APPENDIX D
Miscellaneous Data

SOUTH CAROLINA
DEPARTMENT
OF TRANSPORTATION

May 2004

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Appendix D
Miscellaneous Data

Appendix D presents common tables, figures and miscellaneous data that SCDOT field personnel use such as soils classification, mathematical tables and equations, procedures for measuring and documenting vertical and lateral clearances at structures, and dry run depth check procedures.

COMPARISON OF UNIFIED AND AASHTO SOIL CLASSIFICATION SYSTEMS

UNIFIED	AASHTO	SOIL TYPE
GW	A-1-a	GRAVEL – well graded
GP	A-1-a	GRAVEL – poorly graded
GM	A-1-b	GRAVEL – silty
GC	A-2-6 A-2-7	GRAVEL – clayey
SW	A-1-b	SAND – well graded
SP	A-3	SAND – poorly graded
SM	A-2-4 A-2-5	SAND – silty
SC	A-2-6 A-2-7	SAND – clayey
ML	A-4	SILT – inorganic SILT – sandy
CL	A-6 Lean Clay	CLAY – inorganic
OL	A-4	SILT – organic
MH	A-5	SILT – inorganic
CH	A-7	CLAY – inorganic Fat Clays
OH	A-7	CLAY - organic
PT	---	PEAT – muck
Rock	---	---

Dry Run Depth Checks for Bridge Deck Pours

-SAMPLE-

Centerline of Beams (Girders)

	Near End of Span	¼ Point	½ Point (Midspan)	¾ Point	Near End of Span
Bay 1	(1)	(5)	(9)	(13)	(17)
Bay 2	(2)	(6)	(10)	(14)	(18)
Bay 3	(3)	(7)	(11)	(15)	(19)
Bay 4	(4)	(8)	(12)	(16)	(20)

Measurements Taken:

* 1	=	8¾″	6	=	8″	11	=	8¼″	16	=	8″
2	=	8″	7	=	8¼″	12	=	8″	17	=	8¼″
3	=	8¼″	8	=	8″	13	=	8″	18	=	8″
4	=	8¼″	9	=	8¼″	14	=	8½″	19	=	8½″
* 5	=	7⅜″	10	=	8″	15	=	8″	* 20	=	8¾″

Based on an 8″ deck.

Note to Inspector:

1) A set of depth checks should be taken for each span.

2) Depths should be taken in all bays (between beams) at quarter points and near ends of span. For long spans, it may be necessary to take additional depth checks. (Maximum distance between depth checks shall not exceed 25 feet.

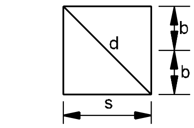
3) Check reinforcing bar clearance at same time as depth checks and record measurements.

4) Check slab depth and clearances along all longitudinal and transverse construction joints.

5) *Notify Bridge Construction Engineer of any variance(s) greater than ± 1/2″ from plan dimension.

AREAS OF PLANE FIGURES

Square



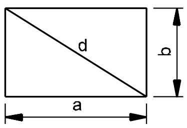
Diagonal = d = $s\sqrt{2}$

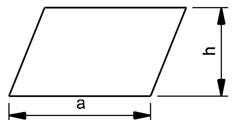
Area = $s^2 = 4b^2 = 0.5d^2$

Example: s = 6; b = 3; Area = $(6)^2 = 36$ Ans.

d = 6 x 1.414 = 8.484 Ans.

Rectangle and Parallelogram



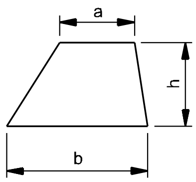


Area = ab or $b\sqrt{d^2 - b^2}$

Example. a = 6; b = 3.

Area = 3 x 6 = 18 Ans.

Trapezoid

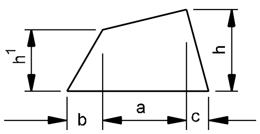


Area = $\frac{1}{2}h\left(a+b\right)$

Example: a = 2; b = 4; h = 3

Area = $\frac{1}{2}\times 3\left(2+4\right) = 9$ Ans.

Trapezium

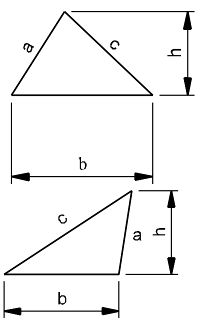


Area = $\frac{1}{2}\left[a\left(h+h^1\right)+bh^1+ch\right]$

Example: a = 4; b = 2; c = 2; h = 3; $h^1 = 2$.

Area = $\frac{1}{2}\left[4\left(3+2\right)+\left(2\times 2\right)+\left(2\times 3\right)\right] = 15$ Ans.

Triangles



Both formulas apply to both figures.

Area = $\frac{1}{2}$ bh

Example: h = 3; b = 5

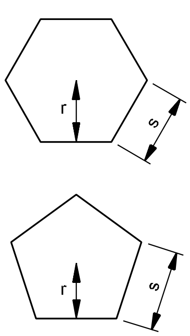
Area = $\frac{1}{2}\left(3\times 5\right) = 7\frac{1}{2}$ Ans.

Area = $\sqrt{S\left(S-a\right)\left(S-b\right)\left(S-c\right)}$ where $S = \frac{a+b+c}{2}$

Example: a = 2; b = 3; c = 4

$S = \frac{2+3+4}{2} = 4.5$; Area = $\sqrt{4.5\left(4.5-2\right)\left(4.5-3\right)\left(4.5-4\right)} = 2.9$ Ans.

Regular Polygons



Area:

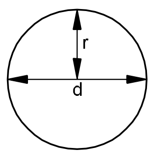
- 5 sides = $1.720477\ S^2 = 3.63271\ r^2$
- 6 sides = $2.598150\ S^2 = 3.46410\ r^2$
- 7 sides = $3.633875\ S^2 = 3.37101\ r^2$
- 8 sides = $4.828427\ S^2 = 3.31368\ r^2$
- 9 sides = $6.181875\ S^2 = 3.27573\ r^2$
- 10 sides = $7.694250\ S^2 = 3.24920\ r^2$
- 11 sides = $9.365675\ S^2 = 3.22993\ r^2$
- 12 sides = $11.196300\ S^2 = 3.21539\ r^2$

n = number of sides; r = short radius; S = length of side; R = long radius.

