

# Appendix A

## Glossary of Terminology

# GLOSSARY OF TERMS

<b>Adhesion</b>	The property of a substance (in our case, cohesive soil) to “stick”, “cling”, or “adhere” to a solid structural element such as a concrete pier or pile, and thus establish a resistance to shearing movement between the soil mass and the structural element.
<b>ADSC</b>	Association of Drilled Shaft Contractors (The International Association of Foundation Drilling Contractors), Address P. O. Box 75228, Dallas, TX 75228.
<b>Aggregate</b>	The stone used in making concrete. “Fine aggregate” is sand; “coarse aggregate”, gravel or gravel-size crushed stone.
<b>Air Lift</b>	A device used to clean material from the bottom of a fluid-filled shaft, usually constructed using an open-ended steel pipe into which compressed air is injected near the bottom in an upward direction.
<b>Allowable Load</b>	The load which cannot be exceeded without incurring (in the opinion of the designer) risk of damaging structural movement.
<b>Anchor Pier</b>	A pier designed to resist uplift or lateral forces.
<b>Artesian Water</b>	Subsurface water underlying a confining bed which has sufficient pressure to rise above existing ground (or water surface) when encountered in cased holes during drilling.
<b>Attapulgit</b>	A clay mineral consisting of complex magnesium aluminum silicates. It occurs naturally near Attapulgus, Georgia where it is mined as Fuller’s earth. Also made into commercial drilling mud useful in salt or brackish water environments.
<b>ASTM</b>	American Society for Testing and Materials
<b>Auger</b>	A helical rotary tool for drilling a cylindrical hole in soil and/or rock.
<b>Axial Load</b>	That portion of the load on a pier or pile which is in the direction of its axis.
<b>Backfill</b>	Any material placed in an excavated area, for the purpose of raising the grade in the area.
<b>Bailing Bucket</b>	A bucket-like tool for removing water from the hole during drilling or in preparation for concrete placement.
<b>Batter</b>	Angle with the vertical, normally expressed as a ratio of horizontal to vertical (i.e., 1:4= 1 horizontal to 4 vertical).
<b>Bearing Stratum</b>	A soil or rock stratum that is expected to carry the drilled shaft load (either by end bearing or by sidewall friction, or by a combination of the two).
<b>Bell</b>	Enlargement of the lower end of a shaft excavation, to increase the bearing area of the drilled shaft (Also called “underream”).
<b>Belling Bucket Underreaming Bucket</b>	A drilling bucket tool with expanding cutters that can enlarge the bottom of the drilled hole, to form a bell or underream. See <b>Bucket Auger, Drilling Bucket.</b>

<b>Bentonite</b>	The mineral, sodium montmorillonite, a highly expansive colloidal clay; the basis for a type of commercial “driller’s mud
<b>Boulder</b>	A rock, usually rounded by weathering and abrasion, greater than 200 mm in size.
<b>Bucket Auger (or Drilling Bucket)</b>	A cylindrical rotary drilling tool with a hinged bottom containing a soil cutting blade; spoil enters the “bucket” and is lifted out of the hole, swung aside, and dumped by releasing the latch on the hinged bottom.
<b>Cage</b>	Reinforcing bars preassembled for quick placing in a drilled shaft.
<b>Cake (Filter Cake)</b>	A layer of clay or clayey soil, built up on the wall of a boring drilled with slurry (drilling mud, bentonite, etc.), having the effect of forming an impermeable lining to prevent (or diminish) loss of water from the hole, and maintain slurry pressure against the wall of the hole.
<b>Calcarenite</b>	Mechanically deposited carbonate rocks consisting of sand size carbonate grains (1/16 to 2 mm diameter)
<b>Calcilutite</b>	Refers to a rock composed of more than 50% silt and clay size carbonate particles.
<b>Calyx (or Shot) Barrel</b>	A core barrel without hard-metal cutting teeth, with which the rock is cut (or ground up) by chilled steel shot which roll and are ground up under the rotating steel edge of the barrel.
<b>Capillarity</b>	The upward movement of water, due to effects of wetting and surface tension, that occurs through the very small void spaces that exist in a soil mass.
<b>Carbonate Rocks</b>	Rocks composed of more than 50% by weight, of carbonate minerals.
<b>Casing</b>	An open-end steel pipe installed by drilling, driving or vibrating; to support the wall of a hole; to seal out groundwater; or to protect the concrete of the shaft from contamination by sloughing of the sides of the hole.
<b>Caving (or Sloughing)</b>	A soil that tends to fall into an uncased hole, during or after the drilling. Usually a cohesionless soil.
<b>Changed Conditions</b>	Job conditions, which differ, substantially from conditions as represented in the plans and specifications, and/or the contract documents.
<b>Chert</b>	A hard, dense microcrystalline sedimentary rock, consisting chiefly of interlocking crystals of quartz. It may contain amorphous silica (opal). Chert occurs principally as nodular or concretionary segregations, or nodules, in limestone and dolomite, and less commonly as layered deposits, or bedded chert. The term flint is equally synonymous.
<b>Clay</b>	A mineral particle of any composition having a diameter less than 0.002 mm.

