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Experimental Investigation on Mechanical & Durability of Concrete Containing fly ash and Quarry Dust

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Abstract - The production of concrete, there is highly demanded in natural river sand. In such a situation the Quarry Dust (QD) can be an economic alternative to the river sand .This experimental study presents the strength of concrete when replacing the combination of various percentages of Quarry Dust (QD) and Fly ash (FA) as replacement of natural sand and cement in M30 grade concrete. Natural sand replaced by Quarry Dust (QD) from (0% to 60%) in steps of 20%.Simultaniously cement is replaced by Fly Ash (FA) at 40% by weight of cement. In the present work studies like the, ultrasonic pulse velocity (UPV), compressive strength, split tensile strength, flexural strength are made to obtain the result give a clear picture that (QD) can be utilized in concrete mixtures as a good substitute for natural river sand giving optimum strength at 40% replacement, with combination of 40% fly ash. Each test results are tabulated and important conclusions are made.

Index terms— Sand, fly ash, Quarry dust, Mechanical & Durability of concrete.

I. Introduction:

Now-a-days concrete is the most widely used composite material. Where constituents materials are Cement, Fine aggregate, Coarse aggregate and water. Due to the demand of natural sand, we are forced to think of alternative materials. From the past few years, the cost of sand is comparatively greater than the cost of quarry dust, even in place where river sand is easily available. In such a situation the quarry dust can be an economic alternative to the river sand. Also the quarry dust is one kind of waste material generated by stone crushing industry. Hence the quarry dust may be used in the place of natural sand in partly. So this usage will reduce the effect on environment. It is also important to make use that this replacement does not affect the strength & workability of concrete. The decreases in early strength by the addition of fly ash is ameliorated by the addition of Quarry dust , the decrease in workability by the addition of Quarry dust is reduced by addition of fly ash.

Job Thomas , B. Harilal (2015) studied the properties of cold bonded quarry dust coarse aggregate being used in concrete mixtures.The artificial aggregate prepared by using of fly ash and Quarry dust with specific gravity ranging between 1.9 and 2.5. This study contains belongs to normal weight aggregate. By using this artificial aggregate the compressive strength of concretes having water cement ratio 0.45 is found out [1].AlaaA. Shakir, Sivakumar Naganathan, Kamal Nasharuddin Mustapha (2013) have studied the properties of bricks made using Fly ash and Quarry dust and billet scale. The best performance with regard to mechanical properties was found for ratio in 1:1 of fly ash and billet scale, quarry dust and billet scale will be showed [2].

Chandana Sukesh, Katakam Bala Krishna, P.Sri Lakshmi Sai Teja, S.Kanakambara Rao (2013) studied partial replacement of sand with Quarry dust in concrete. It was found that the replacement of sand with Quarry dust helps improving the compressive strength of concrete and decreasing the workability of concrete while adding Quarry dust alone [3].

H.A.F.Dehwah(2012) studied of corrosion resistance of self-compacting concrete incorporating Quarry dust powder, silica fume and fly ash , he found the behaviour of chloride permeability in self-compacting concrete. It was preferred for the structures exposed to chloride bearing environments up to 8%QDP+5%SF, w/c 0.4 [4].

S.N. Raman, T.Ngo, P.Mendis, H.B Mahmud(2011) In this study, High strength rice husk ash concrete incorporating Quarry dust as a partial substitute for sand in various mix proportions was carried out. The finding of research indicates that sand with Quarry dust give negative workability. It can be compensated by good mix design and by use of super plasticizer [5].

H. S. Sureshchandra, G. Sarangapani, and B. G. Naresh Kumar (2014) Hollow concrete block was made by replacing sand with Quarry Dust in different proportions. This study compared compressive strength of concrete block which used Quarry dust with admixtures & Quarry dust without admixtures [6].

G. Balamurugan,.P.Perumal(2013) The use of Quarry dust to replace sand is compared for different mix proportions. Optimum value was obtained for 50% replacement of Quarry dust. The maximum strength with respect to cc of M20 grade concrete was found to increase in 24.04% & 6.10 %respectively [7].