Area = $\frac{n}{4}S^2\cot\frac{180°}{n} = \frac{n}{2}R^2\sin\frac{360°}{n} = nr^2\tan\frac{180°}{n}$

AREAS OF PLANE FIGURES (continued)

Circle



$\pi = 3.1416$; A = area; d = diameter

p = circumference or periphery; r = radius

$p = \pi d = 3.1416d$ $\qquad p = 2\sqrt{\pi A} = 3.54\sqrt{A}$

$p = 2\pi r = 6.2832r$ $\qquad p = \frac{2A}{r} = \frac{4A}{d}$

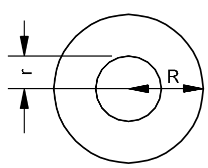
$d = \frac{p}{\pi} = \frac{p}{3.1416}$ $\qquad d = 2\sqrt{\frac{A}{\pi}} = 1.128\sqrt{A}$

$r = \frac{p}{2\pi} = \frac{p}{6.2832}$ $\qquad r = \sqrt{\frac{A}{\pi}} = 0.564\sqrt{A}$

$A = \frac{\pi d^2}{4} = 0.7854d^2$ $\qquad A = \frac{p^2}{4\pi} = \frac{p^2}{12.57}$

$A = \pi r^2 = 3.1416r^2$ $\qquad A = \frac{pr}{2} = \frac{pd}{4}$

Circular Ring



Area = $\pi\left(R^2 - r^2\right) = 3.1416\left(R^2 - r^2\right)$

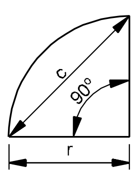
Area = $0.7854(D^2 - d^2) = 0.7854(D-d)(D+d)$

Area = difference in areas between the inner and outer circles.

Example: $R = 4$; $r = 2$.

Area = $3.1416(4^2 - 2^2) = 37.6992$ Ans.

Quadrant

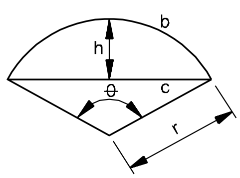


Area = $\frac{\pi r^2}{4} = 0.7854r^2 = 0.3927c^2$

Example. $r = 3$; c = chord.

Area = $0.7851 \times 3^2 = 7.0686$ Ans.

Segment



b = length of arc; θ = angle in degrees; c = chord = $\sqrt{4\left(2hr - h^2\right)}$

Area = $\frac{1}{2}\left[br - c\left(r - h\right)\right] = \pi r^2 \frac{\theta}{360} - \frac{c\left(r - h\right)}{2}$ p

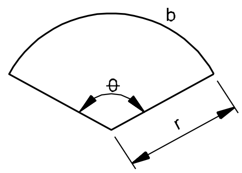
When θ is greater than 180° then $\frac{c}{2} \times$ difference between r and h is added to the fraction $\frac{\pi r^2 \theta}{360}$.

Example: $r = 3$; $\theta = 120°$; $h = 1.5$

Area = $3.1416 \times 3^2 \times \frac{120}{360} - \frac{5.196\left(3 - 1.5\right)}{2} = 5.5278$ Ans.

AREAS OF PLANE FIGURES (continued)

Sector



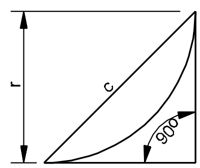
$$\text{Area} = \frac{br}{2} = \pi r^2 \frac{\theta}{360°}$$

θ = angle in degrees; b = length of arc

Example: r = 3; θ = 120°

$$\text{Area} = 3.1416 \times 3^2 \times \frac{120}{360} = 9.4248 \text{ Ans.}$$

Spandrel

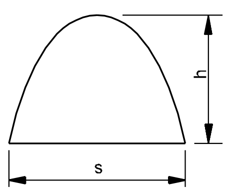


$$\text{Area} = 0.2146r^2 = 0.1073c^2$$

Example: r = 3

$$\text{Area} = 0.2146 \text{ x } 3^2 = 1.9314 \text{ Ans.}$$

Parabola



l = length of curved line = periphery – s

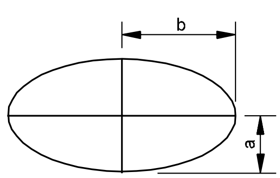
$$l = \frac{s^2}{8h}\left[\sqrt{c\,(1+c)} + 2.0326 \times \log\left(\sqrt{c} + \sqrt{1+c}\right)\right] \text{ where } c = \left(\frac{4h}{s}\right)^2$$

$$\text{Area} = \frac{2}{3}sh$$

Example: s = 3; h = 4

$$\text{Area} = \frac{2}{3} \times 3 \times 4 = 8 \text{ Ans.}$$

Ellipse



$$\text{Area} = \pi ab = 3.1416ab$$

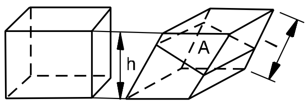
$$\text{Circum.} = 2\pi\sqrt{\frac{a^2 + b^2}{2}} \text{ (close approximation)}$$

Example. a = 3; b = 4.

Area = 3.1416 x 3 x 4 = 37.6992 Ans.

$$\text{Circum.} = 2 \text{ x } 3.1416\sqrt{\frac{(3)^2 + (4)^2}{2}} = 6.2832 \times 3.5355 = 22.21 \text{ Ans.}$$

SURFACE AND VOLUME OF SOLIDS

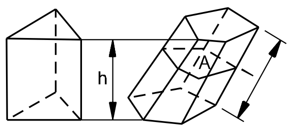


Parallelopiped

S = perimeter, P, perp. to sides x lat. length, l: Pl

V = area of base, B, x perpendicular height, h: Bh

V = area of section, A, perp. to sides x lat. length, l: Al

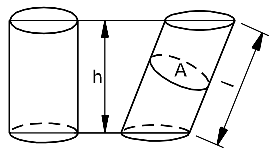


Prism, Right or Oblique, Regular or Irregular

S = perimeter, P, perp. to sides x lat. length, l: Pl

V = area of base, B, x perpendicular height, h: Bh

V = area of section, A, perp. to sides x lat. length, l: Al



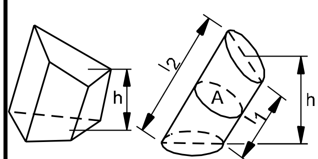
Cylinder, Right or Oblique, Circular or Elliptic, etc.