<b>Cleanout Bucket</b>	A cylindrical tool used for removing “cuttings” from the shaft bottom. The bucket typically has a bottom that opens up when turned clockwise and closes when turned counterclockwise.
<b>Coarse-Grained Soil</b>	The soil types which have particles large enough to be seen without magnification. The coarse-grained soils include the sand and gravel (or larger) soil particles.
<b>Cohesion</b>	The bonding or attraction between particles of certain fine-grained soils that enhances shear strength and is independent of confining pressure.
<b>Cold Joint</b>	Surface where concrete placement was interrupted then later resumed.
<b>Concrete Pump</b>	A truck mounted pump specially designed to transfer fluid concrete through lines (hoses and pipes) to deliver ready mix to locations not readily accessible otherwise.
<b>Continuous Flight Auger</b>	A string of helical augers and a cutting head, used to bore a hole in the earth, into which a pile section may be set, concrete cast in place, or tieback grouted.
<b>Coquina</b>	A soft, porous limestone made up largely of shells, coral, and fossils cemented together.
<b>Core Barrel</b>	A cylindrical rock-drilling tool, designed to cut an annular space around a central cylindrical core of rock, which can then be removed to classify the material or in the case of a drilled shaft removed to deepen the hole.
<b>Crane Carrier</b>	A specially built truck for mounting a drill rig or for carrying a crane.
<b>Crowd</b>	The soil types which have particles large enough to be seen without magnification. The coarse-grained soils include the sand and gravel (or larger) soil particles.
<b>Cuttings</b>	Particles of soil or rock resulting from the cutting action of drilling or augering a hole. See also <b>Spoil</b> .
<b>Dense</b>	Compact
<b>Desander</b>	A specially designed piece of equipment consisting of a series of screens and hydrocyclones which remove sand and silt particles from the slurry used in constructing a fluid-filled excavation.
<b>Dewatering</b>	(1) The removal of water from a construction area, as by pumping from an excavation or location where water covers the planned working surface. (2) Lowering of the groundwater table in order to obtain a “dry” area in the vicinity of an excavation which would otherwise extend below water.
<b>Diatomaceous Earths</b>	Silts containing large amounts of diatoms-the siliceous skeletons of minute marine or freshwater organisms.
<b>Dolomite</b>	A carbonate rock composed of more than 50% by weight, of the mineral dolomite.

