656 | 533 | 381 | 273 |
| 10.0 | 2087 | 1361 | 998 | 781 | 635 | 467 | 337 | 2066 | 1347 | 988 | 772 | 628 | 493 | 356 | 2046 | 1334 | 978 | 764 | 622 | 511 | 370 |
| 11.0 | 2371 | 1547 | 1136 | 889 | 724 | 594 | 432 | 2350 | 1534 | 1125 | 880 | 717 | 600 | 458 | 2330 | 1520 | 1115 | 872 | 710 | 595 | 479 |
| 12.0 | 2655 | 1734 | 1273 | 997 | 813 | 681 | 536 | 2634 | 1720 | 1263 | 989 | 806 | 675 | 571 | 2614 | 1706 | 1253 | 980 | 799 | 669 | 572 |
| 13.0 | 2939 | 1920 | 1411 | 1105 | 901 | 756 | 647 | 2918 | 1906 | 1400 | 1097 | 894 | 750 | 641 | 2897 | 1892 | 1390 | 1088 | 887 | 744 | 636 |
| 14.0 | 3222 | 2106 | 1548 | 1213 | 990 | 830 | 711 | 3202 | 2092 | 1538 | 1205 | 983 | 824 | 706 | 3181 | 2079 | 1527 | 1197 | 976 | 819 | 700 |
| 15.0 | 3506 | 2292 | 1685 | 1321 | 1078 | 905 | 775 | 3486 | 2279 | 1675 | 1313 | 1072 | 899 | 770 | 3465 | 2265 | 1665 | 1305 | 1065 | 893 | 765 |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1058 | 685 | 414 | 243 | 150 | 94 | 58 | 1034 | 669 | 418 | 246 | 152 | 96 | 59 | 1012 | 654 | 416 | 245 | 151 | 95 | 59 |
| 7.0 | 1373 | 892 | 651 | 408 | 262 | 174 | 116 | 1350 | 876 | 640 | 419 | 270 | 179 | 121 | 1327 | 861 | 628 | 425 | 273 | 182 | 123 |
| 8.0 | 1688 | 1099 | 804 | 604 | 395 | 269 | 187 | 1665 | 1083 | 792 | 618 | 411 | 281 | 196 | 1642 | 1068 | 781 | 609 | 421 | 288 | 202 |
| 9.0 | 2004 | 1306 | 957 | 747 | 548 | 379 | 269 | 1981 | 1290 | 945 | 738 | 575 | 398 | 284 | 1958 | 1275 | 934 | 729 | 592 | 412 | 294 |
| 10.0 | 2319 | 1513 | 1109 | 867 | 706 | 502 | 361 | 2296 | 1497 | 1098 | 858 | 698 | 531 | 383 | 2273 | 1482 | 1086 | 849 | 691 | 552 | 399 |
| 11.0 | 2634 | 1719 | 1262 | 987 | 804 | 638 | 463 | 2611 | 1704 | 1250 | 978 | 797 | 667 | 493 | 2589 | 1689 | 1239 | 969 | 789 | 661 | 516 |
| 12.0 | 2950 | 1926 | 1415 | 1108 | 903 | 757 | 574 | 2927 | 1911 | 1403 | 1098 | 895 | 750 | 613 | 2904 | 1896 | 1392 | 1089 | 888 | 744 | 636 |
| 13.0 | 3265 | 2133 | 1567 | 1228 | 1001 | 840 | 694 | 3242 | 2118 | 1556 | 1219 | 994 | 833 | 713 | 3219 | 2103 | 1544 | 1209 | 986 | 827 | 707 |
| 14.0 | 3581 | 2340 | 1720 | 1348 | 1100 | 923 | 790 | 3557 | 2325 | 1708 | 1339 | 1092 | 916 | 784 | 3535 | 2310 | 1697 | 1330 | 1085 | 910 | 778 |
| 15.0 | 3896 | 2547 | 1873 | 1468 | 1198 | 1006 | 861 | 3873 | 2532 | 1861 | 1459 | 1191 | 999 | 855 | 3850 | 2517 | 1850 | 1450 | 1183 | 993 | 850 |

