REPLACEMENT OF QUARRY WASTE AS FINE AGGREGATE IN THE PREPARATION OF SELF-COMPACTING CONCRETE

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ABSTRACT

The increased emphasis on the life-cycle cost analysis for building project requires that new attention to be focused on service life and durability of concrete structures. Durability is the ability to resist weathering action, chemical attack or any other process of deterioration. Concrete's great versatility and relative economy in filling wide range needs has made it a competitive building material. This high demand for concrete in construction lead to the increase in the release of carbon dioxide in cement production and also to the scarcity of natural river sand. So there is an urge to replace the conventional self-compacting concrete materials. Materials like Fly-ash and Quarry dust (QD) are chosen based on the criteria of cost and mechanical properties. This project is concerned with the evaluation of changes in compressive strength and split tensile strength in different mixes of M40 Grade self-compacting concrete which include conventional aggregate self-compacting concrete, concrete with replacement of cement by fly ash and fine aggregates with varying percentages of 0%, 10%, 20%, 30%, 40%, by Quarry Dust (QD). We can conclude that concretes made by Fly ash and Quarry Sand Dust have given good strength and durable properties when compared to conventional self-compacting concrete in severe environment.

Keywords: Fly ash, Quarry dust (QD), M40 Grade concrete.

1. INTRODUCTION

Self-Compacting Concrete was first developed in 1986 in Japan to achieve durable concrete structures since then, various investigations have been carried out and mainly large construction companies have been used this type of concrete in practical structures in Japan. SCC is a new kind of high-performance concrete (HPC) with excellent deformability and segregation resistance. It is a special kind of concrete that can flow through and fill the gaps of reinforcement and corners of moulds without any need for vibration and compacting during the placing process. Though showing good performance, SCC is different from HPC developed in North America and Europe, which emphasizes on high strength and durability of concrete. In terms of workability, HPC may improve fluidity of concrete to facilitate to placing. However, it cannot flow freely by itself to pack in every corner of moulds and all gaps among reinforcement. In other words, HPC steel requires vibration and compaction in the compaction process. Comparatively, SCC has more favorable characteristics such as high fluidity, good segregation resistance and the distinctive self-compacting ability without any need for vibration during the placing process. To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of concrete thus obtained. In practice, SCC in its fresh state high fluidity, self- compacting ability and segregation resistance, all of which contributing to reducing the risk of honey combing of concrete. With these good properties, the SCC shows good performance in compressive strength test and can fulfill other construction needs because its production has taken into consideration the requirements in the structural design.

Compared with conventional concrete of similar mechanical properties, the greater material cost of SCC is due to the relatively high demand of cementitious materials and chemical admixtures, including high-range water reducing admixtures and viscosity enhancing admixtures. Typically, content in cementitious material can vary between 350 to 450 kg/m^3 for SCC targeted for the filling of high-restricted areas and for repair applications. Such applications require low aggregate volume to facilitate flow among restricted spacing without any blockage and ensure the filling the form work without consolidation i.e. incorporation of high volumes of fine ground powder materials is necessary to enhance cohesiveness and increase paste volume required for successful casting of SCC.

Igneous and metamorphic rocks cover about 90-95% of the earth's surface. In earth's crust, most abundantly available type of rock is igneous and due to its wide range of physical and chemical properties, enables its use in all different sectors of construction purposes. Most of the high rise mountains, hills, plateaus and surface of the earth, even in oceanic crust consist of igneous rock. The leading manner of extracting rock or stone is through digging, quarrying and blasting. In India, most of the rocks are extracted through quarrying. Quarrying is the process of extracting rock using explosives. 15 The pieces of rock or stone obtained in quarrying are used in either stone masonry or aggregate in building or road construction. In this blasting process of rock, numerous small or fine particles of stones are transformed into dust particles in the atmosphere. These dust particles surround the environment throughout the quarry and get settled on the leaves and bark of trees, thereby killing the tissues of the tree. Hence to reduce air pollution, this quarry dust is used for construction purposes. It is used as a substitute for fine aggregate in concrete either partially or fully. As it is originated from rock, it offers better strength when compared with sand as fine aggregate in concrete. It can also be used in road construction and manufacturing of bricks and tiles. It is the cheap and best material available in the market for construction purposes.

