

## Concrete, placing & framing

---

---

---

---

---

---

---

---

## Holding together...holding apart



- With plywood, walers and studs on each side of the pour, there has to be one more piece of the form to keep the plywood from spreading apart or falling together.
- The form tie has cones (blue) or washers on a steel rod which act as spacers, holding the plywood apart.
- At the same time the form tie projects through the plywood so it can be clamped to the plywood to hold the form together.
- After the forms are removed, the loop at the blue cone is snapped off with a tool, leaving the pretty round hole we see so often in concrete.

---

---

---

---

---

---

---

---



## Holey concrete..

- The holes we see in this column, at the Ft. Wayne Performing Arts Center by Louis Kahn, are what Kahn considered to be a **tool mark**, an honest expression of the process of making in concrete. This is the mark left by the form tie.

---

---

---

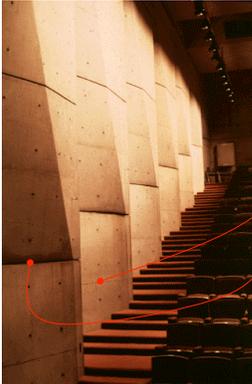
---

---

---

---

---



## Holes & Lines...

- In addition to the holes, there are two kinds of lines on these concrete column.
  - A projecting line made at the joint between two pieces of formwork - form joint
  - A recessed line made at the joint between subsequent pours - a pour joint

---

---

---

---

---

---

---

---

## There won't really be a line there ...will there?



- The joint between wood forms is seldom perfect. Add to this the fact that the end grain of the plywood is absorbing water (and concrete paste) at the joint, and you could guess that many concrete stains are a natural outgrowth of the forming and pouring process.
- Staining... doesn't help that the plywood didn't line up.... But that's the architects job, to draw the form lines so the crew can build them to meet expectations!

---

---

---

---

---

---

---

---

## Not even straight lines...



- Another line commonly seen on concrete is a wiggly line, looking like it separates two colors of concrete.
- This is a pour line, caused by filling the form with concrete, part way, waiting until it sets up, (not screeding, floating, tooling...) then filling it the rest of the way.

---

---

---

---

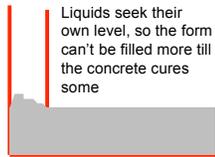
---

---

---

---

## Scar Cause 1.



Liquids seek their own level, so the form can't be filled more till the concrete cures some

- Another line commonly seen on concrete is a wiggly line, looking like it separates two colors of concrete.
- This is a pour line, caused by filling the form (red lines) with concrete, part way, waiting until it sets up, (not screeding, floating, tooling...) then filling it the rest of the way.

---

---

---

---

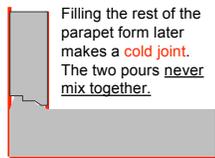
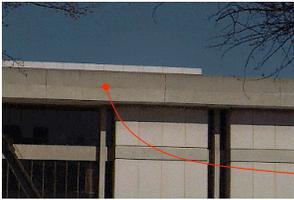
---

---

---

---

## Scar Cause 2.



Filling the rest of the parapet form later makes a cold joint. The two pours never mix together.

- While it cures, paste rises to the top of the pour, the rich line of past makes the stain. It never goes away, a permanent disappointment.

---

---

---

---

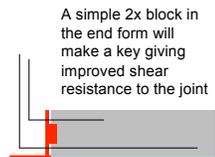
---

---

---

---

## Scar Prevention 1.



A simple 2x block in the end form will make a key giving improved shear resistance to the joint

- So what to do? Are all parapets doomed to appearing to have been designed and executed by people who didn't know what they were doing?
- No, First, pour the slab, but hold it back behind the parapet with a keyed joint. Let the rebar run through the end form for continuity.
- 28 days later, pour the parapet all at once, no stain.

