UFER Grounds

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U.S. Army Air Base 1941

- In 1941, the U.S. Army established an air base in Tucson Arizona.
- Later that year, it was renamed Davis-Monthan Field and is now known as Davis-Monthan Air Force Base.
- As the base grew they began building bomb storage facilities. The facilities needed protection from lightning and the dry and dusty conditions which caused static electricity.
- The Army started to install copper ground rods
- Due to the dry rocky soil, the ground rods were very difficult to pound into the ground.
- The soil was also not very conductive and hundreds of ground rods were necessary to protect the ordnance.

Tucson Soil conditions

- Dry
- Hard
- Rocky
- Caliche
  - Caliche is natural concrete.
  - A mixture of gravel, sand, clay which are cemented by porous calcium carbonate.
  - Occurs two to four feet below the surface and can be several inches to several feet thick.
  - Used in construction for road beds
  - Water normally does not penetrate Caliche
  - Usually broken up with mechanically or using vinegar or acid

Herbert G Ufer

- Herbert G Ufer was a vice president and engineer at Underwriters Laboratories.
- He was tasked with fixing the grounding problem at Davis-Monthan field.
- Ufer found that concrete, which retains moisture for years, had better continuity than the desert soil.
  - Concrete continues to absorb moisture
- He used the rebar in the concrete for grounding
- Half inch, 20 foot reinforcing bars at the bottom of 2 foot deep concrete footings.
- Testing showed steady values of 2-5 ohms over 20 years
  - Requirement was 5 ohms or less
- He presented a paper on his ground at the IEEE western appliance technical conference in 1963.
- IEEE paper CP-978 October 1964 “Investigation and Testing of Footing-Type Grounding Electrodes for Electrical Installations”

National Electric Code (NEC)

- The National Electric Code (NEC) approved this method of grounding in 1968.
  - Not required if a water pipe or grounding electrode was present.
- The NEC allowed half inch rebar to be used as a grounding electrode in 1978.
- The term concrete encased electrode (CEE) is sometimes used for the Ufer ground.
  - NEC 250.52(A)(3)
- The grounding conductors must be sufficiently large to prevent damage when dissipating high current lightning strikes.
  - Concrete, which contains moisture years after it is poured, will superheat and expand at high velocities with high current.

NEC - 250.52 Grounding Electrodes

(A) Electrodes Permitted for Grounding.

1. Metal Underground Water Pipe. A metal underground water pipe in direct contact with the earth for 3.0 m (10 ft.) or more …..
2. Metal Frame of the Building or Structure. The metal frame of the building or structure that is connected to the earth …..
3. Concrete-Encased Electrode. A concrete-encased electrode shall consist of at least 6.0 m (20 ft.) of either…. (UFER)
4. Ground Ring. A ground ring encircling the building or structure, in direct contact with the earth, consisting of
5. Rod and Pipe Electrodes. Rod and pipe electrodes shall not be less than 2.44 m (8 ft.) in length and shall consist of the following materials…. (Ground Rods)
6. Other Listed Electrodes.
7. Plate Electrodes. Each plate electrode shall expose not less than 0.186 m2 (2 ft2) of surface to exterior soil.
8. Other Local Metal Underground Systems or Structures.

NEC - 250.52 Grounding Electrodes – (contd.)

(B) Not Permitted for Use as Grounding Electrodes

The following systems and materials shall not be used as grounding electrodes:

