Poll Res. 40 (4) : 1561-1566 (2021)

ISSN 0257–8050

REPLACEMENT OF FINE AGGREGATE IN SELF CURING CONCRETE BY QUARRY DUST AND GRANITE FINES

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Received August 14, 2021; accepted September 29, 2021

ABSTRACT

Concrete is one of the most used construction material due to its good compressive strength and durability. As construction sector in India is growing at a higher rate, dependency on concrete is at high; in turn the requirement of conventional materials is increasing. With increase in demand, the availability of conventional construction materials is depleting, over usage of which causes environmental imbalances. Over extraction of natural sand from river bed has affected the characteristics of river bed and also damages the road condition during its transportation from river bed to the construction site, which also increases the cost of construction. On the other hand, Quarry dust and granite fines are the byproducts of quarry and granite industry, which also contributes to disposal problem. These two can be coupled together to have a sustainable waste management system, in which quarry dust and granite fines can be used to replace natural sand, which reduces the dependency on natural river sand. With rising scarcity of water globally, curing of concrete will be difficult in future days, which contributes to reduction in characteristic properties of concrete. Construction industry is one of the maximum water consuming industries in the world. Hence optimal water usage and wastage of water during curing should be nullified. Present study is an attempt to incorporate quarry dust and granite fines as a replacement of fine aggregate with self-curing agent in concrete. Self curing agent PEG-400 eliminates the use of external water for curing purpose. Three concrete mix combinations with PEG-400 as self curing agent were considered. Conventional concrete of grade M40 was considered for comparison. 100% replacement of fine aggregate in which 75% quarry dust and 25% granite fines combination achieved 40MPa strength at 28day age. Hence the study concludes over extraction of natural sand from river beds can be reduced by replacing it with quarry dust and granite fines with elimination of curing water by the use of self curing agent PEG 400.

KEY WORDS : Fine aggregate, Quarry Dust, Granite Fines, Self Curing concrete.

INTRODUCTION

Construction sector is one of the fastest growing sectors in India. With the growing population, infrastructure needs are to be met at a faster rate. With fast growing construction sector the demand for the concrete is at high as concrete is most versatile material found in construction. The demand for the concrete enhances more consumption of conventional materials being used in concrete. With the ever increase in demand the natural resources are in verge of depletion. Commonly used fine aggregate, the river sand is commonly extracted from river beds. Over extraction of sand from the river beds has affected characteristics of the river. Due to rapid depletion in natural sand the price of the same is being rising day by day. Increase in cost of natural sand directly affects the cost of construction to rise, as it is one of the important and holds large share among other construction materials in construction industry. Depletion of the source of natural sand and side by side increase in the cost has a made way to find alternative material to replace natural sand in construction industry.

Quarry dust is one of the promising alternative

materials to replace natural sand in concrete. Quarry dust is the byproduct of crushing process. Waste generated during the crushing of rock into different sizes in the quarry is termed as quarry dust. Being a byproduct of disintegration of stone it has the capability to replace natural sand in concrete.

Bengaluru is the home for more than 100 granite industry. Granite Industry is being contributing to more than 150 tones of granite waste per day. Granite waste is generated during the cutting and polishing process of granite. The waste generated in wet process is stored in tank for settling. After sedimentation, of the granite fines, either dries or sometimes wet sludge is disposed into the landfills. It not only reduces the area of the landfill but also a serious environmental concern. Many granite industries have failed to follow the norms set by the government in disposing granite fines. Government has also closed number of granite industries who have failed to follow the norms. Dumping of waste in the landfills without proper care may lead to health issues of the citizens present in the vicinity of landfill.

Water scarcity has been a raising concern in the recent decades. Water scarcity is being contributed by humans dùe to improper management, lack of knowledge, no strict regulations from government in the usage of the precious resource. Improper management of water resources and never ending needs of growing population increases the need of optimal utilization of water usage in each and every point.

