Rapidite: An Experimental Study on Enhancing Properties of Concrete

Zahid Bashir Bhat
Lecturer
Department of Civil Engineering
NIT Srinagar

Irfan Latief
Lecturer
KITE Polytechnic Rangret

Sahil Bhat
Project Specialist
Ericsson

Muneeb Anwar Shah
Civil Engineer
Al-Madad Infratech

Danish Iqbal
Assistant Engineer
PWD (R&B Department) J&K

Abstract

The major problem associated with cold weather concreting is delayed gain in strength resulting in frost action and damage to concrete structures. In this paper the issue of delayed gain in strength and subsequent damage to the structure is addressed by using rapidite in concrete. Rapidite was added in six concrete samples having rapidite dosage .6%, .9%, 1.2%, 1.5%, 1.8% and 2% by weight of cement. The results concluded permissibility of using Rapidite up to 1.8% by weight of cement and also the optimum percentage of rapidite was found to be 1.8% with value of compressive strength, flexural strength and splitting tensile strength being maximum at the age of 7 days.

Keywords: Flexural strength, Cold weather concreting, Compressive strength, Rapidite, Splitting tensile strength

I. INTRODUCTION

On adding water to cement, paste is formed which gradually stiffens and then hardens. The stiffening of cement paste is called setting [1]. Actually, setting is a process of transformation from an initial state, a scattered concentrated suspension, to a final state, a connected and strengthened system of particles [2]. This transformation in the practice of cement and concrete is obtained by chemical reactions between cement particles and water (i.e. hydration of cement)[3]. Normal setting of cement is associated with the hydration of Alite (C₃S) and formation of calcium silicate hydrate (C-S-H) phase[4]. Cement paste / concrete sets gradually under the standard laboratory conditions (temperature ~ 23°C and relative humidity not less than 90%)[5]. But outside the laboratory concreting has to be done under the prevailing climatic conditions.

In many countries or certain regions of countries, fresh concrete is subjected to cold weather. American Concrete Institute (ACI) defines cold weather when two conditions exist for three consecutive days : i) The average daily temperature falls below 5°C, and ii) Air temperature does not rise above 10°C for more than half a day in any 24 hour period[6]. Cold weather, as defined, usually starts during fall and continues till spring and the same is witnessed in Author’s native land Kashmir (India).

Cold weather leads to delay in setting and hardening of concrete, freezing of concrete at early age and thawing which leads to formation of ice needles in concrete and thus cavities are formed after thawing of ice needles which seriously impair the structural integrity of concrete and results in considerable loss of strength. In extreme cases, effects of cold weather may make the concrete an absolutely useless friable mass. On the other hand, if the concrete is sufficiently hardened when freezing conditions are likely to prevail, there will not be much harm to structural integrity of concrete. If the concrete has sufficiently hardened, the water that has been mixed for making concrete will have been utilized either being used up in hydration process or lost by evaporation. Due to the formation of cement gel, the capillary cavities also will have been very much reduced, with the result that there exists very little of free water in the body of concrete to freeze.

Accelerating admixture is an admixture that accelerates the hardening or the development of early strength of concrete[7]. The rates of chemical reactions between clinker materials in cements and water, may be altered by adding small amounts of chemical substances to the cement-water mix. Substances affecting these rates to give an overall increase in the hydration rate, i.e. an accelerating effect, are termed accelerating admixtures or simply accelerators. Hence, an accelerator is added to concrete for the purpose of shortening setting time and/or increasing early strength development. In the first case the main action of the accelerator occurs in the plastic state of the cement paste, while in the latter case the accelerator acts primarily in the hardened state. Some accelerators affect either setting or hardening, while several accelerate both setting and hardening. Accelerating admixtures are usually termed ‘chloride based’ or ‘chloride free’ and may be principally set or hardening accelerators. Care is needed to ensure that the correct one is selected for the required application. Most Concrete specifications restrict the use of calcium chloride or...
admixtures containing calcium chloride to plain unreinforced concrete and ban it for structural concrete that contains embedded metal.

In this research, rapidite is used as accelerating admixture in the dosage range of 0.6% to 2% by weight of cement. Concrete specimens with varying percentage of rapidite were tested for compressive strength, splitting tensile strength and flexural strength. The results obtained were compared with results of normal M-20 concrete mix and it was found that maximum increase in compressive strength, splitting tensile strength and flexural strength occurred for concrete mix containing 1.8% rapidite by weight of cement at 7 days age. However, there was no considerable increase in compressive strength, splitting tensile strength and flexural strength at 28 days age. The results indicated the beneficial effects of admixture in concrete subjected to cold weather.