<b>Downdrag</b>	A downward force exerted on a drilled shaft, pile, or other structural element by settling soil. Sometimes called “negative skin friction”.
<b>Drilled Pier/ Drilled Shaft</b>	A reinforced or unreinforced concrete foundation element formed by drilling a hole in the earth and filling it with concrete. Also called a “caisson”, or a “large-diameter bored pile”.
<b>Drilling Bucket</b>	A closed rotary boring tool with its cutting edge at its base. Spoil is removed from the bucket by lifting it out, swinging it to one side of the hole, and releasing the hinged bottom of the bucket.
<b>Drilling Mud, Mud, or Slurry</b>	A fluid mixture of water and clayey soil, or commercial “driller’s mud” which may be bentonite or attapulgite.
<b>Elastic Movement</b>	Movement under load which is recoverable when the load is removed.
<b>“Elephant’s Trunk”</b>	A collapsible conduit of fabric or plastic which, when coupled to the bottom of a concrete hopper, directs the concrete to a point near the center of the reinforcing cage to prevent concrete from striking the cage or the sides of the shaft.
<b>End Bearing</b>	The portion of load carrying capacity a shaft or pile has due to the end area bearing on the material below.
<b>Extractor</b>	A device for pulling piles or casings out of the ground. It may be an inverted steam or air hammer with yoke so equipped as to transmit upward blows to the pile body, or a specially built extractor utilizing this principle. Vibratory hammers/extractors may be especially effective.
<b>Fill</b>	Any man-made soil deposit. Fills may consist of soils that are free of organic matter and that are carefully compacted to form an extremely dense, incompressible mass, or they may be heterogeneous accumulations of rubbish and debris.
<b>Fine-Grained</b>	Refers to silt and clay-sized particles which exist in a soil.
<b>Fixed-Head Pier</b>	A pier whose top, when deflected laterally with application of lateral force, is so restrained that the pier axis at the top must remain vertical during such movement.
<b>Friction/ End-bearing Pier</b>	A pier that achieves support from the combination of side friction and tip (end) bearing.
<b>Friction Shaft</b>	A pier that derives its resistance to load by the friction or bond developed between the side surface of the pier and the soil or rock through which it is placed.
<b>Fuller’s Earth</b>	Soils having the ability to absorb fats or dyes. They are usually highly plastic, sedimentary clays.

<b>Full-Scale Load Test</b>	A load test made on a full-scale shaft or other structural element, with the load carried at least to the structural design load, and preferable to twice (or more) the design load.
<b>Geomaterial</b>	Material (soils, rock, clays, silts, etc.) underlying the surface
<b>Geotechnical Engineer</b>	An engineer with specialized training and knowledge of structural behavior of soil and rocks, employed to do soil investigations, to do design of structure foundations, and to provide field observation of foundation investigation and foundation construction.
<b>Grains</b>	Discrete particles larger than 0.074 mm. They may form the rock framework, similar to sand grains in a sandstone, or they may be subordinate to smaller particles in the rock.
<b>Grain Size</b>	A term relating to the size of grains. (See above)
<b>Gravel</b>	Small stones or fragments of stone or very small pebbles larger than the particles of sand, but often mixed with them. Generally 4.76 to 75mm in size. (Stones 75 to 300 mm are usually called “cobbles”).
<b>Ground Loss</b>	Subsidence of surface of ground adjacent or close to a shaft excavation, caused by soil moving into the excavation laterally during drilling, or during dewatering after drilling is complete. Common in soft organic soils or clays, and cohesionless soils below the water table.
<b>Groundwater Level</b>	A shallow pit, excavated adjacent to a boring location, used to contain drilling mud (slurry) during drilling.
<b>Hardpan</b>	A term that should be avoided by the engineer. Originally, it was applied only to a soil horizon that had become rocklike because of the accumulation of cementing minerals. The name implies a condition rather than a type of soil.
<b>Head</b>	Shortened form of the phrase “pressure head”, referring to the pressure resulting from a column of water or elevated supply of water.
<b>Hollow-Stem Auger</b>	An earth auger with an end bit on a hollow center shaft.
<b>Hydraulic Pump</b>	The hydraulic pump is the same and performs the same functions as the electric submersible pump except it is hydraulic.
<b>Impervious</b>	Impervious soil is soil in which the spacing of the soil particles is so close as to allow only very slow passage of water. For example, movement of water through a typical clay (an “impervious” soil) may be only 1/1,000,000 as fast as through a typical sand.

