RESEARCH ON SELF COMPACTING'S DURABILITY RENEWABLE AGREGATE GGBS CONCRETE USED IN CONCRETE

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ABSTRACT

Self-compacting concrete is a fluid mixture that may be applied without vibration to constructions with crowded reinforcing. The use of SCC can also aid in reducing hearing-related harm caused by concrete vibration at the job site. In order to comprehend the fresh features of Self Compacting Concrete, experimental research are conducted in this study. Self Compacting Concrete (SCC) prepared using Recycled Concrete Aggregates (RCA) as a partial replacement of Natural Coarse Aggregates (NCA) and contains GGBS as cement replacement with adding Super Plasticizer is the subject of the current investigation. For M30 Grade and M40 Grade, the cement is substituted with 30% GGBS as optimal and 20% as optimal, respectively. The effect of RCA on fresh properties of SCCs was measured using Slump flow test, V-funnel test, L-box test. Whereas the durability properties like acid resistivity and rapid chloride permeability were investigated to study the effect of RCA on SCC. This investigation is to examine the durability properties of SCC having Different Grades by conducting various tests.

Key Words: Self compacting concrete, GGBS, Recycled coarse aggregate, Super plasticizer, Fresh properties, Acid resistivity, Rapid chloride permeability test

INTRODUCTION

Fresh concrete that has the potential to flow while maintaining stability (i.e., no segregation) is known as self compacting concrete (SCC), which enables material consolidation without external vibration. Concrete self-compacting is characterized by three characteristics: The capacity to completely fill all nooks and crannies of the formwork in which it is positioned.

Ability to go through a crowded reinforcement without separating its components or blockage. Segregation resistance: The capacity to keep the coarse mix components suspended to preserve homogenous material.

SCC offers many advantages for the precast,Pre stressed concrete industry &construction. some of them are:

1. Low noise level at the construction sites.
2. Eliminated problems associated withvibration.
3. Less labor involved.
4. Faster construction.
5. Improved quality and durability.
6. Higher strength.

LITERATURE REVIEW

KC Panda et al "Properties of SCC using recycled coarse aggregate" ProcediaEngineering, pp.159-164, 2013.

This paper presents the influence of different amounts of recycled coarse aggregate obtained from a demolished about 25 years old on the properties of self compacting concrete (SCC) and comparedthe results with normal vibrated concrete containing 100% natural coarse aggregate (NCA).The test results indicate that the compressive strength, flexural strength and split tensile strength of SCC is less than the NVC. The compressive strength, flexural strength and split tensile strength of SCC decreases with increase in the amount of RCA. RCA show higher water absorption compared with conventional NCA due to old mortar attached with original concrete and has relatively lower specific gravity.

Prashant O. Modani et al "Self- compacting concrete with recycled aggregate: A solution for sustainable development"International Journal Of Civil And Structural engineering Volume 4, No 3, 2014.

This investigation is an attempt to examine the influence of recycled aggregate onstrength, permeability, resistance to acid attack, chloride penetration, and alkalinity of self compacting concrete. It is observed that recycled aggregate can be effectively used in the production of SCC without any significant reduction in strength and durability. There is a significant potential forgrowth of recycled aggregate as an appropriate and green solution for sustainable development in construction industry. Self-compacting concrete madewith recycled aggregates have achieved the target strength in all the mixes and also satisfied the fresh state properties required for SCC as per EFNARC specification. It was observed that the mixes containing recycled aggregate gains quick early strength due to presence of partially hydrated cement adhered to aggregate whichaccelerates the hydration process.

Shahil M. Bandi et al "Study on Fresh and Hardened Properties of SelfCompacted Concrete Using Recycled Concrete Aggregate" IJIRCT ,Vol5,Issue 5,2016.