## 3 Bars per beam

| SPAN B H | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NO. 3 | | | | | | | NO. 4 | | | | | | | NO. 5 | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 940 | 423 | 220 | 125 | 74 | 43 | 23 | 926 | 603 | 346 | 206 | 130 | 68 | 55 | 911 | 593 | 386 | 231 | 148 | 97 | 65 |
| 7.0 | 1161 | 530 | 277 | 159 | 95 | 57 | 32 | 1146 | 748 | 506 | 306 | 198 | 132 | 76 | 1132 | 738 | 541 | 347 | 226 | 153 | 106 |
| 8.0 | 1381 | 638 | 334 | 194 | 117 | 71 | 41 | 1367 | 893 | 626 | 380 | 247 | 166 | 114 | 1353 | 883 | 648 | 480 | 316 | 217 | 153 |
| 9.0 | 1602 | 747 | 392 | 228 | 139 | 85 | 50 | 1588 | 1037 | 734 | 447 | 291 | 197 | 136 | 1574 | 1028 | 755 | 591 | 418 | 290 | 207 |
| 10.0 | 1823 | 855 | 450 | 263 | 161 | 100 | 60 | 1809 | 1182 | 843 | 514 | 336 | 228 | 158 | 1794 | 1173 | 862 | 675 | 529 | 370 | 267 |
| 11.0 | 2044 | 964 | 509 | 298 | 183 | 114 | 69 | 2029 | 1327 | 953 | 582 | 381 | 259 | 180 | 2015 | 1318 | 969 | 760 | 611 | 429 | 310 |
| 12.0 | 2264 | 1074 | 567 | 333 | 205 | 128 | 78 | 2250 | 1472 | 1063 | 650 | 426 | 290 | 202 | 2236 | 1462 | 1076 | 844 | 684 | 480 | 348 |
| 13.0 | 2485 | 1184 | 626 | 368 | 227 | 143 | 88 | 2471 | 1617 | 1174 | 718 | 471 | 322 | 225 | 2457 | 1607 | 1183 | 928 | 756 | 531 | 385 |
| 14.0 | 2706 | 1294 | 685 | 403 | 250 | 157 | 97 | 2692 | 1762 | 1284 | 787 | 516 | 353 | 247 | 2677 | 1752 | 1289 | 1012 | 827 | 583 | 423 |
| 15.0 | 2927 | 1404 | 743 | 438 | 272 | 172 | 107 | 2912 | 1906 | 1395 | 855 | 562 | 385 | 270 | 2898 | 1897 | 1396 | 1096 | 896 | 635 | 461 |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1007 | 421 | 215 | 120 | 69 | 38 | 17 | 1058 | 689 | 378 | 224 | 141 | 62 | 58 | 1042 | 678 | 424 | 254 | 161 | 106 | 70 |
| 7.0 | 1257 | 527 | 272 | 154 | 89 | 51 | 26 | 1310 | 855 | 515 | 309 | 198 | 130 | 86 | 1294 | 844 | 619 | 380 | 247 | 166 | 114 |
| 8.0 | 1508 | 634 | 329 | 187 | 110 | 64 | 34 | 1562 | 1020 | 623 | 375 | 241 | 160 | 107 | 1546 | 1009 | 741 | 525 | 345 | 236 | 166 |
| 9.0 | 1760 | 742 | 386 | 221 | 131 | 77 | 42 | 1815 | 1186 | 731 | 442 | 285 | 190 | 128 | 1798 | 1175 | 863 | 676 | 455 | 315 | 224 |
| 10.0 | 2014 | 850 | 443 | 255 | 152 | 90 | 50 | 2067 | 1351 | 840 | 508 | 328 | 220 | 150 | 2051 | 1340 | 985 | 772 | 534 | 371 | 265 |
| 11.0 | 2268 | 959 | 501 | 289 | 173 | 104 | 59 | 2319 | 1517 | 949 | 575 | 372 | 250 | 171 | 2303 | 1506 | 1107 | 868 | 605 | 421 | 302 |
| 12.0 | 2523 | 1068 | 558 | 323 | 195 | 117 | 67 | 2572 | 1682 | 1058 | 643 | 417 | 281 | 192 | 2555 | 1671 | 1229 | 964 | 677 | 472 | 339 |
| 13.0 | 2778 | 1177 | 616 | 357 | 216 | 131 | 76 | 2824 | 1848 | 1168 | 710 | 461 | 311 | 214 | 2808 | 1837 | 1352 | 1060 | 749 | 523 | 376 |
| 14.0 | 3034 | 1286 | 674 | 391 | 237 | 144 | 84 | 3076 | 2013 | 1278 | 778 | 506 | 342 | 235 | 3060 | 2003 | 1474 | 1157 | 822 | 574 | 413 |
| 15.0 | 3291 | 1396 | 732 | 425 | 259 | 158 | 93 | 3329 | 2179 | 1389 | 846 | 550 | 372 | 257 | 3312 | 2168 | 1596 | 1253 | 894 | 625 | 450 |