<b>Kelly bar (or Kelly)</b>	The kelly bar transfers the rotary and pull-down force to the drilling tools. The kelly bar is also used to raise and lower the tools in the shaft. It may be solid or hollow with two or more bars telescoping inside each other. The ability of the bar to telescope, allows excavation to greater depths than the boom height would otherwise allow.
<b>Laitance</b>	A fluid mixture of water, cement, and fine sand that appears at the top of concrete soon after pouring
<b>Lateral Load</b>	That portion of load that is horizontal, or at 90 to the axis of a pier or pile, or of the supported structure.
<b>Limestone</b>	A carbonate rock composed of more than 50%, by weight, of the mineral calcite.
<b>Load Cell</b>	A device for measuring the pressure exerted between the soil (or rock) and a structural element (e.g., the bottom or side of a pier); used with a hydraulic or electrical indicating or recording instrument at ground surface.
<b>Matrix</b>	The natural material in which any fossil, pebble, crystal, etc., is embedded.
<b>Micrograined</b>	A grain-size term pertaining to carbonate particles smaller than 0.0625 mm and larger than .004 mm diameter.
<b>Mud</b>	See Drilling Mud
<b>Mud Pit</b>	A shallow pit, excavated adjacent to a boring location, used to contain drilling mud (slurry) during drilling.
<b>Mudding-In</b>	The technique of stirring soil and water by and auger; sometimes with the addition of commercial “driller’s mud”, to form a slurry as the hole is advanced by auger drilling.
<b>Multiple Underreams</b>	Additional underream cut in a bearing soil, at elevations above the bottom underream, to force shearing resistance in the soil into a larger peripheral surface.
<b>Moisture Content</b>	The reduction in diameter in a section of a drilled shaft.
<b>Natural Moisture Content</b>	Moisture content in-situ, at the time of measurement or investigation. May be subject to seasonal variation.
<b>Necking</b>	The reduction in diameter in a section of a drilled shaft.
<b>Negative Skin Friction</b>	Effect of settling soil that grips a pile or pier by friction and adds its weight to the structure load. Also called <b>Downdrag</b> .

<b>NX Core</b>	Rock core taken with an “NX” core barrel, which cuts a core 60mm in diameter.
<b>Oolite</b>	Small spherical or subspherical carbonate accretionary grain generally less than 2.0 mm in diameter.
<b>Over Reaming</b>	Enlarging the diameter of the shaft to remove any slurry cake build up.
<b>Piezometric Head</b>	(See <b>Artesian Pressure</b> )
<b>Plasticity</b>	Term applied to fine-grained soils (such as slays) which when moist can be remolded without raveling or breaking apart.
<b>Rebar</b>	A bar of reinforcing steel.
<b>Reverse Circulation</b>	A counterflow method of circulating drilling fluid and spoil in a drill hole. In the direct circulation method, drilling fluid is pumped down a hollow drill pipe, through the drill bit, and back to the surface in the annular space around the drill pipe; and the cuttings are carried to the surface by the flow. In the reverse-circulation or counterflow system, drilling fluid is pumped out of the drill stem at the top circulated through a pit where cuttings are removed, and returned to the annular space around the drill stem. Circulation is upward inside the drill stem and downward outside it.
<b>Rig, Drilling Rig</b>	A machine for drilling holes in earth or rock.
<b>Rock</b>	A naturally occurring mineral substance cohesively bound by chemical bonds and forming the basic structure of the earth’s crust.
<b>Rock Auger</b>	An auger-type drilling tool, equipped with hard-metal teeth to enable it to drill in soft or weathered rock.
<b>Rock Socket</b>	That portion of a shaft, which penetrates into a rock formation beneath less competent overburden.
<b>Rotary Boring</b>	A method of boring using rotary (as opposed to percussive) means of excavation.
<b>Rotary Drill Rig</b>	A rotary drilling machine powered hydraulically, pneumatically, electrically or mechanically to bore exploratory holes or for installation of drilled shafts, caissons, or in-situ piles. The equipment may use a continuous-flight auger or a rotary table and Kelly bar with various attachments and tools to perform the work.
<b>Sand</b>	Cohesionless soil whose particle sizes range between 0.074 and 4.76 mm in diameter.
<b>Seepage</b>	Small quantities of water percolating through a soil deposit or soil structure.

