EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND QUARRY DUST AS FINE AGGREGATE

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ABSTRACT---- River sand is the most commonly and widely used material for constructions. But now-a-days this has been expensive due to excessive cost of transportation from natural sources and also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. As it is the most commonly used fine aggregate in the production of concrete, it poses the problem of acute shortage in many areas. Where the continuous usage of it has started posing serious problems with respect to its availability, cost and environmental impact.

In such a situation the Fly ash and Quarry rock dust can be an economic alternative to the river sand. Quarry Rock Dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. Usually, Quarry Rock Dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements. Use of Quarry rock dust as a fine aggregate in concrete draws serious attention of researchers and investigators. Fly ash, also known as "pulverized fuel ash" is one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases.

This paper presents the feasibility of the usage of Quarry Rock Dust as forty percent substitutes for Natural Sand in concrete and cement is replaced by fly ash. Mix design has been developed for three grades using design an approach IS, for both conventional concrete, and non conventional concrete. Tests were conducted on physical, mechanical and workability tests, sieve analysis, water absorption tests on concrete of fly ash and Quarry Rock Dust and the results were compared with the Natural Concrete.

INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste.

Concrete is an assemblage of cement, aggregate and water. The most commonly used fine aggregate is sand derived from river banks. The global consumption of natural sand is too high due to its extensive use in concrete and also for better improvement purpose cement is partially replaced with fly ash. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for natural sand.

On the other hand, the advantages of utilization of byproducts or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load & waste management cost, reduction of production cost as well as augmenting the quality of concrete. The utilization of Quarry rock dust which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries of the west for the past three decades. As a result of sustained research and developmental works undertaken with respect to increasing application of this industrial waste, the level of utilization of Quarry Rock Dust in the industrialized nations like Australia, France, Germany and UK has been reached more than 60% of its total production. The use of manufactured sand in India has not been much, when compared to some advanced countries. This paper presents the feasibility of the usage of Quarry Rock Dust as forty percent substitutes for Conventional Concrete. Tests were conducted on cubes and cylinders to study the physical, mechanical and workability and sieve analysis of concrete made of fly ash and Quarry Rock Dust for four different proportions. Workability and water absorption Studies were done for concrete with Quarry Rock Dust and compared with the Conventional Concrete

CEMENT:

The term cement is commonly used to refer powdered materials which develop strong adhesive qualities when combined with water. Cementis a binder, a substance that sets and hardens independently, and can bind other materials together. These materials are more properly known as hydraulic cements. Gypsum plaster, common lime, hydraulic limes, natural pozzolana, and Portland cements are the more common hydraulic cements, with Portland cement being the most important ingredient in construction. Cement was first invented by the Egyptians. Cement was later reinvented by the Greeks and the Babylonians who made their mortar out of lime. Later, the Romans produced cement from pozzolans, an ash found in all of the volcanic areas of Italy, by mixing the ash with lime. Cement is a fine grayish powder which, when mixed with water forms a thick paste. When this paste is mixed with sand and gravel and allowed to dry it is called concrete. About ninety-nine percent of all cement used today is Portland cement. The name Portland cement is not a brand name. This name was given to the cement by Joseph Asp din of Leeds, England who obtained a patent for his product in 1824. The balance of cement used today consists of masonry cement, which is fifty percent Portland cement and fifty percent ground lime rock

COARSE AGGREGATE: Coarse aggregate consists of naturally occurring materials such as gravel, resulting from the crushing of parent rock, to include natural rock, slag, expanded clays and shale's (lightweight aggregates) and other approved inert materials with similar characteristics having hard, strong, durable particles, conforming to the specific requirements. Coarse aggregates are stones that are retained on 4.75mm sieve. All natural aggregates originate from bed rocks. There are three kinds of rocks namely Igneous, Sedimentary and metamorphic. In such many properties of aggregates depend on the properties of parent rock itself. Coarse aggregates are classified into two main groups

Single-size aggregate

Graded aggregate

The properties of the coarse aggregate used in a concrete mixture effects the modulus of elasticity. The particle shape of the aggregate contributes to the effectiveness of producing a high performance concrete. Crushed rock creates a much better bond between the paste and the aggregate than gravel does.