S = perimeter of base, P, x perp. height, h: Ph

S = perimeter, P_1, perp. to sides x lat. length, l: $P_1 l$

V = area of base, B, x perpendicular height, h: Bh

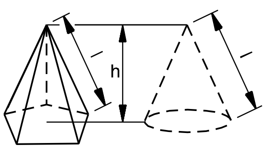
V = area of section, A, perp. to sides x lat. length, l: Al



Frustum of any Prism or Cylinder

V = area of base, B, x perp. distance, h, from base to center of gravity of opposite face: Bh

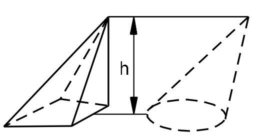
For cylinder: $\frac{1}{2} A(l_1 + l_2)$



Pyramid or Cone, Right and Regular

S = perimeter of base, P, x $\frac{1}{2}$ slant height, l: $\frac{1}{2}Pl$

V = area of base, B, x $\frac{1}{8}$ perp. height, h: $\frac{1}{8}Bh$

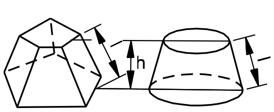


Pyramid or Cone, Right or Oblique, Regular or Irregular

V = area of base, B, x $\frac{1}{3}$ perp. height, h: $\frac{1}{3}Bh$

V = $\frac{1}{3}$ volume of prism or cylinder of same base and perpendicular height

V = $\frac{1}{2}$ volume of hemisphere of same base and perpendicular height



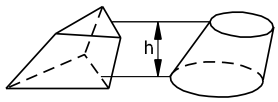
<u>Frustum of Pyramid or Cone, Right and Regular, Parallel Ends</u>

S = (sum of perimeter of base, P, and top, p) x $\frac{1}{2}$ slant height, l: $\frac{1}{2}l\,(P+p)$

V = (sum of areas of base, B, and top, b + square root of their products) x $\frac{1}{3}$ perp. height, h: $\frac{1}{3}h(B+b+\sqrt{Bb}\,)$

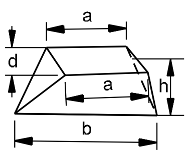
S = Lateral or Convex Surface *V = Volume*

SURFACE AND VOLUME OF SOLIDS (continued)



Frustum of any Pyramid or Cone, Parallel Ends

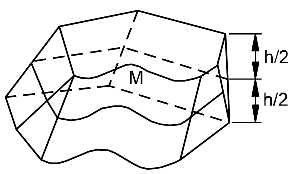
V = (sum of areas of base, B, and top, b + square root of their products) x $\frac{1}{8}$ perp. height, h: $\frac{1}{8}h(B+b+\sqrt{Bb})$



Wedge, Parallelogram Face

V = $\frac{1}{6}$ (sum of three edges, a b a, x perpendicular height, h

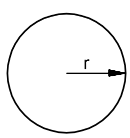
x perpendicular width, d): $\frac{1}{6}dh(2a+b)$



Prismatoid

V = $\frac{1}{6}$ perp. height, h (sum of areas of base, B, and top b, +4 x area of section, M, parallel to bases and midway between them): $\frac{1}{6}h(B+b+4M)$

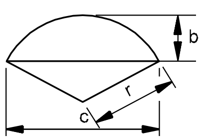
The Prismatoid formula applies also to any of the foregoing solids with parallel bases, to pyramids, cones, and spherical sections, and to many solids with irregular surfaces.



Sphere

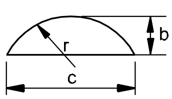
$S = 4\pi r^2 = \pi d^2 = 3.14159265\, d^2$

$V = \frac{4}{3}\pi r^3 = \frac{1}{6}\pi d^3 = 0.52359878\, d^3$



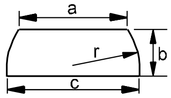
Spherical Sector

$S = \frac{1}{2}\pi r(4b + c)$ $V = \frac{2}{3}\pi r^3 b$



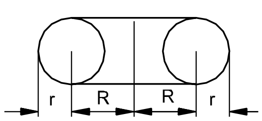
Spherical Segment

$S = 2\pi r b = \frac{1}{4}\pi\left(4b^2 + c^2\right)$ $V = \frac{1}{3}\pi b^2(3r - b) = \frac{1}{24}\pi b\left(3c^2 + 4b^2\right)$



Spherical Zone

$S = 2\pi r b$ $V = \frac{1}{24}\pi b\left(3a^3 + 3c^2 + 4b^2\right)$



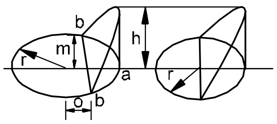
Circular Ring

$S = 4\pi^2 Rr$ $V = 2\pi^3 Rr^2$

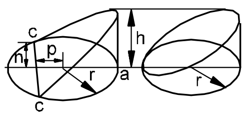
S = Lateral or Convex Surface *V = Volume*

SURFACE AND VOLUME OF SOLIDS (continued)

Ungula of Right, Regular Cylinder

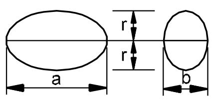


Base = Segment, b a b	Base = Half Circle
$S = (2\,r\,m - o \times \text{arc},\ b\,a\,b)\ \dfrac{h}{r - o}$	$S = 2rh$
$V = \left(\dfrac{2}{3}m^3 - o \times \text{area}, b\,a\,b\right)\dfrac{h}{r - o}$	$V = \dfrac{2}{3} r^2\, h$



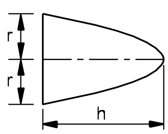
Base = Segment, c a c	Base = Circle
$S = (2\,r\,n + p \times \text{arc},\ c\,a\,c)\ \dfrac{h}{r + p}$	$S = r\ \pi\ h$
$V = \left(\dfrac{2}{3}n^3 + p \times \text{area}, cac\right)\dfrac{h}{r + p}$	$V = \dfrac{1}{2} r^2\, \pi\, h$

Ellipsoid



$V = \dfrac{1}{3}\pi\, r\, a\, b$

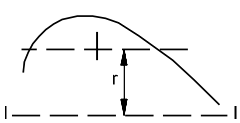
Paraboloid



$V = \dfrac{1}{2}\pi\, r^2 h$

Ratio of corresponding volumes of a Cone, Paraboloid, Sphere, and Cylinder of equal height: $\dfrac{1}{3} : \dfrac{1}{2} : \dfrac{2}{3} : 1$

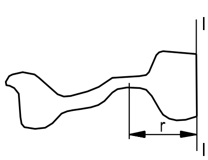
Bodies Generated by Partial or Complete Revolution



$\left.\begin{array}{l} l = \text{length of a curve} \\ A = \text{area of a plane} \end{array}\right\}$ rotating about an axis 1-1 on one side and in plane of axis

r = distance of center of gravity of line or plane from axis 1-1 and for any angle of revolution, a°

$\dfrac{2\,r\,\pi\,a°}{360}$ = length of arc described by center of gravity.



