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Compression and Split Tensile Characteristics of Concrete Containing Quarry Residues

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Abstract: Waterway sand and pit sand are the most normally utilized fine aggregates for concrete creation in many parts of the world. Huge scale extraction of these materials presents genuine ecological risk in numerous parts of the nation. Aside from the ecological danger, there still exists the issue of intense lack in many regions. In this way, substitute material in place of river sand for concrete production should be considered. The paper means to examine the compressive and split tensile qualities of concrete produced using quarry residue, sand, and a blend of sand and quarry dust. The experimentation is absolutely research facility based. A total of 60 concrete cubes of size 150 mm x 150 mm x 150 mm, and 60 cylinders 150 mm in diameter and 300 mm deep, conforming to M50 grade were casted. All the samples were cured and tested with a steady water/concrete proportion of 0.31. Out of the 60 blocks cast, 20 each were made out of natural river sand, quarry dust and an equivalent blend of sand and quarry dust. It was discovered that the compressive strength and split tensile strength of concrete produced using the blend of quarry residue and sand was higher than the compressive qualities of concrete produced using 100% sand and 100% quarry dust.

Keywords: Concrete, Quarry dust, Compressive Strength, Split Tensile Strength

I. INTRODUCTION

Concrete is a constituent made of cement, fine aggregates, coarse aggregates and water with or without different mineral additives. As indicated by Safiuddin[1] et al. (2007), it is a broadly utilized material in the world. In light of its worldwide utilization, concrete is put in runner up after water. Nature of concrete relies upon nature of its constituents. Fine and coarse aggregates are basic segments of concrete. They for the most part possess 60% to 75% of concrete volume. Thus, they impact the solidified properties, blend extents and economy of concrete (Sing[2] et al. 2012). The most regularly utilized fine aggregate is common waterway or pit sand. Research directed by Vijaya Kumar[3] et al. (2015) demonstrated that, quarry residue has the capability of being utilized as substitution of fine aggregate in concrete generation. Quarry residue is an unavoidable by-product in the method of extracting and preparing of aggregates. Now and again it is considered as waste in light of the fact that not many markets presently exist for them. Nonetheless, in contrast to numerous different wastes, they are commonly dormant and non-perilous.

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Quarry residue is commonly considered as a waste material, causing an ecological burden because of disposal issues. Thus, utilizing quarry dust as fine aggregates in concrete blends will diminish the interest for common sand as well as the environmental burden.

As indicated by Saha and Sarker[4] (2017), fusion of modern industrial by-products, for example, quarry dust as aggregate may lessen the disposal cost of these by-products and creation cost of concrete. Accordingly, use of quarry dust as a halfway substitution of stream sand as fine aggregate in concrete will cause it an important resource. Some elective materials have been utilized as a substitution of normal sand. Vinay[5] et al. (2015) opined that materials, for example, fly ash, slag, limestone powder and siliceous stone powder have been utilized in concrete as a halfway substitution of regular sand. A few researchers have utilized manufactured quarry fine aggregate as a fractional substitution of regular sand, and researched its impact on concrete. As indicated by Safiuddin et al. (2007), waterway sand which has consistently been conveyed underway of ordinary concrete is before long getting to be costly and rare. It makes the interest for an elective material exceedingly basic.

As indicated by Priyanka and Dilip[6] (2013), worldwide utilization of characteristic sand is exceptionally high because of broad utilization of concrete. Specifically, the interest for characteristic sand is very high in creating nations attributable to fast infrastructural development. In perspective on this, some developing nations like India are confronting deficiencies in supply of characteristic sand in numerous pieces of the nation. Combined with this deficiency is the mind-boggling expense of the material and the genuine ecological danger it postures to human presence. It has put the construction business of developing nations under worry to discover substitute materials to diminish the interest for characteristic sand. Joel[7] (2010) states that few Asian nations, for example, India and Singapore are confronting serious deficiency of regular waterway sand to address expanding issues for infrastructural development.

The motivation behind this paper is to dissect the compressive and tensile qualities of concrete with quarry residue, sand, and a blend of quarry residue and sand as fine aggregates.

II. MATERIALS FOR CONCRETE GENERATION

Concrete is a composite material comprised of cement, aggregates (fine and coarse) and water. Now and then, mineral admixtures can be added to improve its properties. Kosmatka[8] et al., (2002) are of the view that Portland cement is hydraulic cement made basically out of calcium silicates.

It sets and solidifies by responding chemically with water. During the response, which is called hydration, cement joins with water to shape a stone like mass.

At the point when the paste (cement and water) is added to aggregates (sand, gravel, squashed stone, or other granular material), it goes about as a glue and binds the aggregates together to form concrete, the world's adaptable and most generally utilized construction material (Kosmatka et al. 2002). Sahu[9] et al. (2003) additionally showed that Portland cement and comparative materials are made by heating limestone (a wellspring of calcium) with clay, and granulating this item (called clinker) with a wellspring of sulfate (most generally gypsum).