To achieve economy, it is proposed to study with the use of crush powder, a Quarry waste as an alternative material to replace river sand by crush powder. A comparatively good strength is expected when sand is replaced partially or fully with crush powder.

II. Properties of materials:

Cement:

The ordinary Portland 53 grade cement according to as per IS 12269:1987 [8] was used as a binding material in this experimental work. The properties of cement were tested in the laboratory and the values are given in Table 1.

Table 1. Physical Properties of Cement

S.NO	Description	Values obtained
1	Normal consistency	28%
2	Initial setting time	40min
3	Final setting time	350min
4	Specific gravity	3.15

Fly ash:

Fly ash collected from the Ennore thermal power plant and the properties were conformed with IS 3812:2003[9], used as a supplementary binding material through the study. The specific gravity
Of fly ash were found as 2.17 in laboratory.

Fine aggregate:

Natural river sand collected from river bed used as
Fine aggregate. The properties of sand were found in laboratory as per procedure given in IS 383:1970[10] and values were given in Table 2.

Table 2. Physical properties of sand and quarry dust

S. No	Description	River sand	Quarry dust
1	Specific gravity	2.65	2.61
2	Water absorption	1.24%	2.46%
3	Particle size range	0.15 to 4.75mm	0.15 to 4.75mm

Quarry dust:

Quarry dust used as an alternative to fine aggregate and it was collected from local aggregate crushing unit. The physical properties of quarry dust were found in laboratory and the values were given Table 2.

Coarse aggregate:

Crushed aggregate passing through 20mm and retained over 12.5mm size blue metal were used as coarse aggregate. The specific gravity found as 2.8 used as per IS 383:1970[11].

Chemical admixture:

The mixtures maintained w/c ratio as 0.45 without affecting the water content in concrete mixtures, improved workability of concrete with help of super plasticizer, for this study used ASTM F-type super plasticizer used. Having specific gravity 1.12 as per IS 9103:1999[12].

III. Experimental investigation:

Mix proportioning:

As per the guidelines given in IS 10262:2009[13] arrived mixture proportion of M30 grade concrete. The control concrete was denoted as CC. In all the Mixes 40% of cement with fly ash, also replaced 0%, 20%, 40% and 60% of sand with quarry dust and were denoted as Mix 1, Mix 2, Mix 3 and Mix 4 respectively. The detailed mixture proportion is given in Table 3.

Table 3. Mix Design proportions

Mix ID	Cement (kg/m^3)	Fly ash(kg/m^3)	Fine aggregate(kg/m^3)	Quarry Dust(kg/m^3)	Coarse aggregate(kg/m^3)	Water (kg/m^3)	Super plasticizer (0.4%) in (kg/m^3)
CC	372.41	-	825.849	-	1062.205	167.586	1.489
Mix 1	223.447	148.965	825.849	-	1062.205	167.586	1.489
Mix 2	223.447	148.965	660.679	162.677	1062.205	167.586	1.489
Mix 3	223.447	148.965	495.509	325.353	1062.205	167.586	1.489
Mix 4	223.447	148.965	330.340	488.030	1062.205	167.586	1.489

Casting of specimens:

100x100x100mm concrete cube specimens were casted to study quality and strength of concrete at curing age of 1, 7, 28 and 56 days. 100mmØ X 200mm length cylinder and 500x100x100mm beam specimens were casted to study the split tensile strength and flexural of concrete respectively at 28 and 56 days. Based on the material proportions for corresponding mixtures, concrete were made and casted the specimens after 24 hours, specimens are demoulded from moulds, then kept in the curing tank filled with potable water. Curing process was carried out up to the required curing age. At the age of testing, specimens were taken out from water and dried in room temperature and tested the specimens. Specimens were tested as per procedure given in IS 516:1959[14].

IV. Results and discussion:

A. Compressive strength:

The size of 100x100x100 mm cubes are used in compressive strength at the age of 1day, 7days, 28days, and 56days results is taken as per IS516:1959[14]. Average of three specimens is taken for each test mixes. Specimens are tested after fully dried. The maximum compressive strength is obtained from 40% replacement of sand by quarry dust with combination of 40% replacement of cement by fly ash. Tested results are tabulated in Table 5.