This paper presents an experimental investigation on strength aspects likecompressive and split tensile strength of self-compacting concrete using recycled concrete aggregate and workability tests like(slump, L-box, J-ring, V-funnel and V- funnel T50) are carried out. In this study, it has been found that the workability increase with increase in dosage of super plasticizer. Higher dosage of super plasticizer can lead the high degree of segregation in SCC and after 24 hours when try to demouled cubes AND cylinder then it can collapsed. RCA show higher water absorption compared with conventional NCA due to old mortar attached with original concrete and has relatively lower specific gravity. The workability decreases with increases RCA replacement to natural aggregate because of weak properties of RCA than natural aggregate.

C. Sumanth Reddy & et al "Mechanicaland Durability properties of SelfCompacting Concrete withrecycled concrete aggregates "InternationalJournal of Scientific &Engineering Research Volume 4, Issue 5, May-2013. This work explores the possibility of usingSCC produced using recycled concrete aggregates as new structural concrete. To accomplish that themechanical and durability properties of the concrete arestudied. The processing of recycledaggregates play a crucial role in determiningthe strength and ability of consequentconcrete and a direct relationship can beestablished between them. RCA concreteperformance deteriorated with increase ingrade of concrete suggesting that caution isto be exercised when using RCA for highergrade concretes.

Considering a cursoryanalysis of water sorption results, it can beconcluded that it is safer to replace as muchas 25% of aggregates with RCA withoutsignificant effects in developed concrete.

OBJECTIVES

To determine the durability properties of self compacting concrete with replacing cement by GGBS and Coarse aggregate is replaced by Recycled coarse aggregates.

Grade of the concrete is M30 and M40

Objectives

To determine the fresh properties of Self compacting concrete(SCC) with recycled coarseaggregates (Slump flow test, V funnel test, L-box test etc) and partial replacement of cement by GGBS with optimumpercentage. To determine durability properties of self compacting concrete byconducting

1. Rapid chloride permeability test
2. Acid attack

METHODOLOGY

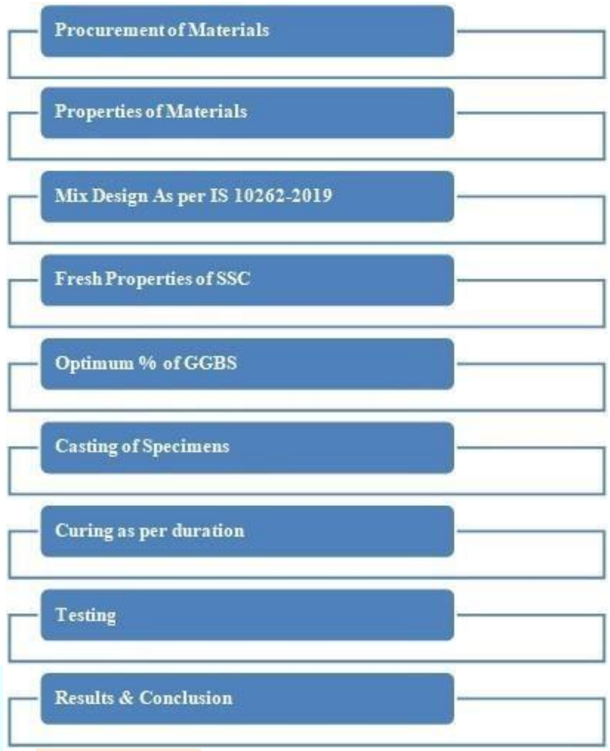


Figure 4. 1 Methodology Chat

EXPERIMENTAL PROGRAMME

Material Properties

Cement, Coarse aggregate, Recycled coarse aggregate, Fine aggregate, Fly ash, Conplast SP-430 and water are the materials which are used in this investigation. The properties of materials are to be found be conducting various tests.

Cement

Fineness: Ordinary Portland cement of 53 grade is used. IS specifies that the Fineness of Cement should be less than 10%. The finenss of cement is measured using 90 microns IS sieve. 100 grams of cement which is free from lumps is taken. Weight of cement retained on 90 microns is measured after completion of sieving. The weight retained on sieve gives fineness of the cement. A weight of 5gm retained on 90 microns sieve, so fineness of the cement obtained is 5% which is within the IS specification.