<b>Segregation</b>	Separation of poured concrete into zones of coarse aggregate without fines, and sand-water-cement without coarse aggregate.
<b>Settlement</b>	(1) The amount of downward movement of the foundation of a structure or a part of a structure, under conditions of applied loading. (2) The downward vertical movement experienced by structures or soil surface as the underlying supporting earth compresses.
<b>Shaft Inspection Device (S.I.D.)</b>	The shaft inspection device is an instrument that allows the inspector to see the bottom of the drilled shaft. It has a video camera that is lowered to the bottom of the drilled shaft. It can also measure the thickness of sediment on the bottom of the shaft and sample sidewall soils.
<b>Sidewall Grooving</b>	The cutting of circular or spiral grooves in the walls of a drilled shaft hole in rock or soil, with the objective of improving sidewall support.
<b>Sidewall Shear</b>	Frictional resistance to axial movement of a pier or pile, developed between the soils surrounding the shaft and the peripheral surface of the shaft. (Does not include resistance to movement of an enlarged base, due to development of shearing strains within the soil below the base).
<b>Silt</b>	A fine-grained nonplastic soil; often mistaken for clay, but quite different in its behavior. (Particle sizes ranging from 0.002 to 0.074 mm).
<b>Skin Friction</b>	Resistance to shearing motion between the concrete of the shaft and the soil or rock in contact with it.
<b>Slurry</b>	See <b>Drilling Mud</b>
<b>Soil Auger</b>	The soil auger is used for cutting and removing the soil from the shaft volume. It typically has several flights of 30 degrees or less.
<b>Sonotube</b>	A cylindrical form of treated cardboard, for forming round columns of concrete; a commercial product.
<b>Spacers</b>	Spacers are used to keep the steel cage centered in the drilled shaft and insure proper concrete cover. The spacers should be concrete wheels or other approved non-corrosive spacing.
<b>Spoil</b>	Soil or rock removed from an excavation; to be wasted or used elsewhere as fill.
<b>Squeezing Ground</b>	A soil formation, usually of clay, silt, or organic material, which tends to bulge or squeeze into the hole during drilling, or afterward if the hole is left uncased.
<b>Standard Penetration Test (SPT) (N)</b>	The number of blows required to drive a 2-inch O.D., 1-3/8 inch I.D., 24-inch long, split soil sampling "spoon" 1 foot with a 140 pound weight freely falling 30 inches. The count is recorded for each of three 6-inch increments. The sum of the second and third increments is taken as the N value in blows per foot. (This is ASTM Designation D 1586).

<b>Strain Gauge</b>	An instrument or device for measuring relative motion (compression, elongation, or shear) between two points in a mechanism or in a structural member such as a drilled shaft
<b>Swelling Soil</b>	A soil subject to volume increase caused by wetting, oxidation, buildup of crystals, or relaxation after load removal.
<b>Telltale</b>	A strain indicator, usually comprised of a sleeved free-standing rod cast in place in a drilled pier or pile to measure relative movement between the anchored (embedded) tips of two or more rods or between the rod anchor and the top of the pier or pile.
<b>Template</b>	A fixed template is required during all excavation and concreting operations when drilling from a barge. This is to maintain shaft position and alignment. A template is not required on land if the contractor can satisfactorily show that he can maintain proper position and alignment without it.
<b>Temporary Casing</b>	Casing left in place until concrete has been placed, or casing placed as protection for workmen or inspector.
<b>Test Hole</b>	With the test hole, the contractor must demonstrate that his construction methods will work. A test hole is typically the same size as the shafts to be constructed.
<b>Tremie</b>	(1) (verb) To place concrete below water level through a pile, the lower end of which is kept immersed in fresh concrete so that the rising concrete from the bottom displaces the water without washing out the cement content. (2) (noun) The hopper and drop pipe used to place the concrete underwater.
<b>Tremie Pipe</b>	The tremie pipe is used to place concrete in the drilled shaft. In shafts constructed by the wet method, the tremie pipe must extend to the bottom of the drilled shaft. In shafts constructed by the dry method, the tremie pipe must extend to within five feet of the shaft bottom. The tremie pipe serves several purposes. It transports the concrete through the slurry. It keeps the concrete from segregating during placement. Also, it helps keep the concrete from mixing with the drilling slurry at the slurry/concrete interface.
<b>Twisting Bar</b>	A tool attached to the kelly, used for “screwing” down casing through caving or squeezing soil. Sometimes used for pulling casing.
<b>Underream</b>	Enlargement of the lower end of an augered or drilled pier hole to increase its bearing area. Also called “bell”.
<b>Underreamer, Belling Tool</b>	See <b>Belling Bucket</b> .

