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STUDY ON THE REPLACEMENT OF CEMENT AND FINE AGGREGATE WITH QUARRY DUST

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ABSTRACT

Quarry dust is the crusher waste of granite quarries which is about 13-15 % of the total quarry products and accumulation of this waste generates environmental issues. For the past three decades, the scarcity of river sand has been taken seriously and research initiated to replace it with quarry dust either in the available form, or fines removed or processed sand. The presence of very fine particles found as 5-8% demands for increased water cement ratio for better workability which could reduce the strength of the concrete. Therefore it is emphasized, to replace cement partially with these fines of quarry dust to produce cost effective concrete. This studyis planned to make concrete totally replacing river sand with the quarry dust considering the fine fraction of quarry dust present for partial replacement of cement.Concrete of M30 grade has been designed by usingfines removed coarser quarry dust as fine aggregate. The cement is replaced with fines of quarry in 0, 2, 4, 6, 8 and 10% by weight. Seven different concrete mixes are prepared, tested and compared in terms of workability and strength with the conventional sand concrete of same grade. It is observed that the optimum replacement level of cement with fines of quarry dust is 6%.

KEYWORDS: Quarry dust, substitutes for concrete constituents, workability and strength.

I. INTRODUCTION

Cement based mortar and concrete are the most prevalent and versatilebuilding materials widely used in construction industries. But, about seven percent of the total atmospheric carbon dioxide (CO_2) comes from cement industries. Production of cement emits almost an equal amount of CO_2 into the atmosphere that promotes the global warming issues. Presently about Ten billion tons of concrete is required globally and hence 15-25% of it by various types of cement. The demand for concrete increases day by day and hencethe demand for the cement that results in more and more pollution. It is also true in the case of river sand as there is a heavy demand for sand and problems in sand mining.

Quarry dust is a byproduct of the quarrying and crushing process which creates air pollution.Sand mining poses the environmental problem and hence restrictions on sand quarrying resulted in scarcity of sand and significant increase in its cost. Frequently, the communities residing near the river sides are also make agitations often against the sand mining. Theconstructionindustriesexpectaseriousshortageofsandinthenearfuturedueto over exploitation of river sand and led to a concomitant price increase in the material.

Use of quarry dust reduces the material cost and hence cost of construction. The developing countries are under pressure to replace fine aggregate in concrete by an alternate material without compromising the quality of concrete.Quarry dust has become a good substitute for conventional river sand for its total replacement and thus quarry dust concrete (QDC).Recently, the trend of using the fine fractions of quarry dust (QDF) of size less than150microns for partial replacement of cement in mortar and concrete has been initiated. However, being high silica, the reacting nature and its degree of reaction have not been fully studied.

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II. LITERATURE SURVEY

Partial replacement of river sand with quarry dust has been successfully reported by **Lohani et al (2012)** the partial replacement of sand with quarry dust (0%, 20%, 30%, 40%, and 50%) for a design mix of M20 grade concrete, **Prachoom Khamput (2008)** the possibility of 70-100% replacement of sand with quarry dust in Thailand. **Waziri and Muazu (2008), Ilangovan et al (2008), Shanmugavadivu, et al (2008), Shahul Hameed and Sekar (2009)and Sivakumar and Prakash (2011)** have done considerable research and recommended for total replacement of river sand with quarry dust.

Krishnamoorthi and Mohankumar (2012) made preliminary studies on the strength properties of quarry dust based concrete. A trial mix design was first arrived for conventional M30 grade concrete and sand replacement by 0-100% with quarry dust was considered. As there was not much difference in the compressive strength of concrete the total replacementof sand with quarry dust was recommended. In the second phase, a mix design was made for M30 concrete with quarry dust as the fine aggregates and the workability, strength and durability characteristics investigated. These characteristics of conventional sand concreteand quarry dust concrete(QDC) were compared and total replacement of sand with quarry dust (QD) was recommended.

