Mechanical Properties of High Performance Concrete in Corporating with Quarry Wastes

T. Subbulakshmi, B. Vidivelli

Abstract-Concrete is a stone like material obtained by designing a carefully proportioned mixture of cement, sand and gravel or other aggregates and water to harden in forms of the shape and dimensions of the desired structure. A High performance concrete is something which demands much higher performance from concrete as compared to performance expected from routing concrete. Use of chemical admixtures reduces the water content, thereby reducing the porosity within the hydrated cement paste. The demand for natural sand in the construction industry has consecutively increased which has resulted in the reduction of sources and an increase in price. In such a situation the quarry dust can be an economical alternative to the river sand. Therefore the quarry dust should be used in construction works, then the cost of construction would be saved significantly and the natural resources would be used efficiently. In this study, I have obtained the quarry dust material sample from the source of Thiruvakkarai and perumukkal source from Villupuram district. The scope of the present study is to investigate the effect of quarry dust towards the performance of High performanceconcrete. An effort has been made to focus on the mechanical properties of High performance concrete made with quarry dust material. This paper presents the results of a study to use quarry dust in concrete as a partial replacement of sand. The strength characteristics such as compressive strength and flexural strength were investigated to find the optimum replacement of quarry dust. The mechanical properties of High performanceconcrete with quarry dust at the replacement levels of 0%, 50%, and 100% were studied at 3 days, 7 days, 14 days, 28 days and 60 days of curing. From the studies contained, it was observed that quarry dust plays a vital role in improving the strength of concrete. The performance of concrete ratio and quarry dust replacement level on the compressive strength of quarry dust concrete was investigated.

Keywords - High performance Concrete, Quarry dust, Strength, Workability, Mechanical properties.

I. INTRODUCTION

HPC define as "concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices". A high performance concrete is something which demands much higher performance from concrete as compared to performance expected from routine concrete. The major difference between conventional concrete and HPC is essentially the use of chemical and mineral admixtures. The economy, efficiency, durability and rigidity of reinforced concrete make it an attractive material for a wide range of structural applications. Concrete is the most popular building material in the world. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy. Based on the global usage, concrete is placed at second position after water. A high performance concrete is something which demands much higher performance from concrete as compared to performance expected from routine concrete. Mineral admixtures, also called as cement replacement materials (CRM), act as pozzolanic materials as well as fine fillers, thereby the microstructure of hardened cement matrix becomes denser and stronger. Materials selection will play a large part in the improved concrete of the new century. Mining the sand, from riverbed is hazardous to environment. Increased sand mining not only affects the aquifer of the river bed but also causes environmental problems. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. Also it is desirable to obtain cheap, environmentally friendly substitutes for fine aggregates that are preferable by-product. Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete.

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II. AIM OF STUDY

Quarry dust is used as a fine aggregate or a filler material for concrete; it might have some beneficial effects on high performance concrete depending on the percentage replacement, so the objective of the investigation subject of this paper is to findout the effects of quarry dust on the performance of concrete. This project presents the feasibility of the usage of quarry dust as fully replacement for fine aggregate in concrete. To find out the extent of improvement in concrete properties for different amounts of quarry dust, proportion of 0%, 50% and 100% of replacement are considered, concrete properties include workability (slump test) of fresh concrete, unit weight, compressive strength, flexural strength of hardened concrete are studied.