S = length of curve x length of arc about axis = $l\ \dfrac{2\,r\,\pi\,a°}{360}$

For complete revolution, $S = 2r\,\pi\,l$

V = area of plane x length of arc about axis = $A\ \dfrac{2\,r\,\pi\,a°}{360}$

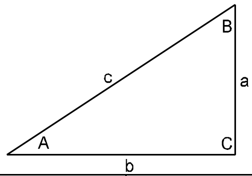
For complete revolution, $V = 2\,r\ \pi\,A$

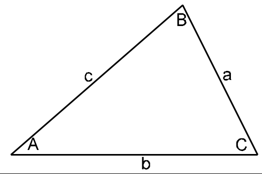
S = Lateral or Convex Surface *V = Volume*

TRIGONOMETRIC FUNCTIONS

Angle	Sin	Cos	Tan	Angle	Sin	Cos	Tan
0	0.000	1.000	0.000	46	0.719	0.695	1.04
1	0.017	0.999	0.017	47	0.731	0.682	1.07
2	0.035	0.999	0.035	48	0.743	0.699	1.11
3	0.052	0.999	0.052	49	0.755	0.656	1.15
4	0.070	0.998	0.070	50	0.766	0.643	1.19
5	0.087	0.996	0.087	51	0.777	0.629	1.23
6	0.105	0.995	0.105	52	0.788	0.616	1.28
7	0.112	0.993	0.123	53	0.799	0.602	1.33
8	0.139	0.990	0.141	54	0.809	0.588	1.38
9	0.156	0.988	0.158	55	0.819	0.574	1.43
10	0.174	0.985	0.176	56	0.829	0.559	1.48
11	0.191	0.982	0.194	57	0.839	0.545	1.54
12	0.208	0.978	0.213	58	0.848	0.530	1.60
13	0.225	0.974	0.231	59	0.857	0.515	1.66
14	0.242	0.970	0.249	60	0.866	0.500	1.73
15	0.259	0.966	0.268	61	0.875	0.485	1.80
16	0.276	0.961	0.287	62	0.883	0.469	1.88
17	0.292	0.956	0.306	63	0.891	0.454	1.96
18	0.309	0.951	0.325	64	0.898	0.438	2.05
19	0.326	0.946	0.344	65	0.906	0.423	2.14
20	0.342	0.940	0.364	66	0.914	0.407	2.25
21	0.358	0.934	0.384	67	0.921	0.391	2.36
22	0.375	0.927	0.404	68	0.927	0.375	2.48
23	0.391	0.921	0.424	69	0.934	0.358	2.61
24	0.407	0.914	0.445	70	0.940	0.342	2.75
25	0.423	0.906	0.466	71	0.946	0.326	2.90
26	0.438	0.898	0.488	72	0.951	0.309	3.08
27	0.454	0.891	0.510	73	0.956	0.292	3.27
28	0.469	0.883	0.532	74	0.961	0.276	3.49
29	0.485	0.875	0.554	75	0.966	0.259	3.73
30	0.500	0.866	0.577	76	0.970	0.242	4.01
31	0.515	0.857	0.601	77	0.974	0.225	4.33
32	0.530	0.848	0.625	78	0.978	0.208	4.70
33	0.545	0.839	0.649	79	0.982	0.191	5.14
34	0.559	0.829	0.675	80	0.985	0.174	5.67
35	0.574	0.819	0.700	81	0.988	0.156	6.31
36	0.588	0.809	0.727	82	0.990	0.139	7.12
37	0.602	0.799	0.754	83	0.993	0.122	8.14
38	0.616	0.788	0.781	84	0.995	0.105	9.51
39	0.629	0.777	0.810	85	0.996	0.087	11.43
40	0.643	0.766	0.839	86	0.998	0.070	14.30
41	0.656	0.755	0.869	87	0.999	0.052	19.08
42	0.699	0.743	0.900	88	0.999	0.035	28.64
43	0.682	0.731	0.933	89	0.999	0.017	57.28
44	0.695	0.719	0.966	90	1.000	0.000	Infinity
45	0.707	0.707	1.000				

TRIGONOMETRIC SOLUTION OF TRIANGLES





$$S = \frac{a+b+c}{2}$$

Given:	Sought:	Formulae:
RIGHT-ANGLED TRIANGLES		
a,c	A,B,b	$\sin A = \frac{a}{c}$, $\cos B = \frac{a}{c}$, $b = \sqrt{c^2 - a^2}$
	Area	Area = $\frac{a}{2}\sqrt{c^2 - a^2}$
a,b	A,B,c	$\tan A = \frac{a}{b}$, $\tan B = \frac{b}{a}$, $c = \sqrt{a^2 + b^2}$
	Area	Area = $\frac{ab}{2}$
A,a	B,b,c	$B = 90° - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$
	Area	Area = $\frac{a^2 \cot A}{2}$
A,b	B,a,c	$B = 90° - A$, $a = b \tan A$, $c = \frac{b}{\cos A}$
	Area	Area = $\frac{b^2 \tan A}{2}$
A,c	B,a,b	$B = 90° - A$, $a = c \sin A$, $b = c \cos A$
	Area	Area = $\frac{c^2 \sin A \cos A}{2}$ or $\frac{c^2 \sin 2A}{4}$
OBLIQUE-ANGLED TRIANGLES		
a,b,c	A	$\sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}}$, $\cos \frac{1}{2}A = \sqrt{\frac{s(s-2)}{bc}}$, $\tan \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$
	B	$\sin \frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{ac}}$, $\cos \frac{1}{2}B = \sqrt{\frac{s(s-b)}{ac}}$, $\tan \frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{s(s-b)}}$
	C	$\sin \frac{1}{2}C = \sqrt{\frac{(s-a)(s-b)}{ab}}$, $\cos \frac{1}{2}C = \sqrt{\frac{s(s-c)}{ab}}$, $\tan \frac{1}{2}C = \sqrt{\frac{(s-a)(s-b)}{s(s-c)}}$
	Area	Area = $\sqrt{s(s-a)(s-b)(s-c)}$
a,A,B	b,c	$b = \frac{a \sin B}{\sin A}$, $c = \frac{a \sin C}{\sin A} = \frac{a \sin(A+B)}{\sin A}$
	Area	Area = $\frac{1}{2} a b \sin C = \frac{a^2 \sin B \sin C}{2 \sin A}$

TRIGONOMETRIC SOLUTION OF TRIANGLES (continued)