Allam et al (2016) studied the behaviour of M35 grade concrete, having partial replacement of cement or sand with granite waste. It is concluded that, the optimum percentage of cement replacement with granite fine powder is 5%. **Ankit Nileshchandra and Jayeshkumar Pitroda (2013)** replaced cement with stone waste up to 50% by weight for M25 concrete and recommended for 30% replacement of OPC but, only 20% for PPC (**Ankit Nileshchandra Patel and Jayeshkumar Pitroda, 2013**). **Husam and Waleed (2013)**tried to replace up to 30% by weight of cement and recommended only 10%. **Chowdary (2015)** tried cement (OPC 53 grade) replacement up to 10% with Granite powder and concluded that the compressive, splitting tensile strength, flexural tensile and modulus of concrete found to increase up to 7.5% replacement and the workability decreased but within limits.

Vishnu Shankar and Saravana Raja Mohan (2015)madedurability studies on cement mortar (1:3) in which cement is partially replaced up to 40% by the weight and concluded that the maximum level of replacement is 30% based on durability. **Yaswanth Kumar et al (2015)** made partial replacement of cement with Granite Slurry up to 20% by weight in M30 grade concrete and observed that substitution of 10% of cement by weight resulted in an increase in strength. **Prem Prakash and Manish Verma (2016)**investigated the optimization of Granite Powder and its effect on fresh and hardened properties of Ready mix concrete (M20 grade) with partial replacement up to 20% to cement.

III. EXPERIMENTAL WORK

Concrete grade of M30 is considered for the present study. Conventional concrete(CC) with sand as fine aggregate and concrete with fines removed quarry dust as fine aggregate(QDC) are designed as per IS specifications. Further, QDC having cement replacement by 0, 2, 4, 6, 8 and 10% with QDF is considered. The schematics of the experimentation are explained in figure 1.

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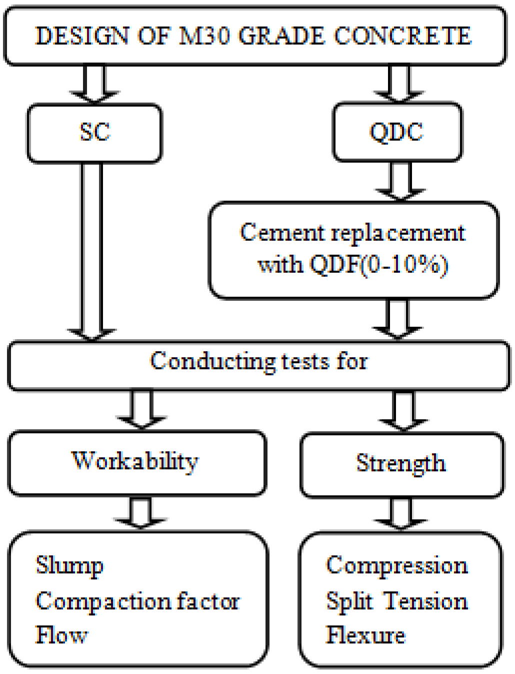

Figure 1. Schematics of the experimental investigation

The main constituents of concrete namely cement, sand, QD and jelly, are procured and properties are determined. PPC 53 super grade cement and river sand from locally available sources are used. Blue granite jelly of maximum size 20mm is used as coarse aggregate. The properties of the constituent materials and the mix proportion details are presented in Tables 1 and 2 respectively. The particle fractions of quarry dust are shown in figure 2. The fraction of QDF passing through 90 micron sieve is used for cement replacement partially.

Table 1. Properties of fine and coarse aggregates

No	Properties	Sand	Quarry dust	Coarse aggregate
1	Specific gravity	2.65	2.407	2.63
2	Fineness modulus	2.43	2.38	6.90
3	Zone	II	II	-
4	Maximum size	-	-	20mm

Table 2.Mix design details for QDC and SC

No		Constituent quantities kg/m^3			
		Cement	Sand/QD(FA)	Jelly(CA)	Water
1	SC	425.7	565.049	1162.460	186.342
		1	1.33	2.73	0.438
2	QDC	425.7	553. 97	1168.302	191.580
		1	1.3	2.744	0.45

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(a) >150µ (81.7%) (b) 150-90µ (10.8%) (c) <90 µ (7.5%)

Figure 2. Particle fractions of quarry dust

Totally seven different mix proportions are considered having QDC with cement replacement by 0, 2, 4, 6, 8 and 10% of QDF and conventional river sand concrete. For all the mix proportions, concrete prepared, workability tests like slump, compaction factor and flow are conducted. The results of the workability test are presented in Table 3.

