Concrete in Practice

What, why & how?

NRMCA®

CIP 21 - Loss of Air Content in Pumped Concrete

WHAT is Air Loss in Pumping?

Increasingly, specifiers are requiring concrete to be tested for air content at the discharge end of concrete pumps at the point of placement in the concrete structure. In some cases it is observed that air contents are much lower than that in samples tested at discharge from the truck chute. It is normal to find a loss of about 0.5 to 1.0 percent air as concrete is conveyed through a pump. However, with long boom pumps have the boom in an orientation with a long, near vertical downward section of pipe, the air content at discharge may be less than half of that of the concrete going into the pump hopper. When the boom is upward or horizontal, or if there is a 12-ft (3.6-m) section of rubber hose placed horizontally at the discharge end, there generally is no significant loss of air. Certainly, air loss through a pump doesn't occur every time. However, it does occur often enough to be considered seriously until better solutions are developed.

WHY is Air Lost?

There are several mechanisms involved, but air loss will occur if the weight of concrete in a vertical downward section of pipe is sufficient to overcome frictional resistance to allow a slug of concrete to slide down the pipe. As the slug of concrete slides down the pipe, it develops a vacuum on the upper end that greatly expands the size of the air bubbles; and when the concrete hits an elbow in the boom or a horizontal surface, the 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.

Most field experience suggests that air loss is greatest with high cement content, flowable concrete mixtures which slide down easier; however, air loss has also been experienced in mixtures with a moderate cement factor at about 500 lb/yd^3 (300 kg/m^3) and moderate

Figure 1: A vertical pump boom configuration can result in loss of entrained air in concrete

slump. Loss of air content in pumped concrete will not reduce freeze thaw durability of concrete as long as the air void system is not compromised.

The air loss due to pumping can be determined by measuring the air content of samples discharged from the ready mixed concrete truck and at discharge from the pump. Testing concrete as discharged from the pump alongside the pump will require the most critical boom configuration that will cause the highest loss of air content. If concrete at a higher air content, to compensate for this loss, is placed at a less critical, more horizontal boom configuration, the concrete placed in the structure will be at a high air content and lower strength.

HOW to Prevent Air Loss?

To minimize the loss of air of concrete through a pump procedures should attempt to keep concrete from sliding down the line under its own weight. Ensure that there si a continuous stream of concrete within the pump and inside the pumpline. Where possible, avoid vertical or steep downward boom sections. Be cautious with high slump, and particularly with high cementitious content mixtures. Steady, moderately rapid pumping may help somewhat to minimize air loss, but will not solve most 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).* This method helps, but won't be 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 restrict discharge and provide resistance.

c) Use of a 6-ft. (2-m) diameter loop in the rubber hose with an extra section of rubber hose is 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.

Figure 2: Loop in pump boom

PRECAUTIONS

Conduct a pre-pour conference in accordance with the agenda outlined in CIP 32 with the contractor, pump operator, and ready mixed concrete supplier present. Discuss the necessity for care in pumping air entrained concrete, and list the precautions to take when pumping air-entrained concrete. Maintain communication between all parties during the placement process.

a) Before the pour, plan alternative pump locations and decide what will be done if air loss occurs. Be prepared to test for air content frequently.

b) Sampling from the end of a pump line can be very difficult and potentially hazardous. Wear proper personal protective equipment. Never sample the initial concrete through the pump line. It is recommended that sampling be done from the concrete placed in the structure as opposed to the end of a pump line.

c) Sample the first load on the job after pumping 3 or 4 cubic yards (2 to 3 m^3). Temper it to the maximum permissible slump. Swing the boom over near the pump to get the maximum length of vertical downward pipe and drop the sample in a wheel barrow. If air is lost, take precautions and sample to measure air content at the point of placement.

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, or almost surely will, be placed in the structure if boom angles are reduced or somewhat lower slump concrete is pumped.

e) Research has indicated that when the loss of air content is not too high (less than about 3%), the air void system in the concrete may still be adequate for freeze-thaw resistance of concrete. This is because most of the air lost is the larger air bubbles that do not significantly affect the durability of concrete.

References

1. Yingling, James; G.M. Mullings; and R.D. Gaynor, "Loss of Air Content in Pumped Concrete," *Concrete International*, Volume 14, Number 10, October 1992, pp. 57-61.
2. ACI 304.2R, "Placing Concrete by Pumping Methods," American Concrete Institute, Farmington Hills, MI.
3. Hoppe, Julian J., "Air Loss in Free-Falling Concrete," Queries on Concrete, *Concrete International*, June 1992, p. 79.
4. Gorsha, Russel P., "Air Loss in Free-Falling Concrete", Queries on Concrete, *Concrete International*, August 1992, p. 71.
5. "Effects of Pumping Air Entrained Concrete," Washington Aggregates and Concrete Association, March 20, 1991, 12 pp.
6. Dyer, R.M., "An Investigation of Concrete Pumping Pressure and the Effects on the Air Void System of Concrete," Master's Thesis, Department of Civil Engineering, University of Washington, Seattle, Washington, 1991.
7. Hover, K.C., Phares, R.J., "Impact of Concrete Placing Method on Air Content, Air-Void System Parameters, and Freeze-Thaw Durability", Transportation Research Record 1532, Transportation Research Board, Washington, DC.

1992, 2005

NRMCA National Ready Mixed Concrete Association • 900 Spring Street, Silver Spring, MD 20910 • www.nrmca.org • 888-84NRMCA