<b>Unit Weight</b>	The weight per unit volume of a material such as soil, water, concrete, and so on. Typically expressed as pounds per cubic foot, rams per cubic centimeter, or kilograms per cubic meter.
<b>Uplift</b>	An upward force exerted on a pier, pile, or other structural elements, by expanding soil or rock, hydraulic pressure, or structural loading.
<b>Vibratory Driver/ Extractor</b>	A pile-driving and extracting machine which is mechanically connected to a pile or casing and loosens it while driving or pulling by oscillating it through the soil. Power source may be either electric or hydraulic.
<b>Vug</b>	A small cavity in a vein or in rock.
<b>“Walking Off”</b>	Tendency for a rotating bit to deflect laterally when encountering harder, deflecting layer of rock or irregular surface.
<b>Water Content</b>	The ratio of the quantity (by weight) of water in a given volume of soil mass to the weight of the soil solids, typically expressed as a percentage.
<b>Water Table</b>	The subsurface elevation at which free water will usually be present. Also called “groundwater”.

# Appendix B

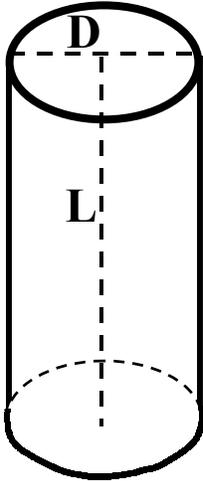
## Inspector Math Tip Sheets

# VOLUMES OF A SHAFT

## EQUATIONS

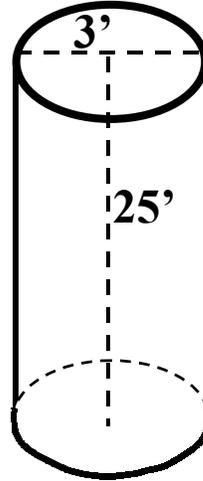
## EXAMPLES

### SHAFT



Shaft diameter= D  
 Shaft length= L  
 B= 3.142  

$$V = \frac{BD^2}{4} \times L$$



$$V = \frac{BD^2}{4} \times L$$

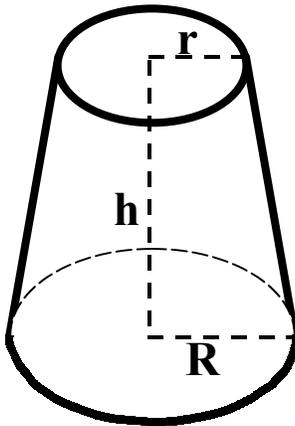
$$V = \frac{3.142 \times 9}{4} \times 25$$

$$V = \frac{28.28}{4} \times 25$$

$$V = 7.07 \times 25$$

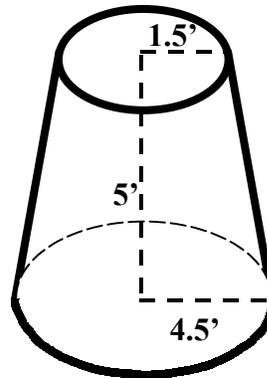
$$V = 176.75 \text{ ft}^3 \text{ or } 176.75/27 = 6.55 \text{ cyds}$$