Table3. Workability results of concrete

No	Cement replacement with quarry fines	Slump mm	Compaction factor	Flow
1	0%	60	0.86	30.3 %
2	2%	63	0.87	31.0 %
3	4%	63	0.87	32.2 %
4	6%	65	0.86	32.1 %
5	8%	65	0.87	33.0 %
6	10%	64	0.87	33.3%
7	SC	73	0.89	34.8%

After mixing the weigh batched constituents, concrete cubes of 150mm size (for compressive strength f_{cu}), cylindrical specimens of size 150×300mm (for compressive strength f_{cy} and splitting tensile strength f_{ct}) and concrete prisms of size 100×100×500mm (for modulus of rupture f_{cr}) are cast, pond cured and then tested on 7, 14 and 28 days for relevant strength. The tests for various strength are conducted as per the relevant Indian standards. The test results are presented in Table 4 and compared. The testing views are shown in figure 3.

Table 4. Comparison of various strength of concrete

No	Cement replacement with QDF	Curing Days	Various strength (MPa)			
			f_{cu}	f_{cy}	f_{ct}	f_{cr}
1	0%	7days	21.92	18.08	2.65	4.32
		14days	28.98	28.43	3.64	5.61
		28days	39.26	32.89(0.84)	4.11(0.105)	6.01(0.153)
2	2%	7days	21.73	17.74	2.43	4.03
		14days	28.34	28.2	3.43	5.55
		28days	38.63	32.54(0.84)	4.02(0.104)	5.88(0.152)
3	4%	7days	21.51	17.23	2.33	3.89
		14days	28.01	27.99	3.12	5.23
		28days	38.15	31.93(0.84)	3.89(0.102)	5.81(0.152)
4	6%	7days	21.08	17.04	2.26	3.76
		14days	27.75	27.65	3.05	5.08
		28days	37.72	31.77(0.84)	3.45(0.091)	5.73(0.152)

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5	8%	7days	20.33	16.11	2.16	3.11
		14days	24.82	24.33	2.77	4.53
		28days	34.03	28.92(0.85)	3.21(0.094)	5.14(0.151)
6	10%	7days	18.98	15.33	1.89	2.72
		14days	23.12	20.25	2.41	4.12
		28days	29.98	25.18(0.84)	2.97(0.099)	4.42(0.147)
7	SC	7days	20.61	16.78	2.11	3.21
		14days	27.32	27.01	2.91	4.84
		28days	37.31	31.54(0.85)	3.37(0.09)	5.62(0.151)

Figure 3. The views of three different strength testing

IV. DISCUSSION OF RESULTS

The workability of QDC by measurements of slump, compaction factor and flow percentage is not at all varied significantly due to the replacement of cement with quarry dust fines. Evidently, conventional sand concrete is slightly more workable than QDC due to the surface nature of sand particles. Therefore, water requirement may be more for QDC than SC.

The cube compressive strength of QDC decreases for the increase in the replacement level of cement with QDF as shown in figure 4. The rate of gain of strength is almost same as shown in figure 5. The cube compressive strength of QDC without cement replacement is 5.2% higher than conventional sand concrete. The strength equivalent to conventional sand concrete is obtained for cement replacement of 6%.

The same trend existed for the cylinder compressive strength of QDC also as shown in figure 6. The ratio of cylinder compressive strength to cube compressive strength obtained as 0.84-0.85 is almost equal for all replacement levels of cement with QDF as in the case of conventional sand concrete.The strength equivalent to conventional sand concrete is obtained for cement replacement of 6%.