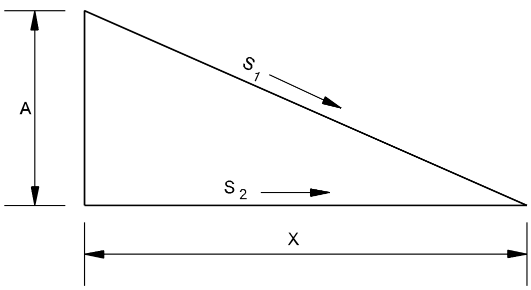
a,b,A	B	$\sin B = \dfrac{b \sin A}{a}$
	c	$c = \dfrac{a \sin C}{\sin A} = \dfrac{b \sin C}{\sin B} = \sqrt{a^2 + b^2 - 2ab \cos C}$
	Area	$\text{Area} = \dfrac{1}{2}\, ab \sin C$
a,b,C	A	$\tan A = \dfrac{a \sin C}{b - a \cos C}$ $\qquad \tan \dfrac{1}{2}(A - B) = \dfrac{a - b}{a + b} \cot \dfrac{1}{2} C$
	c	$c = \sqrt{a^2 \div b^2 - 2ab \cos C} = \dfrac{a \sin C}{\sin A}$
	Area	$\text{Area} = \dfrac{1}{2} ab \sin C$
$a^2 = b^2 + c^2 - 2bc \cos A$, $\quad b^2 = a^2 + c^2 - 2ac \cos B$, $\quad c^2 = a^2 + b^2 - 2ab \cos C$		

SLOPE EQUATIONS

GIVEN: Dimensions A and B
Slopes S_1 and S_2 in feet per foot

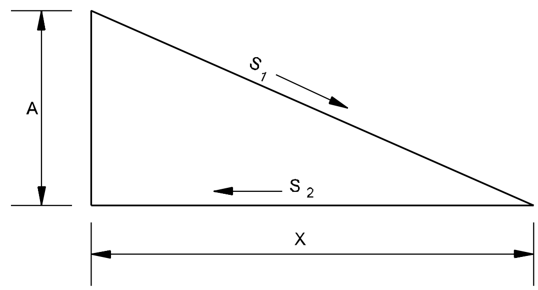
FIND: Horizontal distance X
Area

CASE I



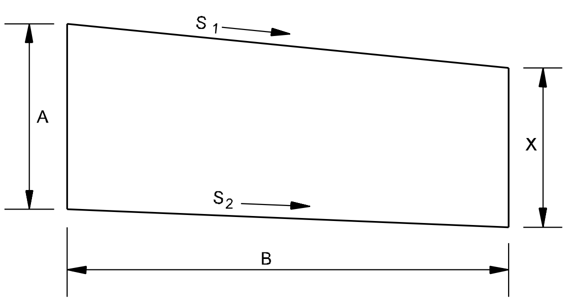
$X = \frac{A}{S_1 - S_2}$ Area $= \frac{AX}{2}$

CASE II



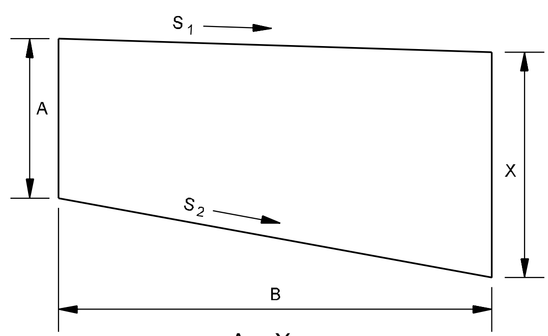
$X = \frac{A}{S_1 + S_2}$ Area $= \frac{AX}{2}$

CASE III



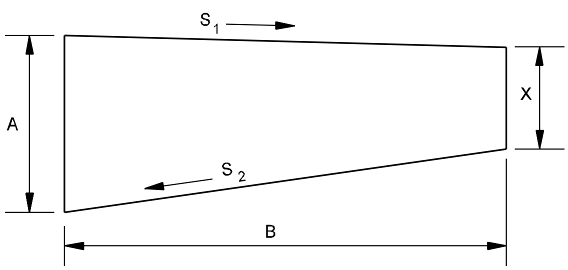
$X = A - (S_1 - S_2)\,B$ Area $= \frac{A + X}{2}\,(B)$

CASE IV



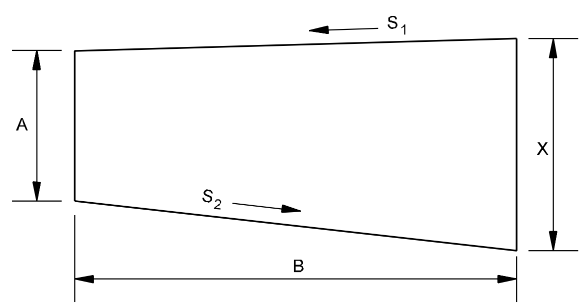
$X = A - (S_1S_2)\,B$ Area $= \frac{A + X}{2}\,(B)$

CASE V



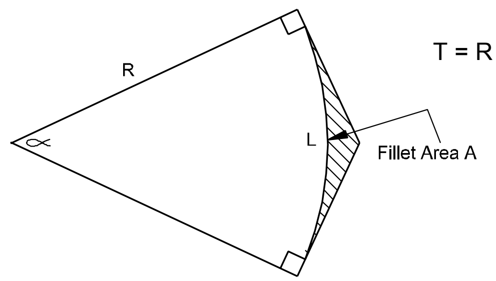
$X = A - (S_1 + S_2)\,B$ Area $= \frac{A + X}{2}\,(B)$

CASE VI



$X = A + (S_1 + S_2)\,B$ Area $= \frac{A + X}{2}\,(B)$

METHODS OF ESTIMATING AREA OF FILLETS, APRONS AND APPROACHES



$$T = R \, \text{Tan} \, \frac{\alpha}{2}$$

ESTIMATING FILLETS & RETURN

FILLET AREA

$$\text{Area A} = 2 \times \frac{1}{2} \times R \times R \, \text{Tan} \, \frac{\alpha}{2} - \pi R^2 \frac{\alpha}{360^\circ}$$

$$= R^2 \left[\text{Tan} \frac{\alpha}{2} - (0.008727 \times \alpha) \right]$$

Area 90° Fillet = $0.2146 \times R^2$

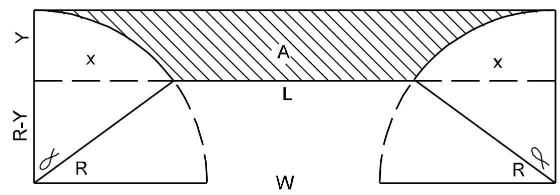
Length of Return

$$L = 2\pi R \times \frac{\alpha}{360^\circ}$$

$$= 0.01745 \times R \times \alpha$$

Length of 90° Return

$$L = 1.5708 \times R$$

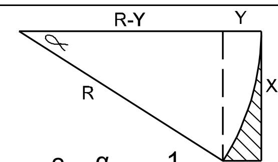


ESTIMATING AREA 90° APRON

$$L = (2R + W) - 2X \qquad \text{Cos } \alpha = \frac{R - Y}{R}$$

$$X = \sqrt{2RY} - Y^2 \qquad \text{A = Area}$$

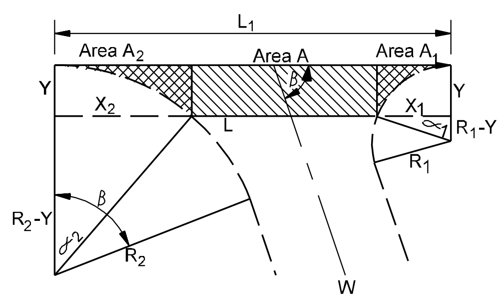
$$A = (2R + W)Y + X(R-Y) - 0.01745 \, R^2\alpha$$