Specific Gravity: Specific gravity isnormally defined as the ratio between theweight of the given volume of cement toweight of an equal volume of a cement sample and its volume measuring the liquid displaced by cement sample. IS specifies that the average specific gravity of Ordinary Portland cement is normally around 3.15.Specific gravity is found using specific gravity bottle (w1) is taken and then its filled with distilledwater and weight (w2) is noted. Now fill the bottle with kerosene and weighted (w3). Remove some amount of kerosene and 10 gm of cement is added.Now fill the remaining part with kerosene and weight (w4) . Specific gravity is calculated by using the following empirical formula.

Specific gravity of cement = $w5(w3-w1)/(w2-w1)(w5+w3-w4)$

By following above process the obtained specific gravity is 2.97. The obtained specific gravity is within the limit 3.15.

Table 5. 1 Properties of Cement

Normal Consistency: This is the main parameter to know to calculate Initial, final setting times, soundness of cement and strength. The Standard or Normal consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10mm dia and 50mm length to penetrate to a depth of 33-35mm from the top of the vicat mould. The obtained normal consistency is 32.

Initial setting time: Setting time is the time required for stiffening of cement paste to a defined consistency. Initial setting time isthe time elapsed between the moment that the water added to the cement, to the time that the paste starts losing its plasticity. Initial setting time was obtained as 65 min for OPC 53 grade Jaypee Cement.

Final Setting time: It is the time taken between adding of water to the cement and the time when the cement lost its plasticity

Property	IS Specifications	Result Obtained
Fineness	Less than 10	5
Specific	Around 3.15	2.97

completely. Vicat apparatus is used to find out the Normal consistency of cement, initial & final setting times.

Physical properties of aggregate

Specific Gravity: Usually specific gravity of coarse aggregate varies in between 2.5to 3.0 and the specific gravity of fine aggregatevaries in between 2 to 2.5. Specific gravity is found by using a container. Initially the weight of the container is measured (w1). Now fill the container with aggregate up to top of the container not exceeding 5cm above the top of container and weight it (w2).

Specific Gravity of aggregate = (w2- w1)/(w4-w1-w3+w2)

From the above equation the specific gravity of coarse aggregate obtained for NCA is 2.664 for 10mm size and 2.7 for 20mm of size aggregate. The specific gravity ofcoarse aggregate obtained for RCA is 2.815 for 10mm size aggregate and 2.909 for 20mm aggregate. The obtained specific gravity is within the limits that are specified. Specific gravity of fine aggregate is found tobe 2.295 which is within the limit 2 to 2.5. As the obtained values are within the limits we can use these aggregates.

Bulk Density: Bulk density is the unit weight of material per unit volume. The quantities required for finding Bulk density is same as the quantities of specific gravity. The bulk density is found by using empiricalformula as given below.

Bulk density = (w2-w1)/(w4-w1)

It is found that the bulk density of NCA is

1.39 g/cc for 10mm size of aggregate and 1.62g/cc for 20mm of aggregate. For RCA bulk density is found to be 1.378 g/cc for 10mm aggregate. The decrease in the bulk density is due to the presence of mortar around the RCA. The bulk density for fine aggregate is found to be 1.54g/cc.

Fineness modulus: Fineness modulus is a numerical of fineness, giving some idea of the mean size of particles present in the entire body of the aggregate. It is defined as sum of the cumulative percentages retained on sieves of standard seizes divided by 100. Initially 5 kg of coarse aggregate is weighed. IS sieves of sizes 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600 microns, 300 microns and 150 microns are arranged in Accordingly and initial weights are measured. This 5 kg sample is sieved and the weight of each sieve is measured and cumulative percentage of weight retained is calculated. Fineness modulus is obtained by dividing this cumulative percentage of weight retained by

100. The obtained Fineness modulus for NCA is 7.21 and for RCAis 7.25. Fineness modulus = Cumulative percentage weight retained/100 For fine aggregate 1 kg of sample is taken and the sieves are 4.75mm, 2.36mm,1.18mm, 600microns, 300 microns, 150 microns are arranged accordingly and empty weights are taken. After sieving the weights retained on each sieve are noted down and cumulative percentage of weight retained is calculated. Thus the Fineness modulus of Fine aggregate is calculated by dividing this cumulative percentage of weight retained by 100. For fine aggregate Fineness modulus obtained is 3.11.