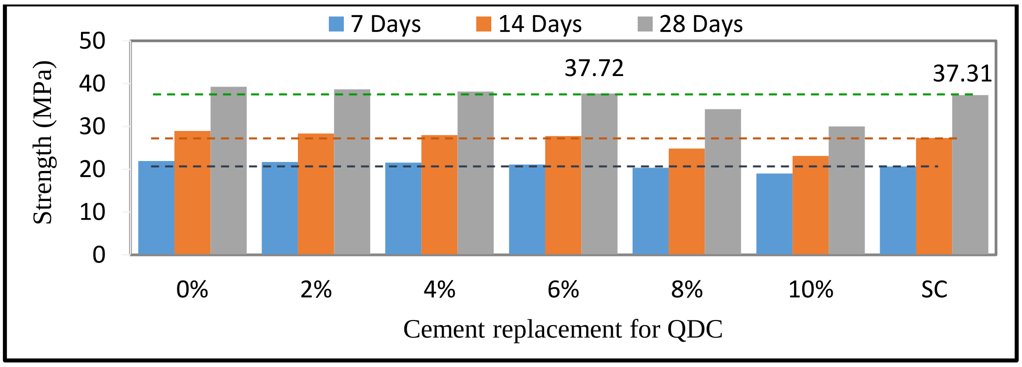

Figure 4. Comparison of cube compressive strength

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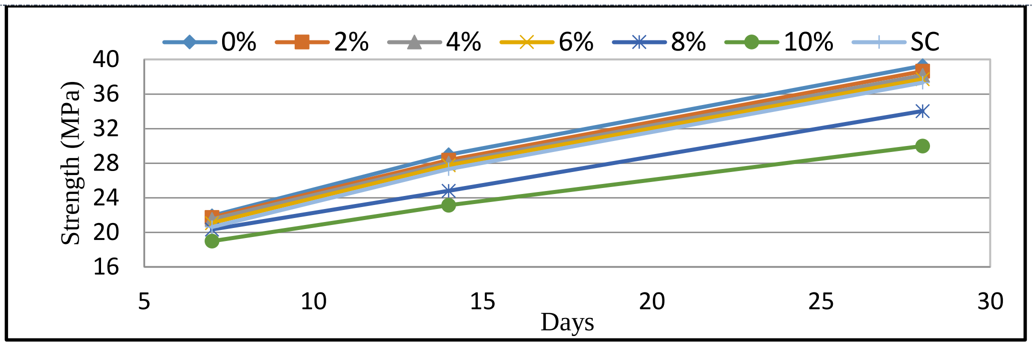

Figure 5. Rate of gain of cube compressive strength

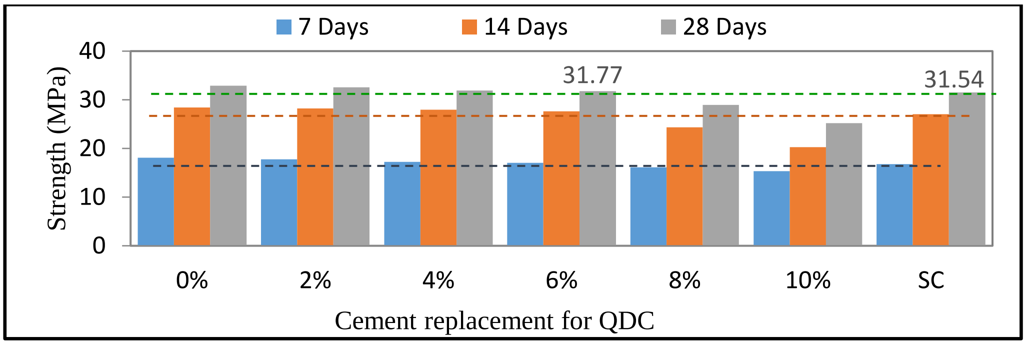

Figure 6. Comparison of cylinder compressive strength

The splitting tensile strength of QDC decreases for the increase in the replacement level of cement with QDF as shown in figure 7. The strength equivalent to conventional sand concrete is obtained for cement replacement of 6%. The ratio of splitting tensile strength to the cube compressive strength is obtained as varied from 0.105 to 0.09 respectively for the increase in the replacement level.

