Concrete....what is it?

Concrete is a mixture of gravel, sand, water and cement in proportions to produce a product that can be made into solid structures or objects to serve our needs. It is NOT Mortar!

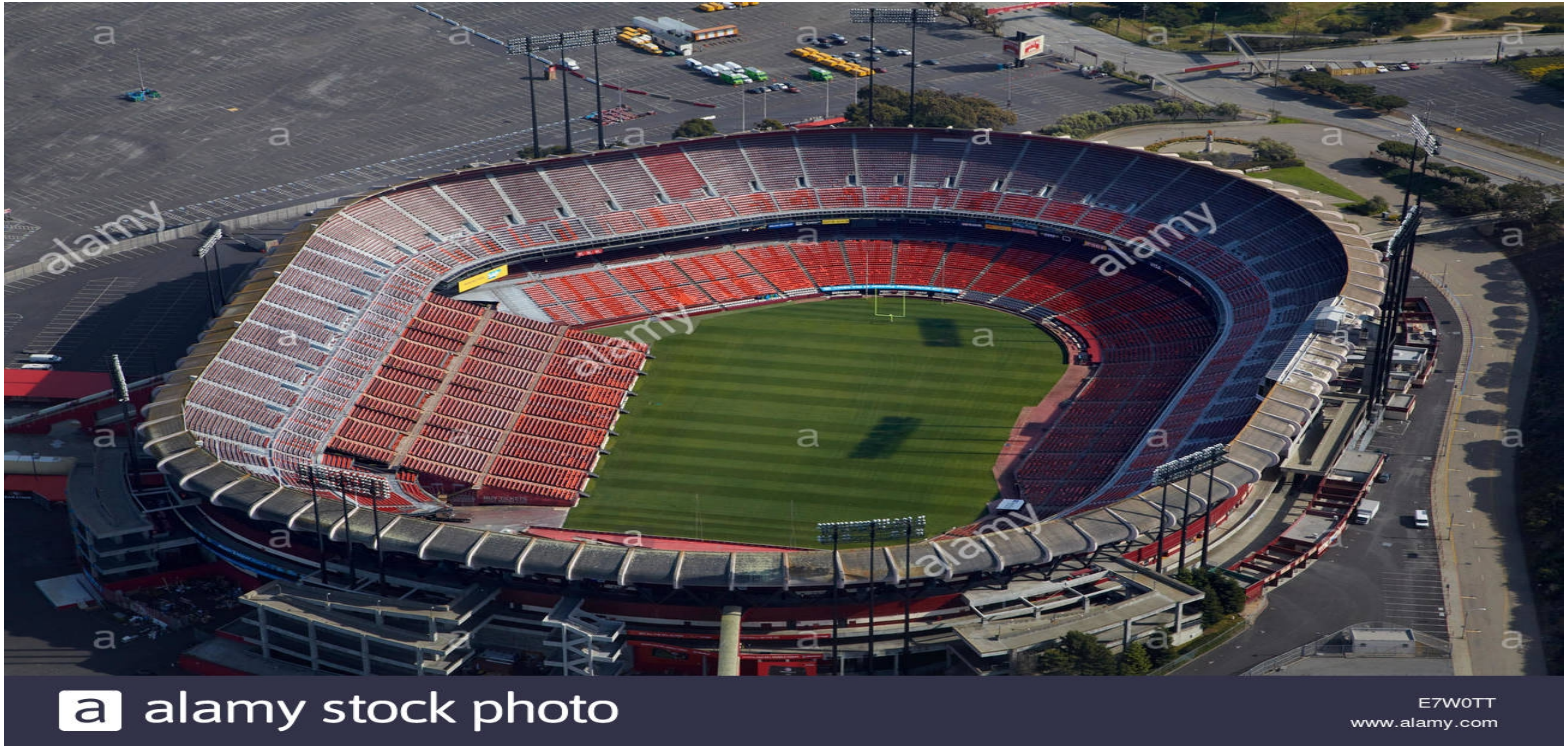
Concrete was discovered/invented by the early Romans by heating limestone then crushing it.

Concrete, when properly proportioned and mixed cures to a desired strength as determined by compression tests. Concrete is weak in tension, but strong in compression.

