Sometimes even the best laid plans…….

Life Magazine 1962 entitled "Trowell and Error"

FOOTSTEPS | This classic shot was taken by photographer Clay Peterson and appeared in LIFE magazine in 1962, wryly labeled "Trowel and Error."

Sometimes even the best laid plans…….

Diagnosing Problems in Concrete

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Concrete Surface Defects

What Do You Call This?

Blistering

- Blisters occur when bubbles of entrapped air or water rising through the plastic concrete are trapped under an already sealed airtight surface
- Blistering can be caused by either too much entrapped air, insufficient vibration of concrete during placement or finishing the surface too soon - before the air has had a chance to escape

Blisters are surface bumps that may range in size from 1/4” to 4” in diameter with a depth of about 1/8”. The photo below illustrates a void trapped under a blister.

How to Prevent Blistering

- Delay steel troweling until after bleed water has evaporated
- Avoid sandy mixes
- Keep air contents within specified limits
- Use windbreaks and sunshades

What Do You Call This?

Delamination

- Top 1/8”, or more, separates from the main body of the concrete slab
- May occur in an area several inches across or up to a foot or more
- The densified paste layer is separated from the base slab by a thin layer of air or water.
- May not be apparent until it starts peeling off
- Sometimes it can be noticed before peeling by a slightly raised and cracked area
- Can be detected by a hollow sound when tapped with a hammer or with a heavy chain drag

Why Does This Happen?

- The primary cause for delaminations is sealing the surface before bleeding has occurred.
- Form during final troweling and are most frequent in early spring and late fall when concrete is placed on a cool subgrade with rising daytime temperatures.
- Cooler subgrade temperatures delay setting of slab bottom relative to the surface
- Low humidity and wind may contribute to drying out of the surface.

How Do You Prevent Delaminations?

- Avoid finishing the surface too early before bleed water and air has escaped
- Maintain uniform temperatures, cover subgrade
- Do not use air entrained concrete for flatwork unless necessary
- Maintain surface moisture
- Heat concrete, or use accelerators

What is Going On Here?

And Here?

And Here?

Spalling !

- Similar to delamination, however the surface loss is deeper
- Usually caused due to the expansion of corroding reinforcing steel in the concrete
- May occur if steel is place too close (1 inch <) to the concrete surface, and water reaches it
- Properly placed steel may also corrode due to cracks allowing water to enter

Prevent Spalling By :

- Provide proper concrete cover over reinforcing steel
- Use low water cement ratio concrete
- Use air-entrained concrete if exposed
- Properly consolidate the concrete
- Cure the concrete

Have You Seen This Before?

- It is not delamination
- Takes a while for it to develop
- It is more common in colder climates
- Usually result of physical action, but sometimes a result of chemical exposure

It is Scaling !

- Surface mortar has peeled away, usually exposing the coarse aggregate.
- Leaves very rough surface
- A physical action caused by freezing / thawing
- Can be caused by lack of an adequate amount of entrained air
- ***However, even well air-entrained concrete can scale if other factors are involved***
- Deicing salts aggravate the freezing and thawing
- Chemical attacks include use of ammonium sulfates and ammonium nitrates (fertilizer).

How Do You Prevent Scaling?

Use the right concrete mixture and use good concrete practices!

- Use the appropriate amount of air-entraining
- Use at least 3500 psi concrete
- Water / cement ratio of 0.45 or less
- Slope concrete to avoid ponding of water
- Use good finishing techniques
- Cure the concrete
- Seal the concrete
- Do not use deicing salts for at least one year

What Do You Call This ?

Aggregate Popout !

Aggregate Popout

- A popout is a small fragment of concrete surface that breaks away due to internal pressure, leaving a shallow, typically conical, depression.
- The usual cause is a piece of porous rock with a high rate of absorption and low specific gravity.
- These low specific gravity aggregates have a higher tendency for buoyancy and therefore are usually more prevalent near the concrete surface.
- The higher the slump of the concrete, the greater the occurrence near the surface.

Aggregate Popout

- As the aggregate absorbs moisture or freezes under moist conditions, the swelling creates internal pressures in the concrete that are strong enough to rupture the surface.
- To avoid, use quality aggregates. In this area, more common with river gravels than crushed limestone or granite.
- Low water/cement ratio, low slump concrete helps to avoid this problem.

Soft surface, comes off on your finger?

Dusting surface

- Surface is soft, shows dust on shoes, or when sweep
- May not be apparent right away due to construction dust and debris
- May be soft as deep as ½ inch, can be easily scratched with a nail or knife
- Caused by finishing bleed water into the surface
- Creates a high w/c ratio surface paste, which is very weak.
- Improper venting of carbon dioxide from heaters during winter concreting can create a weak layer of calcium carbonate on the concrete surface.

Dusting

Discoloration

Many factors effect discoloration including:

- Calcium chloride admixtures,
- Hard-troweled surfaces
- Variation in finishing times
- Inadequate or inappropriate curing
- Variation of the water-cement ratio at the surface
- Changes in the concrete mix
- Variations in subgrade or forming

- Discoloration at later ages may be the result of atmospheric or organic staining
- Calcium chloride will have a retarding effect on the ferrite phase of the hydration process. The ferrite phase gets lighter with hydration. Retardation of the phase causes the concrete to be darker in color.
- “Over-working” or “Burning” the surface of the concrete - attempting to hard-trowel finish after it has become too stiff. This can decrease the w/c ratio causing the surface to become darker
- Individual constituents and proportions can have an effect of the concrete

What Type of Cracking is This?

What Type of Cracking is This?

- Occurs in flatwork when the concrete is still plastic
- Easily identified by its short length, and parallel alignment
- Usually between about 1/16 and 1/8 inch wide
- Shallow depth, ½ inch to 2 inches

Plastic Shrinkage Cracking

Plastic Shrinkage Cracks are caused by a rapid loss of mix water while the concrete is still plastic.

Causes of rapid evaporation include:

- low humidity
- wind
- high concrete temperatures
- moderate to high air temperatures

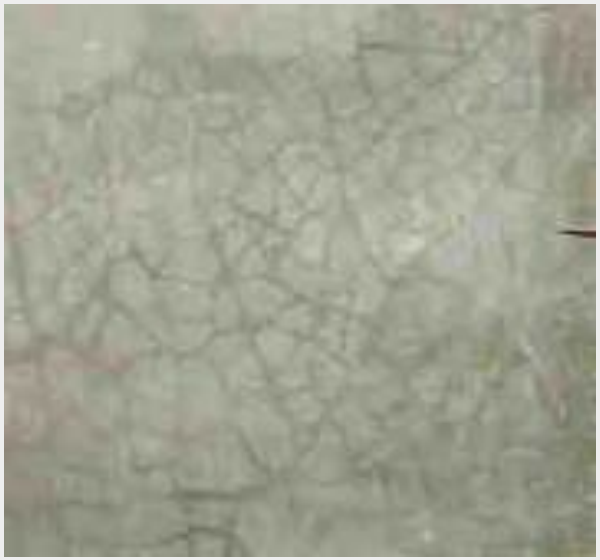
Plastic Shrinkage Cracking

Prevention:

- Plan ahead, pay attention to ambient conditions
- Apply a fog spray to the surface to prevent evaporation
- Lower the mix temperature
- Start curing as soon as possible
- Set up wind breaks

Craze Cracking

or Map Cracking



Craze Cracking is a network of ***superficial*** surface cracks due to minor surface shrinkage caused by moisture loss.

