Performance Evaluation of Durability and Flexural behaviour of Self Compacting Concrete blended with Alccofine

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Abstract. Due to its superior performance over traditional concrete mixes, Self Compacting concrete (SCC) has increased in popularity in the construction industry in recent years. The major downside of using self-compacting concrete is that there is no universal design mix norm. The aim of this research is to determine the best mix proportioning and strength and durability parameters for M40 Alccofine based high strength self-compacted concrete. It often provides an exclusive application for self-compacting concrete since it can flow into any section of a heavily reinforced region without creating any vibration. Consequently, if using self-compacting concrete in beam-column joints does not adversely affect the frame's seismic efficiency, it could be used rather than traditional concrete. During earthquake excitation, the beam-column joints of reinforced concrete building frames play a very important role. As those are the highly congested areas of reinforced concrete framed buildings, effective concrete placement and compaction in these regions is extremely difficult. This study involves determining the impact of Alccofine with replacement levels from 10 to 50 percentages with cement is substituted for M40 grades with Viscosity Modifying Agent, with both the purpose of increasing compressive strength, lowering gas emissions, and making concrete more cost efficient. In specific, increasing the CaO volume of the Alccofine 1203 increases the binding capacity and compressive strength.

1. Introduction

Self-Compacting Concrete (SCC) is a revolutionary concrete that involves no placing and compaction while vibrating. Also, in the existence of congested reinforcement, it is free to flow through its own weight, completely filling the shapes and ensuring complete compaction. Self-compacting concrete, with faster construction times and easy to flow over reinforcement, requires a great rate of placing concrete. The incorporation to the concrete structure of Supplementary Cementitious Materials (SCM's) also including Flyash, Ground Granulated Furnace Slag, Alccofine and Silica Fume enhances its resilience, corrosion resistance, and lateral load carrying ability, thus minimising crack enhancement and dissemination at the same time. The key need for the development of self-compacting concrete is to develop a strong concrete structure that prevents from honeycombing and concrete surface irregularities. In its potential applications, such as nuclear industries where there are heavy dense reinforcements where traditional concrete does not fulfil its specifications, and a need for self-compacting concrete is very well recognised.
For self-compacting concrete, mineral admixtures have a benefit, such as improved workability with minimal cement content. As cement is the most costly part of concrete, an affordable alternative is to reduce the cement content. In addition, these pozzolanic materials can however strengthen the packaging of particles and decreases concrete permeability.

The adjunction of various supplementary cementitious materials to the concrete with cement emerging as the most appropriate binder is demonstrated by SCC dependent blended concrete. In contemporary time concrete practise, fly ash from power plants and metakaolin both have been critical. Increasing the level of SCMs such as Fly ash, Silica fume, Alccofine, Rice Husk Ash and Metakaolin in cement manufacturing and its consumption, guides to the conception of blended cements and concretes.

Viscosity Modifying Agent (VMA) makes the concrete more accommodating for changes in the mixture’s water content and enhances the plastic viscosity and prevents segregation. Surface quality application can be achieved by viscosity modifying agent and the placement level could also be increased and also decreases segregation and bleeding rates. The main difference in the composition during manufacturing at the plant occurs in a well-proportioned SCC due to normal production at the plant changes in the moisture content of the sand and the coarse aggregates.

Variability of 1.5% moisture content were very common for the aggregate, leading to a change throughout the concrete mix of 10 to 15 liters/m^3 of free water. This will result in significant differences in the concrete's flowing and cohesion properties being identified the same day or from one day to another from one batch to the next. By reorientating the mix design parameters for superior structural performance of concrete with thrust on controlling OPC content but increasing the whole cementitious material and controlling water content, consuming chemical admixture, for amended workability, for offsetting deliberate hydration with SCM’s. Concrete incorporating SCM’s will imply a new set of drift in the construction in the new millennium, due to the intensified use of performance built concrete.

2. Research Significance

The primary objective of this section is to assess the outcomes of distinct kinds and percentage of Alccofine 1203 on the mechanical properties of concrete such as Compressive and Flexural strength of reinforced concrete beam with M40 grade mix. According the Compressive strength of concrete of M30 Grade with water-binder ratio as 0.45 and mix proportion of 1:2.12:3.75 with addition of Glenium Stream 22.