My Background…1964 thru 2011

- Penn State Univ (Engineering 1964-1966), USAF (Electrical Power Production 1966-1970), Univ of So Cal Berkley (Prestressed and post tensioned Concrete 1971)
- ICBO/BOCA Certifications in Concrete, Welding, Steel Erection, Post Tensioning
- City of Los Angeles: Certified Inspector, City of LA Building Dept GFRC
- New York City: Directive 14 Certified
- PCI/ACI Certification-Concrete
- AWS Certification-Welding Inspection
- Field engineer, Inspector, Superintendent, Operations Manager, Project Superintendent, QA Director, Plant Manager, Project Manager
- Worked for: Tidewater, Raymond & Kiewit, Tecon Pacific, Ben C Gerwick, TY Lynn, JH Pomeroy, Basalt Rock Co., Zurn Industries, Ceramic Cooling tower co., McCarthy Const., Boeing Construction, Louisville Power & Light, Bechtel, The Austin Co., Ragnar Benson Const., Clark Pacific, Willis Construction, The Quickset Org., GFRC Cladding, XM Satellite, Eastern Exterior Wall Systems, Marcon & Boyer, US Army (Tobyhanna)

Candlestick Park, San Francisco.. Ca. 1972
Field Eng, Inspector..Pomeroy/ Ben C Gerwick



Hyatt Regency Hotel, San Francisco, Ca. built 1972 Precast Plant field inspector/engineer

Sunshine Skyway Bridge (Bradenton to Clearwater, Florida)..1983 to 1985 construction. Precast Supt.

GFRC (Fiberglass Reinforced Concrete) 1985-1995
QA Director..Tecon Pacific Inc., So. Calif.

What you need to know about concrete.

- Strength is most often tested at 7 and 28 days using 6” dia. x 12” high cylinders placed into a calibrated compression machine.
- Based on ingredients, may be anywhere from 3500psi to 10,000psi at 28 days of age. Strength steadily continues to increase but at a much lower rate over time….never stops curing!
- Most critical ingredient in concrete is the amount of water used in the mixture. It is expressed as the **WATER/CEMENT RATIO**…. Or the total amount of water in the batch, divided by the total amount of cement.
- For the mix to hydrate (cure) **the minimum this can be is .38**. The chemical reaction will not occur if it is below this amount, followed by increasing the ratio, will reduce the reaction. An optimum W/C ratio is .44 to .46 for all practical purposes.

Strength of Concrete….

- Concrete cures (hydrates) due to water and heat.
- Concrete stops curing when its temperature drops below 50 degrees Fahrenheit. Once this happens it cannot start again even if returned to a temperature above 50 degrees.
- When concrete reaches a temperature above 90-95 degrees its workability starts decreasing as the temperature increases. This is normally caused by excessive mixing or extreme ambient/materials temperatures. It should not be used if above 95 degrees.
- Concrete can be “worked” up until it reaches initial set or 500 psi. If disturbed after this, it will crack/damage the bonding properties of the mix therefore ruining any structural integrity.