Table 5. Compressive strength results (in MPa)

Mix ID	M30			
	1 days	7 days	28 days	56 days
CC	19.1	20.1	38.6	40.5
Mix 1	18.8	23.1	39.3	39.6
Mix 2	19.9	25.9	39.5	40.5
Mix 3	**20.1**	**28.2**	**39.7**	**41.5**
Mix 4	18.3	23.5	38.6	38.7

From the figure 1 is observed that the 1day, 7days, 28 days, and 56 days compressive strength of concrete reached maximum value at Mix 3.compressive testing images are shown in figure 2.

Figure 1. Compressive strength of 1, 7, 28, 56 days (in MPa)

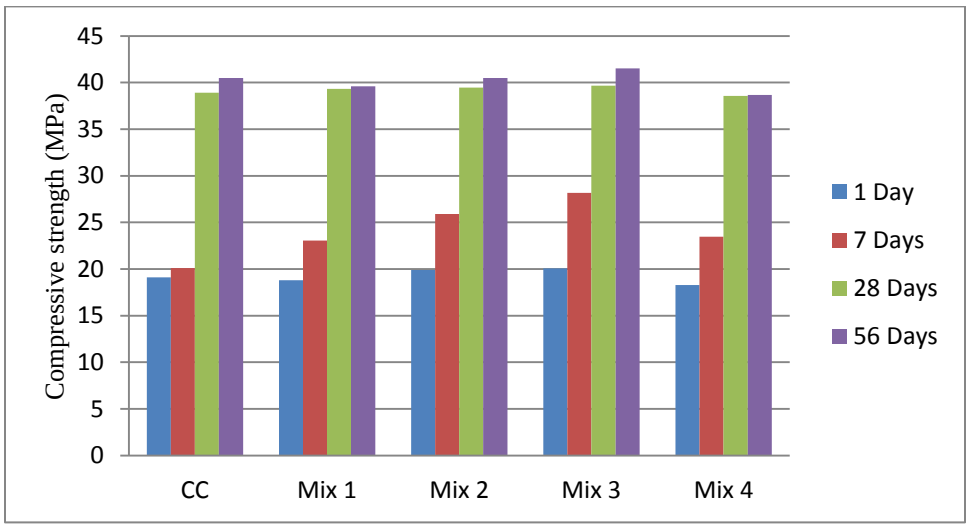


Figure 2. Testing of cubes in laboratory

B. Split tensile strength:

Split tensile test is done with compression testing machine by placing a cylindrical specimen horizontally between the loading surfaces of a plate. The loading is applied to the cylinder up to failure. These strengths are found at the curing ages of 28days and 56 days as per IS 5816:1999[15].Tested results are tabulated in Table 6.

Table 6. Tensile strength of concrete (in MPa)

Mix ID	M30	
	28 days	56 days
Mix 1	2.85	3.04
Mix 2	2.90	3.06
Mix 3	**2.96**	**3.09**
Mix 4	2.66	3.06

From the figure 3, the results obtained from 28 days and 56 days tensile strength of concrete reached maximum strength in Mix 3. The failure of tensile strength specimen is shown in figure 4.

Figure 3. Tensile strength of 28, 56 days (in MPa)