2. LITERATURE REVIEW

Abdullah Anwar *et al.*, (2014) studied the Compressive Strength of Concrete by Partial Replacement of Cement with High Volume Fly Ash and presented a brief review with mixtures containing 10%, 20%, 30% and 40% Fly Ash by the bulk of the cementitious material (OPC) for M30 and M40 grade of concrete. The test result indicates that the compressive strength of mix with 10%, 20% and 30% replaced with fly ash were more as compared with conventional concrete thus enhancing the durability of structures. When the percentage of replacement is increased the water/ binder ratio gets reduced, thereby, increasing the compressive strength. Also, it is observed that the compressive strength of concrete having more than 40% replacement of cement by fly ash suffers adverse effects though water binder ratio is gradually lost weight. The compressive strength of the concrete mix with 40% replacement with fly ash was lesser than the conventional concrete at 28 days. The result obtained for 28 days compressive strength confirms that the optimal percentage for replacement of cement with fly ash is about 30%. Yet, in reality approximately 50% of the Fly Ash produced throughout the world is stockpiled land filled as a wasteland.

Safiuddin *et al.,* (2007) also have tried the partial replacement of sand with quarry dust in fly ash silica fume based concrete and concrete having 20% sand replaced with quarry dust and 10% weight replacement of cement with fly ash and same 10% weight replacement of cement with silica fume by consideration. It was found that quarry dust as fine aggregate enhanced the slump and slump flow of the fresh concretes without affecting the unit weight and air content of the concrete. In hardened concretes, the compressive strength was decreased, the dynamic modulus of elasticity and initial surface absorption were marginally increased. However, the best performance was observed when quarry waste was used in the presence of silica fume.

Shruti *et al.,* (2016) the mechanical behaviour of M20 grade concrete was studied with quarry dust as sand replacement by 25%, 50%, 75% and 100%, ground granulated blast furnace slag (GGBS) as cement replacement by 20%, 30%, 40%, 50% and 60% with plain cement concrete. The optimum replacement of sand by quarry dust recorded from the findings was at 50%. The split tensile strength carried out on specimen with 50% quarry dust replacement on sand and 60% GGBS replacement of cement gave an increase value linearly. Besides, the flexural strength conducted with the same proportion showed an increase value but it did not show the linear value of increased. From the outcome, the 50% or quarry dust and 60% of GGBS by replacement were selected to be incorporated in the concrete in order to achieve maximum mechanical properties.

3. OBJECTIVE AND METHODOLOGY

3.1 Objective

The present study deals with the replacement of cement by Fly ash and replacement of fine aggregates with varying percentages (0, 10, 20, 30, 40%) by Quarry stone Dust for M40 grade of Self-compacting concrete.

i) To study the effect of replacement of different percentages (0, 10, 20, 30, 40%) in fine aggregates by quarry dust and cement by Fly ash in the concrete.

ii) To determine the workability of freshly prepared concrete by Slump test & T_{50} test.

iii) To determine the compressive strength of cubes at 7, 14, 28 days curing

3.2 Methodology

1. The flyash and quarry dust were collected from different sources.
2. Sieved the quarry dust with IS Sieve 4.75mm to IS Sieve 75microns. The passed from 4.75mm and retained on 75microns was used for this study.
3. Physical properties of all materials was tested (mentioned in chapter4).
4. Design mic design of M40 grade concrete was for this study. The partial replacement of cement with fly ash and 10%, 20%, 30%, 40% & 50% of river sand with quarry dust.
5. The fresh properties of self compacting concrete are tested by using slump and T50 test.

6. The harden properties of self compacting concrete is tested by using compressive strength test.
7. Based on the test results, the conclusion will drawn.

4. EXPERIMENTAL WORK

4.1 Materials used

Ordinary Portland Cement of 53 grade with specific gravity 3.15 available in local market, fine aggregate which is chemically inert, clean conforming to grade zone II with specific gravity 2.6 were used. Coarse aggregate of 20 mm size uniform quality with respect to shape and grading conforming to IS standards was used for control concrete and 10 to 12.5 mm size aggregates were used for SCC. Fly ash obtained from NTPC Thermal Power Station (Class F) was used in this investigation to improve workability and durability of SCC. Ceramic waste obtained from 4.75mm IS Sieved passed aggregates are using for partial replacement of fine aggregates. Potable water available in the laboratory was used to cast concrete specimens and for curing.

4.2 PROPERTIES OF MATERIALS

4.2.1 Cement

In this investigation, 53 grade OPC conforming to IS 12269–1987 was used. The cement sample was tested as per the procedure given in IS 4031-1988 and 4032-1985. The physical properties satisfy the requirements of respective codes are listed in Table. 1.