---

---

---

---

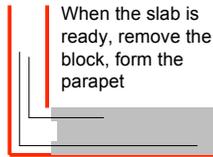
---

---

---

---

## Scar Prevention 2.



- So what to do? Are all parapets doomed to appearing to have been designed and executed by people who didn't know what they were doing?
- No, First, pour the slab, but hold it back behind the parapet with a keyed joint. Let the rebar run through the end form for continuity.
- 28 days later, pour the parapet all at once, no stain.

---

---

---

---

---

---

---

---

## Scar Prevention 3.



- So what to do? Are all parapets doomed to appearing to have been designed and executed by people who didn't know what they were doing?
- No, First, pour the slab, but hold it back behind the parapet with a keyed joint. Let the rebar run through the end form for continuity.
- 28 days later, pour the parapet all at once, no stain.

---

---

---

---

---

---

---

---

## A code note

- Most building codes accept cast in place concrete as a high quality - almost fireproof construction.
- This is because the concrete mass conducts heat away from the reinforcing steel, allowing it to survive longer in a fire than if it was exposed.
- All the codes ask of concrete construction is that the reinforcing bars be covered with at least 1-1/2 inches of concrete to protect them.
- This 1 1/2" of coverage also protects the steel from water on the concrete surface...it prevents rusting.

---

---

---

---

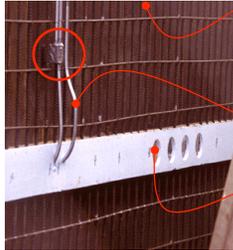
---

---

---

---

## Wall forming



- Reinforcing, both vertical and horizontal are installed after the outside plywood, studs, and walers are erected.
- Next, the electricians and plumbers come in and install conduit and piping.
- Here a strip of white styrofoam is installed to make a recess for the slab and provide access holes for main conduits.

---

---

---

---

---

---

---

---

## Wall forming



- The concrete workers continue installing "hold outs" in the formwork
- Here the holdouts will make openings in the concrete wall for
  - A vent
  - A window
  - A door
- The diagonal rebars direct forces around the opening and reduce cracking at the corners

---

---

---

---

---

---

---

---



- Ideally the formwork is supposed to remain flat, with one plywood form panel exactly in plane with the panel above and below.

This precise alignment is difficult to achieve given the nature of plywood, and generally accepted level of imprecision common in formwork. When the forms don't all line up, *Overpours* sometimes occur.

---

---

---

---

---

---

---

---



- The other trick with hold-outs in the formwork is getting the concrete to flow around the bottom corners to fill beneath the hold-out.

---

---

---

---

---

---

---

---



- Here either the concrete was too stiff, the holdout was too wide or there was insufficient vibration to fill beneath the holdout...not good if you were expecting beautiful-concrete.

---

---

---

---

---

---

---

---

How many people are needed to place 160 cubic yards?

- 6" elevated slab
  - Labor Foreman
  - 5 laborers
  - 1 cement finisher
  - 1 equipment operator

---

---

---

---

---

---

---

---

## ...and equipment?

- Screed pipes / board
- 1 concrete pump
- 2 gas vibrators
  - » \$2,590.00 for 160 cy
  - » \$3,037 for 110 cy with crane & bucket
- Plus 53 cents / s.f. to screed/float/finish

---

---

---

---

---

---

---

---

## 6" Slab on Grade

- Direct chute
- 165 cy/day
  - Labor Foreman
  - 4 laborers
  - 1 cement finisher
- \$1,394 for 165 cy
- Plus 70 cents / s.f. to screed/float/machine finish

---

---

---

---

---

---

---

---

## A pour in process



The bearing wall has large diameter rebar protruding from the top cores to tie the slab into the wall

This pour will be a **Waffle Slab** (two way joist slab) poured over a concrete block bearing wall.

---

---

---

---

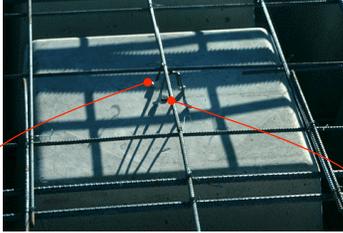
---

---

---

---

## Pans and Grommets



Here the reinforcing is held up off the domed pan with a chair. Below the chair is the grommet used when stripping (removing) the form

- The waffle slab is made by pouring concrete over fiberglass domed pans which displace concrete and make the space between forms behave like a concrete joist. The removal of concrete that isn't working is what makes this system able to span large distances.