1 Metal underground gas piping systems

2 Aluminum

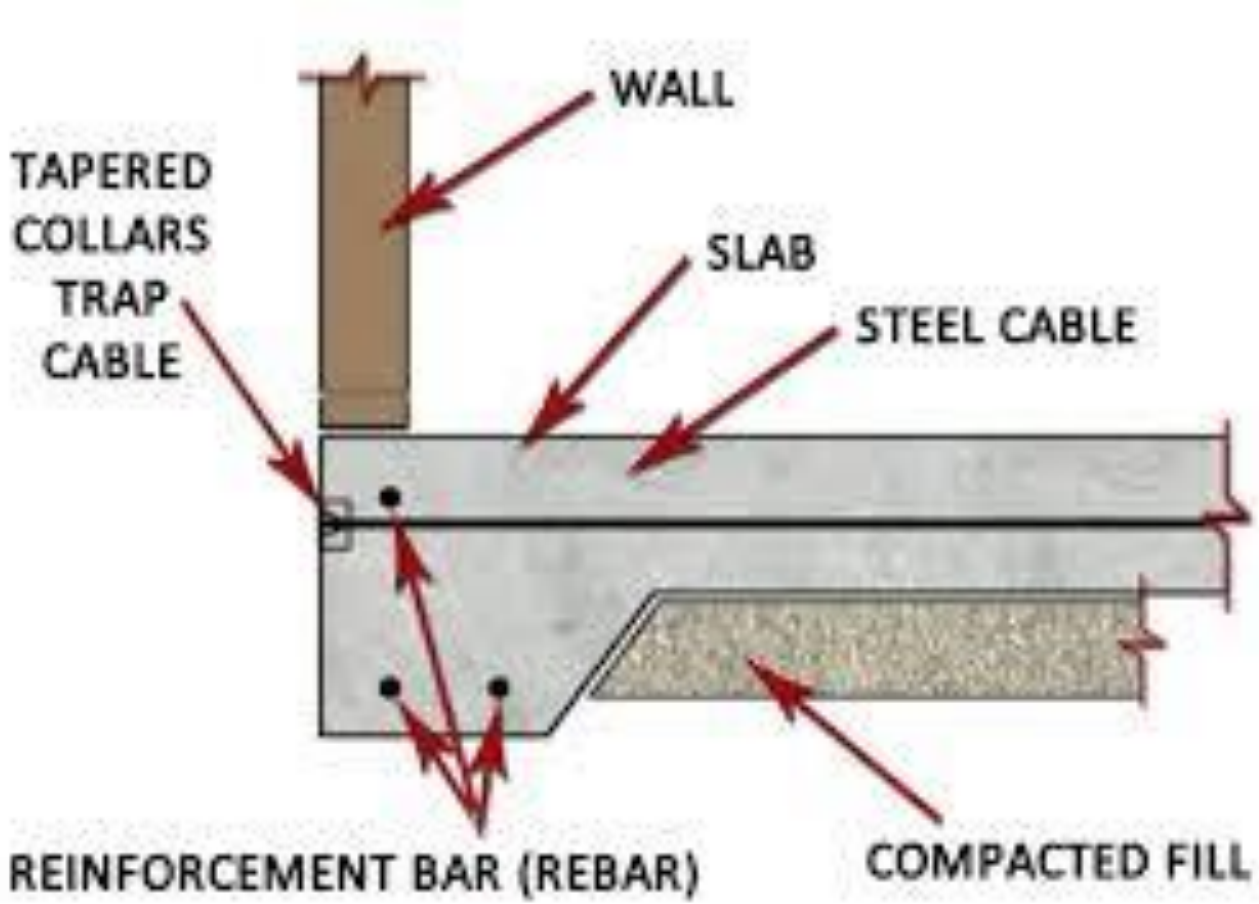
All grounding electrodes as described in 250.52(A)(1) through (A)(7) that are present at each building or structure served shall be bonded together to form the grounding electrode system.

Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) shall be installed and used.

