Concrete in Practice
What, why & how?
NRMCA

CIP 21 - Loss of Air Content in Pumped Concrete

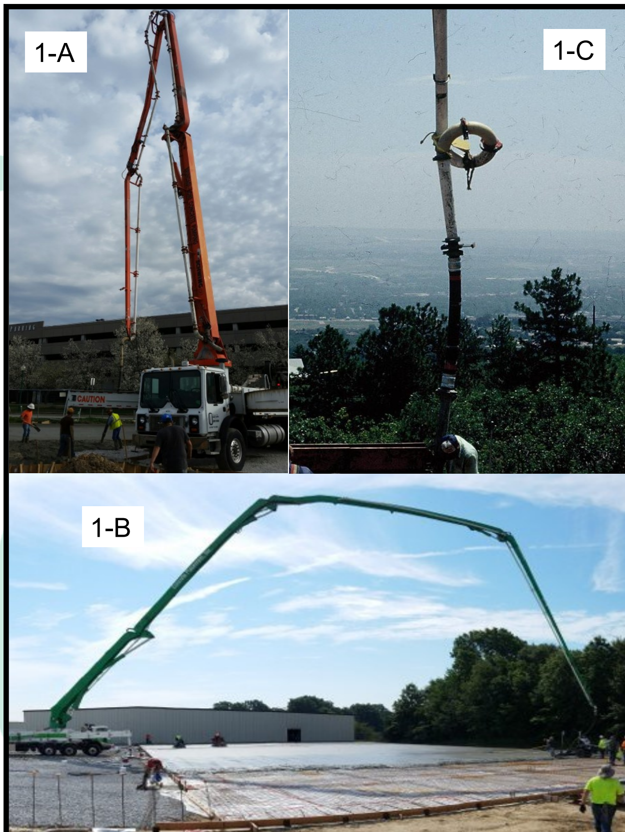
WHAT is Air Loss in Pumping

Specifications increasingly require concrete to be sampled at the discharge end of a concrete pump and tested for air content. The intent is to ensure that the specified air content is attained at the point of placement in the structure. Air content measured on a sample from the discharge of a pump is more often lower than that measured on a sample of the same concrete discharged from the truck chute. Samples obtained from a flowing stream of concrete discharged from a pump under constant pressure as opposed to one obtained by controlling the pressure and rate of discharge can yield very different air content results. A sample obtained from a pump with the boom in a vertical orientation as shown in Figure 1-A may have measured air content less than half of that on a sample obtained at the truck chute. A boom in a horizontal orientation as show in Figure 1-B, will generally not cause a significant loss of air. It should be recognized that air loss through a pump may not occur every time. The pumping conditions at the jobsite cannot be predicted for each load of concrete making it difficult to target an air content to compensate for the anticipated loss due to pumping. Delivering concrete with a higher air content that is not reduced through the pump will result in a strength deficiency. Details regarding sampling and testing should be discussed in a pre-construction meeting.

WHY is Air Lost

Different mechanisms can cause a loss of air through a pump. In a vertical downward section of pipe, if the weight of concrete exceeds the frictional resistance and breaks from continuous flow, the vacuum on the upper end expands the size of the air bubbles. On contact with an elbow in the boom or a horizontal surface the larger bubbles collapse. The effect of this impact can be demonstrated by dropping concrete 15 or 20 ft (4.5 to 6 m). The loss of air can be further exacerbated due to the transition from a high pressure in the pump to a near vacuum condition in the pump line.

Field experience indicates that air loss through a pump is greatest in concrete with higher cementitious material content and flowable concrete mixtures. Air loss is also experienced in mixtures with a moderate cement factor around 500 lb/yd^3 (300 kg/m^3) of total cementitious material and medium slump.



Different pump boom configurations

The air loss due to pumping should be determined by measuring the air content of samples discharged from the ready mixed concrete truck and at discharge from a pump. Testing concrete as discharged from the pump alongside the pump represents the most critical boom configuration that will cause the highest loss of air content. More horizontal boom configurations will cause less loss of air. Charging a pump with high air content that is not lost will result in concrete placed in the structure at a higher air content and lower strength. Typically, a change of 1% in air content will impact compressive strength by 5% or more.

Typically, larger air bubbles are lost during placement, while the smaller entrained bubbles are more robust and retained. The smaller air bubbles are those that contribute to the resistance of concrete to cycles of freezing and thawing. Recommended values for air content of fresh concrete in ASTM C94/C94M and ACI 301 are based on achieving this on samples at the end of the chute of the concrete truck. It is anticipated that some of this air will be reduced when concrete is placed and consolidated in the structure. It has been shown that concrete retains is freeze-thaw durability with air content as low as 3% when air is lost due to placement methods.

It is noted that there is no procedure standardized for sampling concrete from a pump and procedures should be specifically established for projects.

HOW Can Air Loss be Minimized

To minimize the loss of air of concrete through a pump, steps should be taken to prevent concrete from sliding down the line under its own weight and to ensure that there is a continuous, flowing stream of concrete inside the pump boom/line. When possible, avoid vertical or steep downward boom sections. Be cautious with high slump and particularly with high cementitious content mixtures. Steady, moderate, rapid pumping may help to minimize air loss, but these recommendations will not solve all problems.

a. Try inserting a loop in the pipeline just before the rubber hose. (*Do not* do this unless pipe clamps are designed to comply with *all safety requirements*). See Figure 1-C. This method can be helpful but is not a perfect solution. In some cases, it may cause an increase in the air content.
b. Use a slide gate at the end of the rubber hose to control discharge and provide resistance to flow.
c. Use of a 6-ft. (2-m) diameter loop in the rubber hose with an extra section of rubber hose. This method has been reported to be a better solution than (a) or (b).
d. Lay 10 or 20 ft. (3 to 6 m) of hose horizontally on deck pours. This doesn't work in columns or walls and requires additional labor to manage the extra hose.
e. Reduce the rubber hose size from 5 to 4 in. (125 to 100 mm). A transition pipe of length 4 feet (1.2 m) or longer should be used to avoid blockages.

WHAT Steps should be Considered

Schedule a pre-pour meeting with the contractor, pump operator, and ready mixed concrete supplier to discuss these issues. A general agenda for this meeting is outlined in CIP 32 . Discuss the necessity for care in pumping air-entrained concrete and outline the necessary precautions. Maintain communication between all parties during the placement process.

a. Before the placement, plan alternative pump locations and decide what will be done if air loss occurs. Be prepared to test for air content frequently. Measuring density at the chute and the pump discharge can serve as a quick check.
b. Sampling from the end of a pump line can be potentially hazardous. Wear proper personal protective equipment. Sample the first load on the job after pumping 2-3 cubic yards. Never sample the beginning or the end of concrete being placed through the pump line. It is recommended that sample portions be obtained from concrete placed in the structure with the normal discharge rate, as opposed to directing the pump line and controlling the flow into a sample container.
c. When a sample is obtained ensure that concrete is being discharged at a constant rate with a full pump line and avoiding a "sputtering" discharge. Manipulation of the pumping process to facilitate sampling, such as shutting off, jogging etc., will cause temporary vacuum in the pump line resulting in lower air content in the concrete sample.
d. If air loss occurs, do not try to solve the problem by increasing the air content delivered to the pump beyond the upper specification limit. High air content concrete with low strength could potentially be placed in the structure if boom configuration changes.
e. Research has shawn that when the loss of air content is not too high (about 3%), the air void system in the concrete may still be adequate for freeze-thaw resistance of concrete. An extra cylinder may be cast to verify this if needed.

References

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