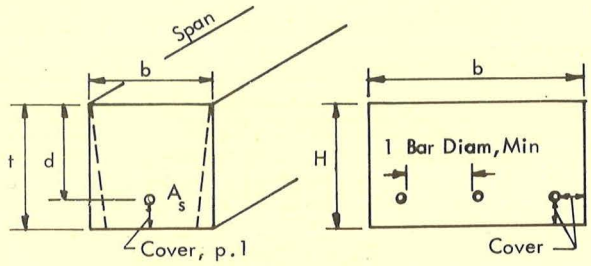
**Table 9. (continued) Superimposable load in pounds per foot on slats and beams**

## 3 Bars per beam

| SPAN B H | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | NO. 3 | | | | | | | NO. 4 | | | | | | | NO. 5 | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1007 | 417 | 211 | 115 | 63 | 32 | 12 | 1190 | 764 | 406 | 240 | 150 | 56 | 61 | 1172 | 763 | 460 | 275 | 174 | 113 | 71 |
| 7.0 | 1257 | 523 | 267 | 148 | 83 | 44 | 19 | 1474 | 960 | 512 | 305 | 192 | 124 | 80 | 1456 | 949 | 678 | 411 | 266 | 179 | 122 |
| 8.0 | 1508 | 630 | 323 | 180 | 103 | 57 | 26 | 1758 | 1148 | 619 | 370 | 235 | 153 | 100 | 1739 | 1135 | 833 | 567 | 372 | 254 | 177 |
| 9.0 | 1760 | 737 | 379 | 213 | 123 | 69 | 34 | 2042 | 1334 | 727 | 436 | 278 | 182 | 121 | 2023 | 1322 | 971 | 695 | 458 | 315 | 222 |
| 10.0 | 2013 | 845 | 435 | 246 | 143 | 81 | 41 | 2325 | 1520 | 835 | 502 | 321 | 212 | 141 | 2307 | 1508 | 1108 | 800 | 528 | 364 | 257 |
| 11.0 | 2267 | 952 | 492 | 279 | 163 | 94 | 48 | 2609 | 1706 | 943 | 568 | 364 | 241 | 161 | 2591 | 1694 | 1246 | 906 | 599 | 414 | 293 |
| 12.0 | 2522 | 1061 | 549 | 312 | 184 | 106 | 56 | 2893 | 1893 | 1052 | 634 | 407 | 271 | 182 | 2875 | 1880 | 1383 | 1012 | 670 | 463 | 329 |
| 13.0 | 2777 | 1169 | 606 | 346 | 204 | 119 | 63 | 3177 | 2079 | 1162 | 701 | 451 | 300 | 202 | 3159 | 2067 | 1521 | 1119 | 741 | 513 | 366 |
| 14.0 | 3032 | 1277 | 663 | 379 | 224 | 131 | 71 | 3461 | 2265 | 1271 | 768 | 495 | 330 | 223 | 3443 | 2253 | 1658 | 1226 | 813 | 564 | 402 |
| 15.0 | 3288 | 1386 | 720 | 412 | 245 | 144 | 78 | 3745 | 2451 | 1381 | 835 | 539 | 360 | 244 | 3726 | 2439 | 1795 | 1334 | 885 | 614 | 438 |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1006 | 414 | 206 | 110 | 58 | 27 | 6 | 1322 | 763 | 403 | 236 | 145 | 50 | 55 | 1302 | 848 | 494 | 294 | 186 | 121 | 65 |
| 7.0 | 1256 | 519 | 261 | 142 | 77 | 38 | 12 | 1638 | 958 | 508 | 300 | 187 | 118 | 74 | 1617 | 1055 | 728 | 440 | 284 | 190 | 129 |
| 8.0 | 1507 | 625 | 316 | 173 | 96 | 49 | 19 | 1953 | 1155 | 615 | 364 | 228 | 146 | 93 | 1933 | 1262 | 926 | 586 | 382 | 260 | 180 |
| 9.0 | 1759 | 731 | 372 | 205 | 115 | 60 | 25 | 2269 | 1353 | 722 | 429 | 270 | 175 | 113 | 2248 | 1469 | 1079 | 690 | 452 | 308 | 214 |