Post Tension Slab

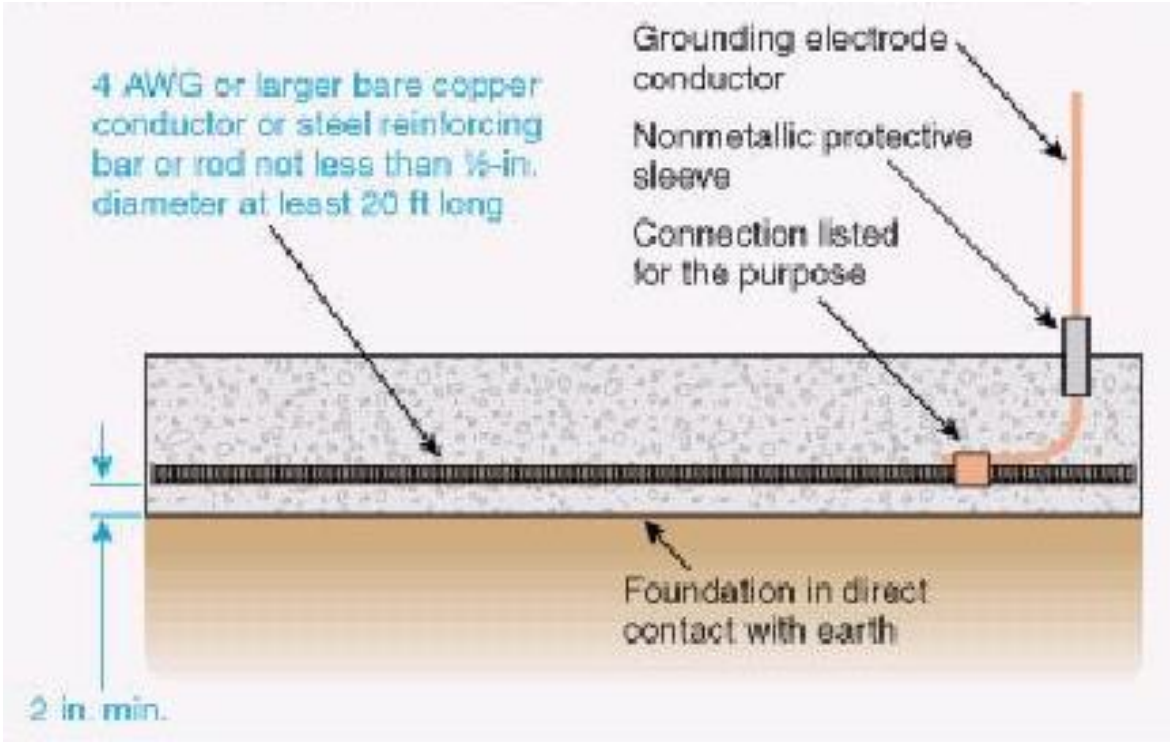
- Concrete slab that has steel cables running through them placed under ~30,000 pounds of tension.
- Tension makes the concrete slab and foundation much stronger and reduces likelihood of cracking.
- All Post tension slabs must be identified.
- Can be identified by patched holes in side of slab every 2 to 4 feet.
- Must never be cut or drilled.