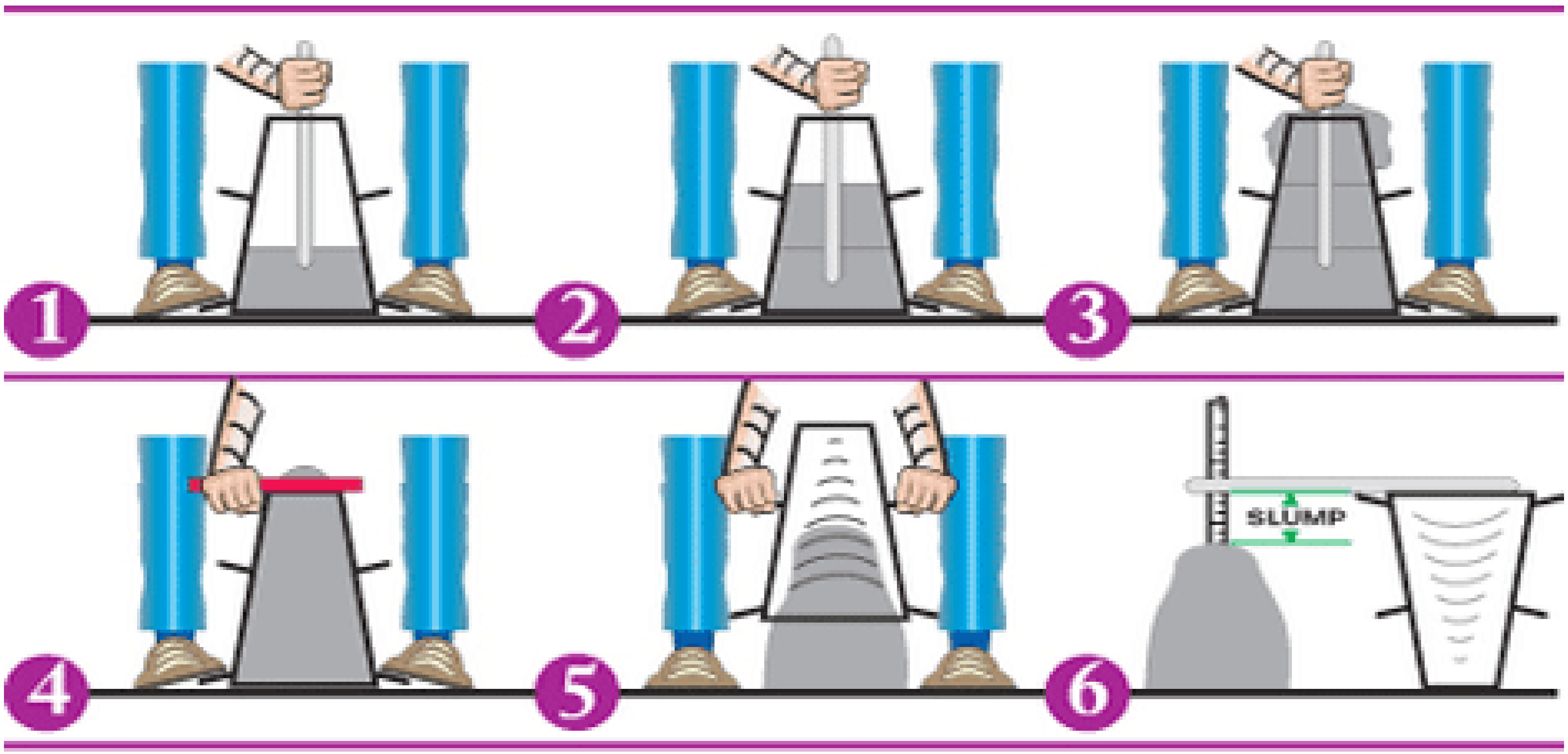
Concrete mix designs

- One cubic yard of concrete = 27 cubic feet.
- Final weight of normal weight concrete is 145 to 150 pounds per cubic foot. Therefore a yard of concrete weighs about 4000 pounds.
- Water weighs 8.33 pounds per gallon
- One sack of cement weighs 94 pounds.
- **W/C ratio = total water (lbs.) / total cement (lbs.)=.45 to .46 is ideal**
- The best way to measure water when mixing concrete is using a 5-gal plastic bucket and a scale. Mark a line on the inside of the bucket, or , drill a hole to let excess water out. <u>Always weigh the water </u>when mixing concrete! All "Sackcrete" type products have the required amount of water marked on the bags…<u>follow this religiously</u>!

Concrete mix designs….cont.

- Sand, gravel, and cement are proportioned in a mix based upon their specific gravity. (The weight of the material as compared to an equal volume of water), the combined ingredients equal 1 cubic yard.
- Type II cement (normally gray) is normally used to make concrete. Fly Ash can be substituted for some of the cement up to 15 to 30%.
- Type III cement (gray or white) is considered “high early strength” because of it’s finer grind and its additives. It is used extensively in the Precast Concrete industry.
- “Mortar” cannot be substituted for cement in a concrete mix due to its chemical properties effect on final compressive strengths.

An ASTM standard Slump Test is performed to determine Concrete Workability:



Test cylinders that have been tested.

Weather Conditions….

- When average ambient mean temperature falls below 50 degrees Fahrenheit for 3 consecutive 24-hour periods steps must always be taken to insure concrete stays above 50 degrees . (using warm water, and/or heated materials) There isn't such a thing as "antifreeze" for concrete mixing.
- Hot weather concrete procedures require means to keep all materials cool or chilled and may include using ice in the mixing water to keep the fresh mix temperature at 90 degrees or less. (fogging coarse and fine aggregate)
- Concrete will generate its own heat due to the hydration process…the larger the mass, the more heat generated.
- In cold weather…. measures must be taken to ensure concrete stays above 50 degrees Fahrenheit after it is placed and until it reaches minimum design strength.