SAND:

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions it passes through 4.75 mm IS sieve, and contains not more than 5 per cent coarser material. They may be classified as follows

Natural sand

Crushed stone sand

Crushed gravel sand

The fine aggregates serve the purpose of filling all the open spaces in between the coarse particles. Thus, it reduces the porosity of the final mass and considerably increases its strength. Usually, natural river sand is used as a fine aggregate. However, places, where natural sand is not available economically, finely crushed stone may be used as a fine aggregate.

1.4QUARRY ROCK DUST:

Quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes to form fine particles less than 4.75mm.Properties of Quarry Dust varies from quarry to quarry as it depends on type of the granite stones .For example the Specific gravity depends on the nature of the rock from which it is processed and the variation is less

1.5 FLY ASH:

Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminum oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

1.6CONCRETE:

Concrete is a very strong and versatile mould able construction material. It consists of cement, sand and aggregate (gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement chemically reacted with the water(hydrated),it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete continue harden and gain strength over many years.

TYPES OF CONCRETE:

Concrete is generally classified in to three main types

Normal strength concrete
High strength concrete
Ultra high strength concrete

Normal strength concrete:
The concrete in which common ingredients i.e. aggregate, water, cement are used is known as normal concrete. The common strength value is 10-40mpa, at 28 days 80% of the total strength is attained

High strength concrete:
High strength concrete holds more strength; the common strength value is 50-100mpa.

Ultra high strength concrete: Ultra high strength concrete yields high strength than Normal and High strength concrete, the common strength value is 100-150mpa

3 EXPERIMENTAL PROGRAMME

CONSTITUENT MATERIAL:
The ingredients of concrete consist of cement, fine aggregate and coarse aggregates, water. When the reaction of water with cement takes place hydration process is done and a hard material is formed. In this project work we used quarry rock dust as a partial replacement of fine aggregate and fly ask replaced by cement. The ingredients are used in proper proportion. Also the cement and fine aggregate is replaced with fly ash and quarry rock dust at 10%,20%,30%,40%,50%. They are described in details with their properties are as follows

CEMENT
The Ordinary Portland Cement (OPC) 53 grade used in the project work. This is used as main binder in the mixes.

FINE AGGREGATE AND COARSE AGGREGATE:
Fine and coarse aggregate make up the bulk of concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose. For fine aggregates natural sand is provided with maximum size of 4.75 mm. coarse aggregates are used with size between 20mm-4.75mm

Fly ash: This kind of ash is extracted from flue gases through Electrostatic Precipitator in dry form. This ash is fine material & possesses good pozzolanic property.

BOTTOM ASH: This kind of ash is collected in the bottom of boiler furnace. It is comparatively coarse material and contains higher un burnt carbon. It possesses zero or little pozzolanic property.

POND ASH: When fly ash and bottom ash or both mixed together in any proportion with the large quantity of water to make it in slurry form and deposited in ponds wherein water gets drained away. The deposited ash is called as pond ash.

MOUND ASH:: (PFA). When fly ash and bottom ash or both mixed together in any proportion with the large quantity of water to make it in slurry form and deposited in ponds wherein water gets drained away. The deposited ash is called as pond ash. Fly ash and bottom ash or both mixed in any proportion and deposited in dry form in the shape of a mound is termed as mound ash.

As per the Bureau of Indian Standard IS: 3812 (Part-1) all these types of ash is termed as Pulverized Fuel Ash Fly ash produced in modern power stations of India is of good quality as it contains low sulphur & very low unburnt carbon i.e. less loss on ignition. In order to make fly ash available for various applications, most of the new thermal power stations have set up dry fly ash evacuation & storage system. In this system fly ash from Electrostatic Precipitators (ESP) is evacuated through pneumatic system and stored in silos. From silos, it can be loaded in open truck/ closed tankers or can be bagged through suitable bagging machine. In the ESP, there are 6 to 8 fields (rows) depending on the design of ESP. The field at the boiler end is called as first field & counted subsequently 2 , 3 onwards. The field at chimney end is called as last field. The coarse particles of fly ash are collected in first fields of ESP. The fineness of fly ash particles increases in subsequent fields of ESP.