---

---

---

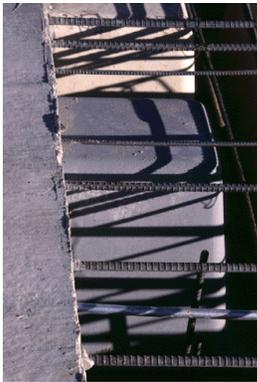
---

---

---

---

---



## Cold Joints

- Last weeks pour was stopped in mid-pan, allowing rebar to be continuous across the joint between the old pour and the new one.
- Fluid concrete doesn't bond to semi-cured concrete. The continuous steel will insure that both pours behave as one slab, but the two pours will never seal together fully.

---

---

---

---

---

---

---

---

## Pouring tools



- Rubber boots and a concrete vibrator are ready to begin the pour. NEVER pour (wade in) concrete wearing sneakers, the concrete will seriously burn your skin after an afternoon of slogging around in it. Concrete workers in the know wear tall rubber boots, and seal the tops to their jeans with duct-tape!

---

---

---

---

---

---

---

---

## Pouring tools



- The architect should walk the forms prior to the pour with a flashlight, looking into the forms for soda cans, shoes, and other debris that will become a permanent part of the building after the pour is complete....

don't overlook the old tires!

---

---

---

---

---

---

---

---

## Concrete Pumping



- In many low rise placing procedures, it is often more economical to **pump** the concrete to the floor or roof being placed than it is to place it with a crane and bucket.
- Pumping requires a **superplasticizing admixture** in the concrete to make it more fluid without reducing strength

---

---

---

---

---

---

---

---

## Pump operation



- The pump is operated by a person standing near the pour, unlike a crane who's operator is in the machines cab.
- This operator wears a portable control panel and controls the pump velocity and location from the site of the pour

---

---

---

---

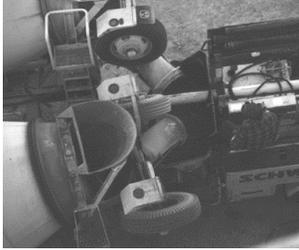
---

---

---

---

## Continuous Concrete



- Two concrete trucks back up to the pump, when one truck is empty, the second truck starts to unload into the pump's hopper. At that point a new truck shows up to replace the empty. In this way there is a continuous stream of concrete is available to pour.

---

---

---

---

---

---

---

---

## Placing pumped concrete



- The pump's boom allows the operator to place the concrete very close to where it is to be placed, preventing excessive horizontal dragging of the concrete by the crew...(remember segregation?)
  - In this case the crew has added extension hoses to the boom to reach the far corner of the roof slab being poured.
- Spare tires

---

---

---

---

---

---

---

---

## Spare tires and concrete placing



- The long hoses are difficult to move while walking around on the rebar so the laborers tied rope to the hose to act as a handle.
- The hose catches on rebar ends as they move it around. To keep it from hanging up on the rebar, the workers tie one of the spare tires to the hose to "float" it above the rebar.

---

---

---

---

---

---

---

---

## Fill the form, vibrate the mix,...



- The concrete with the superplasticizer admixture flows quickly from the hose.
- To insure the form is getting completely filled, this worker places the vibrator in the forms to drive out trapped air.

---

---

---

---

---

---

---

---

## Concrete trellis



- Like the styrofoam *holdouts* seen earlier in the wall forms, these wooden boxes will keep the concrete out, but allow it to form the two way joists between the boxes. This will produce a concrete trellis.
- The edge of each concrete box will have to be troweled and finished by hand to prevent chipping (*spalling*) of the concrete when the wood box forms are removed.