Table. 1: Physical properties of OPC 53 grade cement.

Property	Value	Code recommendations
Specific gravity	3.15	3.10 – 3.15
Consistency	29%	25 – 35
Initial setting time	45mint	Not less than 30mint
Final setting time	6hours 35mint	Not greater than 10hours
fineness	4%	Not greater than 10%

4.2.2 Fine Aggregate

Locally available river sand was used as fine aggregate conforming to grade zone II in this investigation. The sand was cleaned and screened at laboratory to remove deleterious materials and tested according to IS: 383-1970. The results of fine aggregate water absorption was 0.75% and specific gravity was 2.68.

4.2.3 Coarse Aggregate

The coarse aggregate occupies more than 85% of the volume of concrete and their impact on various properties of the concrete is predominant. The maximum size of the coarse aggregate was limited to 20 mm for control concrete and 12.5 mm for SCC. The results of coarse aggregate water absorption was 0.5% and specific gravity was 2.72.

4.2.4 Quarry dust

Quarry dust is a result of crushers while doing quarrying activities. Quarry dust was obtained from nearby quarries at the Medchal. The specific gravity of quarry dust we got 2.7.

4.2.5 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement in concrete. Drinking water available in the laboratory conforming to IS 456-2000 was used to cast concrete specimens and for curing in this investigation.

4.2.6 Fly Ash

Fly ash is a fine residue resulting from the burning of powdered coal at high temperatures. The most common sources of fly ash are electric power-generating stations. Fly ash becomes the predominant pozzolan in use throughout the world due to performance and common factors. In this investigation, class F fly ash obtained from NTPC Thermal Power Station was used. The results of flyash specific gravity was 2.3 and fineness value was 2%.

4.3 Mix design

The concrete mix was designed for M40 grade concrete to study the various properties of the concrete as per IS 10262:2009.

Table. 2: Mix design.

Material	**Kg/m3**
Cement	450
Flyash	150
Water	210
Fine aggregate	746
Coarse aggregate	737
	20 – 10 mm = 442 10 – 4.75mm = 295

Volume of cube = (0.15)3 x 1.1 = 0.0037125

Volume of cylinder = 1.1 X 5.3014 x 10^{-3} = 0.005831

Table. 2: For single cube.

MIX %	**CEMENT**	**FLYASH**	**FA**	**QD**	**CA**	**WATER**
0	1.67	0.556	2.77	0	2.736	780

10			2.63	0.1385		
20			2.5	0.277		
30			2.35	0.4155		
40			2.216	0.554		

4.4 Fresh Properties of SSC

4.4.1 Slump flow test

The slump flow is used to assess the horizontal free flow SCC in the absence of obstruction. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

This is simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is most commonly used test and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can profitably be used to assess the consistency of supply of ready-mixed concrete to a site from load to load.

4.2 Harden Properties of SSC

4.2.1 Compressive Strength

The compressive strength test was carried out on 150 mm x 150 mm x 150 mm cubes as specified by IS 516-1959(1989) as shown in Figure 4.9. This test was carried by using the AIMIL compression testing machine of 2000kN capacity at uniform stress after the specimen had been centred in the test machine. The ultimate load (P) was noted down. The compressive

strength was calculated by using the relationship.

$$\text{Compressive Strength} = (P/A)\ \text{MPa}$$

where,

P is ultimate load in Newton

A is area of cube in mm2.

5. RESULTS AND DISCUSSIONS

5.1 Test Results and Graphs

5.1.1 Fresh concrete properties of SCC

Table. 3: Fresh properties of SCC test results.

Tile waste (%)	Slump value (mm)	T_{50} (sec)	J- ring value (mm)
0	600	4.6	550
10	610	3.4	558
20	615	3.2	560
30	620	3.0	564
40	622	2.6	568