| 10.0 | 2011 | 838 | 427 | 237 | 134 | 72 | 31 | 2584 | 1552 | 829 | 495 | 313 | 203 | 132 | 2564 | 1676 | 1232 | 795 | 521 | 356 | 249 |
| 11.0 | 2265 | 945 | 483 | 270 | 153 | 83 | 38 | 2899 | 1752 | 937 | 560 | 355 | 232 | 151 | 2879 | 1882 | 1384 | 900 | 592 | 405 | 284 |
| 12.0 | 2519 | 1053 | 539 | 302 | 173 | 95 | 44 | 3215 | 1953 | 1046 | 626 | 398 | 260 | 171 | 3194 | 2089 | 1537 | 1006 | 662 | 454 | 320 |
| 13.0 | 2774 | 1160 | 596 | 334 | 192 | 107 | 51 | 3530 | 2153 | 1154 | 692 | 440 | 289 | 191 | 3510 | 2296 | 1690 | 1112 | 733 | 504 | 355 |
| 14.0 | 3029 | 1268 | 652 | 367 | 212 | 118 | 58 | 3845 | 2355 | 1263 | 758 | 483 | 318 | 210 | 3825 | 2503 | 1842 | 1219 | 804 | 553 | 391 |
| 15.0 | 3284 | 1376 | 708 | 399 | 231 | 130 | 64 | 4161 | 2557 | 1372 | 824 | 526 | 347 | 230 | 4141 | 2710 | 1995 | 1326 | 875 | 603 | 426 |
| | | | | NO. 6 | | | | | | | NO. 7 | | | | | | | NO. 8 | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1007 | 653 | 384 | 226 | 140 | 89 | 55 | 989 | 641 | 401 | 237 | 148 | 94 | 59 | 970 | 629 | 411 | 243 | 152 | 98 | 62 |
| 7.0 | 1291 | 839 | 608 | 366 | 235 | 156 | 104 | 1273 | 827 | 605 | 389 | 251 | 168 | 113 | 1254 | 815 | 595 | 406 | 262 | 176 | 120 |
| 8.0 | 1575 | 1026 | 751 | 531 | 346 | 235 | 163 | 1556 | 1013 | 742 | 569 | 373 | 255 | 178 | 1538 | 1001 | 733 | 572 | 394 | 270 | 190 |
| 9.0 | 1859 | 1212 | 889 | 695 | 473 | 326 | 230 | 1840 | 1200 | 879 | 687 | 513 | 355 | 253 | 1822 | 1187 | 870 | 680 | 545 | 379 | 271 |
| 10.0 | 2142 | 1398 | 1026 | 803 | 614 | 427 | 306 | 2124 | 1386 | 1017 | 795 | 648 | 468 | 337 | 2106 | 1374 | 1008 | 788 | 642 | 501 | 362 |
| 11.0 | 2426 | 1584 | 1163 | 911 | 742 | 538 | 389 | 2408 | 1572 | 1154 | 903 | 736 | 592 | 430 | 2390 | 1560 | 1145 | 896 | 730 | 612 | 464 |
| 12.0 | 2710 | 1771 | 1301 | 1019 | 831 | 642 | 466 | 2692 | 1758 | 1292 | 1012 | 825 | 692 | 531 | 2674 | 1746 | 1283 | 1004 | 819 | 686 | 575 |
| 13.0 | 2994 | 1957 | 1438 | 1127 | 920 | 715 | 520 | 2976 | 1945 | 1429 | 1120 | 914 | 766 | 639 | 2957 | 1932 | 1420 | 1112 | 907 | 761 | 651 |
| 14.0 | 3278 | 2143 | 1576 | 1235 | 1008 | 789 | 575 | 3260 | 2131 | 1567 | 1228 | 1002 | 841 | 720 | 3241 | 2119 | 1557 | 1221 | 996 | 836 | 715 |
| 15.0 | 3562 | 2329 | 1713 | 1343 | 1097 | 863 | 629 | 3543 | 2317 | 1704 | 1336 | 1091 | 916 | 784 | 3525 | 2305 | 1695 | 1329 | 1085 | 910 | 780 |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1119 | 726 | 414 | 243 | 150 | 94 | 58 | 1099 | 712 | 434 | 256 | 159 | 101 | 63 | 1078 | 699 | 447 | 264 | 165 | 105 | 66 |