EXPERIMENTAL WORK
The experimental work was carried out in our college concrete technology laboratory. In this study, total of four groups of concrete mixes were prepared in laboratory. First group was normal cement concrete mix. Second, third fourth fifth sixth and seventh group was cement replacement by fly ash particle size from 90 micron to 150 micron with replacement from 10%, 20%,30%,40% and 50% respectively afrom and firm aggregate replaced with quarry rock dust from 150 microns to 4.75mm 10%,20%,30%,40% and 50%respectivly.

Casting and testing Six different mixes (**Mix0, Mix1, Mix2, Mix3, Mix4, and Mix5**) were prepared using cement replaced by glass powder at varying percentage of **0%, 2%, 4%, 8%, 16% and 20%**. Thirty six number standard specimens of dimensions 150 × 150 × 150 mm were cast according to the mix proportion and cured in water at room temperature in the laboratory for 28.60 and 90 days. At the end of each curing period, three specimens for each mixes were tested for compressive strength and the average strength was recorded. The size of the specimen is as per the IS code 10086 – 1982. The compressive strength test both conventional and replacement materials added concrete was performed on standard compression testing machine of 3000kN capacity, as per IS: 516-

1959 and also the cube are tested under flexural testing machine and spilt tensile test, water absorption test and compaction factor test are also included, from the following above tests results are concluded

Mix proportion:

GRADE OF CONCRETE	W/C RATIO	CEMENT	FLY ASH	FINE AGGREGATE	QUARY DUST	COARSE AGGREGATE
M30(CONV)	0.45	414	0	633	0	1197
M30(10%)	0.45	372.6	41.4	569.7	63.3	1197
M30(20%)	0.45	331.2	82.8	506.4	126.6	1197
M30(30%)	0.45	289.8	124.2	443.1	189.9	1197
M30(40%)	0.45	248.4	165.6	379.8	253.2	1197
M30(50%)	0.45	207	207	316.5	316.5	1197

grade of concrete	w/c ratio	Cement	fly ash	fine aggregate	Quarry dust	Coarse Aggregate
M50(conv)	0.45	515	0	433.3	0	1325
M50(10%)	0.45	463.5	51.5	389.97	43.33	1325
M50(20%)	0.45	412	103	346.64	86.66	1325
M50(30%)	0.45	360.5	154.5	303.31	129.99	1325
M50(40%)	0.45	309	206	259.98	173.32	1325
M50(50%)	0.45	257.5	257.5	216.65	216.65	1325

M30 **-** 0.45 : 1 : 1.529 : 2.89 with water/cement ratio of 0.45

M50 **-** 0.35 : 1 : 0.86 : 2.57with water/cement ratio of 0.35

4 RESULTS AND DISCUSSION

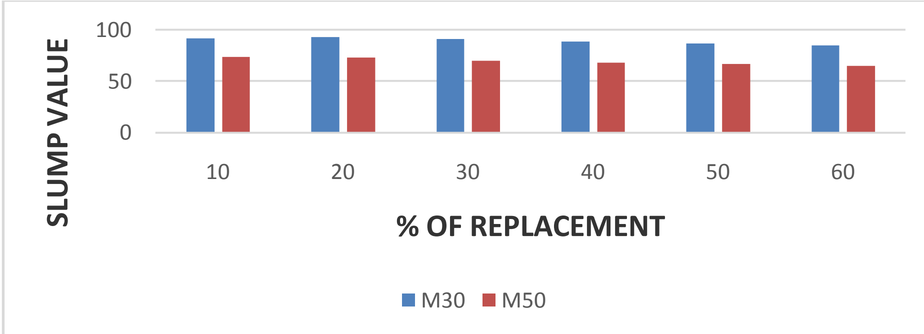
SLUMP CONE TEST:

The measured slump values of quarry dust with constant water/cement ratio i.e. w/c ratio (0.5) are 65, 66, 71,80mm for different mixes such as M1 (10% quarry dust), M2 (20% quarry dust), M3 (30% quarry dust), M4 (40% quarry dust) respectively. It is observed that the slump value increases with increase in percentage replacement of sand with quarry dust for the same w/c ratio. Concrete does not give adequate workability with increase of quarry dust. It can be due to the extra fineness of quarry dust (Jain et.al., 1999).Increased fineness require greater amount of water for the mix ingredients to get closer packing, results in decreased workability of the mix. The above slump value corresponds to low degree of workability as per IS: 456-2000.