Studies have shown that the use of up to 10 percent of small percentages of superplasticisers in Self Curing Concrete including the use of appropriate amounts of high-range water to minimise admixture reduces the paste's viscosity, decreasing water demand and bleeding danger. The use of pozzolanic materials increases SCC’s rheological properties and decreases concrete cracking due to decreased hydration heat and therefore can be used. In the development of conventional concrete, the addition of concrete additives and admixtures was the exception, although it is appropriate for SCC and their percentage at SCC is significantly greater.

The factors for improved SCC attribute efficiency to improved microstructure and homogeneity. Several tests, conducted by accurate microscopes including, seem to have an advanced microstructure of SCC compared to traditional concrete. Throughout the interfacial transition region, the void ratio of SCC between cement paste and aggregate was observed to be decreased and the pores were dispersed even more uniformly. For SCC mix design, there is no standard technique and several research organizations, admixture, ready-mixed, precast and contractual firms already established their own methods of mix proportioning. However, a higher proportion of ultrafine materials and also the incorporation of chemical admixtures were necessary to obtain the appropriate properties of fresh concrete throughout the SCC. An attempt has been made to performance characteristics of strength parameters of casting control samples with Glenium 33 incorporation as 1.0 percent in Blended Self Compacting concrete and M40 Grade concrete mix controlled Self Compacting concrete. Ordinary Portland Cement, Fine and Coarse Aggregate, Potable Water, Alccofine 1203 were the materials used in the current conclusions and identify the durability characteristics of SCM based Self Compacting Concrete.
3. Materials and Mix Proportioning

This study was conducted out using the Materials and Proportioning of M40 Blended Mix with Portland Cement and Alccofine, widely available in India for concrete production, siliceous river sand with a fine aggregate having fineness modules of 2.73 and a proportional maximum size of 20 mm. In accordance with the Indian Standard IS 2386-1963, the coarse aggregate ingested cooperates with the Indian Standard IS 383-1970 code and is measured for its physical characteristics, its special gravity 2.6 as just an angular coarse aggregate. The free-state bulk density is 1455 kg/m³ and the compressed state is 1529 kg/m³. Potable water have been used in the investigations for both mixing of SCM specimens.

Alccofine is more importantly resistant to the ingress of ions found in chloride and within concrete away with each other in the concrete mixtures, associated with decreased permeability having Silica content of 35.30%, Alumina as 21.4 % and Calcium Oxide content as 32.2 % was found and physical properties such as Specific Gravity as 2.70 and Bulk density as 680 kg/m³.

Consequently, the silica fume used has a 92.5 % SO₂ content and was in fine and powdered form. In the present study, Glenium Stream 2 is a dominant liquid, organic, viscosity-modifying admixture (VMA) ready-to-use, specifically formulated for the development of concrete with strengthened viscosity and rheological regulated properties. The Glenium Stream 2 admixture comprising concrete possesses superior stability and regulated bleeding characteristics, thereby increasing segregation resistant and facilitating placement.

To validate the properties of the initial mix composition regarding the specified characteristics and groups, laboratory studies will be used Now that all the criteria have been met, the mixture should be checked on a full scale in the concrete plant and on site to check both fresh and hardened properties. By great selection and proportioning of the cement and additions, by limiting the Water/Powder ratio and then by applying a super plasticizer and viscosity modifying admixture, the fluidity and viscosity of the paste is modified and balanced. The method of achieving good filling capacity, passing ability and resistance to segregation is the regulation of SCC, its usability and interaction.

The paste is the mechanism for the transfer of the aggregate; thereby, the volume of the paste must be larger than the amount of the paste in the aggregate, such that the paste layer is sufficiently covered and lubricated by all the individual aggregate particles. This increases fluidity and decreases friction in aggregates. The coarse to fine aggregate ratio throughout the mix is minimized such that a layer of mortar is completely surrounded by individual coarse aggregate particles.

As the concrete enters through narrow openings or gaps throughout reinforcement and improves the SCC’s passing capacity, this decreases aggregate interlock and structure. Although the specimen samples were cast of M40 grade blended concrete beams produced with optimal Alccofine replacement quantities. Tests for workability was obtained by Slump cone test and defined in Table 2.