| 7.0 | 1434 | 933 | 655 | 394 | 252 | 166 | 111 | 1414 | 919 | 672 | 420 | 270 | 180 | 121 | 1394 | 906 | 662 | 439 | 284 | 190 | 129 |
| 8.0 | 1750 | 1140 | 835 | 570 | 371 | 251 | 174 | 1729 | 1126 | 824 | 614 | 402 | 274 | 191 | 1709 | 1113 | 814 | 635 | 425 | 291 | 204 |
| 9.0 | 2065 | 1347 | 987 | 770 | 507 | 348 | 245 | 2045 | 1333 | 977 | 764 | 552 | 381 | 271 | 2025 | 1319 | 967 | 755 | 588 | 408 | 291 |
| 10.0 | 2381 | 1554 | 1140 | 892 | 658 | 456 | 326 | 2360 | 1540 | 1130 | 884 | 719 | 502 | 361 | 2340 | 1526 | 1120 | 876 | 713 | 539 | 389 |
| 11.0 | 2696 | 1760 | 1293 | 1012 | 804 | 562 | 404 | 2676 | 1747 | 1283 | 1004 | 818 | 634 | 460 | 2655 | 1733 | 1272 | 996 | 811 | 680 | 498 |
| 12.0 | 3011 | 1967 | 1445 | 1132 | 907 | 634 | 457 | 2991 | 1954 | 1435 | 1124 | 917 | 768 | 568 | 2971 | 1940 | 1425 | 1116 | 910 | 763 | 617 |
| 13.0 | 3327 | 2174 | 1598 | 1252 | 1010 | 707 | 511 | 3306 | 2161 | 1588 | 1244 | 1015 | 851 | 684 | 3286 | 2147 | 1578 | 1236 | 1008 | 846 | 724 |
| 14.0 | 3642 | 2381 | 1751 | 1373 | 1113 | 780 | 565 | 3622 | 2368 | 1741 | 1364 | 1114 | 934 | 799 | 3601 | 2354 | 1730 | 1356 | 1107 | 929 | 795 |
| 15.0 | 3957 | 2588 | 1903 | 1493 | 1217 | 854 | 618 | 3937 | 2575 | 1893 | 1485 | 1212 | 1017 | 871 | 3917 | 2561 | 1883 | 1476 | 1205 | 1012 | 866 |
| | | | | NO. 9 | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |
| 6.0 | 1058 | 685 | 451 | 267 | 167 | 107 | 67 | | | | | | | | | | | | | | |
| 7.0 | 1373 | 892 | 651 | 451 | 291 | 195 | 133 | | | | | | | | | | | | | | |
| 8.0 | 1688 | 1099 | 804 | 627 | 441 | 303 | 213 | | | | | | | | | | | | | | |
| 9.0 | 2004 | 1306 | 957 | 747 | 608 | 427 | 306 | | | | | | | | | | | | | | |
| 10.0 | 2319 | 1513 | 1109 | 867 | 706 | 568 | 411 | | | | | | | | | | | | | | |
| 11.0 | 2634 | 1719 | 1262 | 987 | 804 | 674 | 528 | | | | | | | | | | | | | | |
| 12.0 | 2950 | 1926 | 1415 | 1108 | 903 | 757 | 647 | | | | | | | | | | | | | | |
| 13.0 | 3265 | 2133 | 1567 | 1228 | 1001 | 840 | 718 | | | | | | | | | | | | | | |
| 14.0 | 3581 | 2340 | 1720 | 1348 | 1100 | 923 | 790 | | | | | | | | | | | | | | |
| 15.0 | 3896 | 2547 | 1873 | 1468 | 1198 | 1006 | 861 | | | | | | | | | | | | | | |