Water scarcity has also hit the construction industry, as it is one of the major ingredients of concrete. Water being a least expensive ingredient has important role to play in concrete in terms of workability and strength. Part of water added to concrete is utilized for the hydration of cement to form a cement paste for binding the aggregates. Remaining water is used as lubricant between the fine and coarse aggregate to make concrete workable. Cement requires around 30% of water by its weight for hydration process.

Concrete being an important construction material, its characteristic properties mainly depend on proportioning, mixing, placing and curing. Curing among them plays a vital role in the strength gain of concrete. Curing is a process where external application of water is done for the concrete surface to counter act the loss of water due to evaporation. Negligence in curing may lead to reduced strength of concrete. Curing of concrete may not be done effectively in water scarcity regions. Also in high rise buildings pumping of curing water is not economical as it requires energy to pump water from ground surface to higher floors. Studies have been carried out to produce concrete that cures internally with no aid of external water. Researchers have found a way to develop self curing concrete using self curing agents know as Self Absorbent Polymers (SAP).

Concerning to these problems an attempt is made to incorporate waste materials such as quarry dust and granite fines in concrete to develop sustainable product. Experiment conducted to develop internal curing concrete for M40 grade using Super Absorbent Polymers (SAP) for conventional concrete and concrete samples with waste materials. SAP is varied for different dosage in conventional concrete to obtain optimum dosage.

MATERIALS AND METHODS

A. Reagents

PEG – 400: Polyethylene glycol (PEG) is a condensation polymer oxide having molecular weight 400, specific gravity 1.126 and of 5-7, used in the present study as self curing agent, reduce the wastage of water in curing and to optimize water utilization in concrete mix.

B. Materials

Cement: OPC cement of grade 53 confirming to IS – 12269 – 2013 used for the preparation of concrete.
Quarry Dust: Locally available quarry dust used as fine aggregate for the experiment confirming to I – 383 - 1970.
Granite Fines: Granite fines obtained from local granite industrial area, used for the experiment.
Coarse Aggregate: Locally available coarse aggregate confirming to IS – 383 - 1970 used in experiment.

C. Experimental Studies

Quarry dust and granite fines were dried, cleaned, sieved and tested to obtain basic properties. Sieve analysis and properties of quarry dust are given in Table 1 and 2, respectively. Properties of quarry dust are given in Table 3. Test were conducted as per IS 2386: 1963 (Part III).

The value indicates that quarry dust falls in the category of coarse sand (Range 2.9-3.2).

Quarry dust is of very irregular shape and the fineness modulus is very high compared to natural

Table 1. Sieve analysis of Quarry Dust

Sieve size	Weight retained(g)	% weight retained(g)	% cumulative weight retained	% passing
4.75 mm	0	0	0	100
2.36 mm	125	25	25	75
1.18 mm	151	30.2	55.2	44.8
600 micron	85	17	72.2	27.8
300 micron	55	11	73.2	26.8
150 micron	42	8.4	91.6	8.4
Pan	42	8.4	100	0

• Fineness Modulus = 3.17

Table 2. Properties of Quarry Dust

Sl. No.	Property	Results
1	Specific gravity	2.60
2	Water absorption	13%
3	Fineness modulus	3.17

Table 3. Properties of Granite Fines

Sl. No.	Property	Results
1	Specific gravity	2.68
2	Water absorption	1.6%
3	Fineness modulus	2.41

sand. Hence granite fines mixed with quarry dust.

Granite fines are of less than 1mm size. 80% are of less than 0.1mm size.

Concerning to the problems, experiment investigations were carried out on self curing concrete incorporating quarry dust and granite fines as a replacement of fine aggregate. PEG-400 was used as self curing agent. The dosage of PEG-400 was kept constant at 0.5% by weight of cement. Quarry dust and Granite fines were incorporated at 25%, 50% and 75% by weight of fine aggregate. This study provides a way to utilize quarry dust and granite fines, converting a waste into useful product and a way to reduce external curing of water completely.

Initially basic material tests were carried out on Cement, Quarry dust, Granite fines and Coarse aggregate. Specific gravity, standard consistency and setting time tests on cement were carried out in accordance with IS 4031-1988(Part 4). Specific gravity, water absorption, gradation and fineness modulus of aggregates, quarry dust and granite fines were found out as per IS – 2386 – 1963 (Part 4).