The modulus of rupture (flexural strength) of QDC decreases for the increase in the replacement level of cement with QDF as shown in figure 8 similar to all other concrete strength. The strength equivalent to conventional sand concrete is obtained for cement replacement of 6%. The ratio of modulus of rupture to the cube compressive strength is obtained as varied from 0.153 to 0.151 respectively for the increase in the replacement level. Evidently, itt is observed that the modulus of rupture is higher than the splitting tensile strength.

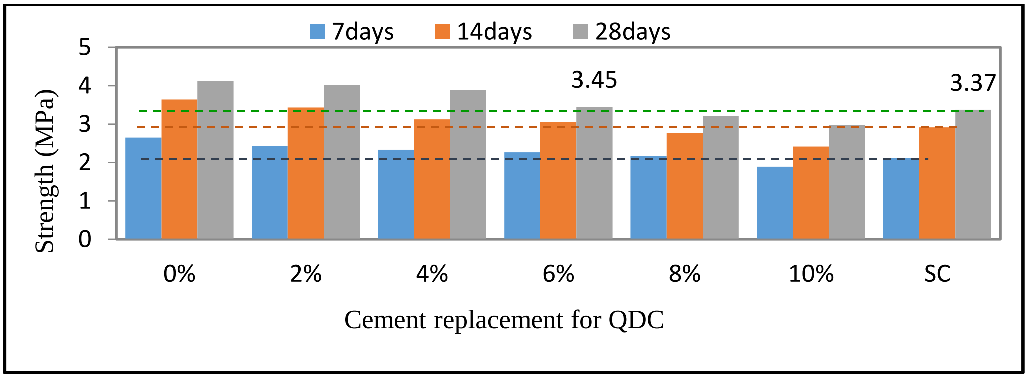

Figure 7. Comparison of splitting tensile strength

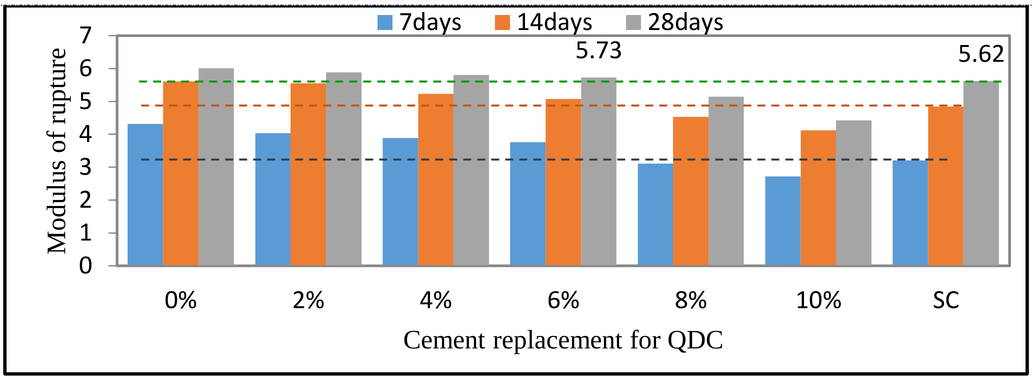

Figure 8. Comparison of flexural strength

V. CONCLUSIONS

- The concrete workability of QDC is not much influenced by the level of cement replacement with QDF.
- The increase in the percentage replacement of cement with QDF decreases the strength of QDC.
- The optimum level of replacement of cement with QDF for equivalent strength in compression, splitting tension and modulus of rupture is obtained as 6%.
- The ratio of cylinder compressive strength to cube compressive strength of QDC is same as that of SC.