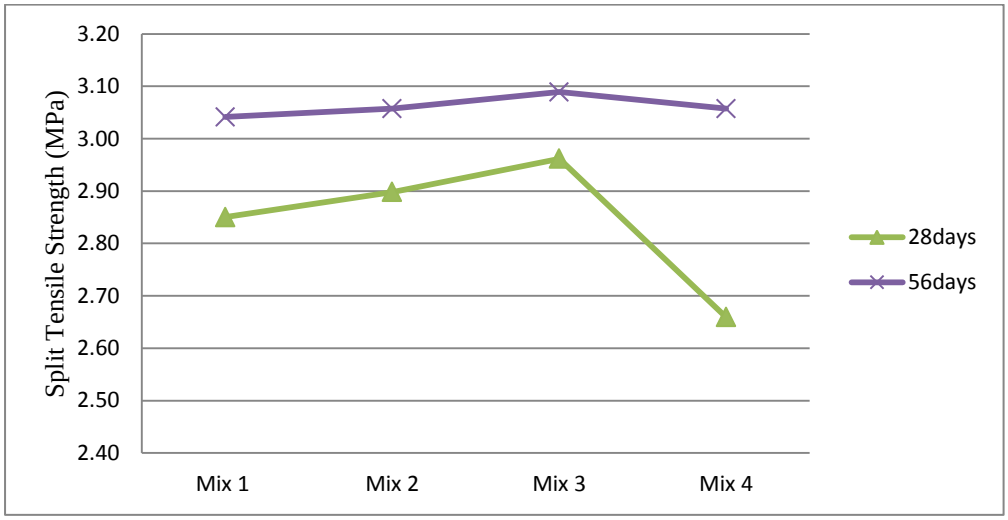


Figure 4. Split tensile strength

C. Flexural strength :

Flexural strength of concrete is obtained the result at curing age of 28 days and 56 days as per IS 516:1959[14]. It can be found that the maximum strength reached in Mix3. The flexural strength is shown in Table7.

Table 7: Flexural strength (in MPa)

Mix ID	M30	
	28 days	56 days
Mix 1	3.27	3.61
Mix 2	4.5	4.95
Mix 3	**4.83**	**5.03**
Mix 4	3.58	3.84

The optimum flexural strength analysis result is shown in figure5 and the failure mode of specimen is shown in figure 6.

Figure 5. Flexural strength of 28, 56 days (in MPa)