---

---

---

---

---

---

---

---

## Screeding



- After the concrete is placed from the hose and vibrated, the next step is to roughly level it to the correct elevation. This is called *screeding*. It is often done with a simple 2x4 board, the workers move the board across the concrete in a back and forth sawing motion, pulling towards themselves at the same time. The worker with the shovel removes excess concrete built up behind the screed board and places it in any low spots that show up during the screeding process.

---

---

---

---

---

---

---

---

## Concrete Floats!



- After screeding, the concrete is **float**ed. The float (often made of metal) is pulled slowly across the screeded surface. This pulls fine aggregate and concrete paste to the surface, making it less porous.
- This long handled (6 or 8 feet) float is called a **bull float**.

---

---

---

---

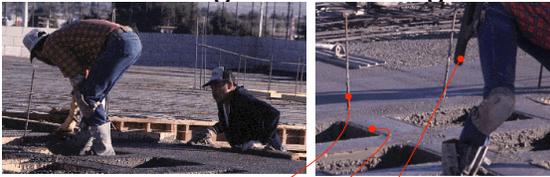
---

---

---

---

## Floating and Finishing



- After floating, dowels are placed in this concrete roof slab to tie the parapet wall to the slab.
- Now the **concrete finishers** come in to **tool** the edges around each trellis opening. They use steel trowels with a curved edge to separate the mix from the top of the form so the trellis edge won't chip when the forms are pulled.

---

---

---

---

---

---

---

---

## Floats with headlights



- When the floor areas are large enough, and when the slab is on grade, the extra weight of a riding power float is not a factor and speeds conc. finishing

---

---

---

---

---

---

---

---

## Almost done



- The process of placing the concrete, vibrating the concrete, screeding the concrete, floating the concrete and tooling the edges is continuous process, one that began here at 5:30 AM and will conclude around 7:30 PM to pour this 80' x 80' roof slab.

---

---

---

---

---

---

---

---

## Under the pour



- While the concrete is reaching it's 28 day strength it is supported by this aluminum **shoring** which holds up the formwork

---

---

---

---

---

---

---

---

## Removing the forms



- Once the concrete has reached the 28 day strength successfully, the forms are **stripped**.
- To strip these fiberglass dome forms, the workers squirt a little compressed air through a nozzle into the rubber grommet at the top of the form. This puff of air between the form and concrete pops the form free.

---

---

---

---

---

---

---

---

## Drafty forms



- The form pops down enough to get ahold of and pull it free of the slab.
- This is made easier by the sloped sides of the form. Forms made with a slight slope or **draft** are easier to remove and do less damage to the concrete in the process.

---

---

---

---

---

---

---

---

## Leaky forms



- A crack or hole in the top of the form will not only leak concrete, but will leak the little squirt of compressed air needed to pop out the form.
- Here, one of the workers stands ready with a pry bar to pry the form free if the air squirt doesn't work.

---

---

---

---

---

---

---

---

## Dropped beams



- Beams that project below the slab must be formed separately. These beam forms below the slab are called drops.
- Drops are labor intensive to form, leak if not made well, and are something most concrete subs would like to avoid.

---

---

---

---

---

---

---

---

## Successful pour . . . who designed this?



- With the forms removed, the level of investment in the quality of the mix, form construction, and placing can be known.
- Here, the mix, forms, and placing went pretty well, no streaking on the beams to show a form leak, no voids in the slab indicating poor mix design, or segregation, but the mismatch between the form pattern and the shape of the slab show that the designer was not working with the order of the waffle slab.

---

---

---

---

---

---

---

---



A bit too much salt on the slab during winter?

---

---

---

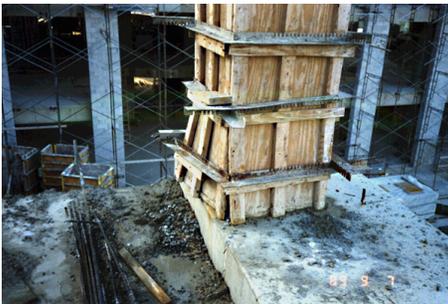
---

---

---

---

---



A not so square column form

---

---

---

---

---

---

---

---