Weather Conditions….cont.

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- Depending on how large the mass is, this may be simply covering with tarps, and adding a 100-watt light bulb under it to maintain temperature of 50 degree's or more. Steam curing is a common way used to accelerate the curing process and is used extensively in Precast and block/brick manufacture.

Thermometer used to measure freshly mixed Concrete temperature:

Workability of concrete

Most often determined by use of the "slump test" at the point of actual use.

W/C ratio's can be kept low using High Range Water Reducer's and Superplasticizers in the actual mix and still have desired workability.

A good workable slump is between 4" to 6" depending on end use.

Designing Concrete applications…

- Reinforcing bars are placed inside concrete to act as a means of holding concrete together as it is put in tension. Since concrete is weak in tension, this means the location and size of the rebar must be determined mathematically to insure it will take on the tension loads imposed on the concrete during its lifespan. **Its location is critical**!!!!
- Prestressing or Post Tensioning are other methods of doing this.
- **Concrete expands and contracts due to temperature change**…..and therefore must be reinforced to prevent cracking of its structure during these events. Polypropylene fibers may be added to the mix (at 2% of cement content) to help with this if **High** flexure forces will not be imposed on the finished concrete.

Designing Concrete applications…cont.

- Concrete is **<u>permeable</u>**. Water will penetrate it depending on its density and compressive strength. Adequate cover of rebar is necessary under all circumstances to prevent corrosion and the eventual effects of it. Correct compaction/vibration is necessary.

- Minimum cover of rebar must allow the largest aggregate particle in the mix to pass between it and another object. It should be a minimum of 1 ½”-2” above any ground or more to slow down water absorption from the ground. (depends on drainage)

Reinforcing Bar:

- Rebar is <u>now</u> normally grade 60.. having a tensile break strength of 60,000 pounds minimum. Grade 40 used to be the standard with a 40,000 lb. tensile strength.
- The deformations on rebar are there **<u>to allow grip/bond to the concrete</u>** and allow loads applied to the concrete to be transferred to the rebar, as the concrete is put into tension. Size and location of rebar is critical and should be inspected properly before any concrete is placed. (+/- 1/8" is a normal tolerance…)
- Epoxy coated rebar is now required for all bridges and highway construction due to water penetration and rust problems. It is gaining in popularity due to its resistance to corrosion.

Reinforcing Bar..cont.

- As water is absorbed into the concrete and meets the rebar it will cause oxidation (rust) of the steel rebar. As this continues over time, the layers of rust expand and fracture the concrete and or reduces its bond to the rebar causing spalling and loss of structural integrity of the concrete as designed.
- Water repellants applied after the concrete is cured inhibits the migration of water thru the substrate and getting to the rebar but does not stop it entirely over time as the water repellants may break down. Most effective water repellants for concrete are **<u>silane</u>** based which bond to the cement/sand particles reducing the openings between them to **<u>NOT</u>** allow the water molecules to travel into the substrate. Most only penetrate the concrete approx. 1/8”

Good Practices…

- When mixing concrete try **to keep the water/cement ratio about .45**.
- A **good layer of compacted gravel first…**to ensure water drainage is provided for any flat slabs such as walkways, etc. This will help during freeze/thaw cycles it will encounter during its lifespan.
- When placing concrete mixtures**, good vibration or compaction** via rodding or mechanical vibrators is necessary to ensure all voids are closed within the final substrate.
- **"ponding" of water on the surface is indicative of too much water in the mix**. It must be corrected, or it will produce a very weak surface when cured.

Good Practices…cont.

- Finishing top/exposed surfaces should be done using **bare minimum** of water to ensure strength of the surface is not compromised. The most common result is flaking of the surface or/and a very powdery soft texture **Finishing aids** are available and should be used.

- **Curing compound or tarp covering** should be done once finishing is completed. Light fogging with water mist is ok after the concrete reaches its initial set (500psi). Direct sunlight or wind speeds up drying and should be addressed when finishing. If drying/curing occurs too quickly, cracking will result.

- **Curing concrete must include both heat and water** to make the chemical reaction take place. Concrete will generate its own heat depending on its mass and may not require additional heat for this process. Water fogging for 7 days after initial cure is quite common for critical structures.