Table 5. 2 Properties of Aggregates

Characteristics	Natural coarse aggregate		Recycled coarse aggregate		Fine aggregate
	10mm	20 mm	10mm	0mm	
Specific gravity	2.664	2.7	2.815	2.909	2.295
Bulk density	1.39	1.62	1.378	1.354	1.54
Fineness modulus	7.21		7.252		3.11

IMPACT VALUE

The aggregate impact value indicates a relative measure of the resistance of aggregate to sudden shock or impact. The impact value test is conducted under impact testing machine which consists of a metal hammer of weight in between 13.5 to 14 kg and cylinder in shape. This hammer is allowed to fall on the test sample from a height of 38cm. A cylindrical metal having internal diameter of 7.5 cm and depth of 5 cm is used for measuring aggregate. The sample is taken such that it is passing through 12.5mm and retained on 10mm sieve. The aggregates are filled up to 1/3rd full in cylinder and 25 strokes are given by tampering rod.

Surplus aggregates are stuck off by usingtampering rod as straight edge. Initially the weight of cylinder is taken and fill the cylinder with the sample of aggregates that passing through 12.5mm and retained on 10mm sieves. Measure the weight of the cylinder along with the aggregates. From this we can calculate the weight of aggregates(w1) that is used for filling cylinders. Now this aggregates is subjected to 15 blows by raising the hammer to a height of 38cm under impact testing machine. The crushed aggregate is then removed from the cup and the whole is sieved on 2.36mm until no further significant amount pass. The weight of aggregate amount passing through 2.36mm sieve is measured (w2).

Impact value = weight retained on 2.36mm sieve(w2)/total weight aggregatesample(w1)

The impact value for NCA obtained by following above process is 20% and the impact value of RCA obtained is 13.33%. For the impact values between 10 to 20 the toughness property is very tough and strong. Thus the sample of aggregate which weare using is very strong.

Table 5. 3 Impact Test properties

Aggregate Impact value(%)	Toughness Properties
<10	Exceptionallytough/strong
10-20	Very tough/Strong
20-30	Good for pavement surfacecourse
>35	Weal for pavement surfacecourse

Flakiness index

The flakiness index of aggregates is the percentage by weight of particles whose least dimensions is less than 3/5 or 0.6 of their mean dimensions. This is not applicable for sizesmaller than 6.3mm. The sample is sieved through IS sieves. A minimum of 200 pieces of each fraction is taken and weighed. In order to separate flaky materials, each fractionis then gauged individually for thickness on a thickness gauge having sizes of 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 12.5mm, 10mm and6.3mm.

The total amount of flaky material retained by the thickness gauge is weighed to an accuracy of 0.1% of the weight of sample. In order to calculate the flakiness index of the entire sample of aggregates, first the weight of each fraction of aggregate passing and retained on the specified set of sieves is noted (Y1, Y2, Y3, Y4 etc). Each piece of these are tried to be passed through the slot of the specified thickness of the thickness gauge are found and weighed (Y1, Y2, Y3, Y4 etc). Then the flakiness index is the percentage of materials passed through the thickness gauge on the various thickness gauges, expressed as a total weight of the sample gauged.

The Flakiness Index obtained for RCA is 8%.

Elongation Index: The Elongation index of aggregates is percentage by weight of particles whose greatest dimensions is greater than 4/5 or 0.8 times their mean dimensions. The elongation is not applicableto size smaller than 6.3. Surface dry samplesis used for the test. A minimum number of

200 pieces of any specified fraction isrequired to do the test. The sample is sieved through IS sieve as if as mention in flakinessindex. A minimum of 200 pieces of each fraction is taken and weighed. In order to separate elongated materials, each fraction isthen gauged individually for length in the length gauge.