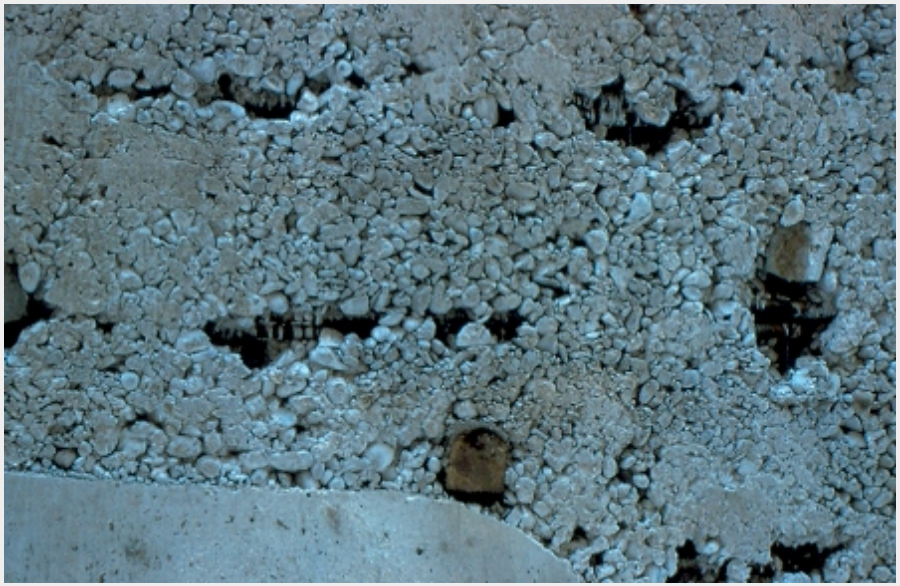
Moisture loss can be caused by low humidity, high concrete and air temperature, hot sun, and / or drying wind

Although crazing surfaces are poor in appearance, they generally are not a serious condition nor is it an indication of future deterioration

Prevention:

- Avoid wet mixes
- Limit troweling and don’t trowel too early
- Do not use a jitterbug
- Cure the concrete surface and start curing early
- DO NOT dust cement onto surface to absorb bleed water

Honeycombing

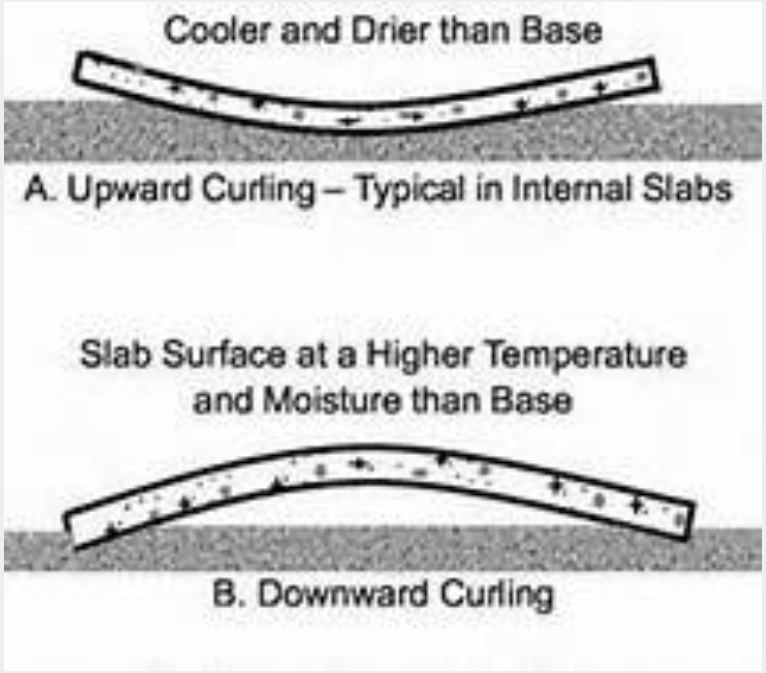


Bug holes

Any Other Surface Issues ?

Curling of Concrete Slabs

Curling is the upward movement of a slab's corners and edges due to differences in moisture content or temperature between the top and bottom of a slab. The top dries or cools and contracts more than the wetter or warmer bottom.



Curling of Concrete Slabs

Cracks can develop due to reduced subgrade support

Preventing Curling

- Reduce temperature differences between subgrade and concrete surface
- Maximize coarse aggregate in the concrete
- Use low water / cement ratio mixture
- Reduce paste of the concrete

What are 3 Things Everyone Knows About Concrete ?

1) It is gray
2) It gets hard
3) **IT CRACKS !**

What is this ?

Concrete cracks for the same reason mud cracks

- It shrinks as it gets hard
- Restraint

Results in drying shrinkage cracks

In concrete flatwork, it can shrink as much as 1/16" for every 10'

What causes restraint of the concrete?

- Weight of the concrete itself, base friction
- Irregular subgrade surface (variance in thickness)
- Reinforcing
- Walls, columns, footings, utilities that are not isolated

To accommodate shrinkage and control locations of cracks, joints are placed at regular intervals. Use the following rules of thumb for flatwork:

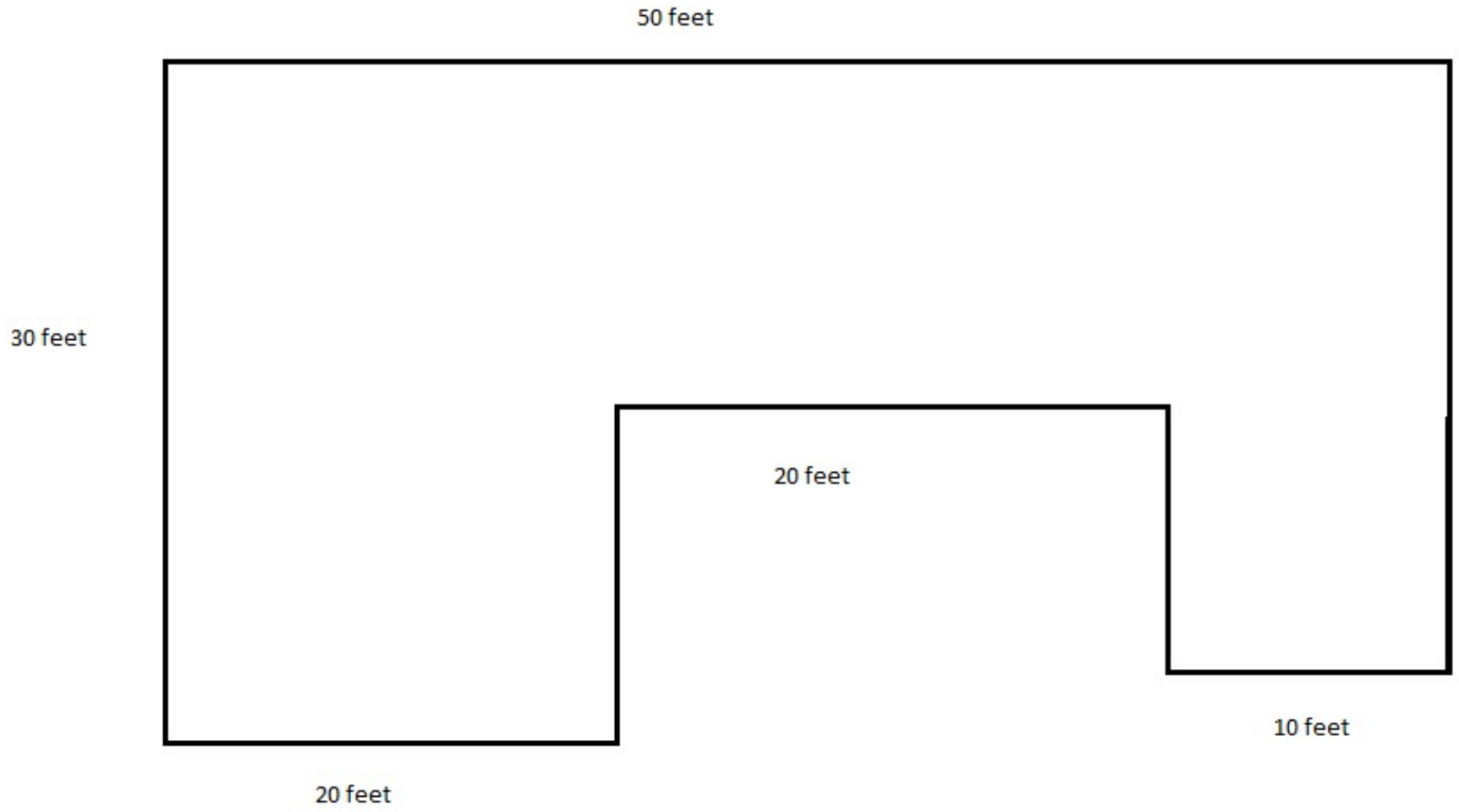
- The depth of the sawed or tooled joint should be a minimum of 1/4 the slab thickness in inches.
- The joint spacing in feet should not exceed 2.5 times the slab thickness in inches.
- The length of an area should not exceed 1.5 times the width.

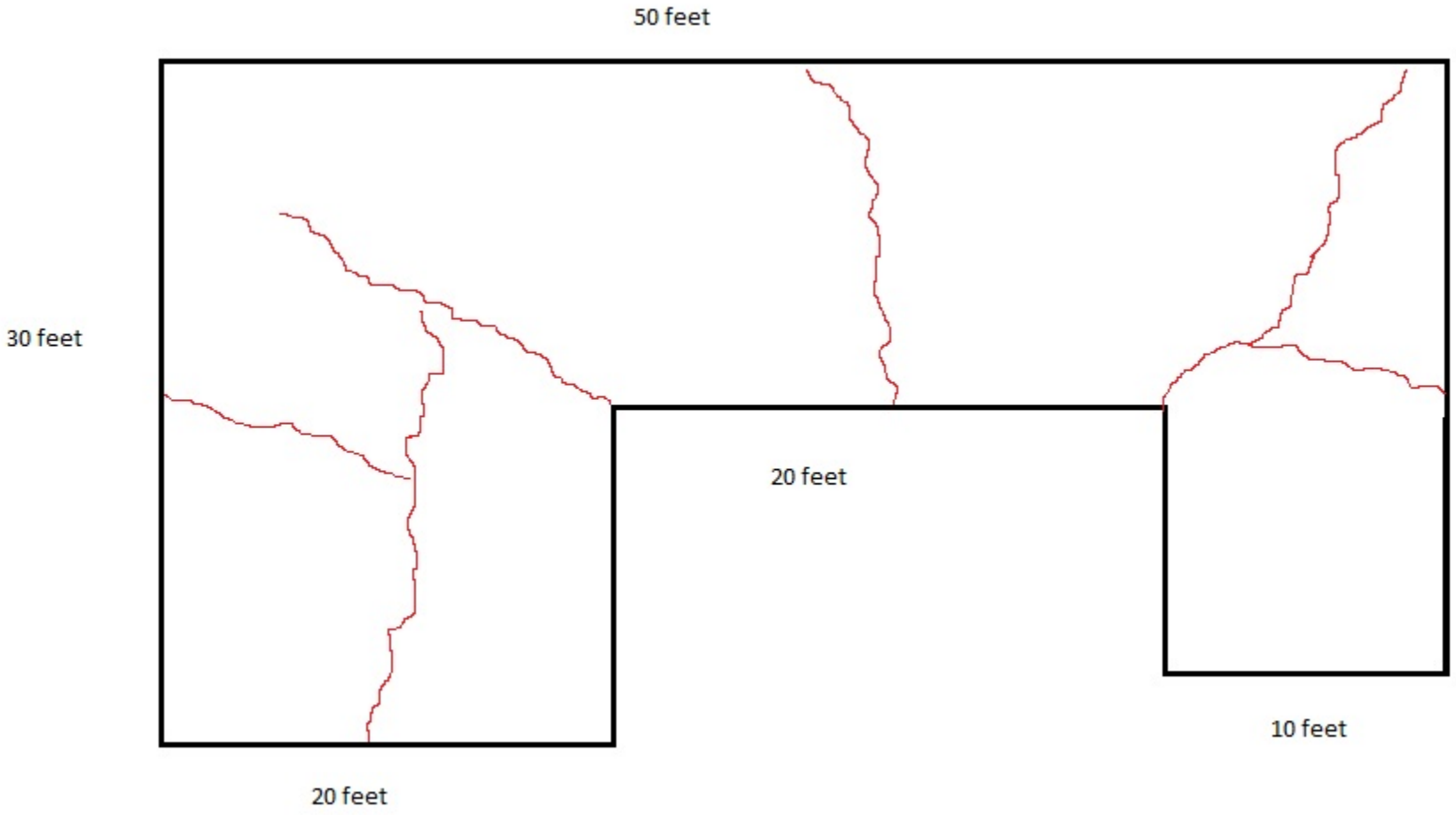
Cracks in Walls

- “Properly designed walls will have contraction joints spaced from one to three times the wall height.” – ACI 224

- Rule of Thumb: In 8’ high, 8” thick walls, joints should be spaced at 30 times the wall thickness = 240” or 20’ max.