Too much water in concrete:

looks like this: ends up like this:

What to do about standing water on top of freshly placed concrete???

- 1. Allow the water to naturally evaporate with sunlight, wind, and time.
- 2**. Do not ever try to remove it** as you will be removing the cement along with the water.
- 3. After allowing the standing water to evaporate, then “float” the surface to push down the coarse aggregate and build up a consistent slurry/fat that can be floated smoothly.
- 4 **Realize you must be patient!!** Allow time for the reactions to happen, act quickly when they do!!!
- 5. Throwing raw cement on standing water (called “hot-shoting”) creates a paste with the cement particles only….it is inherently weak and will flake off as the substrate cures properly. THIS IS A VERY BAD PRACTICE…

Proper rebar placement and finishing

Poor rebar placement and Poor compaction:

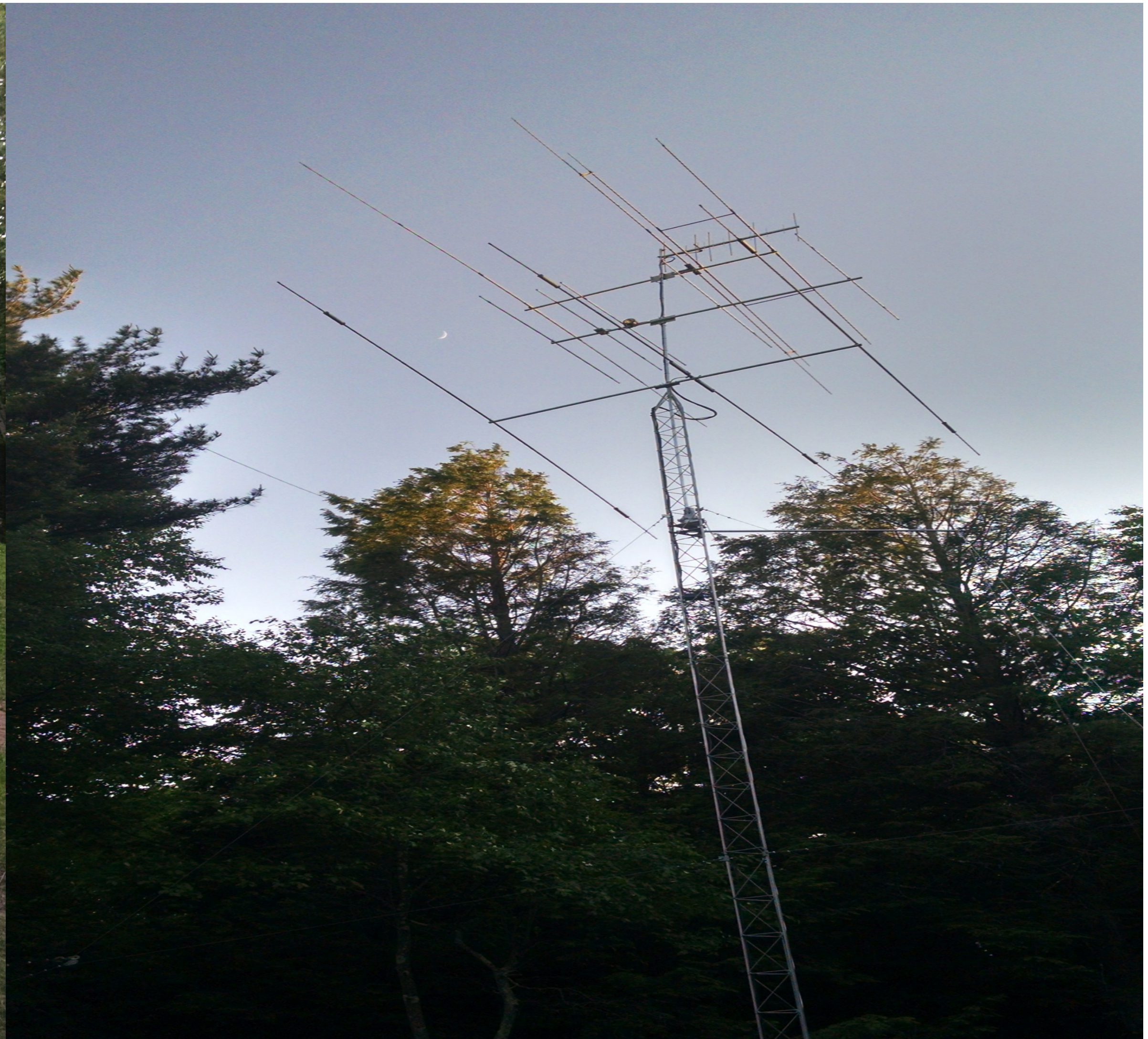
Rebar or not in a Tower Foundation:
2% polypropylene fibers………or conventional rebar
what is missing in these?