II. MATERIALS USED

A. Cement and Aggregates:
Khyber ordinary Portland cement of 43 grade conforming to IS 8112 [9] was used throughout the work. Fine aggregates used throughout the work comprised of clean river sand with maximum size of 4.75mm conforming to zone II as per IS383-1970 [10] with specific gravity of 2.6. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.7.

B. Rapidite:
Rapidite was used as accelerating admixture and was purchased locally.

III. EXPERIMENTAL INVESTIGATION

A. Mix Proportion:
The concrete mix design was proposed by using IS 10262 [11]. The grade of concrete used was M-20 with water to cement ratio of 0.5. The mixture proportions used in laboratory for experimentation are shown in TABLE 1. Fig.1 shows the mixing of ingredients.

B. Test on Fresh Concrete:
The workability of all concrete mixtures was determined through slump test utilizing a metallic slump mould. The difference in level between the height of mould and that of highest point of the subsided concrete was measured and reported as slump. The slump tests were performed according to IS 1199-1959 [12]. Fig.2 shows slump in Plain Concrete.

C. Tests on Hardened Concrete:
From each concrete mixture, cubes of size 150mm x 150mm x 150mm, 150mm x 300mm cylinders and 500mm x 100mm x 100mm beams have been casted for the determination of compressive strength, splitting tensile strength and flexural strength respectively. The concrete specimens were cured under normal conditions as per IS 516-1959 [13] and were tested at 3 days, 7 days and 28 days for determining compressive strength as per IS 516-1959 [14], splitting tensile strength as per IS 5816-1999 [15] and flexural strength as per IS516-1959[16].

IV. RESULTS AND DISCUSSION

A. Fresh Concrete:
The slump values of all the mixtures are represented in TABLE 1. Increase in slump value was observed in fresh concrete samples containing rapidite as admixture as compared to slump value of normal concrete. The variation of slump with varying admixture content is depicted in Fig. 3.

B. Hardened Concrete:
1) Compressive strength:
The compressive strength tests are presented in TABLE 2. Compressive strength tests, splitting tensile strength tests and flexural strength tests were carried out at 3, 7 and 28 days. An increase in compressive strength was observed up to 1.8% addition of rapidite as admixture and there after decreasing. The maximum compressive strength measured was 43% and 47.5% more than that of reference mix at 3 days and 7 days respectively, corresponding to concrete mix containing 1.8% rapidite by weight of cement. 17% increase in compressive strength was observed at 28 days with respect to reference mix. Compressive strength for concrete mix with 2% rapidite by weight of cement was found to be less than that of reference mix.
2) Splitting tensile strength:
The splitting tensile strength tests are presented in TABLE 3. Splitting tensile strength witnessed an increase of 60%, 95% and 40% at 3, 7 and 28 days of age respectively, corresponding to concrete mix containing 1.8% rapidite by weight of cement.

3) Flexural strength:
The flexural strength tests are presented in TABLE 4. Flexural strength witnessed an increase of 47%, 26% and 31% at 3, 7 and 28 days of age respectively, corresponding to concrete mix containing 1.8% rapidite by weight of cement. Both splitting tensile strength and flexural strength for concrete mix with 2% rapidite by weight of cement was found to be less than that of reference mix. Fig. 4, 5 and 6 present compressive strength of all mixtures at 3, 7 and 28 days respectively. Fig. 7, 8 and 9 present flexural strength of all mixtures at 3, 7 and 28 days respectively. Fig. 10, 11 and 12 present splitting tensile strength of all mixtures at 3, 7 and 28 days respectively.

![Fig. 1. Mixing of ingredients](image1)

![Fig. 2. Slump test](image2)

**Table – 1**
Mix Proportion.

<table>
<thead>
<tr>
<th>Rapidite %</th>
<th>W/C ratio</th>
<th>Water (Kg/m³)</th>
<th>Cement (Kg/m³)</th>
<th>Rapidite (Kg/m³)</th>
<th>Fine Aggregate (Kg/m³)</th>
<th>Coarse Aggregate (Kg/m³)</th>
<th>Slump (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5</td>
<td>191.6</td>
<td>383</td>
<td>0</td>
<td>546</td>
<td>1188</td>
<td>18.5</td>
</tr>
<tr>
<td>0.6</td>
<td>0.5</td>
<td>191.6</td>
<td>383</td>
<td>2.3</td>
<td>546</td>
<td>1188</td>
<td>19.4</td>
</tr>
<tr>
<td>1.2</td>
<td>0.5</td>
<td>191.6</td>
<td>383</td>
<td>4.6</td>
<td>546</td>
<td>1188</td>
<td>20.2</td>
</tr>
<tr>
<td>1.5</td>
<td>0.5</td>
<td>191.6</td>
<td>383</td>
<td>5.74</td>
<td>546</td>
<td>1188</td>
<td>21.0</td>
</tr>
<tr>
<td>1.8</td>
<td>0.5</td>
<td>191.6</td>
<td>383</td>
<td>6.9</td>
<td>546</td>
<td>1188</td>
<td>22.8</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>191.6</td>
<td>383</td>
<td>7.67</td>
<td>546</td>
<td>1188</td>
<td>23.6</td>
</tr>
</tbody>
</table>