The pieces of aggregate from each fraction tested which could not pass through the specified gauge length with its long sides elongated are collected separately to find the total weight of aggregate retained on the length gauge from each fraction. The total amount of elongated material retained by the length gauge is weighted to an accuracy of 0.1% of the weight of the sample. In order to calculate the elongation index of the entire sample of aggregates, first the weight of each fraction of aggregates passing & retained on the specified set of sieves is noted(Y1, Y2,Y3,Y4…etc). each piece of these are tried to be passed through specified length of the gauge length with its longest side and those elongated pieces which do not pass the gauge are separated and weighed(Y1, Y2, Y3,Y4…..etc). Then the elongated index is the total weight of the material retained on the various length gauges, expressed as apercentage of the total weight of the sample gauged.

The obtained elongation index for RCA is43% Un Processed Recycled CoarseAggregates:

Recycled Coarse Aggregates obtained by crushed concrete were used for concrete production. Conservation of resource isalways the need of human kind. In the starting of era/civilization, we have used the resources but soon after we have started over exploitation, this result in the scarcity of resources. Later on we have known the fact that we need to conserve the resources. Thus humans have decided that we have to use resources efficiently and wisely. Thisphenomenon is discussed by using the principleof 3R i.e. reduce, reuse and recycle.Our study primarily focuses on these "3R".we have use the already made cubes from the laboratory.

Figure 5. 1 Unprocessed Recycled coarseaggregate

Fly ash

Fly ash is generally used material in concrete as it has got some special characteristics like strength increasing and making concrete workable. Over 100 milliontons of fly ash is generated from nearly 100 thermal power stations. But the qualities of fly ash generated in many of the thermalplants are not of right quality, fit for usingin concrete. In western countries the fly ash generated in thermal plants are furtherprocessed to render it fit for using in concrete. In India, the processing of fly ash just started at Nashik thermal plant by one organization named Dirk India Pvt Ltd. Earlier the use of fly ash in concrete was notallowed in India due to the poor quality of fly ash in concrete was not allowed in India due to the poor quality of fly ash, lack of general awareness and fear psychics on part of users.

This makes PPC to not become muchpopular. After in 2000's the production of PPC to was about 19% of total cement production. But today it has become more important and we are using it in every construction. The use of fly ash in concrete has rapidly increased. Now the uses of fly ash in concrete works are of about 75%.This shows the importance of it. It is an industrial waste bi-product. So, it is an economical constraint in every concrete work.

Ground Granulated Blast Furnace Slag(GGBS)

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of Iron industry and which is obtained from during the manufacture of iron. The molten slag is secondary product of sintering of the raw materials and this is quenched under high pressure of water jets, which results as granulates. In the case of pig ironmanufacture the flux consists mainly of a mixture of limestone and forsterite or withinsome cases dolomite. In the blast furnace theblast float on top of the iron and decant for separation. Slow cool of slag melts result in an uncreative crystalline material consisting of collection of Ca-Al-Mg Silicates.

Towards get a good slag reactivity orhydraulicity, the slag liquefy desires to be rapidly cooled or quench below 800 °C in order to avoid the crystallization ofmerwinite and melilite. In this research, commercially obtainable GGBS particle size less than 20 Nano meters was supplied by ASTRRA chemicals pvt, Chennai with specific gravity was used for all concrete mixtures. Specific gravity shell area of Ground GranulatedBlast furnace Slag is 400m2/kg.

Figure 5. 2 Ground Granulated BlastFurnace Slag SUPERPLASTICIZERS

Super plasticizers are one type of admixtures generally used in concrete. These constitute a relatively new category and improved version of plasticizer, the use of which was developed in Japan and Germany during 1960 and1970 respectively. They are chemically different from normal plasticizers. Use of superplasticizers permit the reduction of water to the extent up to 30% without reducing workability in contrast to the possible reduction up to 15% in case of plasticizers. The use of super plasticizer is practiced for production of flowing, self-levelling, self-compacting tremie concreting and for the production of high strength and high performance concrete.