III. LITERATURE COLLECTION

Kapugamage and Amarasiri (2009) reported that the loss in early strength due to the addition of 15 % fly ash can be completely negated by the addition of 30 % quarry dust. The strength at 28-day age has not been adversely affected at all by the addition of up to 30 % fly ash. The addition of quarry dust causes a loss in slump though such loss in sump can be significantly reduced by the addition of fly ash. Replacement fine aggregate by crusher dust up to 50% by weight has a negligible effect on the reduction of a compressive strength, flexural strength, split tensile strength etc. Water absorption is well below the limit as per Indian codes. Durability test shows no variation for different

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replacements of quarry dust. Krishnamoorthi and Kumar (2010) reported that The 3 and 7 days cube compressive strength for concrete with 20% and 40% quarry dust is same as conventional concrete and with above 40% quarry dust the strength decreases subsequently. 28 days strength satisfies the target strength. The split tensile strength and flexural strength of concrete made with 40% of replacement of sand with quarry dust is more than that made with other percentage of replacement. The compressive strength of concrete made with 40% of quarry dust is more than that made with 0%,20%,50%,60% of quarry dust. Tensile strength of concrete made with 40% of quarry dust is more than that made with 0%,20%,50%,60% of quarry dust. Tensile strength of concrete made with 60% of quarry dust is more than that made with 0% of quarry dust. Reddy et al (2007) , reported that The compressive strength of concrete was increased with increase of age of concrete with partial replacement of fine aggregate by quarry dust. Compare to the control specimen the corresponding increase in 56 days compressive strength of specimens with 10 and 40% of partial replacement of fine aggregate by quarry dust was 11% to 5% respectively. Nadgir and bhavikatti (2008), The experimental result show that the split tensile strength increases up to 40% stone quarry dust beyond which reduces They have contended that partially replacement of sand by stone quarry dust ,will not affect the strength. Shukla et al (1998). Sahu et al (2003) and Krishnamoorthi et al (2003) , is reported that the compressive strength, split tensile strength and flexural strength of concrete made with 40% or 50% replacement of sand with quarry dust is more than that made with other percentage of replacement Natural river sand, if replaced by hundred percent Quarry Dust from quarries, may sometimes give equal or better than the reference concrete made with Natural Sand, in terms of compressive and flexural strength studies Rao et al (2004) and Ilangovana et al (2008). All concretes provided excellent ultrasonic pulse velocity and quarry waste fine aggregate did not adversely affect the quality of concrete. The combined use of quarry waste fine aggregate and silica fume exhibited excellent performance due to efficient microfilling ability and pozzolanic activity of silica fume. Quarry waste fine aggregate can be utilized in concrete mixtures as a good substitute of natural sand Nagabhushana and Sharada (2011). The mean aspects of the concrete performance that will be improved by fly ash are increased long term strength and reduction permeability of the concrete resulting in a better durability Nadgir and Bhavikatti (2007) [13]. The cost of quarry dust much cheaper than that of the sand as such the proposal is also financially viable. This also reduces the burden of dumping crusher dust on earth and hence environmental pollution Radhikesh et al (2010). Shreeti S.Mavinkurve, (2003) Present paper discusses the approach adopted to develop HPC mix by means of laboratory trials using HRM. The various properties of concrete, both in the fresh and hardened states are also highlighted .It can be concluded the high strength concrete up to compressive strength of 82.75 M pa, having quite low permeability and with reasonably high slump can be developed using Indian HRM and cement".

Table 1 Mix Proportions Used

Components	M20	M40
Cement (kg/m^3)	334	400
Coarse Aggregate (kg/m^3)	1189	1170
Fine Aggregate (kg/m^3)	750	690
Water (litres)	175	160
Admixture (litres)	2.9	4.186
W/C	0.53	0.40
Mix proportion	1 : 2.3 : 3.6	1 : 1.7 : 2.9