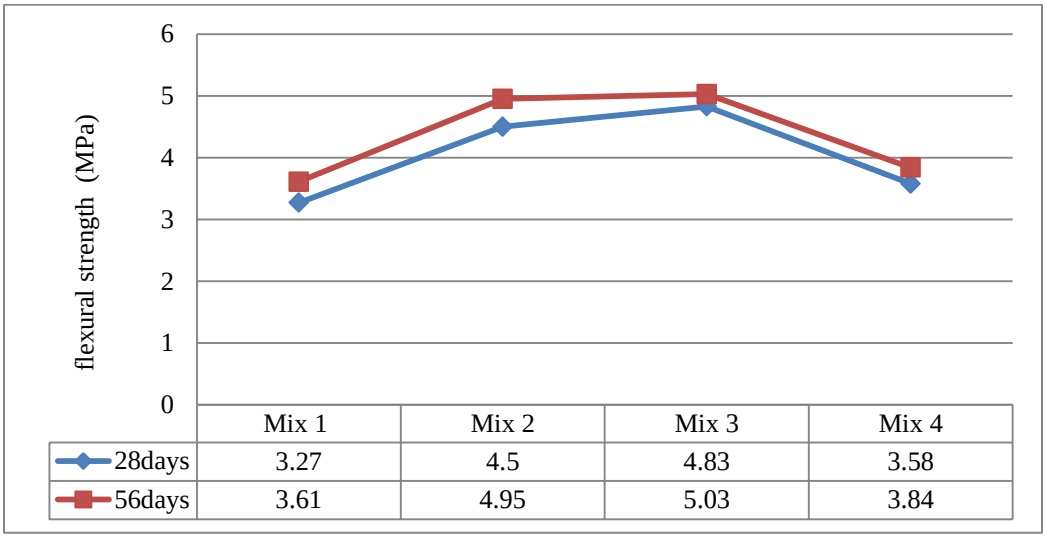


Figure 6. flexural strength test

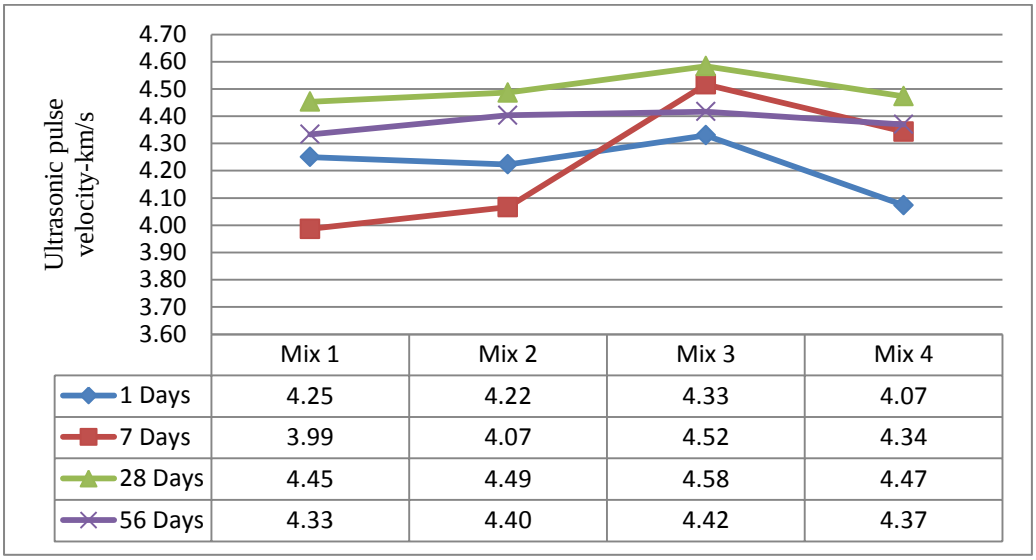
D. Ultrasonic pulse velocity:

Ultrasonic pulse velocity test is used to identify the quality of concrete with in different proportions. In this test helps to find the quality of concrete is referred from as per IS 13311-(Part 1):1992[16], tabulated in Table 8. This experimental test is to found a quality of concrete increased in Mix 3 proportions; it is shown in figure 7.typical testing of velocity is shown in figure 8.

Table 8. Quality of concrete as per IS: 13311-(Part 1):1992

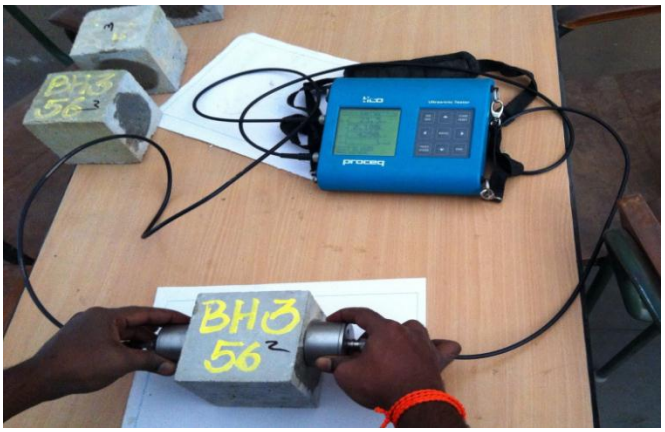
Sl No:	Pulse velocity in (Km/s)	Quality of concrete
1	4.5 <	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	> 3.0	Doubtful

Figure 7. Ultrasonic pulse velocity at 1, 7, 28, 56 days concrete



	Mix 1	Mix 2	Mix 3	Mix 4
1 Days	4.25	4.22	4.33	4.07
7 Days	3.99	4.07	4.52	4.34
28 Days	4.45	4.49	4.58	4.47
56 Days	4.33	4.40	4.42	4.37

Figure 8. Ultrasonic pulse velocity tests



V. Conclusion

- In this experimental work concluded that, by replacing the combination of cement with fly ash and sand with Quarry dust will increase the strength up to certain percentage, without sacrificing the workability.
- Addition of admixtures in all mixes improves the Quality of concrete; also improve the compressive strength of concrete.
- The combination of 40% fly ash in cement and 40% Quarry dust in fine aggregate of concrete showed the maximum strength in compressive strength, split tensile strength, flexural strength and Ultrasonic pulse velocity test.
- From the Mix 3 combination results shows the increasing flexural strength at 28days and 56 days in strength of 4.83Mpa, 5.03Mpa. So this combination can be used conventionally to the road concrete slabs.
- Ultrasonic pulse velocity results obtained the quality of concrete is increased in combination of Mix 3.Based on quality of concrete, the compressive strength is increased.

- The above results to be concluded that the application of Quarry dust and fly ash combination concrete mixture can be use in cement plastering and ceiling works, also can be use in tilting work applications.

  Hence this Ideal replacement of cement by Fly ash and sand by Quarry dust is not only increase the strength of concrete, also reduce cost of constituent materials. At the same time will be reduce the environmental pollutions.

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