The use of super plasticizer in concrete is animportant milestone in the advancement of concrete technology. Since their introduction in the early 1960 in Japan andin the early 1970 in Germany, it is widely used all over the world. India is catching up with the use of super plasticizer in the construction of high rise buildings, long span bridges and the recently become popular Ready Mixed Concrete Industry. Common builders and Government departments are yet to take up the use of thisuseful material. Super plasticizers can produce

Figure 5. 3 Conplast SP 430

Table 5. 4 Super Plasticizer Properties

S. No	RCA%	M30 Grade	M40 Grade
1	0	8.35	8.30
2	25	8.57	8.49
3	50	8.62	8.53
4	100	8.64	8.53

S. No	Property	Specification
1	Appearance	Brown liquid
2	Specific gravity	1.18 @ 25º C
3	Chloridecontent BS	5075 / BS :EN 934
4	Air entrainment	Less than 2% additionalair is entrained at normaldosages

RESULTS & DISCUSSIONS

In this work OPC 53 grade cement was used as per the code IS 12269 -2015. Fine aggregate used as Zone-2 according to IS383-1970. The super plasticizer Conplast SP- 430 & Fly ash and GGBS was used. Specimens are casted manually and tested. Acid attack Results: Cubes was tested foracid attack and the weights are taken after28 days water curing as initial weights.

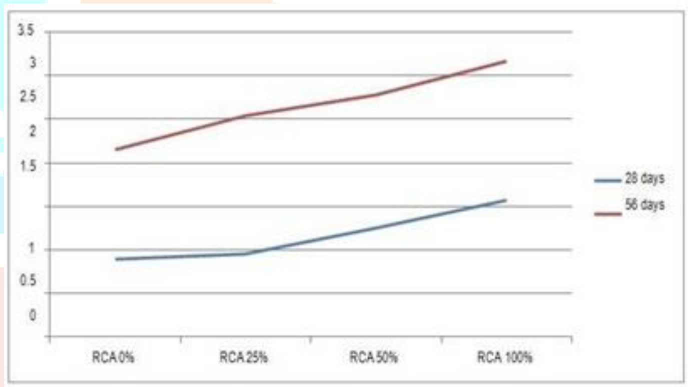
Acid attack test was done for both GradesM30 & M40.

Table 6. 1Initial weights of test specimens Acid attack Results M30 Grade

Table 6. 2 Acid attack Results M30 Grade

S. No	Mix Type (RCA %)	28 Days		56 Days	
		ght Loss(%)	Loss in Compressive strength (%)	ght Loss(%)	Loss in Compressiv estrength (%)
1	0	0.89	2.15	1.57	3.83
2	25	0.95	2.54	2.92	4.12
3	50	1.25	2.78	3.15	4.94
4	100	1.57	3.17	3.98	6.23

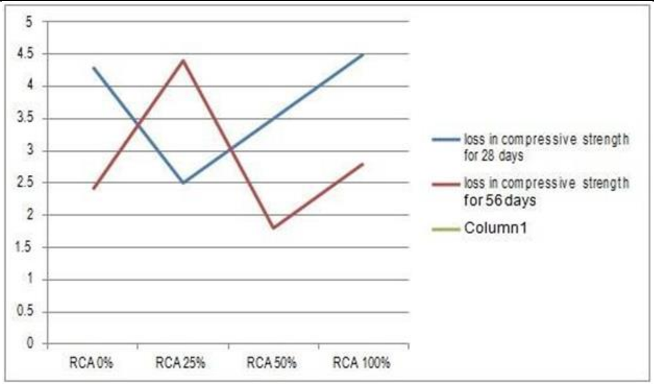
Graph 6. 1 Comparison b/w 28 days& 56 days weight loss %



Graph 6. 2 Comparison b/w loss in Compressive strength in 28 & 56 daysAcid attack test results for M40 as follows Acid attack Results M40 Grade