A = Area

$$A = XY - \left[\pi R^2 \frac{\alpha}{360^\circ} - \frac{1}{2} \times (R - Y) \right]$$

$$= XY + \frac{X(R-Y)}{2} - 0.08727 \, R^2 \, \alpha$$



ESTIMATING AREA APRON OTHER THAN 90°

$$\text{Cos}\,\alpha_1 = \frac{R_1 - Y}{R_1} \qquad \text{Cos}\,\alpha_2 = \frac{R_2 - Y}{R_2}$$

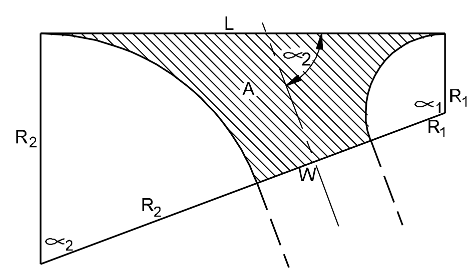
$$X_1 = \sqrt{2R_1Y - Y^2} \qquad X_2 = \sqrt{2R_2Y - Y^2}$$

$$L_1 = (R_2 - R_1) \, \text{Tan} \, \beta \qquad L = L_1 - (X_1 + X_2)$$

$$A = LY$$

$$A_1 = X_1 Y + \frac{X_1(R_1 - Y)}{2} - 0.008727 R_1^2 \, \alpha_1$$

$$A_2 = X_2 Y + \frac{X_2(R_2 - Y)}{2} - 0.008727 R_2^2 \, \alpha_2$$



ESTIMATING AREA APPROACH OTHER THAN 90°

$$\alpha_1 = 180^\circ - \alpha_2$$

$$L = (R_2 - R_1) \, \text{Tan} \, \alpha_2$$

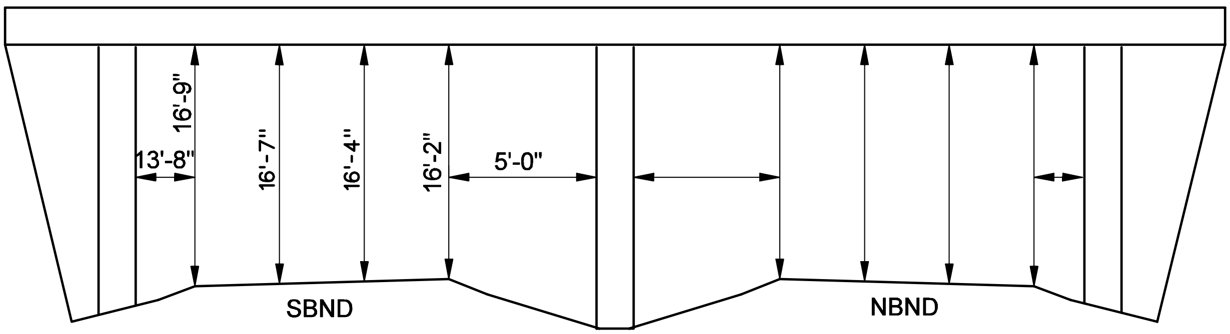
$$\text{Area A} = \frac{(R_1 + R_2)L}{2} - 0.008727(R_1^2 \, \alpha_1 + R_2^2 \, \alpha_2)$$

NOTES:

$$\pi = 3.1416 \qquad \frac{\pi}{180} = 0.01745$$

$$\frac{\pi}{2} = 1.5708 \qquad \frac{\pi}{360} = 0.008727$$

PROCEDURE FOR MEASURING AND DOCUMENTING VERTICAL AND LATERAL CLEARANCES FOR BRIDGES AND SIGNS
(Applicable to New Construction, Reconstruction, Overlay, and Rehabilitation Projects)



LOOKING N

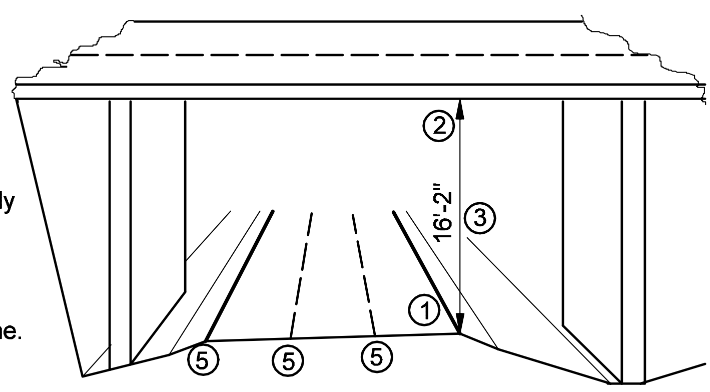
EXAMPLE

Recording Vertical and Lateral Clearances

1. Make an accurate sketch of bridge or sign structure.
2. Take measurements of vertical clearances as shown below. Be sure to measure the clearances under all the girders to determine the minimum along each lane line. Also meaure and record lateral clearances.
3. On sign structures, the minimum may not be the sign support. It may be a cat walk or an appurtenance hanging lower.
4. Record the measurements on a sketch of the bridge or sign as shown above.
5. Note which direction you are looking on the sketch. On a divided highway, record measurements for both structures while looking in one direction only. Do not look in the direction of traffic for each of the bridges.
6. Send the information to Bridge Maintenance.

Where to Measure Vertical Clearances

1. Locate the edge of roadway, excluding shoulder. Typically, a solid white line represents the edge of roadway.
2. Locate the lowest point of the structure directly above that line.
3. Measure the clearance.
4. Record the measurement.
5. Repeat steps 2, 3, and 4 for each roadway line.