**Table – 2**
Compressive strength results.

<table>
<thead>
<tr>
<th>Rapidite %</th>
<th>Average cube compressive strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 days</td>
</tr>
<tr>
<td>0</td>
<td>11.80</td>
</tr>
<tr>
<td>0.6</td>
<td>14.20</td>
</tr>
<tr>
<td>1.2</td>
<td>14.80</td>
</tr>
<tr>
<td>1.5</td>
<td>16.00</td>
</tr>
<tr>
<td>1.8</td>
<td>16.90</td>
</tr>
<tr>
<td>2</td>
<td>10.10</td>
</tr>
</tbody>
</table>

**Table – 3**
Splitting tensile strength results.

<table>
<thead>
<tr>
<th>Rapidite %</th>
<th>Average cylinder splitting tensile strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 days</td>
</tr>
<tr>
<td>0</td>
<td>1.20</td>
</tr>
<tr>
<td>0.6</td>
<td>1.52</td>
</tr>
<tr>
<td>1.2</td>
<td>1.62</td>
</tr>
<tr>
<td>1.5</td>
<td>1.68</td>
</tr>
<tr>
<td>1.8</td>
<td>1.92</td>
</tr>
<tr>
<td>2</td>
<td>1.16</td>
</tr>
</tbody>
</table>
Table 4: Flexural strength results.

<table>
<thead>
<tr>
<th>Rapidite %</th>
<th>3 days</th>
<th>7 days</th>
<th>28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.28</td>
<td>2.05</td>
<td>2.80</td>
</tr>
<tr>
<td>0.6</td>
<td>1.66</td>
<td>2.34</td>
<td>3.03</td>
</tr>
<tr>
<td>1.2</td>
<td>1.69</td>
<td>2.37</td>
<td>3.12</td>
</tr>
<tr>
<td>1.5</td>
<td>1.75</td>
<td>2.46</td>
<td>3.39</td>
</tr>
<tr>
<td>1.8</td>
<td>1.88</td>
<td>2.58</td>
<td>3.68</td>
</tr>
<tr>
<td>2</td>
<td>1.12</td>
<td>1.74</td>
<td>3.10</td>
</tr>
</tbody>
</table>

Fig. 3: Variation of slump with admixture percentage

Fig. 4: Compressive strength at 3 days
Fig. 5: compressive strength at 7 days

Fig. 6: compressive strength at 28 days

Fig. 7: Flexural strength at 3 days
V. CONCLUSION

On the basis of results obtained, following conclusions can be drawn:

1) 1.8% rapidite addition as accelerating admixture showed 43%, 47.5% and 17% increase in compressive strength of concrete with respect to reference mix at 3, 7 and 28 days.
2) 1.8% rapidite addition as accelerating admixture showed 60%, 95% and 40% increase in splitting tensile strength of concrete with respect to reference mix at 3, 7 and 28 days.
3) 1.8% rapidite addition as accelerating admixture showed 47%, 26% and 31% increase in flexural strength of concrete with respect to reference mix at 3, 7 and 28 days.
4) Percentage increase of compressive strength, splitting tensile strength and flexural strength for concrete mixes containing rapidite less than 1.8% was less than that occurred at 1.8% addition.
5) Compressive strength, splitting tensile strength and flexural strength for concrete mix containing 2% rapidite by weight of cement was less than that of reference mix.
6) An increase of compressive strength, splitting tensile strength and flexural strength at 3 and 7 days corresponding to 1.8% rapidite addition specifies its absolute possibility of usage as accelerating admixture.
7) Workability of concrete increases slightly, the increase is noticeable at 1.81% rapidite addition.
8) Rapidite can be used as accelerating admixture particularly in cold climates at 1.8% dosage by weight of cement without any pronounced harmful effects.

9) For M20 mix having w/c as 0.5, 1.8% rapidite by weight of cement is recommended as accelerating admixture in cold weather.

REFERENCES