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Loss of Air Content in Pumped Concrete

1. 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, the air contents are much lower than that in samples tested at discharge at the truck chute. It is normal to find a loss in air content of about 0.5 to 1.0 percent as concrete is conveyed through a pump. However, when long boom pumps have the boom in an orientation with a long, near vertical downward section of pipe, the air content at the discharge may be less than half of the concrete going into the pump hopper. When the boom is upward or horizontal, except for a 3.7m section of rubber hose, there generally is no significant loss of air. There is some controversy over how frequently air loss is a problem in pumped concrete. Certainly air loss through a pump doesn't occur every time, or even most times. However, it does occur often enough to be considered seriously until better solutions are developed. In rare instances, the air content of concrete has been observed to increase after going through a pump. However, the root cause of this phenomena is still under study.

2. WHY is Air Lost?

There are several mechanisms involved, but air loss will occur if the weight of concrete in a vertical or near vertical downward pipe is sufficient to overcome frictional resistance and let a slug of concrete slide down the pipe. As the slug of concrete slides down the pipe, it develops a vacuum on the upper end which greatly expands the air bubbles; and when they hit an elbow in the boom or a horizontal surface, the bubbles collapse. The effect of this impact can be demonstrated by dropping concrete 4.5m – 6m. 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 mixes which slide down easier; however, air loss has also been experienced in mixes with a moderate cement factor such as 300kg/m^3 as well as moderate slump.

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3. HOW to Prevent Air Loss.

To minimize loss of air content of concrete through a pump, placement procedures should attempt to keep concrete from sliding down the line under its own weight. Ensure there is a continuous stream of concrete within the pump and the pump line. Where possible, avoid vertical or steep downward boom sections. Be cautious with high slump, particularly with high cement content mixes and mixes containing silica fume. Steady pumping may help somewhat to minimize air loss, but will not solve most problems.

a. Try inserting four 90 degree elbows just before the rubber hose. (Do not do this unless pipe clamps are designed to comply with all safety requirements). This helps but won't be a perfect solution.

b. Use a slide gate at the end of the rubber hose to restrict discharge and provide resistance.

c. Use of a 1.8 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 3.5 - 6.0 m of hose horizontally on deck pours. This doesn't work in columns or walls and requires labor to handle the extra hose.

e. Reduce the rubber hose size from 125mm to 100mm. A transition pipe may be needed to avoid blockages.

PRECAUTIONS

Conduct a pre-pour conference with the contractor, pump operator and ready-mix supplier present. Discuss the necessity for care in pumping air entrained concrete, and list the precautions to be taken 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.

c. Sample the first load on the job after pumping 2 or 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 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 3%), the air void system in the concrete may be still adequate for freeze-thaw resistance of concrete. This is because most of the air lost is the larger air bubbles that have a less significant affect the durability of concrete.

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