IV. EXPERIMENTAL INVESTIGATION

In the experimental study, generally a good quality of cement like 43 grade cement is preferred but it may vary according to the grade of HPC needed. Natural sands crushed and rounded sands and manufactured sands are suitable for HPC. River sand of specific gravity 2.65 and conforming to zone II of IS 363 was used for the present study. The shape and particle size distribution of the aggregate is very important as it affects the packing and voids content. The moisture content, water absorption, grading and variations in fines content of all aggregate should be closely and continuously monitored and must be taken into account in order to produce HPC of constant quality. Coarse aggregate used in this study had a maximum size of 10mm. Specific gravity of coarse aggregate used was 2.75 as per IS 363. Ordinary potable water was used. The pH value is not less than 8.0. Super plasticizers are high range water reducing admixtures an essential component of HPC. Conplast SP 430 was used as super plasticizer. Silica fume imparts very good improvement to rheological, mechanical and chemical properties. It improves the durability of the concrete by reinforcing the microstructure through filler effect and thus reduces segregation and bleeding. It is also helps in achieving high early strength. Fly ash produced from the burning of younger lignite or sub bituminous coal, in assertion to having pozzolanic properties, also has some self-cementing properties. In Puducherry, the production of quarry dust is available in Perumukkal and Thiruvakkarai. Among them, Perumukkal region has 250 quarries which is greater than Thiruvakkarai region which has 175 quarries. The grand total number of quarries available in an around Puducherry is 425 quarries.

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Table 2 Properties of Raw Materials

SL.NO.	PROPERTIES	FINE AGGREGATE	COARSE AGGREGATE	QUARRY DUST	QUARRY DUST
1	Specific Gravity	2.65	2.7	2.31	2.83
2	Fineness modulus	2.80	2.86	2.5	2.46
3	Water absorption	1%	0.05%	1.20	1.50
4	Bulk density	1560 kg/m^3	1420 kg/m^3	1690kg/m^3	1695kg/m^3
5	Particle shape	-	-	ANGULAR	ANGULAR
6	Grading	II	-	-	-

V. RESULTS AND DISCUSSION

Before conducting the slump test, the internal surface of all moulds are cleaned and placed on smooth rigid and non-absorbent surface. Then the moulds were filled with concrete in four layers and each layer was tampered twenty five blows by standard tamping rod. The slump is measured for all types of concrete based on the procedure described in IS: 1199 – 1959. To determine the compressive strength of both grades of concrete, 100 mm size cube specimens were test at the ages of 3, 7, 14, 28 and 60 days. At the end of above curing period, the specimens are tested in a compression testing machine 3000 KN capacity under a uniform rate of loading (at 140 kg/cm²/min) and compressive strength is calculated as per IS 516 – 1959. The Indian standard method resulted in highly conservative results of compressive and flexural strengths for all the three grades of concrete mainly due to high cement content used in conjunction with low aggregate/cement and w/c ratio in comparison with other advanced by other countries in both cases. To determine the flexural strength of both grades of concrete, 500 mm x 100mm x 100mm beam specimens were test at the ages of 28 and 60 days, the specimens are tested in a Universal wood testing machine proving ring of capacity 5000 kg. The 150mm size concrete cubes, concrete cylinder of size 150mm dia and 300 mm height were used as test specimens to determine the compressive strength and split tensile strength respectively. The flexural strength corresponding to failure of the specimen is calculated using the formula. Compressive strength of conventional concrete and quarry dust concrete for M20 and M40 are given in table 3 & 4. Flexural strength of conventional concrete and quarry dust concrete for M20 and M40 are given in table 5. From the results it can be seen that the compressive strength (at 14 days) of quarry dust concrete which is 21% and 14.14% higher than the conventional concrete for M20 and M40 respectively. From the results it can be seen that the flexural strength (at 60 days) of quarry dust concrete which is 10.7% and 16% higher than the conventional concrete for M20 and M40 respectively.

Table 3 Compressive Strength for M20 Grade of Concrete

Ages	Reference	SAMPLE 1 (Thiruvakkarai)		SAMPLE 2 (Perumukkal)	
		50%	100%	50%	100%
3	24.51	29.58	27.88	31.73	30.71
7	31.06	38.44	38.10	40.32	38.60
14	33.17	41.99	39.03	41.96	40.90
28	44.24	45.83	45.32	47.68	45.94
60	47.23	49.39	47.46	50.29	48.01