SHOWING SLUMP CONE VALUES

grade	value	grade	Value
M30(CONV)	112	M50(CONV)	110
M30(10%)	92	M50(10%)	74
M30(20%)	93	M50(20%)	73
M30(30%)	91	M50(30%)	70
M30(40%)	89	M50(40%)	68
M30(50%)	87	M50(50%)	67
M30(60%)	85	M50(60%)	65

We have measured the height of the fall of the cone of concrete for various water-cement ratios and recorded the values for ordinary concrete. The same procedure is done with the concrete having the partial replacement of sand with raw quarry dust at various percentages



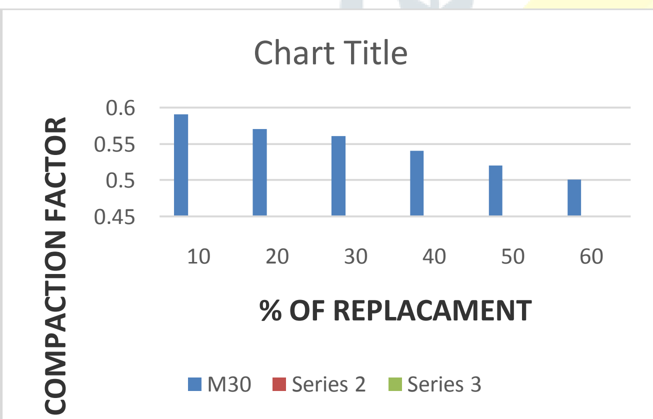
COMPACTION FACTOR TEST:

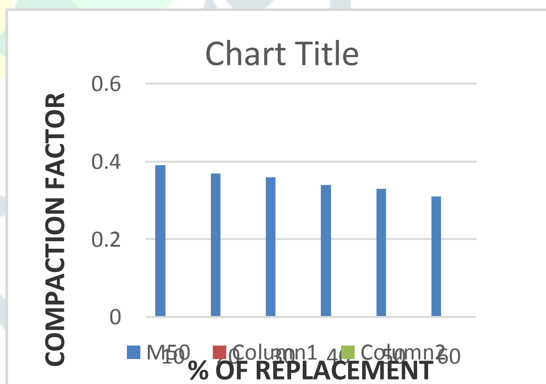
The variation of workability is measured in terms of compaction factor with constant w/c ratio (0.5) (Jain et.al., 1999). The values are obtained for different mixes such as M1 (0% quarry dust), M2 (20% quarry dust), M3 (30% quarry dust), M4 (40% quarry dust), M5 (50% quarry dust) are 0.90, 0.851, 0.845, 0.827, 0.802 respectively.

TABLE 4.3 SHOWING COMPACTION FACTOR VALUES :

VARIATION OF COMPACTING FACTOR OF QUARY ROCK DUST AS FINE AGGREGATE AND FLYASH AS THE CEMENT

Grade	value	Grade	Value
M30(CONV)	0.89	M50(CONV)	0.85
M30(10%)	0.59	M50(10%)	0.39
M30(20%)	0.57	M50(20%)	0.37
M30(30%)	0.56	M50(30%)	0.36
M30(40%)	0.54	M50(40%)	0.34
M30(50%)	0.52	M50(50%)	0.33
M30(60%)	0.5	M50(60%)	0.31