D. Mix Design

Concrete mix with characteristic strength of 40MPa with above mentioned materials were used in the investigation.

Mix design is based on the guidelines of IS-10262-2009 for a slump of 100mm. Based on several trial mixes; mix proportion is finalized and is mentioned in Table 4.

0.45 w/c ratio maintained.

Concrete cubes based on the above mix design were casted for 3 different replacement samples for 7 and 28 days compressive strength. Compressive strength test on cubes were carried out as per the guidelines of IS –516 -1959.

RESULTS AND DISCUSSION

Variation of compressive strength of 7 and 28 days is shown in Figure 1.

- Strength of self-cured concrete with 25% granite fines and 75% quarry dust replacement for river sand acquired required minimum strength for both 7 and 28 days.
- This combination of sample has comparable results with that of self-cured concrete with conventional material due to the better

Table 4. Mix Proportion

Sample	Quarry Dust (%)	Granite Fines (%)	Cement (kg/m^3)	Proportion C:QD:GF:CA
S1	100	0	350	1:2.3:3.1
S2	75	25	350	1:1.7:0.6:3.1
S3	50	50	350	1:1.15:1.20:3.1
S4	25	75	350	1:0.57:1.81:3.1

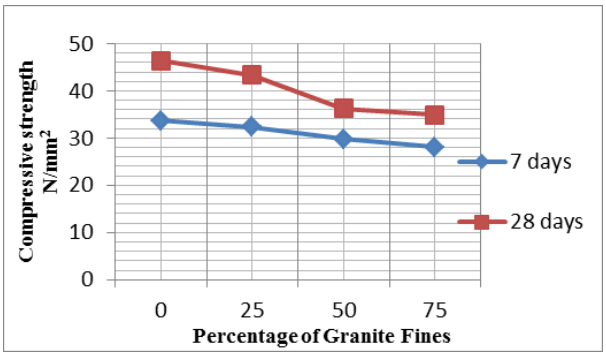

Fig. 1. Variation of Compressive Strength of concrete cubes with Natural Sand replacement

compaction which is caused by the filling of gaps in fine aggregate by the finer granite fines.

- With increase in percentage of granite fines, compressive strength tend to decline compared to conventional concrete due to reduction in uniform gradation of fine aggregate.
- With higher percentage of granite fines present in the concrete the strength reduced due to higher fine fraction of granite fines.

Compressive strength of conventional and various percentage variations of quarry dust and granite fines for river sand are given in Table 5.

From the Table 6, results show that optimum of fine aggregate replacement has a reduction of 9% in cost compared to conventional concrete. It also increases enormously when there is a short fall of river sand. The reduction in cost can also help in overall reduction of cost of large project and utilization of the quarry dust and granite fines in the construction industry.

Microstructure is the subtle structure of concrete that is resolved with the help of a Scanning Electron Microscope. Internal microstructure aids in modifications of properties by initiating suitable changes.

Micro structural studies would help in discussing the strength, creep, shrinkage and durability which influence the characteristic properties of the concrete. But, the present scope of investigation deals only with the relationship between strength and cracking by treating the SEM imaging as physical evidence. Figures 2 and Figure 3 show the microstructure image of self - cured concrete mix with 75% quarry dust and 25% granite fines at 1000x and 5000x magnification respectively. These images show the dense formation of the mortar. The granite fines and quarry dust show a better compaction structure. Granite fines fill the pores of quarry dust and forms a dense structure. Compaction structure formed by the quarry dust and granite fines adds up

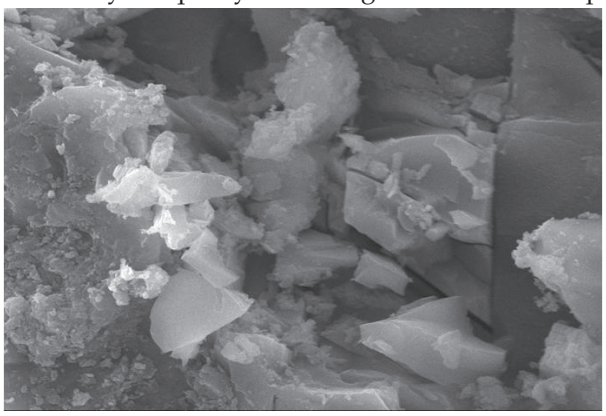

Fig. 2. SEM Image of Self cured concrete (75% Quarry dust and 25% granite Fines) at 1000x magnification