### BELL



h: height  
 R,r: radius of bases  
 V: volume  
 B= 3.142  

$$V = B(R^2 + rR + r^2)h/3$$



$$V = B(R^2 + rR + r^2)h/3$$

$$V = 3.142(20.25' + 6.75' + 2.25')5'/3$$

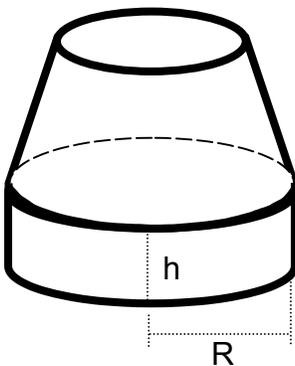
$$V = 3.142(29.25)5/3$$

$$V = 91.90 \times 5/3$$

$$V = 459.5/3$$

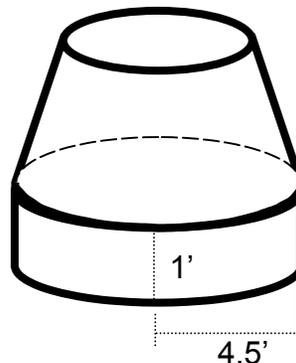
$$V = 153.16 \text{ ft}^3 \text{ or } 153.16/27 = 5.67 \text{ cyds}$$

### TOE OF BELL



h: height  
 R: radius of base  
 V: volume  
 B= 3.142  

$$V = BR^2 h$$



$$V = BR^2 h$$

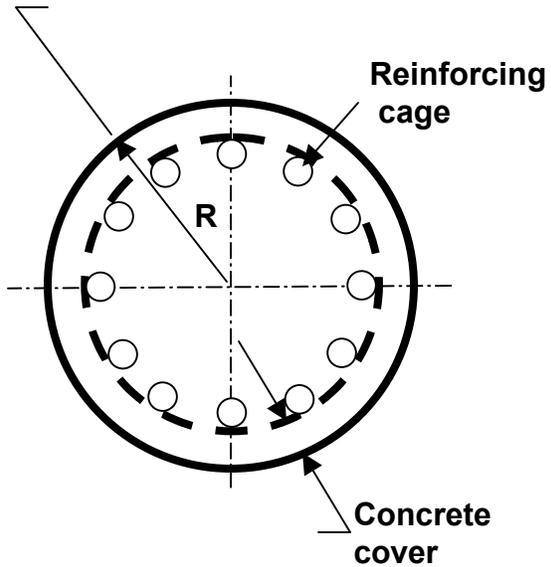
$$V = 3.142 \times 20.25 \times 1$$

$$V = 63.62 \times 1$$

$$V = 63.62 \text{ ft}^3 \text{ or } 63.62 / 27 = 2.36 \text{ cyds}$$

## CIRCUMFERENCES

### CIRCUMFERENCE OF SHAFT/REINFORCING CAGE



$D = \text{diameter} = 2 \text{ times } R \text{ (radius)}$   
 $\pi = 3.142$

**CIRCUMFERENCE OF SHAFT (C) =  $\pi D$**

**CIRCUMFERENCE OF CAGE**

**$C = \pi (D - 2 \times \text{Req'd Concrete Cover})$**

<b>SI CONVERSION FACTORS</b>				
APPROXIMATE CONVERSIONS FROM SI UNIT				
<b>Symbol</b>	<b>When You Know</b>	<b>Multiply By</b>	<b>To Find</b>	<b>Symbol</b>
<b><u>LENGTH</u></b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<b><u>AREA</u></b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b><u>VOLUME</u></b>				
ml	milliliters	0.034	fluid ounces	fl oz
l	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.71	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b><u>MASS</u></b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
<b><u>TEMPERATURE</u></b>				
°C	Celsius	1.8 C + 32	Fahrenheit	°F
<b><u>WEIGHT DENSITY</u></b>				
g/cc	grams per cubic centimeter	62.4	poundforce/cubic foot	pcf
kN/m <sup>3</sup>	kilonewton/cubic meter	6.36	poundforce/cubic foot	pcf
<b><u>FORCE and LOAD</u></b>				
N	newtons	0.225	poundforce	lb
kN	kilonewtons	225	poundforce	lb
kg	kilogram (force)	2.205	poundforce	lb
MN	meganewtons	112.4	tons (force)	t
<b><u>PRESSURE and STRESS*</u></b>				
kPa*	kilopascals	0.145	poundforce/square inch	psi
kPa	kilopascals	20.9	poundforce/square inch	psi
MPa	megapascals	10.44	tons per square foot	tsf
kg/cm <sup>2</sup>	kilograms per square cm	1.024	tons per square foot	tsf

\*Notes: 1 kPa = kN/m<sup>2</sup> = one kilopascal = one kilonewton per square meter.