M30 GRADE COMPACTION FACTORS

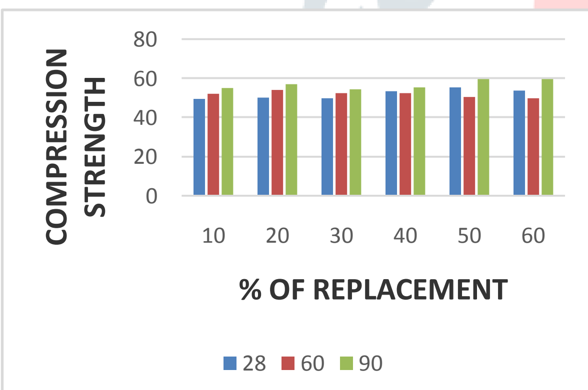
COMPRESSIVE STRENGTH:

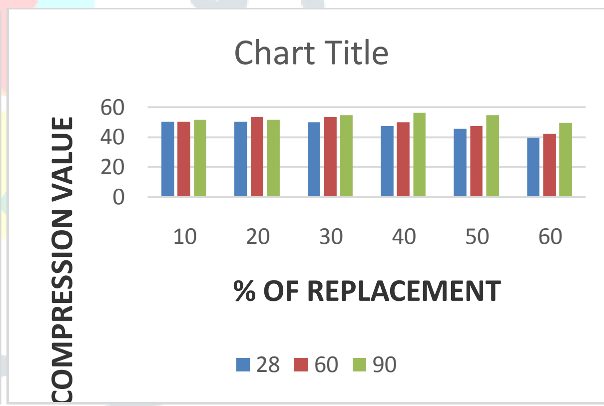
The results of compressive strength of cubes for (7, 28, 91) days curing are shown in Figureure. 3, 4 and 5. It is observed that the compressive strength of cubes at 28 days curing for control mixture (M1) is 30.5 Mpa for 53 grade concrete and 29.6 Mpa for 33 grade concrete (Naidu et. al., 2003). Dust content increases to 30%, the 28 days compressive strength increases to a maximum of 31.5 Mpa for 53 grade and 30.7Mpa for 33 grade.

TABLE 4.4 INDICATING VARIOUS VALUES OF COMPRESSIVE STRENGTH TEST

GRADEOF CONCRTE	LOAD (KN)	28 DAYS	LOAD(KN)	60 DAYS	LOAD(KN)	90 DAYS
M30(CONV)	652.5	29	1015.4	45.13	1121.85	49.86
M30(10%)	1116	49.6	1174.5	52.2	1240.2	55.12
M30(20%)	1131.7	50.3	1221.75	54.3	1285.2	57.12
M30(30%)	1127.2	50.1	1183.5	52.6	1229.62	54.65
M30(40%)	1208.4	53.714	1181.25	52.5	1252.1	55.65
M30(50%)	1251.25	55.61	1139.4	50.64	1341.9	59.64
M30(60%)	1215	54	1121.62	49.85	1346.4	59.84

GRADEOF CONCRTE	LOAD (KN)	28 DAYS	LOAD(KN)	60 DAYS	LOAD(KN)	90 DAYS
M50(CONV)	585	26	1132.5	50.56	950.17	42.23
M50(10%)	1131.9	50.31	1174.5	53.42	1166.40	51.84
M50(20%)	1139.6	50.65	1172.9	53.35	1229.62	54.65
M50(30%)	1127.2	49.94	1129.8	50.25	1274.62	56.64
M50(40%)	1114.6	47.65	1175.62	52.25	1229.42	54.63
M50(50%)	1031.6	45.85	1070.10	47.56	1121.4	49.84
M50(60%)	890.1	39.56	950.62	42.25	1057.5	47





M30&M50 GRADE COMPRESSION STRENGTH CHART

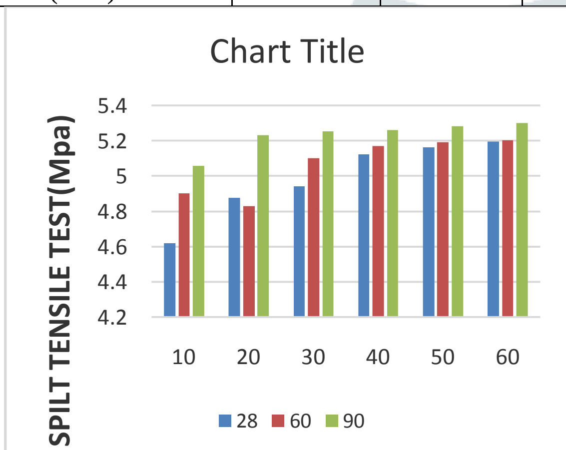
SPLIT TENSILE TEST:

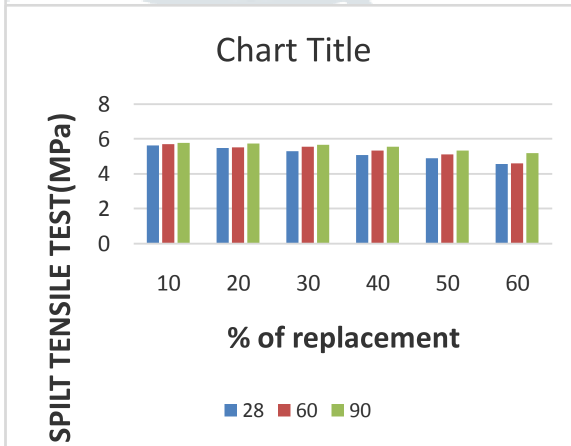
The results of split tensile strength of cylinder for 28,60,90 days are given in Figureure. 6 for M30,M50 grade, the split tensile strength is 2.18 Mpa and 2.72 Mpa respectively for 0% quarry dust content at 7 and 28 days for 53 grade concrete. The tensile strength value of concrete decreases with increase in percentage of fine aggregate replacement with quarry dust The tensile strength increases a maximum of 3.54 Mpa

GRADEOF CONCRTE	LOAD (KN)	28 DAYS	LOAD(KN)	60 DAYS	LOAD(KN)	90 DAYS
M30(CONV)	258.15	3.654	335.58	4.75	312.62	4.425
M30(10%)	326.40	4.62	346.18	4.9	357.20	5.056
M30(20%)	344.41	4.875	341.23	4.83	369.49	5.23
M30(30%)	349.01	4.94	360.31	5.1	370.91	5.25

M30(40%)	361.72	5.12	365.04	5.167	371.61	5.26
M30(50%)	364.69	5.162	366.67	5.19	373.03	5.28
M30(60%)	366.88	5.193	367.38	5.2	374.44	5.3

GRADEOF CONCRTE	LOAD (KN)	28 DAYS	LOAD(KN)	60 DAYS	LOAD(KN)	90 DAYS
M50(CONV)	335.72	4.752	353.25	5	368.51	5.216
M50(10%)	399.38	5.653	403.41	5.71	407.65	5.77
M50(20%)	387.86	5.49	391.40	5.54	406.23	5.75
M50(30%)	375.36	5.313	394.22	5.58	400.58	5.67
M50(40%)	360.31	5.1	377.27	5.34	392.10	5.55
M50(50%)	345.47	4.89	361.72	5.12	376.56	5.33
M50(60%)	322.16	4.56	322.16	4.59	367.38	5.2





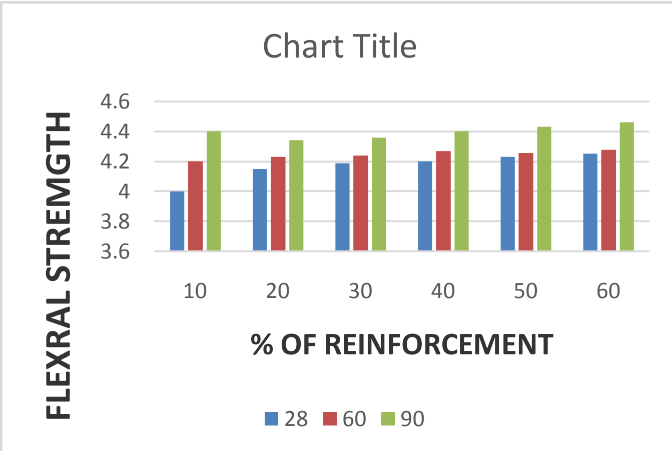
M30 & M50 GRADE SPILT TENSILE TEST STRENGTH CHART