Examples of Tower Foundations:

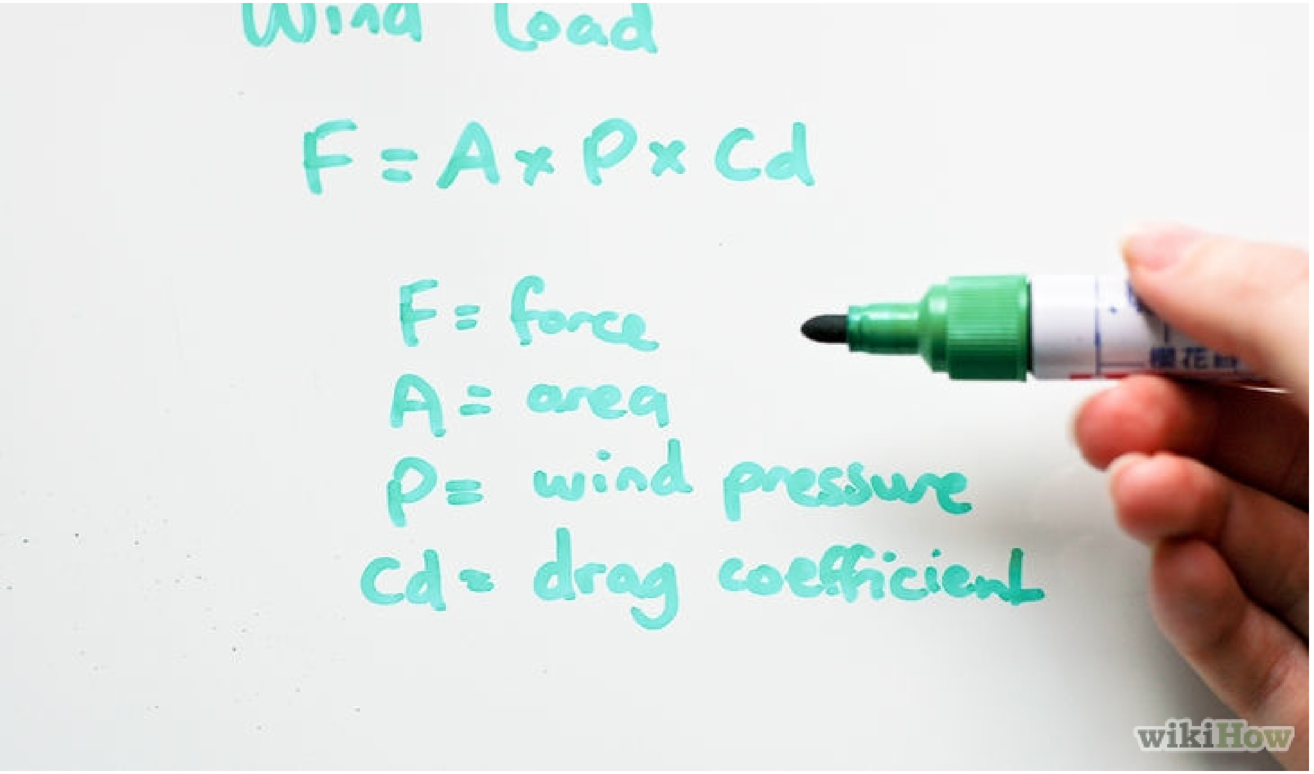
may save concrete, but looses soil bond to sides