Post Tension Slab

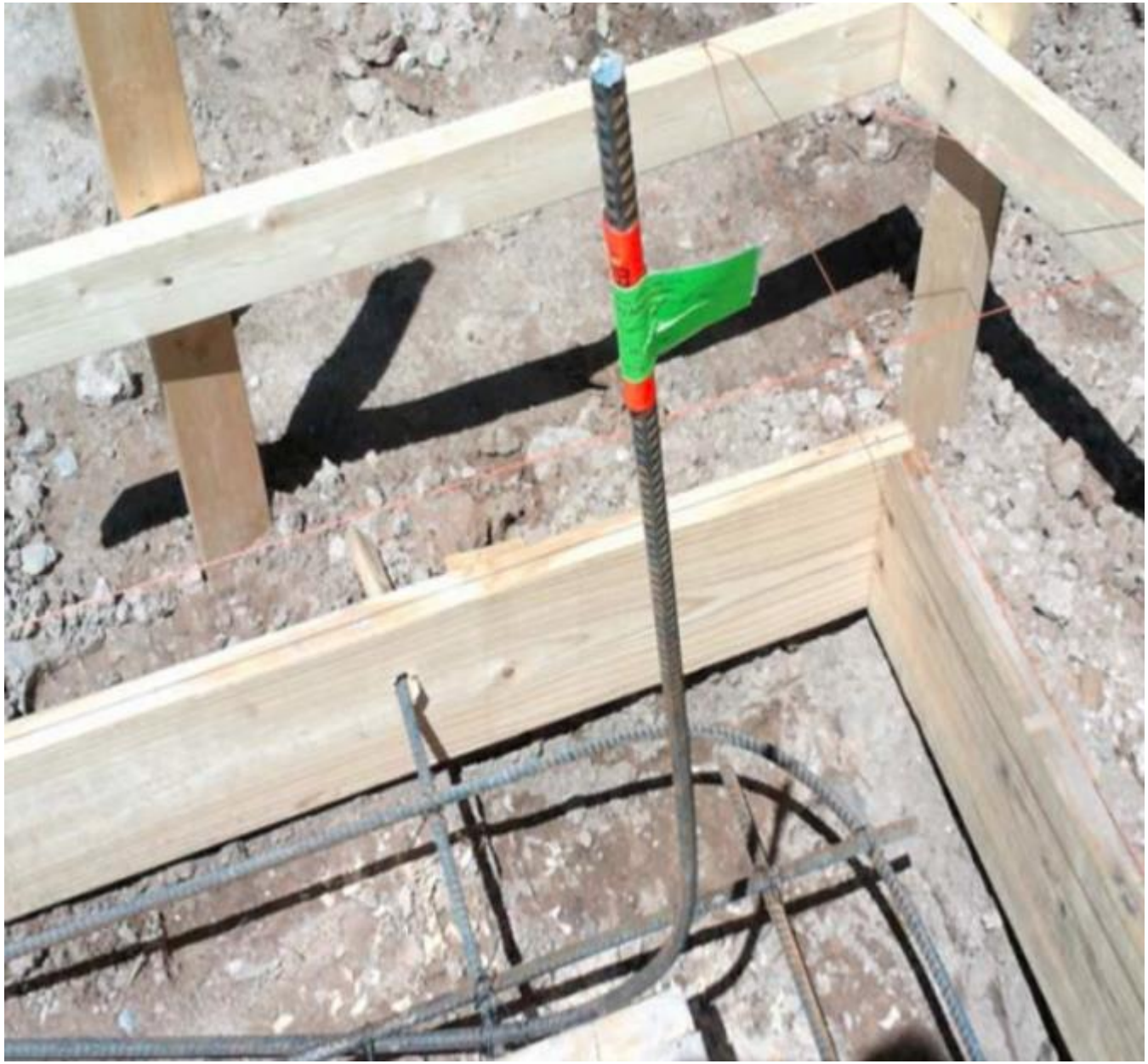


UFER Ground

- Concrete below UFER ground must be in direct contact with earth.