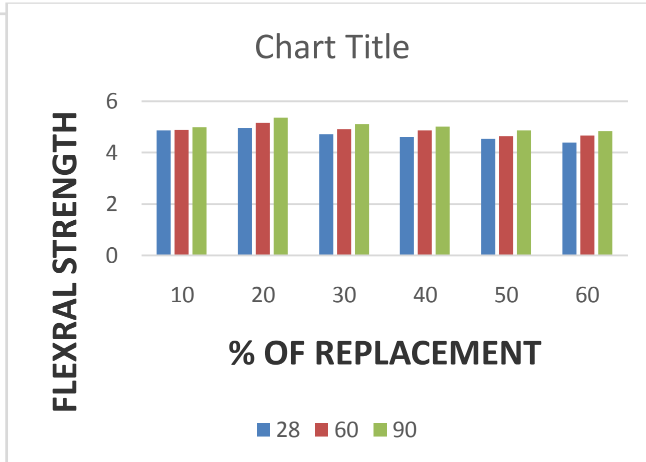
FLEXRALTENSILE TEST:

The results of flexral tensile strength of cylinder for 7, 28, 91 days are given in Figureure. 6 for m30 &m50 grade.

GRADEOF CONCRTE	LOAD (KN)	28 DAYS	LOAD(KN)	60 DAYS	LOAD(KN)	90 DAYS
M30(CONV)	17.51	3.892	17.68	3.93	16.06	3.57
M30(10%)	18.00	4	18.90	4.2	19.80	4.4
M30(20%)	18.67	4.15	19.03	4.23	19.53	4.34
M30(30%)	18.85	4.189	19.21	4.27	19.60	4.356
M30(40%)	18.90	4.2	19.17	4.269	19.79	4.398
M30(50%)	19.03	4.23	19.15	4.256	19.93	4.43
M30(60%)	19.12	4.25	19.25	4.278	20.07	4.46

GRADEOF CONCRTE	LOAD (KN)	28 DAYS	LOAD(KN)	60 DAYS	LOAD(KN)	90 DAYS
M50(CONV)	22.27	4.95	22.54	5.01	23.58	5.24
M50(10%)	21.96	4.88	22.12	4.916	22.55	5.013
M50(20%)	22.41	4.98	23.29	5.176	24.21	5.38
M50(30%)	21.24	4.72	22.16	4.926	23.12	5.139
M50(40%)	20.88	4.64	21.97	4.884	22.594	5.021
M50(50%)	20.52	4.56	20.97	4.66	21.91	4.87
M50(60%)	19.88	4.4	21.01	4.67	21.78	4.84



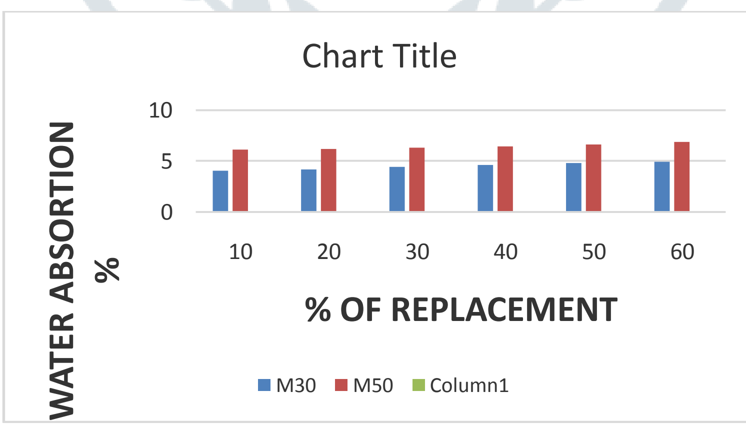


M30&M50 GRADE FLEXRALSTRENTH VALUES

WATER ABSORPTION :

Water absorption % of concrete has decreased for dust contents from 0 to 20% and then it started to increase for 30% to 50% of dust contents (Figure. 10 & Figure. 11). Quarry dust acts as filler in concrete and contributes to reduce the absorption of concrete.