W3MJ Tower Installation

AB3ME Tilt Over Tower

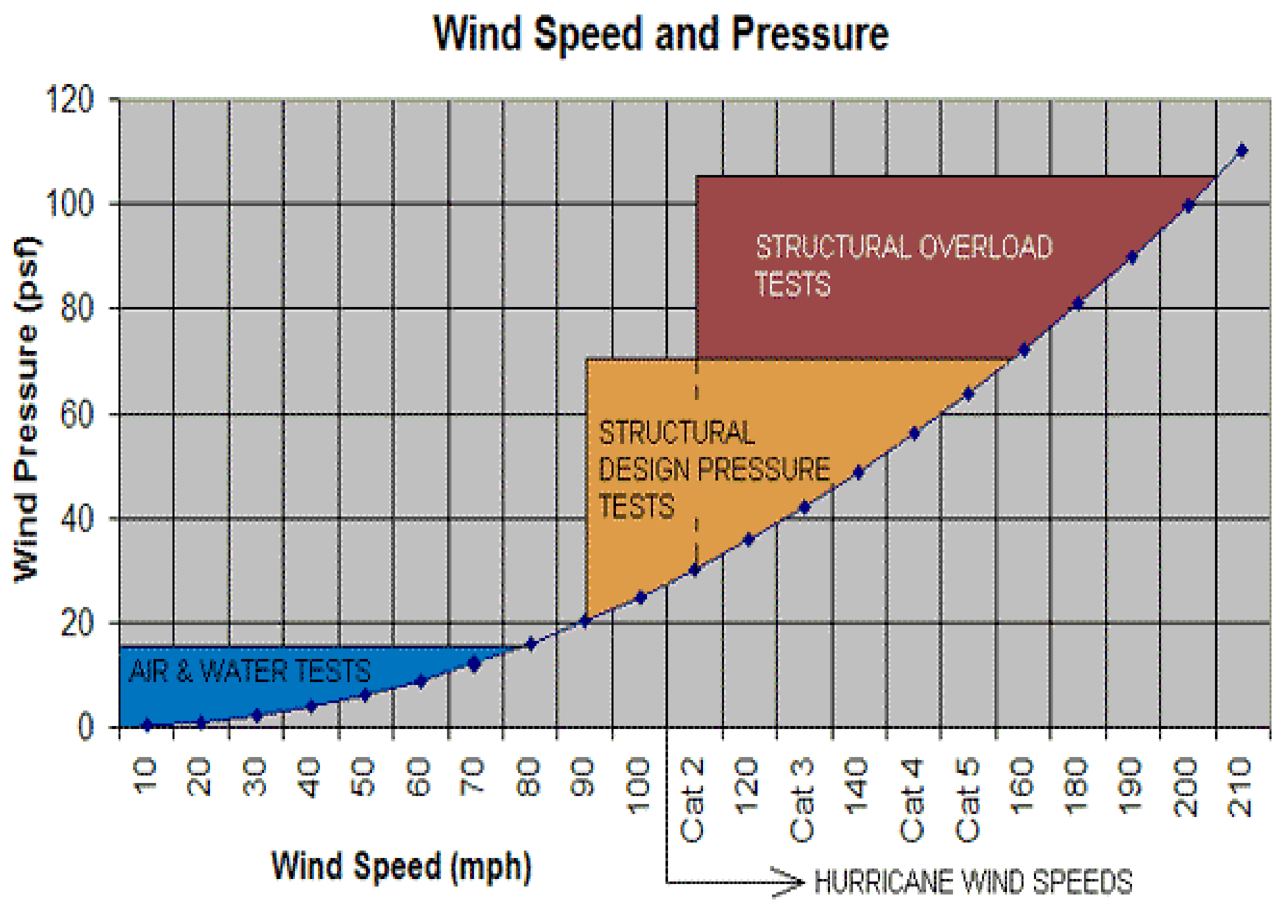



How do I know how large a footing I need:
drag coefficient of a cylinder can be assumed to be about 1.14.



- Knowing this you can get a pretty good idea of how much force is exerted on your tower from the wind.
- Antenna mfgrs. indicate square foot area of their antennas for this purpose.
- **USE AN ENGINEER TO CALCULATE FOOTING SIZE!!!**

The Higher up you go, the greater the forces are from wind alone:



MPH	PSF
10	0.256
20	1.024
30	2.304
40	4.096
50	6.400
60	9.216
70	12.544
80	16.384
90	20.736
100	25.600
110	30.976
120	36.864
130	43.264
140	50.176
150	57.600
160	65.536
170	73.984
180	82.944
190	92.416
200	102.400