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VII. REFERENCES

[1] Allam, M. E., Bakhoum, E. S., Ezz, H and Garas, G. L (2016). Influence of using granite waste on the mechanical properties of green concrete, ARPN Journal of Engineering and Applied Sciences, 11(5): 2805-2811.

[2] Ankit Nileshchandra Patel and Jayeshkumar Pitroda (2013). Stone waste in India for concrete with value creation opportunities, International Journal of Latest Trends in Engineering and Technology (IJLTET), 2(2):113-120.

[3] Ankit Nileshchandra Patel and Jayeshkumar Pitroda (2013). Stone waste: Effective replacement of cement for establishing green concrete, International Journal of Innovative Technology and Exploring Engineering (IJITEE), 2(5): 24-27.

[4] Chowdary, P. L (2015). Studies on strength properties of effect of waste granite powder on the compressive strength of concrete, Journal of Environmental Science, Computer Science and Engineering & Technology (JECET), Section- A: Environmental Science, 4(3): 716-727.

[5] Husam D. Al- Hamaiedeh and Waleed H. Khushefati (2013). Granite Sludge Reuse in Mortar and Concrete. Journal of Applied Sciences, 13: 444-450.

[6] Ilangovan, R., Mahendran, Nand Nagamani, K (2008). Strength and durability properties of concrete containing quarry rock dust as fine aggregate, ARPN Journal of Engineering and Applied Sciences, 3(5): 20-26.

[7] IS 516-1959.Indian standard code of practice methods of test for strength of concrete, Bureau of Indian Standards, New Delhi, India.

[8] IS 5816-1999 - Indian standard code of practice for method of test for splitting Tensile strength of concrete cylinders, Bureau of Indian Standards, New Delhi, India.

[9] IS 10262-1982. Recommended guidelines for concrete mix design, Bureau of Indian Standards, New Delhi, India.

[10] Krishnamoorthi, A and Mohankumar, G (2012). Preliminary studies on the Three Dimensional Characteristics of Quarry Dust Concrete, International Journal of Applied Engineering Research, 7(13): 1479-1492.

[11] Lohani T.K., Padhi M., Dash K.P and Jena, S(2012). Optimum utilization of Quarry dust as partial replacement of sand in Concrete, International Journal of Applied Sciences and Engineering Research, 1(2):391-404.

[12] Prachoom Khamput, E (2005). A study of compressive strength of concrete using quarry dust as fine aggregate and mixing with admixture type E, Rajamangla University of Technology, Thanyaburi, Pathumthani, Thailand.

[13] Prem Prakash Gautam and Manish Verma (2016). Green Concrete for partial replacement of cement with marble and Granite Slurry: A Case review, International Journal for Innovative Research in Multidisciplinary field, ISSN – 2455-0620, 2(6): 1-4.

[14] Shahul Hameed, M and Sekar, A.S.S (2009). Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate, ARPN Journal of Engineering and Applied Sciences, 4(4): 83-89.

[15] Shanmugavadivu, P.M., Ezhilarasi, P and Prabhakar, K(2008). Mix design for concrete with quarry dust, Proceedings, International conference on Advances in Concrete and Construction, ICACC-2008, 7-9 February, 2008, Hyderabad, India, pp. 440-449.

[16] Sivakumar, A and Prakash, M (2011).Characteristic studies on the mechanical properties of quarry dust addition in conventional concrete, Journal of Civil Engineering and Construction Technology, 2(10):218-235.

[17] Vishnu Shankar, S and Saravana Raja Mohan, K (2015). Durability Studies on Cement Mortar with Granite Powder as A Partial Replacement of Cement, International Journal of ChemTech Research, CODEN (USA): IJCRGG, 8(3): 1417-1422.

[18] Waziri B.S.,Muazu, N (2008). Properties of Quarry- sand concrete: A preliminary assessment, Research Journal of Science, 15:55-62.

[19] Yaswanth Kumar, Y., Vivek Vardhan, C.M and Anitha, A(2015). Use of granite waste as partial substitute to cement in concrete, International Journal of Engineering Research and Applications (IJERA), 5(4, Part-6):25-31..

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