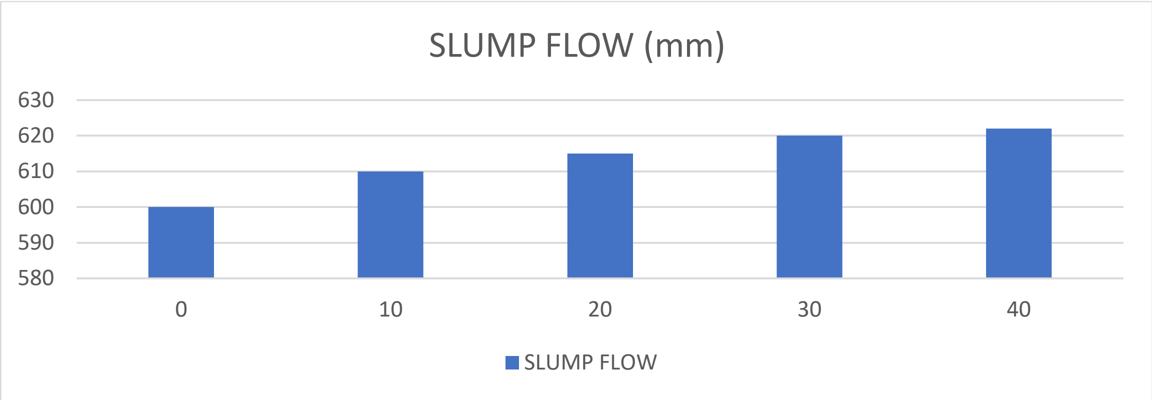

Fig. 1: Slump values graphs.

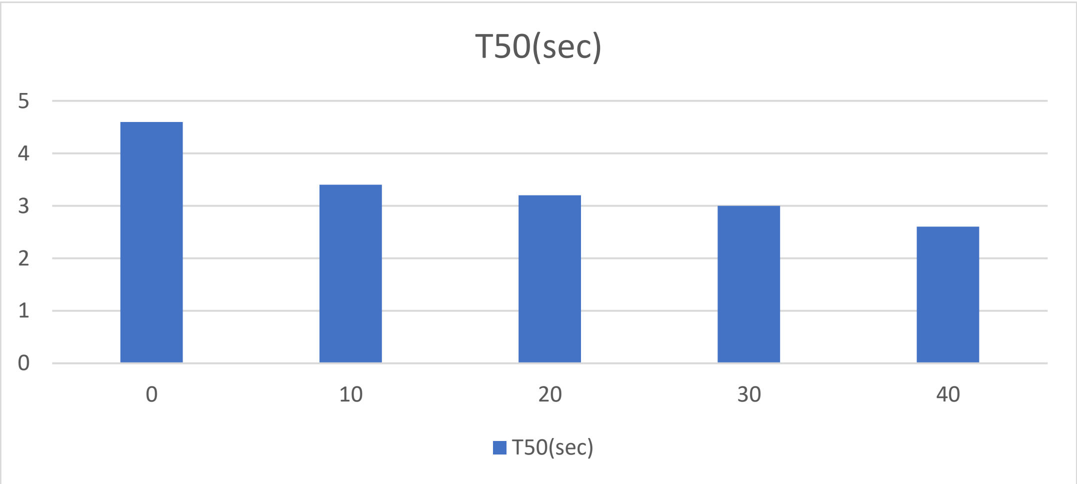

Fig. 2: T50 values graphs.

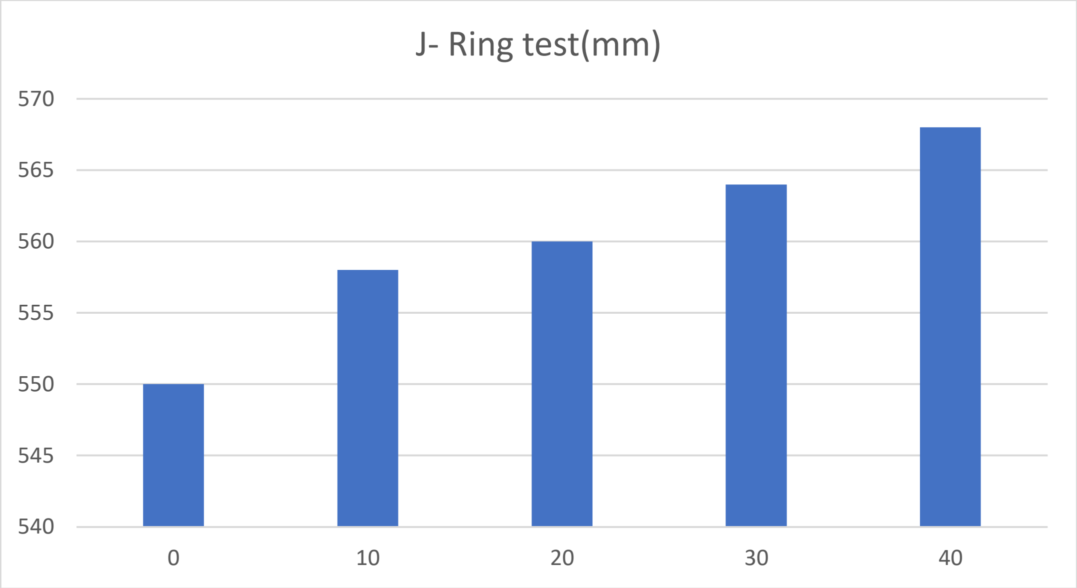

Fig. 3: J-ring test values graphs.