UFER Ground



Post Tension Slab, Steel cables inside green plastic tubing

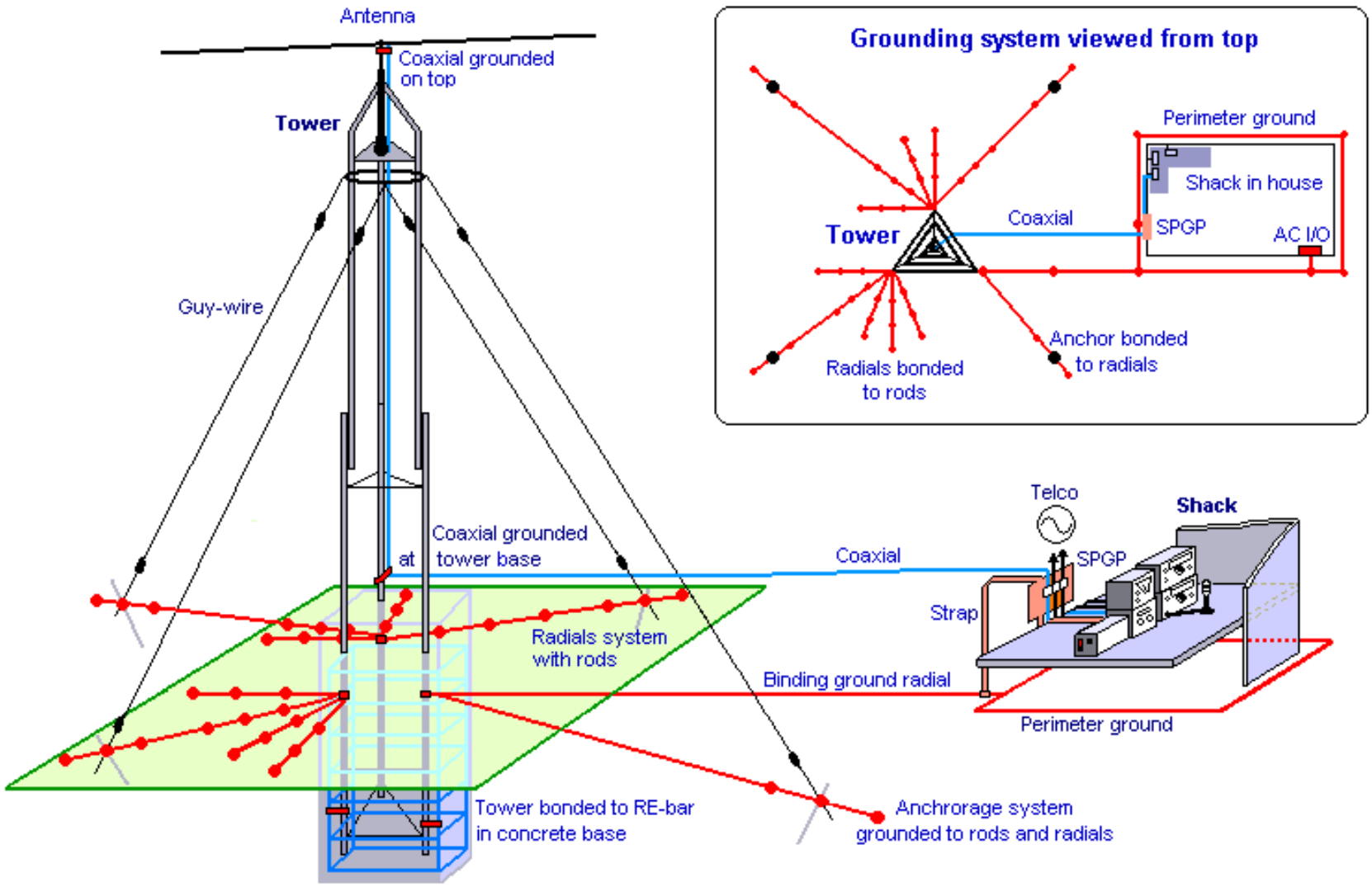
Poured Post Tension Slab

Post Tensioned Slab

Post Tension Ground

- Normally found inside the framed wall
- Should have an access cover to inspect ground connection

Antenna and Shack Grounding System



Grounds should not run through tower concrete base.