- Reentrant corners provide a location for the concentration of stress and, therefore, are prime locations for initiations of cracks due to high stresses. Additional, properly anchored, diagonal reinforcement is required to keep the cracks narrow and from propagating.


50 feet
30 feet
20 feet
10 feet
20 feet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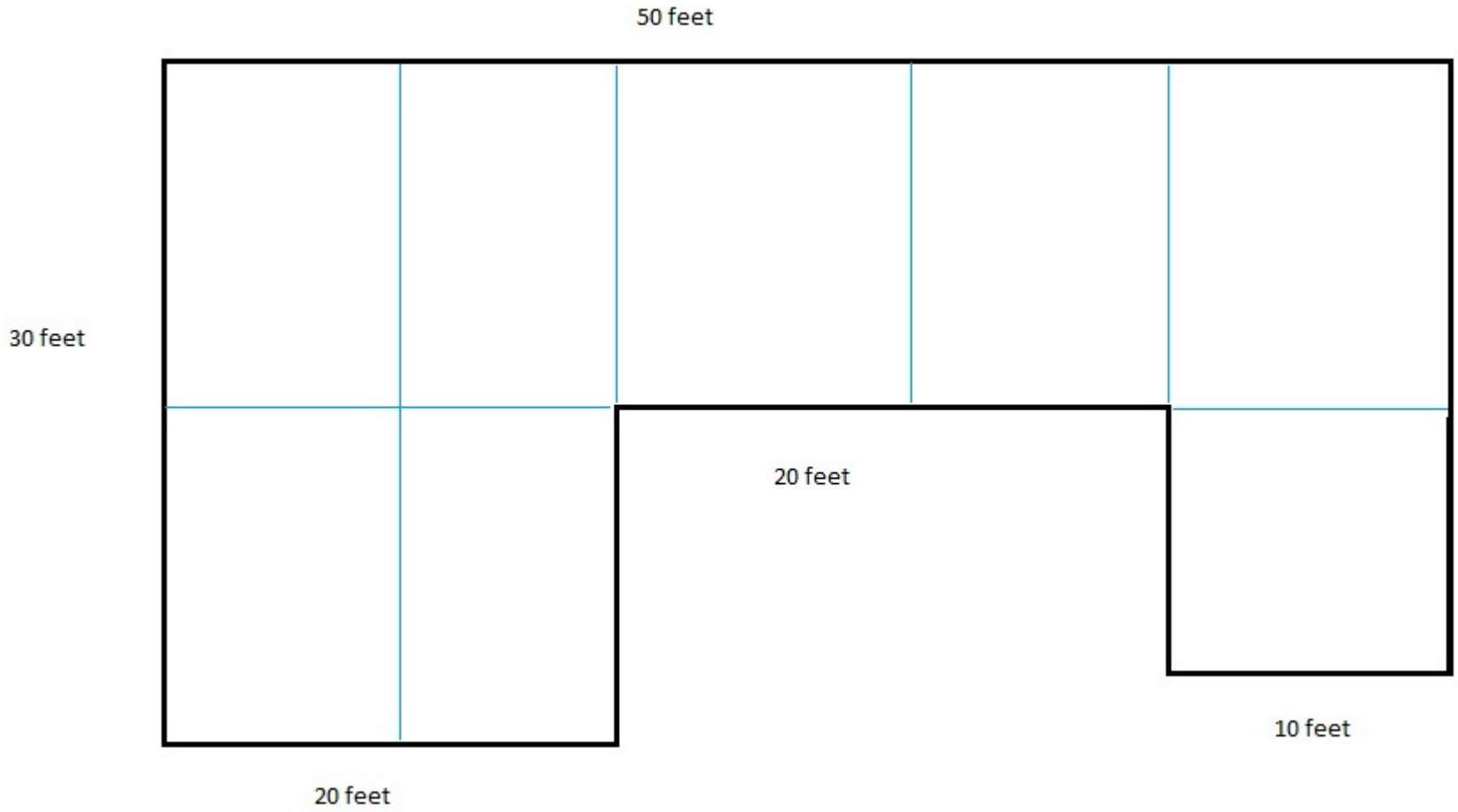
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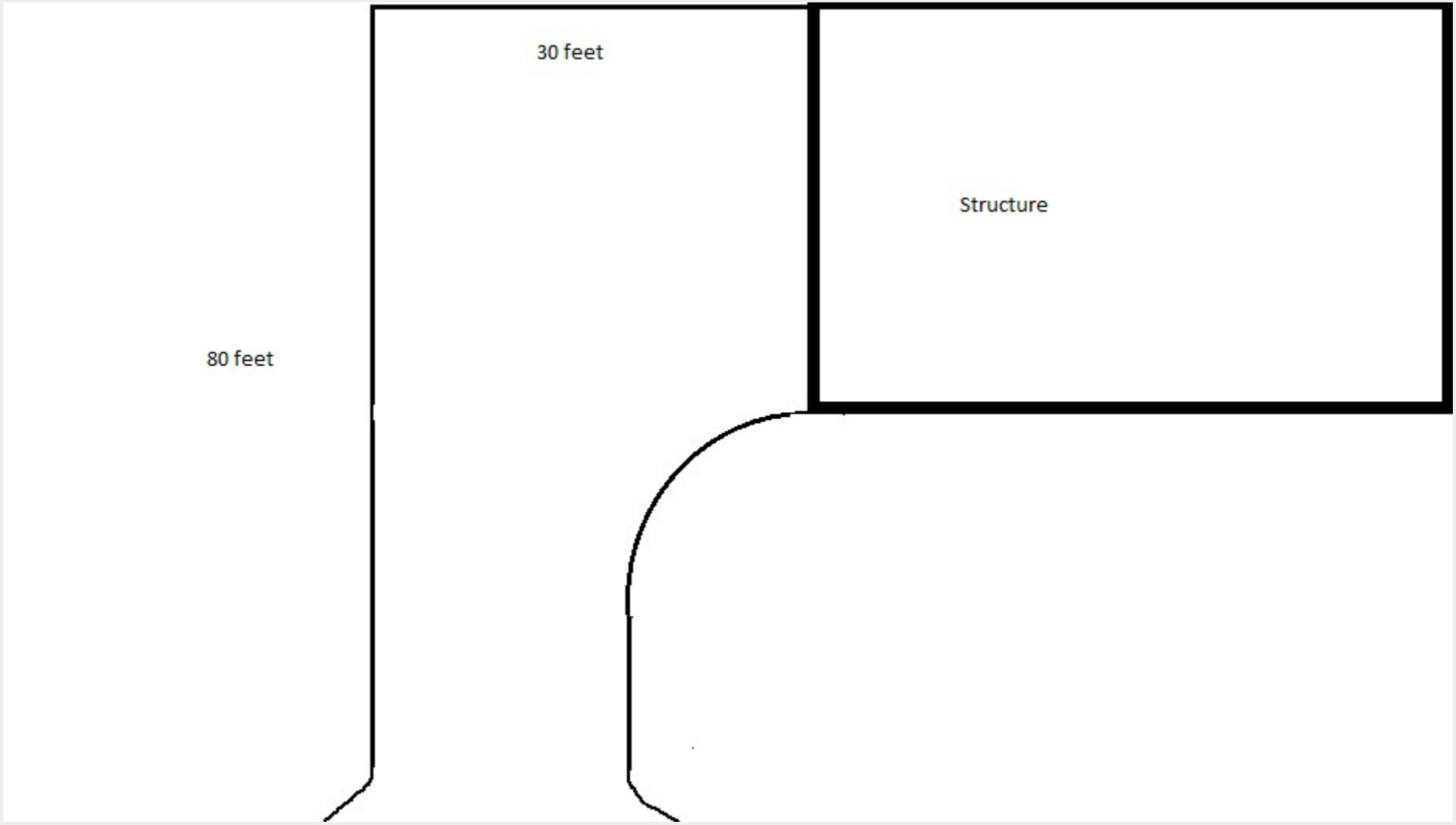
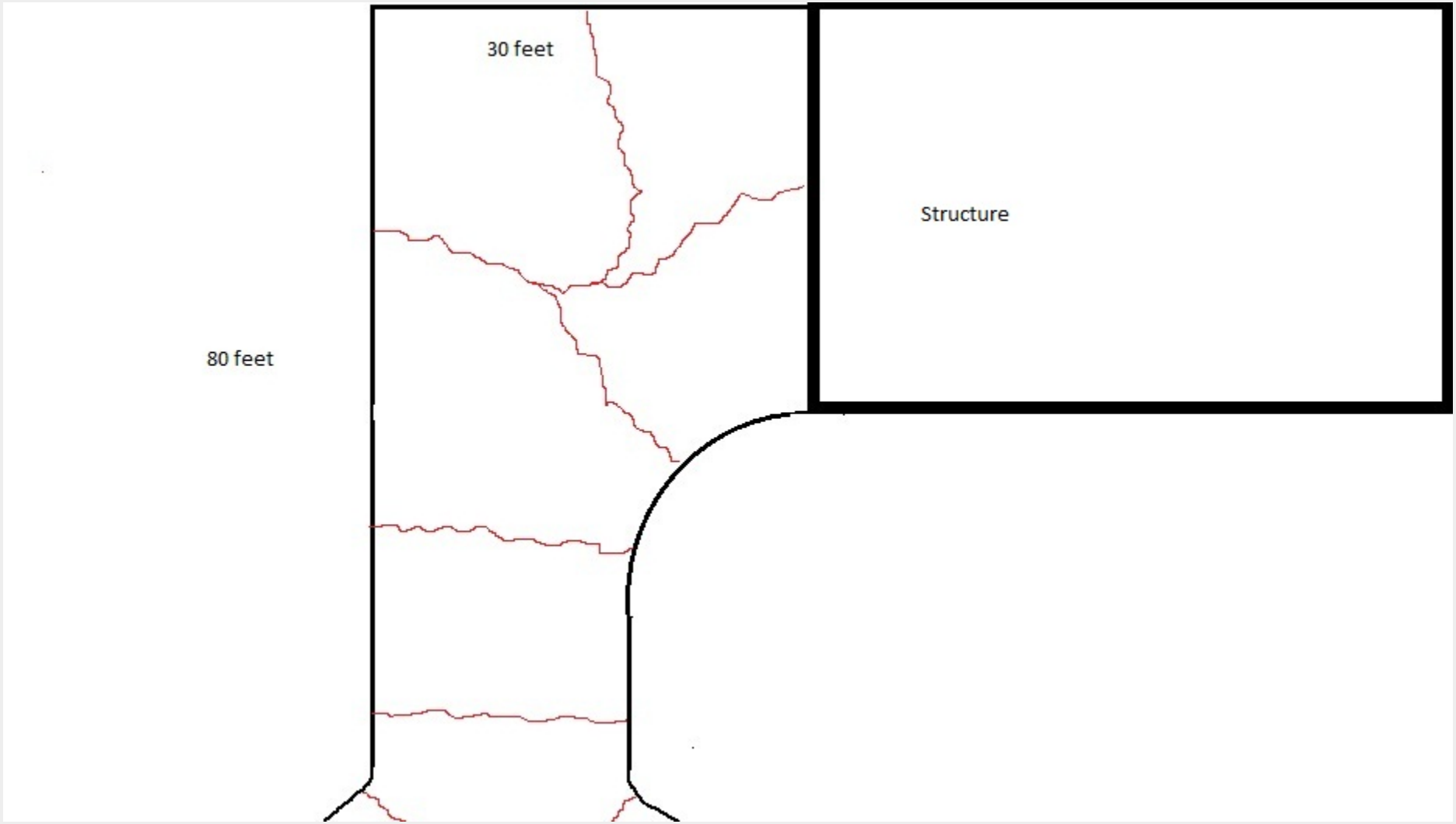