Table 1. Mix Proportioning of Self Compacting Concrete for M40 Concrete

| Materials   | Cement | Fine Aggregate | Alccofine | Coarse Aggregate | Glenium Stream 2 | Water | Water-Cement Ratio |
|-------------|--------|----------------|-----------|------------------|------------------|-------|-------------------|
| Quantity    | 350    | 725.3          | 175       | 1125.5           | 3.5              | 190   | 0.4               |
| Ratio       | 1      | 2.07           | 0.5       | 3.21             | ** bwp - by weight of powder |

Table 2. Fresh Properties of SCC Mixes

| MIX          | Slump Flow (mm) | T50 (sec) | V- Funnel (Seconds) | U-Box (h2-h1) mm | L-Box (h2/h1) mm |
|--------------|-----------------|-----------|---------------------|------------------|------------------|
| M CONTROL    | 550             | 5.5       | 12.05               | 30               | 0.82             |
| Alccofine -10% | 640           | 4.35      | 10.85               | 28               | 0.87             |
| Alccofine -20% | 655           | 3.75      | 9.25                | 25               | 0.92             |
| Alccofine -30% | 670           | 3.62      | 8.55                | 23               | 0.93             |
| Alccofine -40% | 655           | 3.55      | 8.34                | 24               | 0.93             |
| Alccofine -50% | 645           | 3.89      | 8.29                | 26               | 0.92             |
The Marsh cone test is a basic method for evaluating the rheological activity of cement pastes. To identify maximum super-plasticizer saturation point, whereas these dosage beyond which the flow time does not decline appreciably, this has already been used during cement-based materials design mix. Taking into the account the experiment used for the monitoring of post-tension grouts with just a 10 mm nozzle and a viscosity below 200 mPa, it can be shown that the flow time may not always be intimately proportional to the viscosity that use the past findings.

Table 3. Super Plasticizer vs Flow time

| Ordinary Portland Cement (OPC 53 Grade) | Super plasticizer (SP) dosage ( % of cement mass) | Flow time (in seconds) |
|----------------------------------------|---------------------------------------------|----------------------|
|                                        | 0.1                                         | 56.65                |
|                                        | 0.2                                         | 49.89                |
|                                        | 0.4                                         | 36.45                |
|                                        | 0.8                                         | 26.99                |
|                                        | 0.87                                        | 21.33                |
|                                        | 0.9                                         | 22.45                |
|                                        | 1                                           | 24.17                |

Distinct mechanical properties, such as compressive strength and split tensile strength, must be investigated experimentally in different specimens. Within each mechanical characteristics, the size of the specimens has to be determined and analysed. The SCC specimen descriptions and work scheme are shown in Table . The structural properties of the different mineral admixture replacements of specimens, such as 10%, 20%, 30%, 40%, and 50%, were investigated in this study. For 7 days, 28 days and 56 days, the respective samples were cast and examined. The functional necessity of a joint, which is also the beams and columns conjunction region, is to allow the adjacent members to build their ultimate ability and retain it. The demand on this finite-size factor is always strong, particularly during earthquakes. The joints must be solid and stiff enough to withstand the internal forces exerted by a framing members. Saturated moisture content, porosity, acid resistant, sulphate attack, carbonation depth, alkalinity assessment was moisture-curing with each combination after 28, 56 and 90 days. The Indian Standard mixtures were prepared (by weight) is used in mixes of traditional 1 : 2.07 : 0.5 : 2.82 after many trials for durability studies. For weight, the water/cement ratio were 0.45.

The aim of this durability study was to examine into drying and shrinkage, degradation, and water absorption for Alccofine-based self-compacting concrete in compliance with codal requirements. Saturated water absorption experiments were performed on 100 mm cube specimens at 28, 56, and 90 days after curing according to ASTM C 642. Figure displays the overall dimensions as well as the specifics of the beam-column joint reinforcement. The column were strengthened with four deformed high yield strength (HYS) bars of 10 mm diameter and four HYS bars of 10 mm diameter at the top and bottom were supplied to the beam. Transverse links in the columns and stirrups throughout the beams were made of 8 mm HYS bars.