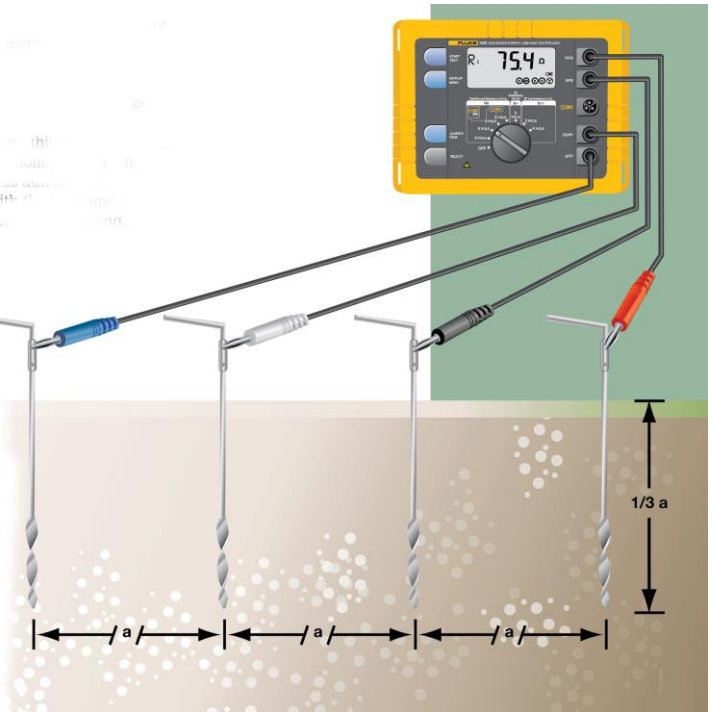
Tower Ground

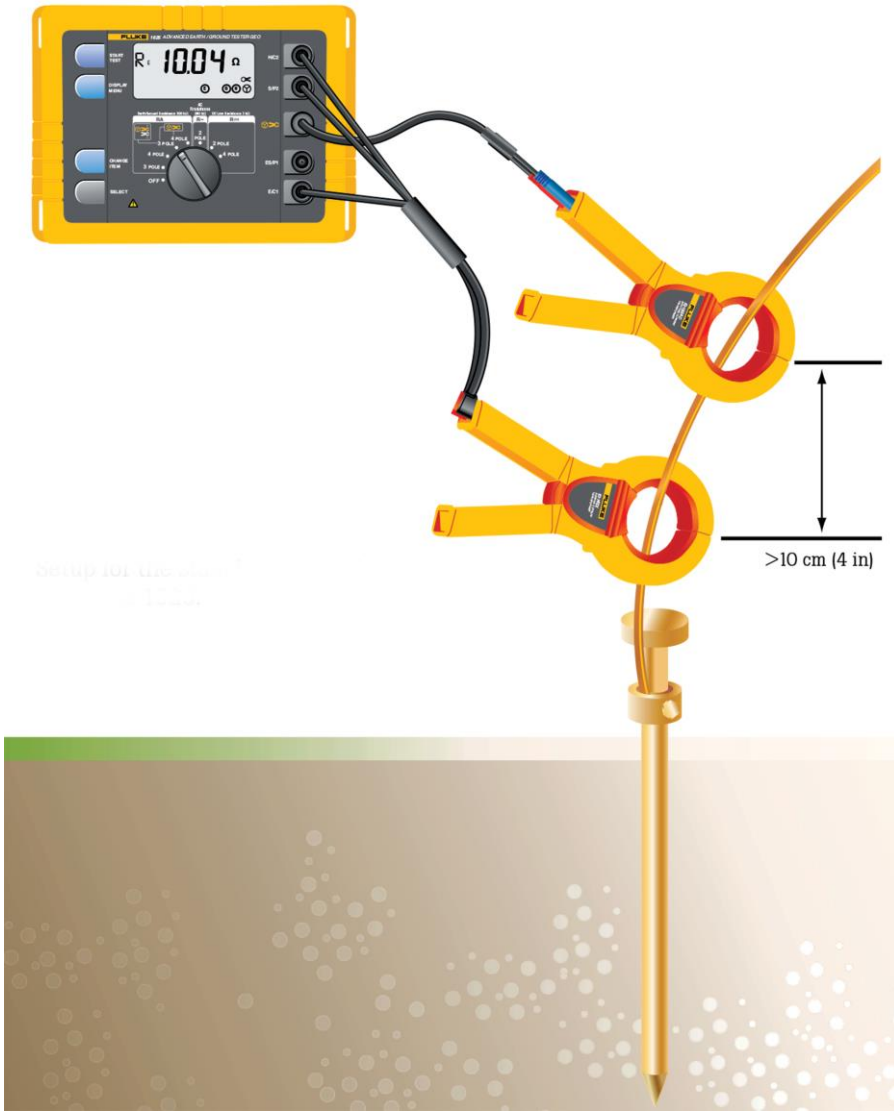
- Ground from tower should not run thru concrete
- Run it above ground to ground rods away from concrete

Do it right, avoid damage from lightning

Ground resistance measurement

- Should be less than 5 ohms
- 4 pole soil resistivity testing
- Earth ground rod testing using 1 or 2 clamps





Various Earth tester configurations and prices

Lowest cost is not always the best answer

Improving grounds

- To improve grounds
  - More ground rods
  - Water ground
  - Chemical treatment of soil
    - Magnesium sulfate AKA Epsom Salts (lease corrosive)
      - Epsom salts available at home ceter
    - Copper sulfate
    - Ordinary rock salt (Cheapest)

Questions?