30 feet
Structure
80 feet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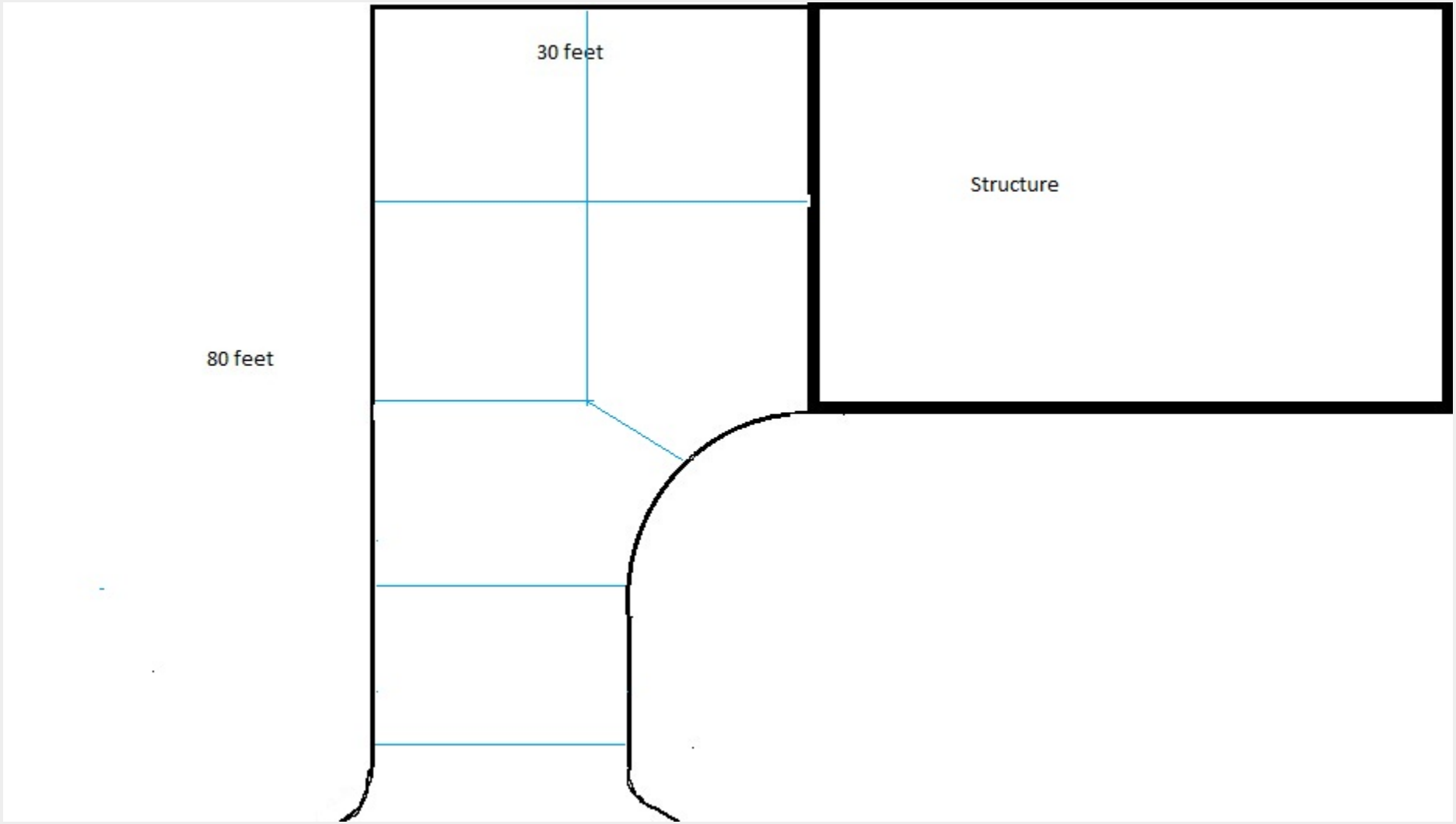
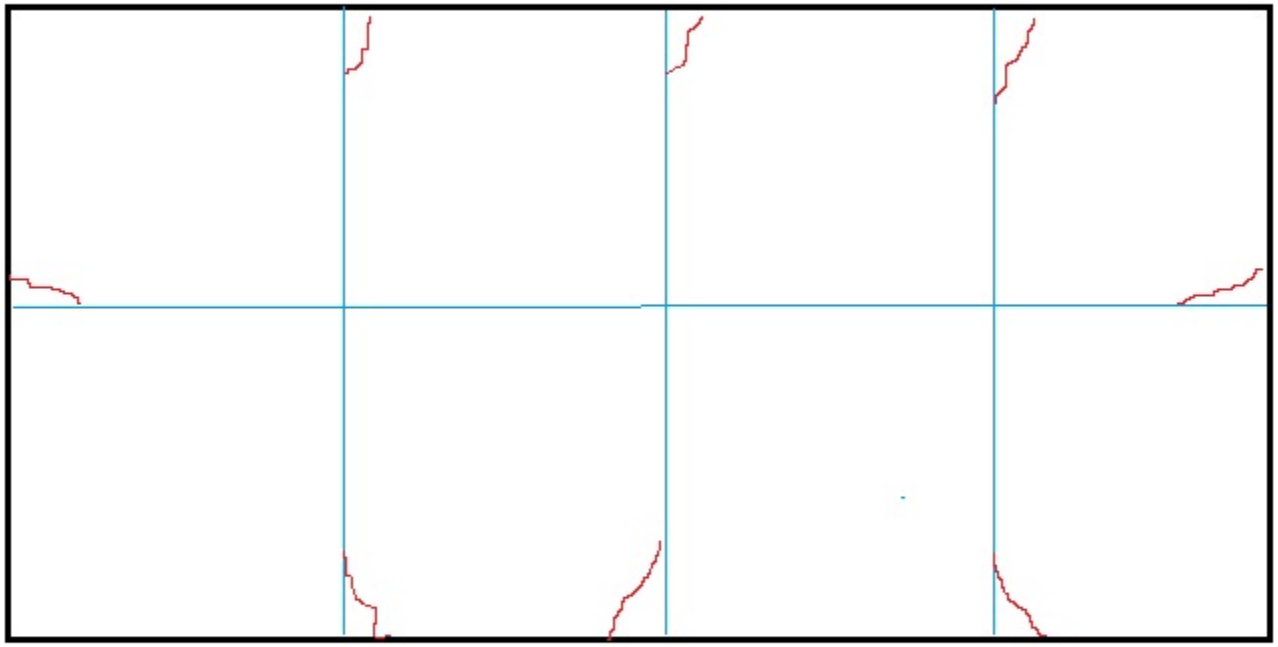