Table 4 Compressive Strength for M40 Grade of Concrete

Ages	Reference	SAMPLE 1 (Thiruvakkarai)		SAMPLE 2 (Perumukkal)	
		50%	100%	50%	100%
3	30.33	32.66	31.71	39.01	37.28
7	32.37	38.43	37.21	41.79	39.27
14	37.15	40.41	39.93	43.27	41.36
28	41.58	44.14	42.27	47.33	45.27
60	45.17	47.14	46.53	54.84	49.92

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Table 5 Flexural Strength for M20 & M40 Grade of Concrete

% of Replacement	Ages	M20		M40	
		S1	S2	S1	S2
0%	28	5.63	5.63	6.25	6.25
	60	6.15	6.15	6.60	6.60
50%	28	5.85	5.86	6.41	6.59
	60	6.28	6.31	7.32	7.45
100%	28	5.67	5.79	6.30	6.36
	60	6.19	6.24	6.68	6.65

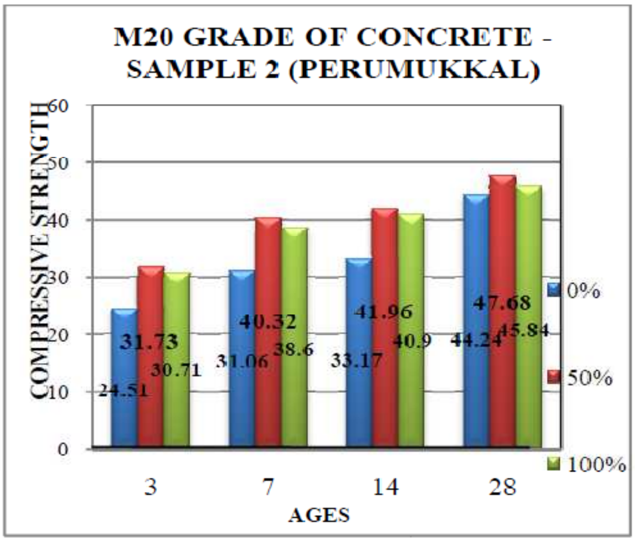

Fig. 4.1 Compressive Strength for M20 Grade of Concrete (Sample – 1)

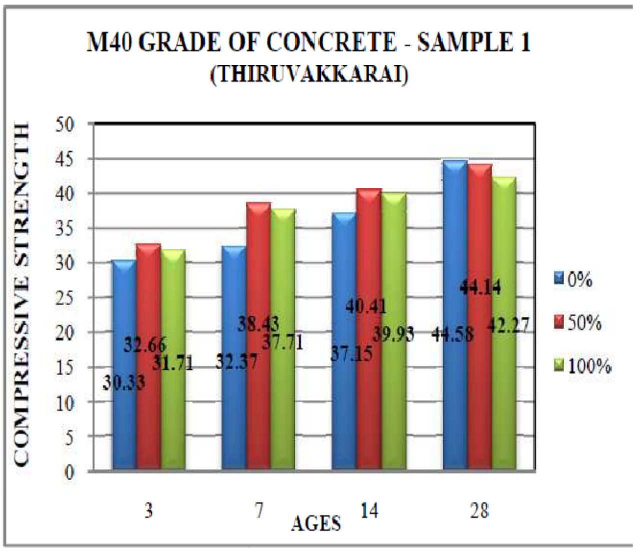

Fig. 4.2 Compressive Strength for M20 Grade of Concrete (Sample – 2)