CONVERSION FACTORS — US CUSTOMARY TO METRIC

TYPE OF MEASUREMENT	TO CONVERT FROM US CUSTOMARY	TO METRIC		MULTIPLY BY
Length	inch	millimeter	mm	25.4
	foot	millimeter	mm	304.8
	foot	meter	m	0.3048
	yard	meter	m	0.9144
	mile	kilometer	km	1.609344
Area	square inch	square millimeters	mm^2	645.16
	square foot	square meters	m^2	0.09290304
	square yard	square meter	m^2	0.83612736
	acre	hectare (10,000 m^2)	ha	0.404687
	square mile	square kilometer	km^2	2.589998
Volume	gallon	liter	L	3.785412
	cubic inch	cubic millimeter	mm^3	16,387.06
	cubic foot	cubic meter	m^3	0.02831685
	cubic yard	cubic meter	m^3	0.7645549
	acre-foot	cubic meter	m^3	1233.489
Mass	pound	kilogram	kg	0.4535924
	ton (2000 lbs)	metric ton (1 Mg)	t	0.9071847
Mass per Unit Length	pound per inch	kilogram per meter	kg/m	17.85797
	pound per foot	kilogram per meter	kg/m	1.488164
	pound per yard	kilogram per meter	kg/m	0.496055
Mass per Unit Area	gallon per square foot	liter per square meter	L/m^2	41.13219
	gallon per square yard	liter per square meter	L/m^2	4.527317
	gallon per acre	liter per hectare	L/ha	9.353925
	pound per square foot	kilogram per square meter	kg/m^2	4.8824248
	pound per square yard	kilogram per square meter	kg/m^2	0.542492
	pound per acre	kilogram per hectare	kg/ha	1.120847
	ton per square foot	metric ton per square meter	t/m^2	9.764856
	ton per square yard	metric ton per square meter	t/m^2	1.084984
	ton per acre	metric ton per hectare	t/ha	2.241695
Mass per Unit Volume	pound per cubic foot	kilogram per cubic meter	kg/m^3	16.01846
	pound per cubic yard	kilogram per cubic meter	kg/m^3	0.5932763
	ton per cubic yard	metric ton per cubic meter	t/m^3	1.186553

Conversion Examples:

To convert a rate-of-application of 50 gallons per acre to liters per hectare (L/ha), multiply by 9.353925.

(50 gallons/acre)(9.353925) = 467.70 L/ha Possible rounding: 478 L/ha or 480 L/ha

To convert a mowing pay item from $15 per acre to dollars per hectare, divide by 0.404687.
($15/acre)/(0.404687) = $37.07/ha Possible rounding: $37/ha, $35/ha or $40/ha

CONVERSION TABLE – INCHES TO DECIMALS OF A FOOT

INCH	0″	1″	2″	3″	4″	5″
0	0	0.0833	0.1667	0.2500	0.3333	0.4167
1/32	0.0026	0.0859	0.1693	0.2526	0.3359	0.4193
1/16	0.0052	0.0885	0.1719	0.2552	0.3385	0.4219
3/32	0.0078	0.0911	0.1745	0.2573	0.3411	0.4245
1/8	0.0104	0.0938	0.1771	0.2604	0.3438	0.4271
5/32	0.0130	0.0964	0.1797	0.2630	0.3464	0.4297
3/16	0.0156	0.0990	0.1823	0.2656	0.3490	0.4323
7/32	0.0182	0.1016	0.1849	0.2682	0.3516	0.4349
1/4	0.0208	0.1042	0.1875	0.2708	0.3542	0.4375
9/32	0.0234	0.1068	0.1901	0.2734	0.3568	0.4401
5/16	0.0260	0.1094	0.1927	0.2760	0.3594	0.4427
11/32	0.0288	0.1120	0.1953	0.2786	0.3620	0.4453
3/8	0.0313	0.1146	0.1979	0.2812	0.3646	0.4479
13/32	0.0339	0.1172	0.2005	0.2839	0.3672	0.4505
7/16	0.0365	0.1198	0.2031	0.2865	0.3698	0.4531
13/32	0.0391	0.1224	0.2057	0.2891	0.3724	0.4557
1/2	0.0417	0.1250	0.2083	0.2917	0.3750	0.4583
17/32	0.0443	0.1276	0.2109	0.2943	0.3778	0.4609
9/16	0.0469	0.1302	0.2135	0.2969	0.3802	0.4635
19/32	0.0495	0.1328	0.2161	0.2995	0.3828	0.4661
5/8	0.0521	0.1354	0.2188	0.3021	0.3854	0.4688
21/32	0.0547	0.1380	0.2214	0.3047	0.3880	0.4714
11/16	0.0573	0.1406	0.2240	0.3073	0.3906	0.4740
23/32	0.0599	0.1432	0.2266	0.3099	0.3932	0.4766
3/4	0.0625	0.1458	0.2292	0.3125	0.3958	0.4792
25/32	0.0651	0.1484	0.2318	0.3151	0.3984	0.4818
13/16	0.0677	0.1510	0.2344	0.3177	0.4010	0.4844
27/32	0.0703	0.1536	0.2370	0.3203	0.4036	0.4870
7/8	0.0729	0.1563	0.2396	0.3229	0.4063	0.4896
29/32	0.0755	0.1589	0.2422	0.3255	0.4089	0.4922
15/16	0.0781	0.1615	0.2448	0.3281	0.4115	0.4948
31/32	0.0807	0.1641	0.2474	0.3307	0.4141	0.4974

CONVERSION TABLE – INCHES TO DECIMALS OF A FOOT (continued)