## Designing Slats and Beams

Safe superimposable loads were computed for several sizes and spans of reinforced concrete beams with one, two, and three tension bars. The design procedure consisted of selecting the size, span, and reinforcing, and then determining the load-carrying capacity.




**Several criteria were met:**

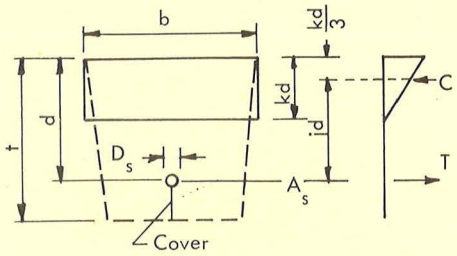
Criteria were selected from ACI-318-63, WSD Part IV A.

Only designs for beams wide enough to provide at least minimum side cover and bar spacing are tabulated.

Allowable load in bending, shear, bond, and deflection (span/180) were computed, and the least printed out.

A tabulated allowable load = 0 means the design will not support even the dead weight of the beam.

Taper in slats was ignored.




**Procedure**

Read data on steel bars off data cards and compute allowable bond for each size.

Select overall beam dimensions, b and t.

Compute dead weight = t x b x 145pcf/144 $in^2/ft^2$ rounded to t x b.

Select bar size.

d = t - cover - Ds/2
k=½(-C + (C2 + 4C)$^{½}$)
where C = (number of bars) (2nAs/bd)
I= b(kd)$^3$/3 + nAs(d-kd)$^2$
j = 1 - k/3
Mc = fcbkjd$^2$/2 = compression couple
Ms = fsjdAs = tension couple
M = Ms/12 or Mc/12 ft lb
whichever is smaller
P = 8M/Span$^2$ = total load/ft
WLOAD = P - deadweight, max load in bending
= 0 if beam won't hold deadweight

SHEAR = ½P x Span/db = shear stress
IF less than fv, WSHEAR = WLOAD because shear is not limiting. If shear limiting: WSHEAR = 2bdfv/Span - deadweight