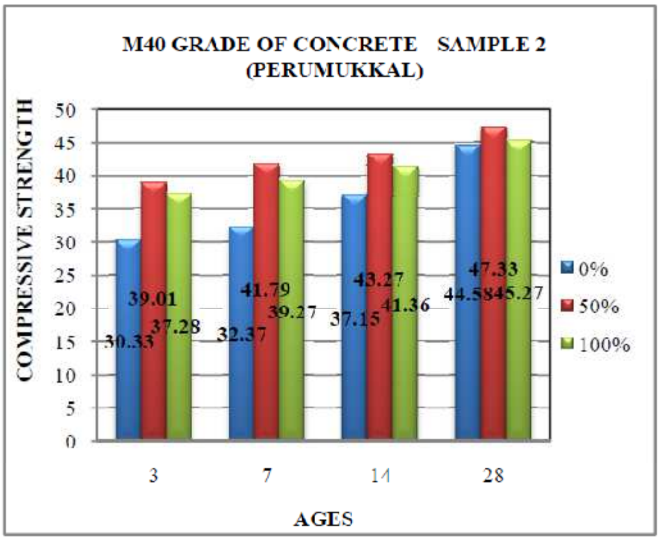

Fig. 4.3 Compressive Strength for M40 Grade of Concrete (Sample – 1)

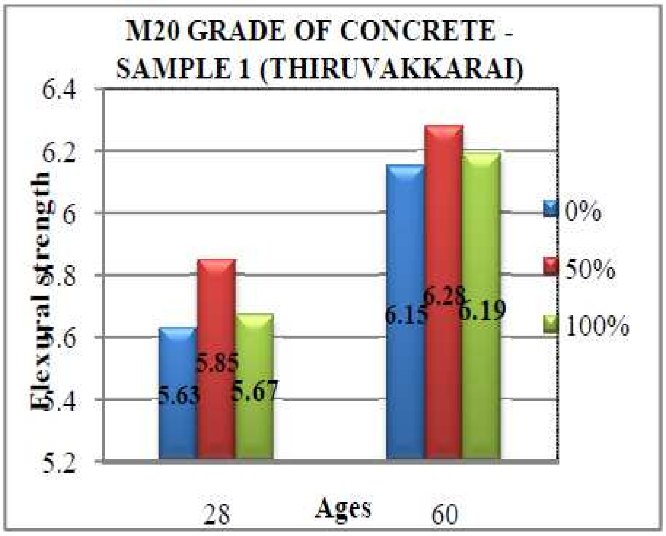

Fig. 4.4 Compressive Strength for M40 Grade of Concrete (Sample – 2)

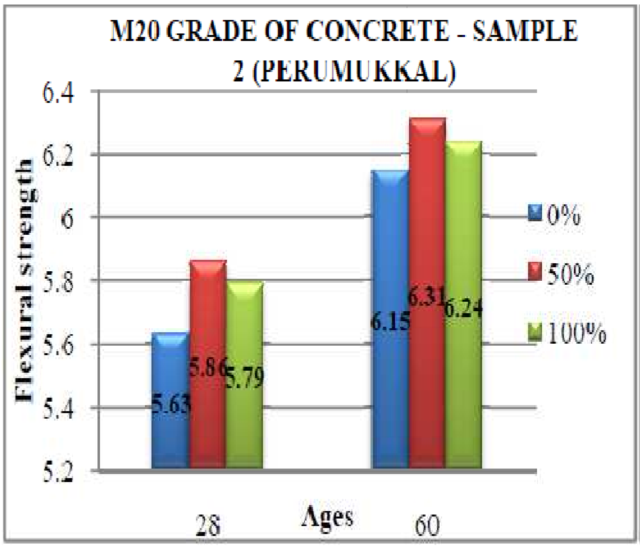

Fig. 4.5 Flexural Strength for M20 Grade of Concrete (Sample – 1)

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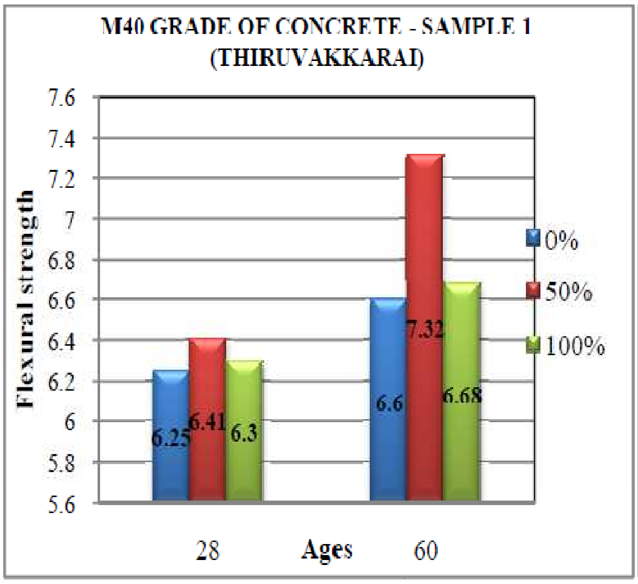