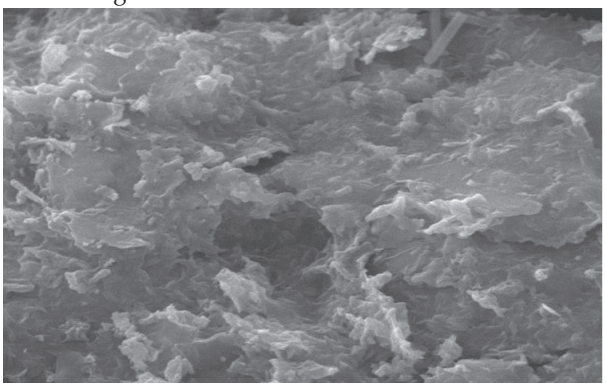

Fig. 3. SEM Image of Self cured concrete (75% Quarry dust and 25% granite Fines) at 5000x magnification

Table 5. Compressive Strength of Concrete cubes

Sl. No.	Natural Sand (%)	Quarry Dust(%)	Granite Fines (%)	7 days strength (MPa)	28 days strength (MPa)
1	100	0	0	33.74	46.43
2	0	75	25	32.4	43.4
3	0	50	50	29.8	36.3
4	0	25	75	28.07	34.9

Cost benefit Analysis: The cost benefit analysis of conventional concrete and optimum mix concrete is as shown in Table 6.

Table 6. Cost Analysis of Quarry Dust and Granite Fines based Concrete

Materials	Conventional Concrete			Fine Aggregate Replacement		
	Quantity Kg	Rate/Kg INR	Amount INR	Quantity Kg	Rate/Kg INR	Amount INR
Cement	547	7	3829	547	7	3829
Fine Aggregate	911	0.85	775	0	0.85	0
Quarry Dust	0	0	0	683	0	0
Granite Fines	0	0	0	238	0	0
Coarse Aggregate	1220	0.535	652	1220	0.535	652
Water	286 litre	0.06/litre	17	286 litre	0.06/litre	17
PEG- 400	2.7 litre	1000/litre	2700	2.7 litre	1000/litre	2700
Total cost in INR			7973			7198

to the strength of the concrete with the help of PEG-400.

CONCLUSION

Water scarcity has been a raising concern in the recent decades. Improper management and wastages of water in construction industry adds to the scarcity of water. With concern to the wastages created in curing of water, the present study incorporated self-curing agent PEG-400 to produce self-curing concrete. Self-cured concrete has possessed higher strength than conventional concrete. Based on the experiments conducted optimum dosage of PEG-400 for M40 grade concrete is found to be 0.5% with strength of 46.43MPa. Self-cured concrete can be a promising replacement for conventionally cured concrete in future as it has achieved more strength and eliminates use of external curing water completely. Self-cured concrete can majorly help in areas such as draught areas, high rise buildings, and in construction of concrete roads. Wastage of water in construction industry in form of overflow of water and excess addition of water curing can be eliminated with help of implementation of self-curing concrete.

Quarry and granite industries produces huge amount of waste in the form of quarry dust and granite fines whose storage or disposal creates air pollution, land pollution, health and other problems. Disposal into the landfills reduces the intake of landfill and fills up in very early stage as these wastes are produces in huge quantity in lesser period of time. Thus consumes larger space of high value land.

Replacement of fine aggregate with quarry dust and granite fines in self-curing concrete has shown achievement of 43.4MPa for proportion of 75:25 (quarry dust: granite fines). Incorporation of quarry dust and granite fines in concrete will not only reduces the problem of waste disposal from these industries but also substitute conventional fine aggregate and helps in conserving natural resources.

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