5.1.2 Harden concrete properties of SCC

Compressive strength

Table. 4: Compressive Strength at 7, 14 and 28 days for SCC.

QD (%)	Compressive strength in (Mpa)		
	7 DAYS	**14 DAYS**	**28 DAYS**
0	33.9	39.9	47.43
10	**36.2**	46.2	49.92
20	38.1	45.1	52
30	**42.2**	**47**	**55**
40	40.1	46.2	53.7

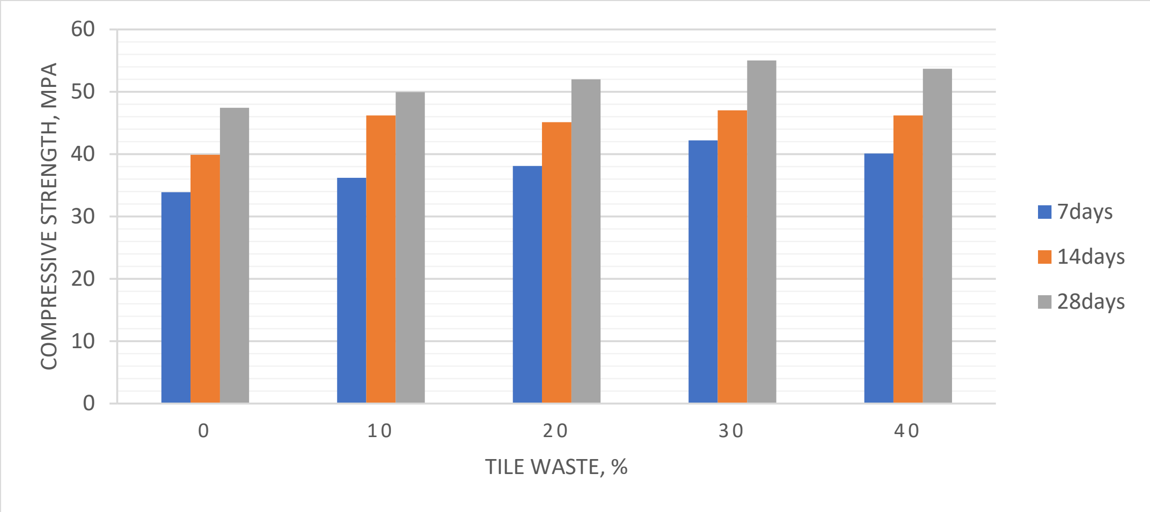

Fig. 4: Compressive strength test result graph for SCC.

5.2 DISCUSSION

5.2.1 Strength Characteristics

The compressive strength values obtained by testing standard cubes for SCC (with partial replacement of fine aggregate with quarry waste) samples. The average value is taken as final output. The SCC mix has strength above 40 MPa in compression. The compressive strength of quarry dust based SSC, replacement of 30% gains higher strength compare to conventional SSC. The strength for quarry waste based SSC gains 16% more than Conventional SSC.

5.2.2 Workability

The workability properties those are T_{50}, J-ring and Slump value was good. The T_{50} and Slump value and J-ring values are more for quarry waste based SSC as compare to the conventional SSC.

6. CONCLUSIONS

1. Based upon its properties quarry dust aggregates are appropriate concrete material which is used as an alternative material to fine aggregates in concrete.
2. This study was carried to obtain the results, test conducted on the quarry dust modified fine aggregate SSC concrete mix, in order to ascertain the influence of quarry dust on the characteristic strength of SSC concrete. The higher compressive and tensile strength of SSC concrete, when the quarry dust replacing of 30% in the fine aggregate content. The results show if around 16% of compressive strength as more than the conventional SSC.
3. For all types of mixes considered always an increase in strength up to a certain level is seen for both 7,14 & 28days curing.
4. Also, they reduce the cost of construction when compared to conventional aggregate based concrete.

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