Table 4. Strength Parameters of Alccofine blended with SCC

| MIX       | Slump (mm) | Compressive Strength (MPa) | Split Tensile Strength (MPa) |
|-----------|------------|----------------------------|------------------------------|
|           | 7 days     | 28 days | 56 days | 7 days | 28 days | 56 days |
| Control Mix | 550        | 18.48   | 48.21   | 54.21  | 1.99   | 3.4     | 5.41    |
| Alccofine -10% | 640        | 19.04   | 47.12   | 57.34  | 2.08   | 4.21    | 5.12    |
| Alccofine -20% | 655        | 20.79   | 51.16   | 53.16  | 1.97   | 4.18    | 4.98    |
| Alccofine -30% | 670        | 18.25   | 46.85   | 51.65  | 1.88   | 4.13    | 4.76    |
| Alccofine -40% | 655        | 17.28   | 45.21   | 49.21  | 1.76   | 4.03    | 4.58    |
| Alccofine -50% | 645        | 15.49   | 43.21   | 47.21  | 1.44   | 3.4     | 4.33    |
4. Analysis of Beam–Column Joint

Finite Element Methods are highly versatile and powerful, enabling designers to learn more about behaviour of complex structures under virtually any load. The obtained results must also be closely analysed before which can be used, considering the negligible advancements that have already been made in designing finite element packages. Four different replacements of ALCCOFINE as 20%, 30%, 40% and 50% were used. At 10% and above 50 percentage of replacement of admixture, concrete mix became less workable, and hence, only the above mentioned mixes were considered in this study.

A total of five cast beam columns, one is a conventionally reinforced concrete beam column under the loading monotonic loading frame of 1000kN capacity, all beam columns were examined. With simply supported conditions under two-point loading, these beam-columns were checked. With LVDTs, deflections were assessed under the loading point and at the mid span. In reinforced concrete framed structures, beam-column joints are essential sub-assemblages that ensure structural contribution and move forces from one part to another. The specimens of the beam-column joint were subjected to monotonic loading at the beam tip. The aim of the loading pattern is to generate forces that replicate high levels of inelastic deformation during a serious earthquake. The testing results showed that a higher percentage of relatively fine powdered materials in the combination resulted in significantly greater value of slump (as seen in Fig) and self-compaction. The test results also confirmed that blends with a higher powder content and a lower coarse aggregate achieved a faster slump of 500 mm in less time in T 50 Slump test. The flow time was lowest for the mix containing less coarse aggregate and more fine powder materials, according to V-funnel test results. According to the findings of the L-box apparatus, the blocking was small for a mix containing minimal coarse aggregate, and the ratio was equal to 1.

5. Mechanical Behaviour of Alccofine based Self Compacting Concrete

The mechanical strength have been increased by 23% when the control mix with 0% Alccofine has been compared to 10% cement which holds the greater strength parameters substituted by Alccofine after 28 days of curing among all the mixes, according to the experimental results. The results show which only a 10% substitution of cement with Alccofine material improves the strength. If the quantity of alccofine in the concrete is elevated above that amount, it functions as a filler and gives the concrete good workability. Concrete prices would be higher since the components are more costly than cement, but this can be changed during the prosecution of structures. Later, performing durability tests on the Alccofine content, it is suggested that it be used with cement.
Table 5a. Water Absorption, Porosity and Carbonation depth

| ALCCOFINE (%) | Water Absorption (%) | Effective Porosity (%) | Penetration Depth (mm) |
|---------------|----------------------|------------------------|------------------------|
|               | 28 days              | 56 days                | 28 days                | 56 days |
| 0%            | 3.63                 | 3.45                   | 6.70                   | 6.43    | 58     | 51     |
| 10%           | 3.57                 | 3.25                   | 6.66                   | 6.31    | 47     | 40     |
| 20%           | 3.24                 | 3.12                   | 6.26                   | 6.00    | 42     | 34     |
| 30%           | 2.92                 | 2.70                   | 6.00                   | 5.81    | 40     | 32     |
| 40%           | 2.45                 | 2.41                   | 5.20                   | 5.00    | 37     | 30     |
| 50%           | 1.94                 | 1.86                   | 4.30                   | 4.00    | 35     | 29     |