BOND = ½P x Span/dφj = bond stress
IF less than u, WBOND = WLOAD. IF greater, WBOND = 2uφjd/Span - deadweight

DEFLECTION = 5PSpan$^4$ x 1728/384EcI
If deflection less than span/180,
WDEFL = WLOAD. IF more than span/180
WDEFL = 384 EcISpan/180Span$^4$x5x1728
PRINT least of WLOAD, WSHEAR, WBOND, WDEFL

## Designing Waste Storage Tanks

Safe designs were computed for walls and covers of liquid storage tanks using loads in a proposed ASAE Recommendation. The design procedure determined the reinforcing required for various wall thicknesses, spans, and loads.

The printed output listed bar size, inches spacing, and the variable "FAIL" for each combination of geometry and load.

**FAIL**

A dummy variable, FAIL, reported which tests a given design failed.

A single row of bars has a maximum As = #11 bars 1¼" apart = 6.65 sq in per foot of width. Any solution requiring a greater As was beyond the program's limits. Bar size = 0, Spacing = 0, FAIL = 99, and the other checks were not made.

Other FAIL codes were:
1 = Deflection above span/180
10 = Shear above allowable
100 = Bond above allowable
7 = Concrete stress too high
70 = Steel stress too high

These codes were all additive. If print-out said 108, FAIL was 1 + 7 + 100; deflection, bond, and concrete stress were all out of range.

Successful designs had FAIL = 0.

**Procedure**

(wall design, triangular hydrostatic load)
Balanced design:

k = 1/(1 + fs/nfc) = 0.4012
j = 1-k/3 = 0.8663
W = Psf x Span $^2$/2 = wall load, lb
M = 1.5396W x Span, in-lb
RBOT = 2W/3 = reaction in bottom of wall

**First Approximation:**

d = t - 2" cover
As = M/fsjd, balanced design

Both cover and d are functions of bar diameter; therefore As must be converted to a specific bar number.

If As greater than 6.65, FAIL = 99.

If As less than 0.20 (the area of a #4 bar), bar = #3. Between 0.20 and 6.65 the following equation was used:

$$NO = -2.164As^2 + 8.784As + 2.454$$

The equation assigns a given bar number between its own area (#4 = 0.20) and the next larger (#5 = 0.31). Bar spacing is therefore no larger than 12".

**Second Approximation:**

d = t - Ds/2 - cover

cover = 1½" to #5, 2" for larger bars.

$k = \frac{1}{2}(-C + (C^2 + 4C)^{\frac{1}{2}})$

where C = 2nAs/bd

j = 1 - k/3

As = M/fsjd

Return to equation for bar size; recompute bar number using the new As.

Compute stresses and compare with allowable; assign FAIL code if outside range.

fc = 2M/12jdkd if (b = 12")

fs = 0.995M/Asjd (Because As is computed from fs = 20,000.0, and there is slight error in the computer calculations. ½% error was permitted; computed fs was compared to 0.995 allowable fs)

Bond = RBOT/ $\phi$jd

Shear = RBOT/bd

$I = b(kd)^3/3 + nAs(d-kd)^2$

$Defl = 0.013044\ W(1728Span^3)/EcI$

Bar Spacing = 12(Area of one bar)/As

Write bar size, spacing, and FAIL.

## Designing Tank Lids

Lids for loads up to 150 psf were designed the same as tank walls with adjusted coefficients for uniform instead of triangular load.

Lids for tractor or wagon loads (2 - 5000 lb loads 4' apart) were designed using the bridge design equation from AASHO:

$$M = \left(\frac{Span + 2}{32}\right)(\text{axle load})$$

to which was added the term $wl^2/8$ for deadload.

In AASHE, load = wheel load, and wheels are 6′ apart on axles 14′ apart. Tractors and tank wagons may be shorter and narrower than trucks. Therefore designs are based on load = axle load.