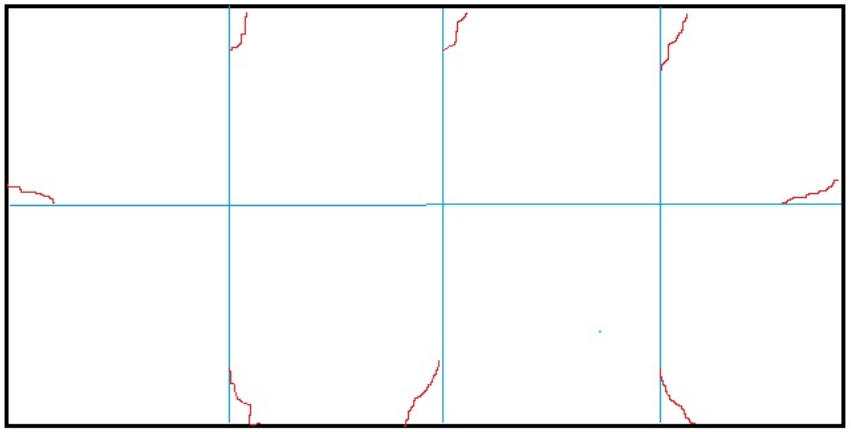
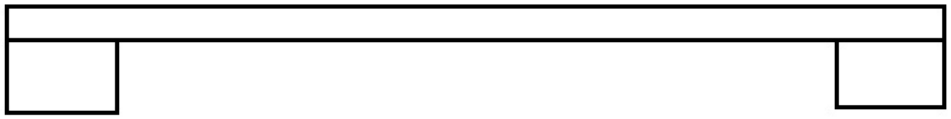
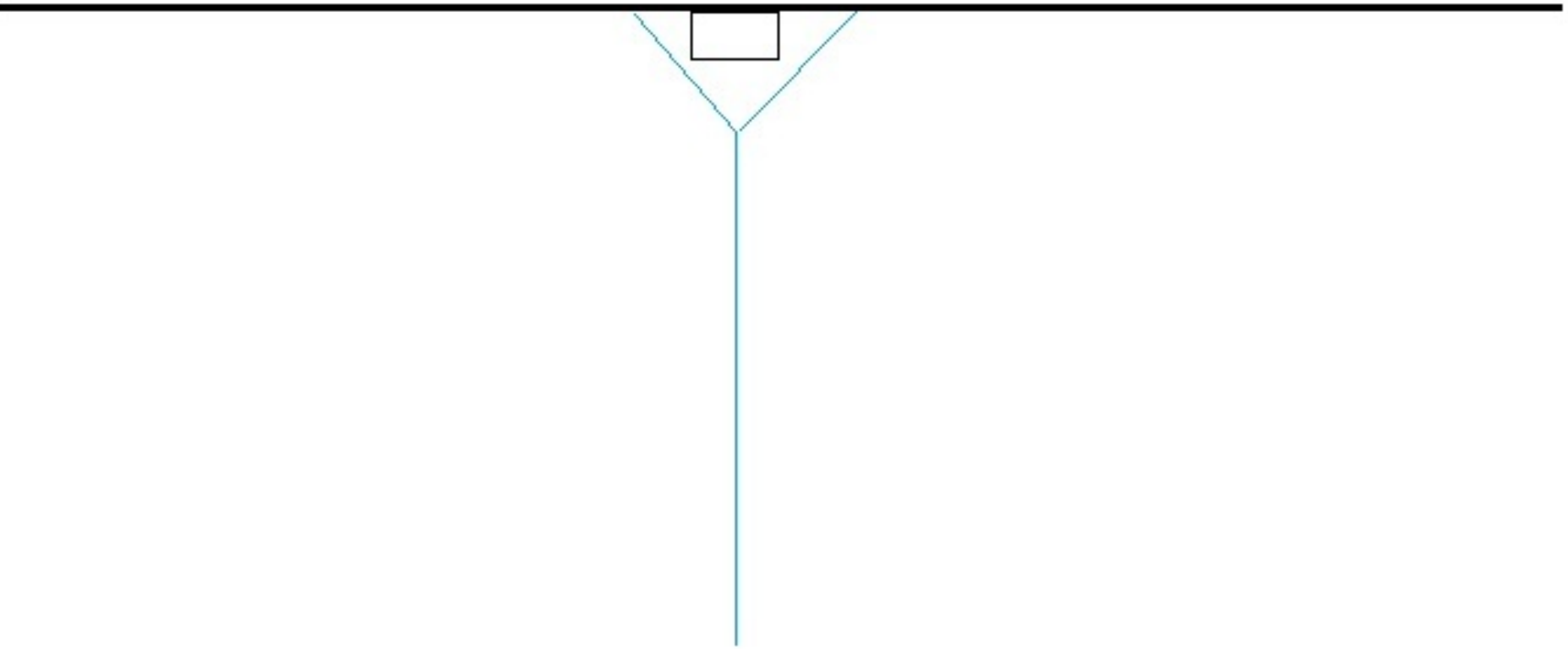
Structure
80 feet