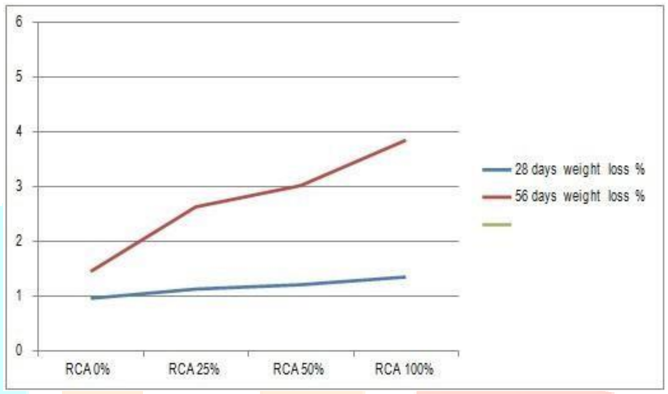
Table 6. 3 Acid attack Results M40 Grade

S. No	Mix Type(RCA %)	28 Days		56 Days	
		Weight Loss(%)	Loss in Compressive strength (%)	Weight Loss(%)	Loss in Compressive strength (%)
1	0	0.96	2.05	1.45	3.62
2	25	1.13	2.32	2.63	4.02
3	50	1.21	2.42	3.02	4.75
4	100	1.35	3.05	3.85	6.05



Graph 6. 3 Comparison b/w weight loss % in 28 & 56 days

Graph 6.4 Comparison b/w loss in compressive strength in 28 & 56 day



Rapid chloride Permeability Test ResultsRapid chloride Permeability test was done for Concrete of Grades M30 & M40. And theresults are tabulated below.

Q = 900 (I0+2 I30+2I60+2I90+2I120+2I150+2I180+2I210+………+2I360)

Q = Current flowing through one cell(Coulombs)

I0 = Initial current reading in amperesimmediately after voltage is applied

I_t = Current reading in amperes at t minutesafter the voltage is applied

RCPT Specifications

Table 6. 4 RCPT Specifications

100-1000	Very Low
<100	Negligible

M30 Grade RCPT Results

Table 6. 5 RCPT Test results sample 1

S. No	Channel	Charge in Coulombs	Chloride Permeability
1	R-0	835	Very Low
2	R-25	720	Very Low
3	R-50	685	Very Low
4	R-100	690.9	Very Low

M30 Grade RCPT Results

Table 6. 6 RCPT Test results sample 2

Charge (Coulombs)	Chloride Permeability
>4000	High Permeable Concrete
2000-4000	Moderate
1000-2000	Low

S. No	Channel	Charge in Coulombs	Chloride Permeability
1	R-0	842	Very Low
2	R-25	769	Very Low
3	R-50	745	Very Low
4	R-100	675	Very Low

CONCLUSIONS

Based on the investigation conducted for the durability study on behavior of self- compacting concrete the following conclusions are arrived.

1. As per IS 10262-2019 the mix design can be done and suitable adjustments can be done as per the guidelines provided by different agencies.
2. So, we should made trail mixes for maintaining filling ability, flowing ability, passing ability, self compatibility and obstruction clearance.
3. By making the replacement of cement withGGBS increases consistency.
4. With the use of super plasticizer it possible to get a mix with low water to cement ratio to get the desired strength.
5. In this project we done Durability tests. The compressive strength of normal concrete is equal to the normal strength of 25% Fly ash and 30% GGBS.
6. Durability properties of concrete of the following mix was taken as optimum i.e 30% GGBS and 25% Fly ash, if we increasethe percentage again the strength decreases.
7. In this project along with Cementecious material, Coarse aggregates are partially replaced by Recycled coarse aggregates. As we increase the % of RCA strength decreases. Recycled aggregates absorb more water compared to natural aggregatesbecause of the mortar attached on the recycled aggregates.
8. In Acid attack test, I concluded that weight loss is little more in 56 days compared to 28 days and compressive strength is reduceddue to weight loss. Strength is more for Natural aggregate concrete as compared to Recycled Coarse aggregate concrete.
9. In Rapid chloride permeability test, the concrete Permeability is Very low because the charge is less than 1000 Coulombs.

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