An Effect of Liquid Argon in Temperature and Strength Properties of Concrete

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Abstract:
Temperature-related issues are particularly a problem with mass concrete placements. In hot weather conditions, solar radiation and elevated temperatures preheat concrete mixing materials and the drums of ready-mix trucks, increases the placement temperature of the concrete. Concrete suppliers have been using multiple methods of reducing the placement temperature of concrete, such as cooling the mixtures with ice or chilled water, shading the aggregate piles, placing concrete at night, and using evaporative cooling of aggregate piles. It is common practice to cool concrete during hot weather or for mass placements. Liquid argon works on the principle of “Leidenfrost Effect” which states that “When cryogenic liquids it poured into the concrete; it forms a gaseous layer around the concrete material”. The cryogenic liquid (liquid argon) is discharged into the concrete mixture by spraying or injecting directly into the rotating concrete mixture. To determine the effect of liquid argon at normal temperature range, its impact on properties and performance of concrete, to determine the workability, compressive strength, setting time and tensile strength (destructive and non-destructive testing) of the concrete thus casted and whether its application if preferable at normal climatic conditions. Concrete properties such as strength, setting time, and workability (slump) are sensitive to temperature. Elevated curing temperatures increase strength at early ages, decrease setting times, and reduce workability.

Keywords: Conventional Concrete, Liquid Argon, Temperature effect, Workability.

1. INTRODUCTION
Concrete, usually Portland cement concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens over time. Although cooling concrete ingredients is an effective means of lowering the fresh temperature of concrete, there are several limitations to the cooling procedures in terms of their efficacy, cost, and effects on concrete properties. The largest disadvantage to cooling aggregates by evaporation is that it can only be performed in dry climates. Many of the warm weather climates around the world are relatively humid, thereby limiting this method to a few select regions or to specific conditions. Chilled water is a common method of cooling concrete but has severe limitations in terms of cooling potential. Even if all of the mixing water is replaced with chilled water, the temperature reduction that can be expected may be not enough to reach the required initial temperature.

2. TEMPERATURE EFFECT ON CONCRETE
Concrete properties such as strength, setting time, and workability (slump) are sensitive to temperature. Elevated curing temperatures increase strength at early ages, decrease setting times, and reduce workability (Burg, 1996). High curing temperatures cause an increase in strength as the microstructure is more homogeneous (Mindess et al., 2003). Strength is reduced, however, at later ages. Several sources confirm that the rate of cement hydration decreases at later ages for samples cured at elevated temperatures, thereby reducing strength gain (Idorn, 1969). On the other hand, samples cured at cooler temperatures actually have a higher degree of reaction, which results in increased strengths at later ages.

Elevated curing temperatures increase the rate of hydration and decrease setting time and workability. Recent research has shown that a 30% decrease in setting time can be expected for each 10°F increase from ambient temperature (Burg, 1996). This can cause significant problems with respect to workability. Results from the same study also showed that slump decreases approximately 0.8 in. for each 20°F increase from ambient temperature (Burg, 1996). Therefore, lower curing temperatures provide many benefits to concrete properties.

3. METHODOLOGY

4. LIQUID ARGON
Argon is most commonly used in its gaseous state. It is widely used in the lighting industry for filling bulbs and with combinations of other rare gases for the filling of special bulbs and tubes for special colour effects. The welding industry uses argon as a shielding gas to protect metal from oxidation during welding. Argon is also used extensively in the semiconductor manufacturing process as a purge gas.
5. MIX DESIGN

Design mix is considered for all type of construction. Mix ratio is designed based on the material properties. We have proposed a design mix ratio of 1:1.64:2.43 for M25 grade concrete (Cement: Fine aggregate: Coarse aggregate), designed as per IS 10262:2016.

1. PROPORTION OF LIQUID ARGON

Argon concrete is casted as per conventional concrete mix design along with liquid argon. 120-130 scf of liquid argon can cool a cubic yard of concrete by 1°F. 4-4.7 litres of liquid argon can cool 26.83 cubic feet of concrete by 1°F. In conventional concrete water has been used with water-cement ratio of 0.45), Whereas in Argon concrete mix, liquid argon has been used (800 ml, 2000 ml) to find the optimum results.

6. RESULT AND DISCUSSION

1. CHANGE IN TEMPERATURE:

The concrete is mixed as per the design made, and the specimens are casted as per the requirements and they are tested. The following result will show the comparison between the conventional concrete and argon concrete. As of adding liquid argon to the concrete, it reduces the temperature of the concrete due to hydration of the cement with water. Adding 800 ml of liquid argon reduces the temperature of 3.0°C, 1500 ml of argon reduces 6.3°C, 2000 ml of argon reduces 8.1°C. Further increasing of addition of liquid argon does not showed much change in the temperature. The temperature of conventional concrete is measured and also temperature of concrete during the addition of LA is also measured. It has been noted that 4 - 4.7 liters of liquid argon can cool 26.83 ft³ of concrete by 1°F and due to the addition of Liquid Argon the temperature is reduced up to 14.5°F compared to Conventional Concrete.

2. SLUMP VALUE:

The slump value is used to determine the workability of the concrete. The table shows the change in slump value with change in addition of liquid argon.

### Table 1. Slump values of conventional concrete and Argon concrete

<table>
<thead>
<tr>
<th>S.NO</th>
<th>SPECIMEN</th>
<th>SLUMP VALUE (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Conventional Concrete</td>
<td>260</td>
</tr>
<tr>
<td>2.</td>
<td>Argon Concrete</td>
<td>With 800 ml LA</td>
</tr>
<tr>
<td>3.</td>
<td>Argon Concrete</td>
<td>With 1500 ml LA</td>
</tr>
<tr>
<td>4.</td>
<td>Argon Concrete</td>
<td>With 2000 ml LA</td>
</tr>
</tbody>
</table>

3. COMPRESSION TEST:

The compressive strength values have gradually increased. Adding of 800 ml per cubic feet will increase the compressive strength without any changes in the other properties of concrete. And the test were carried out at 28th day.

4. SPLIT TENSILE STRENGTH

Increasing the amount of liquid argon, the split tensile strength decreases and for addition of 2000 ml, the split tensile strength reduced to about 19.12%. which is not within permissible limits.

7. CONCLUSION

In this project an experimental investigation on effect of liquid argon in temperature and strength properties of conventional concrete. For addition of 800 ml of Liquid argon shows 1.46% reduction in compressive strength compared to Conventional Concrete.
Concrete. Whereas for 1500 ml addition of LA shows a reduction of about 8.04% and for addition of 2000 ml of LA shows about 18.57% reduction compared to Conventional Concrete. For addition of 800 ml of LA shows a reduction of about 1.32% in Spilt Tensile Strength compared to Conventional Concrete. Whereas addition of 1500 ml of LA shows about 8.80% reduction and for addition of 2000 ml of LA shows about 19.12% reduction compared to Conventional Concrete. Hence by increasing the amount of LA the compressive strength and spilt tensile strength of concrete gets reduced beyond the permissible limits. Even though addition of 2000 ml LA reduces the temperature of concrete mix by 14.5°F, it is not preferable since compressive strength and spilt tensile strength decreases. Therefore, the usage of LA is not preferable for building construction, but it can be used for mass concreting (Example: Lining of cannals).

8. REFERENCE