INCH	6″	7″	8″	9″	10″	11″
0	0.5000	0.5833	0.6667	0.7500	0.8333	0.9167
1/32	0.5026	0.5859	0.6693	0.7526	0.8359	0.9193
1/16	0.5052	0.5885	0.6719	0.7552	0.8385	0.9219
3/32	0.5078	0.5911	0.6745	0.7578	0.8411	0.9245
1/8	0.5104	0.5938	0.6771	0.7604	0.8438	0.9271
5/32	0.5130	0.5964	0.6797	0.7630	0.8464	0.9297
3/16	0.5156	0.5990	0.6823	0.7656	0.8490	0.9323
7/32	0.5182	0.6016	0.6849	0.7682	0.8516	0.9349
1/4	0.5208	0.6042	0.6875	0.7708	0.8542	0.9375
9/32	0.5234	0.6068	0.6901	0.7734	0.8568	0.9401
5/16	0.5260	0.6094	0.6927	0.7760	0.8594	0.9427
11/32	0.5286	0.6120	0.6953	0.7786	0.8620	0.9453
3/8	0.5313	0.6146	0.6979	0.7813	0.8646	0.9479
13/32	0.5339	0.6172	0.7005	0.7839	0.8672	0.9505
7/16	0.5365	0.6198	0.7031	0.7865	0.8698	0.9531
13/32	0.5391	0.6224	0.7057	0.7891	0.8724	0.9557
1/2	0.5417	0.6250	0.7083	0.7917	0.8750	0.9583
17/32	0.5443	0.6276	0.7109	0.7943	0.8776	0.9609
9/16	0.5469	0.6302	0.7135	0.7969	0.8802	0.9635
19/32	0.5495	0.6328	0.7161	0.7995	0.8828	0.9661
5/8	0.5521	0.6354	0.7188	0.8021	0.8854	0.9688
21/32	0.5547	0.6380	0.7214	0.8047	0.8880	0.9714
11/16	0.5573	0.6406	0.7240	0.8073	0.8906	0.9740
23/32	0.5599	0.6432	0.7266	0.8099	0.8932	0.9766
3/4	0.5625	0.6458	0.7292	0.8125	0.8958	0.9792
25/32	0.5651	0.6484	0.7318	0.8151	0.8984	0.9818
13/16	0.5677	0.6510	0.7344	0.8177	0.9010	0.9844
27/32	0.5703	0.6536	0.7370	0.8209	0.9036	0.9870
7/8	0.5729	0.6563	0.7396	0.8229	0.9063	0.9896
29/32	0.5755	0.6589	0.7422	0.8255	0.9089	0.9922
15/16	0.5701	0.6615	0.7448	0.8281	0.9115	0.9948
31/32	0.5807	0.6641	0.7474	0.8307	0.9141	0.9974

SQUARE YARDS OF ROAD SURFACE FOR VARIOUS ROAD WIDTHS

ROAD WIDTH	PER LINEAL FOOT	PER 100 FEET	PER MILE	ROAD WIDTH	PER LINEAL FOOT	PER 100 FEET	PER MILE
6′	0.67	66.67	3,520	24′	2.67	266.67	14,080
7′	0.78	77.78	4,107	25′	2.78	277.78	14,667
8′	0.89	88.89	4,693	26′	2.89	288.89	15,253
9′	1.00	100.00	5,280	28′	3.11	311.11	16,427
10′	1.11	111.11	5,867	30′	3.33	333.33	17,600
11′	1.22	122.22	6,453	32′	3.56	355.56	18,773
12′	1.33	133.33	7,040	34′	3.78	377.78	19,947
13′	1.44	144.44	7,627	36′	4.00	400.00	21,120
14′	1.56	155.56	8,213	38′	4.22	422.22	22,293
15′	1.67	166.67	8,800	40′	4.44	444.44	23,467
16′	1.78	177.78	9,387	50′	5.56	555.56	29,333
17′	1.89	188.89	9,973	60′	6.67	666.67	35,200
18′	2.00	200.00	10,560	70′	7.78	777.78	41,067
20′	2.22	222.22	11,733	75′	8.33	833.33	44,000
22′	2.44	244.44	12,907	80′	8.89	888.89	46,933

LINEAR FEET COVERED BASED ON TANK CAPACITY AND WIDTH AND RATE OF APPLICATION

To compute the number of linear feet which will be covered by a tank of any capacity, for various widths and rates of application, use the following formula:

$$L = \frac{9C}{RW}$$

Where:

L = Number of linear feet which will be covered.
C = Capacity of tank in gallons (or quantity of asphalt in tank).
R = Rate of application in gallons per square yard.
W = Width of application in feet.

QUANTITIES FOR VARIOUS DEPTHS OF CYLINDRICAL TANKS IN HORIZONTAL POSITION

% DEPTH FILLED	% OF CAPACITY	% DEPTH FILLED	% OF CAPACITY	% DEPTH FILLED	% OF CAPACITY	% DEPTH FILLED	% OF CAPACITY
1	0.20	26	20.73	51	51.27	76	81.50
2	0.50	27	21.86	52	52.54	77	82.60
3	0.90	28	23.00	53	53.81	78	83.68
4	1.34	29	24.07	54	55.08	79	84.74
5	1.87	30	25.31	55	56.34	80	85.77
6	2.45	31	26.48	56	57.60	81	86.77
7	3.07	32	27.66	57	58.86	82	87.76
8	3.74	33	28.84	58	60.11	83	88.73
9	4.45	34	30.03	59	61.36	84	89.68
10	5.20	35	31.19	60	62.61	85	90.60
11	5.98	36	32.44	61	63.86	86	91.50
12	6.80	37	33.66	62	65.10	87	92.36
13	7.64	38	34.90	63	66.34	88	93.20
14	8.50	39	36.14	64	67.56	89	94.02
15	9.40	40	37.39	65	68.81	90	94.80
16	10.32	41	38.64	66	69.97	91	95.55
17	11.27	42	39.89	67	71.16	92	96.26
18	12.24	43	41.14	68	72.34	93	96.93
19	13.23	44	42.40	69	73.52	94	97.55
20	14.23	45	43.66	70	74.69	95	98.13
21	15.26	46	44.92	71	75.93	96	98.66
22	16.32	47	46.19	72	77.00	97	99.10
23	17.40	48	47.45	73	78.14	98	99.50
24	18.50	49	48.73	74	79.27	99	99.80
25	19.61	50	50.00	75	80.39		

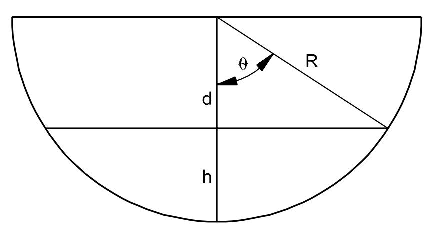
Full capacity of tank in U.S. gallons = $\dfrac{0.7854 \times D^2 \times L}{231}$

Note: *The formula for direct computation of quantity when tank is less than half full is shown below. When more than half full, compute the full capacity of the tank as noted above; consider the shaded portion to represent the unfilled portion at the top of the tank and compute its volume as indicated below; then, deduct the volume determined for the unfilled portion from the total volume of the tank to arrive at the volume of the filled portion*

First, compute θ where $\cos\theta = \dfrac{d}{R} = \dfrac{R - h}{R}$

Then $A = \pi R^2 \dfrac{\theta}{180} - R\sin\theta(R - h)$

And $V = \dfrac{L\left[\pi R^2 \dfrac{\theta}{180} - R\sin\theta(R - h)\right]}{231}$



Where: A = Cross-section area of filled portion of tank in square inches
V = Volume of filled portion of tank in U.S. gallons
L = Length of interior of tank in inches
D = Diameter of interior of tank in inches
R = Radius of interior of tank in inches
h = Depth of liquid in inches
d = R – h, inches

Note: *The volume occupied by any piping, fittings or other material inside the tank must be deducted from the volume computed by use the table or formula.*