For dimensionless graphs and equations, a reference stress of one atmosphere can be used, such that  $\sigma_a = p_{atm} = 1 \text{ bar} = 100 \text{ kPa} \approx 1 \text{ tsf} \approx 1 \text{ kg/cm}^2$ .

## Shaft Areas and Volumes

Per Linear Foot				Per Linear Meter			
Shaft Diameter (in.)	Volume (yd <sup>3</sup> )	Side Shear Area (ft <sup>2</sup> )	Bearing Area (ft <sup>2</sup> )	Shaft Diameter (cm)	Volume (m <sup>3</sup> )	Side Shear Area (m <sup>2</sup> )	Bearing Area (m <sup>2</sup> )
12	0.03	3.14	0.79	30	0.07	0.94	0.07
14	0.04	3.67	1.07	35	0.10	1.10	0.10
16	0.05	4.19	1.40	40	0.13	1.26	0.13
18	0.07	4.71	1.77	45	0.16	1.41	0.16
20	0.08	5.24	2.18	50	0.20	1.57	0.20
22	0.10	5.76	2.64	55	0.24	1.73	0.24
24	0.12	6.28	3.14	60	0.28	1.88	0.28
26	0.14	6.81	3.69	65	0.33	2.04	0.33
28	0.16	7.33	4.28	70	0.38	2.20	0.38
30	0.18	7.85	4.91	75	0.44	2.36	0.44
32	0.21	8.38	5.59	80	0.50	2.51	0.50
34	0.23	8.90	6.31	85	0.57	2.67	0.57
36	0.26	9.42	7.07	90	0.64	2.83	0.64
38	0.29	9.95	7.88	95	0.71	2.98	0.71
40	0.32	10.47	8.73	100	0.79	3.14	0.79
42	0.36	11.00	9.62	105	0.87	3.30	0.87
44	0.39	11.52	10.56	110	0.95	3.46	0.95
46	0.43	12.04	11.54	115	1.04	3.61	1.04
48	0.47	12.57	12.57	120	1.13	3.77	1.13
50	0.51	13.09	13.64	125	1.23	3.93	1.23
52	0.55	13.61	14.75	130	1.33	4.08	1.33
54	0.59	14.14	15.90	135	1.43	4.24	1.43
56	0.63	14.66	17.10	140	1.54	4.40	1.54
58	0.68	15.18	18.35	145	1.65	4.56	1.65
60	0.73	15.71	19.63	150	1.77	4.71	1.77
62	0.78	16.23	20.97	155	1.89	4.87	1.89
64	0.83	16.76	22.34	160	2.01	5.03	2.01
66	0.88	17.28	23.76	165	2.14	5.18	2.14
68	0.93	17.80	25.22	170	2.27	5.34	2.27
70	0.99	18.33	26.73	175	2.41	5.50	2.41
72	1.05	18.85	28.27	180	2.54	5.65	2.54
74	1.11	19.37	29.87	185	2.69	5.81	2.69
76	1.17	19.90	31.50	190	2.84	5.97	2.84
78	1.23	20.42	33.18	195	2.99	6.13	2.99
84	1.43	21.99	38.48	210	3.46	6.60	3.46
90	1.64	23.56	44.18	225	3.98	7.07	3.98
96	1.86	25.13	50.27	240	4.52	7.54	4.52
102	2.10	26.70	56.75	255	5.11	8.01	5.11
108	2.36	28.27	63.62	270	5.73	8.48	5.73
114	2.63	29.85	70.88	285	6.38	8.95	6.38
120	2.91	31.42	78.54	300	7.07	9.42	7.07
126	3.21	32.99	86.59	315	7.79	9.90	7.79
132	3.52	34.56	95.03	330	8.55	10.37	8.5