grade	value	grade	value
M30(CONV)	0.26	M50(CONV)	0.2
M30(10%)	4.07	M50(10%)	6.12
M30(20%)	4.2	M50(20%)	6.21
M30(30%)	4.42	M50(30%)	6.35
M30(40%)	4.65	M50(40%)	6.48
M30(50%)	4.815	M50(50%)	6.67
M30(60%)	4.92	M50(60%)	6.89



5 CONCLUSION

All the experimental data shows that the addition of the industrial wastes improves the physical and mechanical properties. These results are of great importance because this kind of innovative concrete requires large amount of fine particles (Aitcin,1990). Due to its high fines of quarry dust it provided to be very effective in assuring very good cohesiveness of concrete. From the above study it is concluded that the quarry dust may be used as a replacement material for fine aggregate.

Quarry dust and fly ash has been used for different activities in the construction industry such as for road construction and manufacture of building materials such as light weight aggregates, bricks, tiles and auto clave blocks. However its use as rigid payment is very much limited. Thorough reaction with the concrete admixture, quarry dust, improved pozzolanic reaction, micro aggregate filling and concrete durability.

As the properties are good as sand, the quarry dust is used as fine aggregate in replacement with sand and flyash in replacement of cement in the cement concrete. From the various laboratory investigations made for characteristics study of quarry dust concrete and based on the studies conducted as explained in Chapter- 3 and Chapter- 4 following conclusions are drawn. Non availability of sand at reasonable cost as finer aggregate in cement concrete for various reasons, search for alternative material stone crusher dust qualifies itself as a suitable substitute for sand at very low cost.

1.The measured slump values of quarry dust concrete with constant water cement ratio 0.5 are found to be observed that the slump value increases with increase in percentage replacement of sand with quarry dust. Due to flaky particles shape and higher percentage of fines, concrete does not give adequate workability and the concrete tends to segregate. The above slump value correspond to low degree of workability, suitable for construction of tiles, bricks, canal lining and autoclave blocks as per IS 456-2000.
2.The measured compaction factor value for quarry dust concrete with constant w/c ratio (0.5) are found to be 0.59,0.57,0.56,0.54,0.52,0.5 for M30mixes such as M1 (10%) , M2 (20%), M3 (30%) , M4 (40%),M5(50%),M6(60%) respectively. 0.39,0.37,0.36,0.34,0.33,0.31 for M50 mixes such as M1 (10%) , M2 (20%), M3 (30%) , M4 (40%),M5 (50%),M6 (60%)respectively. The above values shows concrete do not give adequate workability with the increase of quarry dust as fine aggregate. The above compaction factor corresponds to low degree of workability.

3.Further investigation results that the Compressive strength of concrete is increased by 55.06% for m30 &45.85% for m50 at 50% replacement of fine aggregate by quarry rock dust and cement by fly ash, and up to 76.60%replacement, concrete gain more strength than control mix concrete strength.

4.It is observed that, the flexural strength of concrete at 28 days is higher than design mix (Without replacement) for 50% replacement of fine aggregate by quarry rock dust and cement by fly ash, the flexural strength of concrete is increased by 4.62% for m30 20.26% for m50. This also indicates flexural strength is more for replacements up to 60% than design control mix.

5.It is also observed that, for, the split tensile strength of concrete at 28 days is higher than design mix (Without replacement) for 50% replacement of fine aggregate by quarry rock dust and cement by fly ash, the split tensile strength of concrete is increased by 4.62 %. For m30,for m50 20.52% This also indicates split tensile strength is more for replacements up to 75% than design control mix.

6.Compressive strength, flexural Strength and split tensile strength are increased due to high toughness of Copper slag up to 75% replacement

7.The water absorption percentage of quarry dust, concrete decreased for dust content from (0-20) % and then it started to increase for 30%, 40%, and 50% of dust contents. Lower the particle size results in faster absorption and greater surface area results in faster evaporation leading to concrete setting quickly. It was observed that the density of concrete increases with increase in percentage of dust content. As expected the compressive strength increases with increase in density of concrete.

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