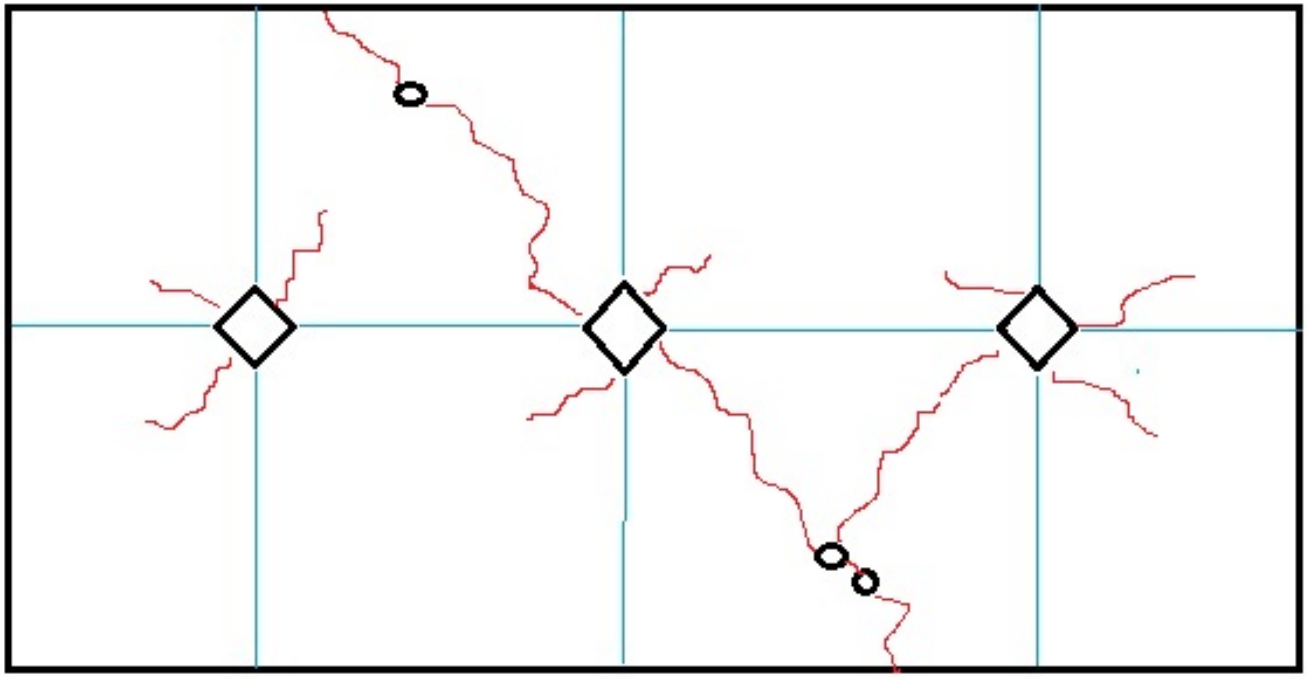

30 feet
Structure
80 feet

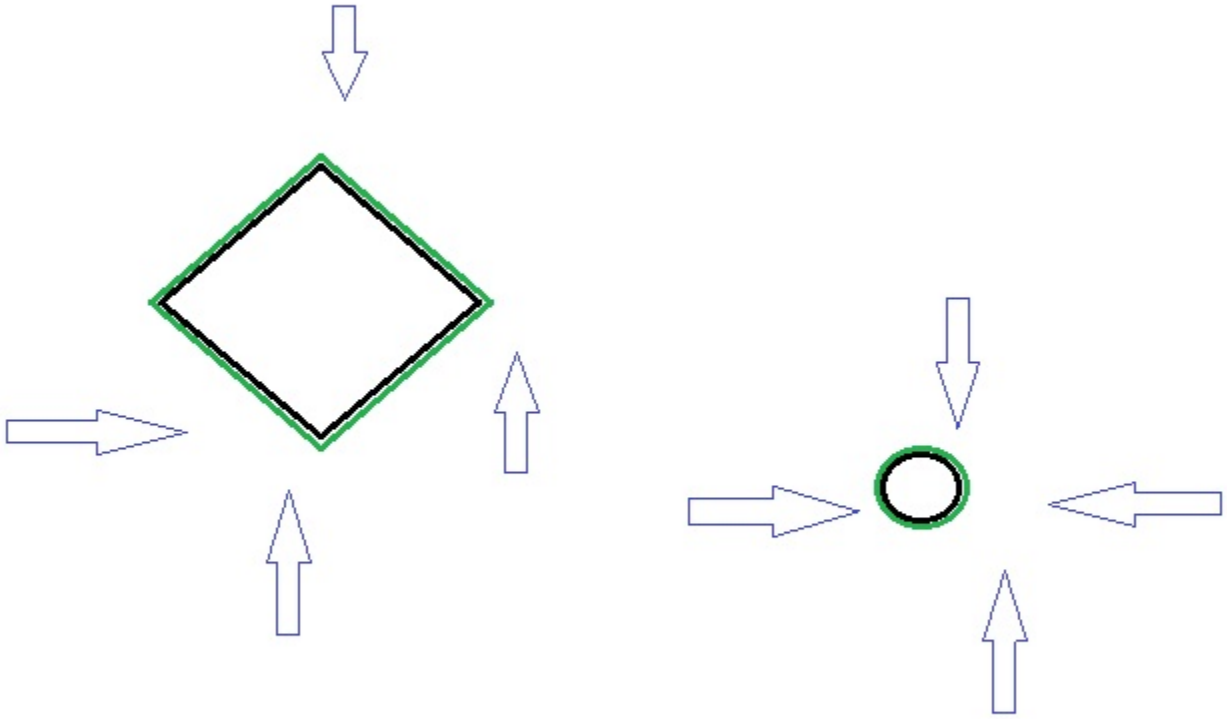


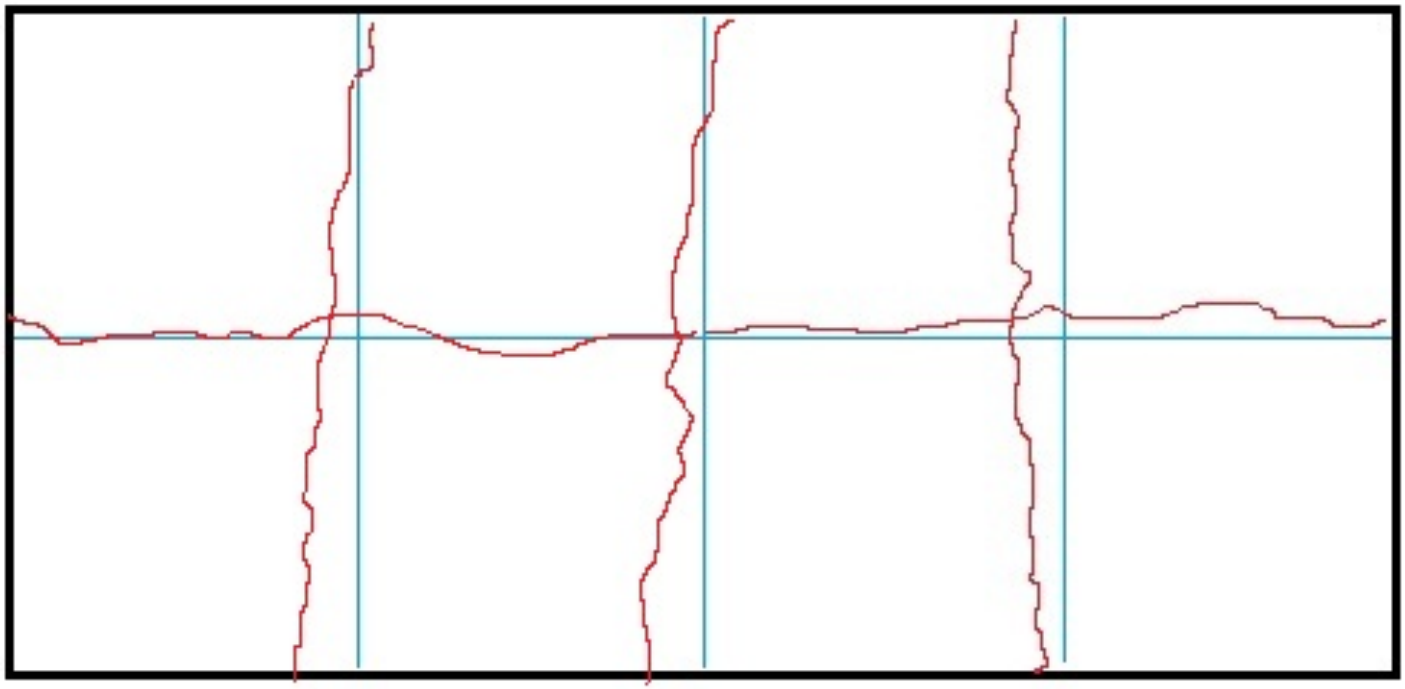












Failing Concrete Test Reports

The Problem Could Be:

- Poor, or inappropriate mix design
- Material issue
- Batching / mechanical issue
- Testing issue

The Problem Could Be:

- Poor, or inappropriate mix design
  - Not enough overdesign
  - Designed for different application
  - Proper submittal / review should avoid this
- Material issue
- Batching / mechanical issue
- Testing issue

The Problem Could Be:

- Poor, or inappropriate mix design
- Material issue
  - One or more of the material not performing
- Batching / mechanical issue
- Testing issue

The Problem Could Be:

- Poor, or inappropriate mix design
- Material issue
- Batching / mechanical issue
  - Check batch plant scales / processes
  - Review batch weight tickets
  - Material mix ups
  - Truck mixing
  - Slump and air is specification?
- Testing issue

The Problem Could Be:

- Poor, or inappropriate mix design
- Material issue
- Batching / mechanical issue
- Testing issue
  - Who conducted jobsite testing ?
  - Cylinders protected at 60 – 80 degrees?
  - Picked up the next day ?
  - Breaking procedures?

If the Concrete Must be Cored:

- Follow ACI 318 procedures
- Obtain cores per ASTM C42
- Test 3 cores for each area not meeting criteria
- Store cores in water tight bags/containers
- Test > 48 hours and 7 days<

Questions ????????