Table 5b. Alkalinity, Acid and Sulphate Resistance

| ALCCOFINE (%) | Alkalinity (pH) | Average Loss in weight by Acid Attack (%) | Average Loss in weight by Sulphate Attack (%) |
|---------------|----------------|------------------------------------------|---------------------------------------------|
|               | 28 days        | 56 days                                  | 28 days                                     | 56 days |
| 0%            | 11.8           | 11.61                                    | 3.94                                        | 4.54 |
| 10%           | 11.0           | 10.57                                    | 3.86                                        | 3.93 |
| 20%           | 10.8           | 10.13                                    | 3.38                                        | 3.43 |
| 30%           | 10.4           | 9.94                                     | 2.68                                        | 2.93 |
| 40%           | 9.93           | 9.60                                     | 1.98                                        | 2.76 |
| 50%           | 9.79           | 9.25                                     | 1.51                                        | 2.26 |

Table 6 Load-Deflection reading for Control Mix.

| Deflection | Control Mix | Deflection Alccofine 10% | Deflection Alccofine 20% | Deflection Alccofine 30% | Deflection Alccofine 40% |
|------------|-------------|--------------------------|--------------------------|--------------------------|--------------------------|
| End Joint  | End Joint   | End Joint                | End Joint                | End Joint                | End Joint                |
| 0          | 0           | 0                        | 0                        | 0                        | 0                        |
| 5          | 0.86        | 0.15                     | 0.60                     | 0.42                     | 0.56                     |
| 10         | 1.23        | 0.21                     | 1.39                     | 1.06                     | 1.02                     |
| 15         | 2.08        | 0.35                     | 2.30                     | 2.02                     | 2.00                     |
| 20         | 3.48        | 0.60                     | 2.69                     | 2.82                     | 2.42                     |
| 25         | 5.17        | 0.88                     | 3.10                     | 3.00                     | 3.00                     |
| 30         | 6.93        | 1.18                     | 4.90                     | 4.00                     | 3.88                     |
| 35         | 7.61        | 1.30                     | 6.53                     | 7.12                     | 5.42                     |

The figure shows a typical load-deflection diagram through joining the peak points, the envelope curve is formed. On graphs, the loads and associated deflections for control mix, Alccofine 10%, Alccofine 20%, Alccofine 30%, Alccofine 40%, And Alccofine 50% specimens were mapped. These results were obtained by the load test performed on the corresponding samples.
6. Conclusions

Based on the experimental the following conclusion is drawn within the limitation of test result. For 30% Alccofine replacement, the fresh properties observed were good as compared to 10%, 20%, 40% and 50% ALCCOFINE replacement. Hence if we increase the Alccofine replacement we can have a better workable concrete. The dosage of VMA should be properly designed as it may change the basic criterion of SCC. In other words, the flow ability may fall below 500 mm slump if the dosage of VMA is more than desired.

The locally available Viscosity Modifying Admixture (VMA) has a substantial influence on the fresh properties of SCC. A small change in VMA dose makes a substantial change in SCC properties i.e., flowing ability, passing ability, stability and segregation resistance. A sequential method of adjusting the mix proportions by increasing the fine aggregate content and decreasing the coarse aggregate content helps to obtain SCC mix without any segregation. Addition of Alccofine results in obtaining more viscous mix and also for 30% Alccofine replacement, the compressive strength observed higher as compared to 10%, 20%, 40% and 50% Alccofine replacement. The SCC mixes shows higher value of ultimate capacity of about 1.33 times than the control mix.

The SCC beam-column failed due to crushing of concrete with an explosive sound. The load carrying capacity of the beam-column increases up to 30% replacement of Alccofine mix, then decreases, from all the mixes, maximum ultimate load was obtained for Alccofine -30%. Compared to control beam-column joint, increase in first crack load was observed for beam-column joint with 20% and 30% Alccofine respectively. Increasing the replacement rates of mineral admixtures have decreased compressive strength and increase both split tensile strength.

7. Discussions

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