Fig. 4.6 Flexural Strength for M20 Grade of Concrete (Sample – 2)

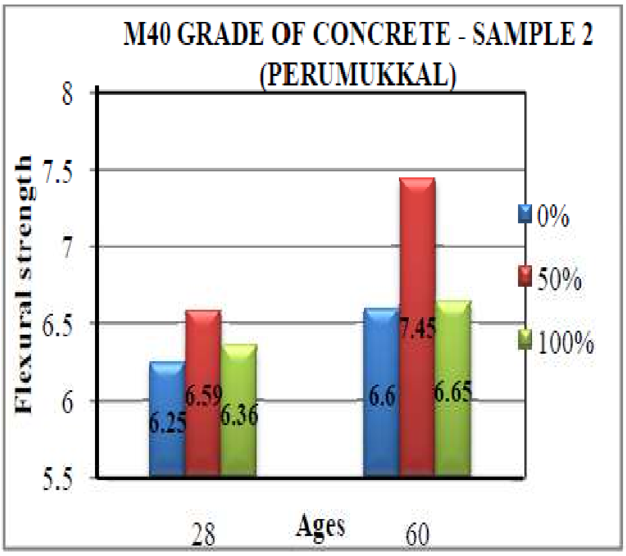

Fig. 4.7 Flexural Strength for M40 Grade of Concrete (Sample – 1)

VI. CONCLUSION

All the experimental data shows that the addition of the quarry wastes improve the physical and mechanical properties. These results are of great importance because this kind of innovative concrete requires large amounts of fine particles. Due to its high fineness of the quarry dust material it provided to be very effective in assuring very good cohesiveness of concrete. From the above study, it is concluded that the quarry wastes material may be used as a replacement material for fine aggregate.

- The physical and chemical properties of quarry dust material are satisfied the requirements of code provision in properties studies. Natural river sand, if replaced by hundred percent quarry rock dust from quarries, may sometimes give equal or better than the reference concrete made with Natural sand, in terms of compressive and flexural strength studies. To get the design degree of workability, the use of superplasticizer was essential.
- Studies reported here and elsewhere have shown that the strength of quarry rock dust concrete is comparatively ten to twenty percent more than that of similar mix of conventional concrete. Also the result of this investigation shows that drying shrinkage strains of quarry rock dust concrete ate quite large to the shrinkage strain of conventional concrete.
- Thus, it can be concluded that the replacement of natural sand with quarry rock dust, as full replacement in concrete is possible. However, it is advisable to carry out trial casting with quarry rock dust proposed to be used, in order to arrive at the water content and mix proportion to suit the required workability levels and strength requirement.
- The compressive strength of concrete increases with the increase in quarry dust upto an optimal value, concrete made with 50% quarry dust replacement by fine aggregate showed higher compressive strength is increased.
- However, more research studies are being made on quarry rock dust concrete necessary for the practical application of quarry rock dust as fine aggregate.
- It is observed that there is consistent increase in the strength of conventional concrete when natural sand is fully replaced by quarry dust. The sharp edges of the particles in quarry dust provide better bond with cement than the rounded particles of natural sand resulting in higher strength. The increase in compressive stress is marginal as compared to flexural and split tensile strength.
- The test results obtained from well planned and carefully performed experimental programme encourages the full replacement of natural sand by quarry dust considering the technical, environmental and commercial factors.

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