As indicated by Kosmatka et al. (2002), fine and coarse aggregates occupy 60% to 75% of concrete by volume (70% to 85% by mass) and therefore, emphatically impact the concrete's fresh and solidified properties, blend extents and economy. Fine aggregates by and large comprise of characteristic sand and squashed stone with most particles littler than 5 mm. Coarse aggregates then again, comprise of one or a blend of rock or squashed stone with particles prevalently bigger than 5 mm and for the most part between 9.5 mm and 37.5 mm. Any regular water that is drinkable and has no articulated taste or scent, called potable water, can be utilized as blending water for making concrete (Kosmatka et al. 2002). In any case, a few waters that are not fit for drinking might be appropriate in concrete creation. Water is required for chemical response known as hydration. Hydration includes various responses, frequently happening simultaneously. As the responses continue, results of the cement hydration process step by step bond the individual sands and rock particles, and different segments of cement together to shape a strong mass (Sahu et al. 2003).

III. QUARRY DUST/FINES

As indicated by Prakash and Rao[10] (2016), quarry dust, which is a concentrated material utilized as fine aggregate for concreting, is a result of crushing process. As indicated by Mitchell[11] et al. (2008), quarry fines, as characterized by BS EN aggregate standards, are portion of aggregate under 0.063 mm (63 microns). They additionally demonstrated that the term was utilized to mean both fine aggregate and quarry fines. The extent of quarry fines created relies upon mineral arrangement and texture of the stone, energy utilized in blasting, crusher types utilized, utilization of shut or open crushing circuits, and taking care of moving and transport of aggregate items.

Mitchell et al. (2008) likewise affirmed that quarry residue is commonly latent and non-risky and it is delivered from overburden materials, through scalping, crushing and dry screening. Nisnevich[12] et al. (2003) likewise expressed that as a standard guideline, coarse-grained rocks create less fines than fine-grained rocks since it takes less energy to isolate individual minerals. Likewise, substance of minerals with low abrasion resistance unequivocally impact the measure of fines created during all phases of preparing and taking care of. That is, softer materials will breakdown more effectively than harder materials and henceforth produce more fines.

IV. MATERIALS & METHODOLOGY

The concrete was essentially made of cement, coarse aggregate (20mm & 12.5 mm), fine aggregates (pit sand and quarry residue) and potable water.

Ordinary Portland cement conforming to grade 53 was utilized as binding material for the concrete samples. Quarry residue and common pit sand which were locally available were utilized as fine aggregates for the concrete. Rock stone of size 20 mm and 12.5 mm from a quarry in the city was utilized as coarse aggregates for the concrete samples. Water from a clean source was utilized for both casting and curing of the concrete samples. Technique for curing embraced was ponding, where all the specimens were completely inundated.

To accomplish concrete cubes with a characteristic strength of 60 N/mm2, a blend proportion of 1:2:4 was utilized. Cubes of size 150 mm x 150 mm x 150 mm were cast with a water/binder proportion of 0.50. The specimens were demolded towards the finish of 24 hours and cured normally for the required number of days. All 3D square samples were utilized to decide the compressive quality towards the finish of 7, 28, 90 and 180 days, taking the average of three samples for each test. The test was carried on an advanced compression testing machine of 2000 KN capacity and the load at the failure of the sample was recorded to figure the compressive strength.

Table 1: Mix Proportions for M50 grade concrete

Cement	475 kg/m^3	1
Supplementary cementitious materials	95 kg/m^3	0.2
Fine aggregates	759 kg/m^3	1.59
Coarse aggregates	20 mm- 844.8 kg/m^3	2.25
	12.5 mm - 211.2 kg/m^3	
Water	151 kg/m^3	0.31
Superplasticizer	62 kg/m^3	0.13

V. RESULTS

5.1. Compression Test Results

The average compression of concrete matured 7 days, 28 days, 90 days and 180 days were investigated and the outcomes are exhibited in Table 2. From the test outcomes, it was uncovered that there was roughly 5.41% expansion in the average compressive strength of concrete cubes made with sand (control) when contrasted with the average compressive strength of concrete made with 100% quarry dust at 7 days. The test outcomes further demonstrated that there was roughly 6.52% expansion in the average compressive strength of concrete 3D squares made with half sand and half quarry dust as fine aggregates when contrasted with the average compressive quality of concrete made with sand as fine aggregates at 7 days.

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It was additionally uncovered from the test results at age 7 days that, there was around 11.58% expansion on the average compression of the solid 3D squares made with half sand and half quarry dust as its fine aggregates contrasted with those made with 100% quarry dust as fine aggregates.

All tests that were led at age 28 days demonstrated that, concrete 3D squares made with half sand and half quarry and 100% sand (control) as their fine aggregates had 11.24% and 8.38% expansion in compression qualities individually when contrasted with concrete 3D squares made with 100% quarry dust. There was around 3.11% expansion in compressive quality of concrete made with half quarry residue and half sand when contrasted with that made with 100% sand (control) towards the finish of 28 days. Moreover, at 90 days, there were 7.22% and 10.4% increment on the average compressive qualities by concrete cubes made with 100% sand and made with half quarry residue and half sand as their fine aggregates individually. It was more than average compressive quality of concrete 3D squares made with 100% quarry dust. There is around 3.42% expansion in compressive quality of concrete made with half quarry residue and half sand when contrasted with that made of 100% sand (control) towards the finish of 90 days. The similar trend of results was noticed at 180 days curing process. As per Neville[13], concrete of grade M50 at 28 days must accomplish a compressive quality of 50 MPa. From the test results, following 28 days the accompanying average compressive qualities were accomplished:

- Concrete made with 100% quarry dust as its fine aggregate = 48.16 MPa
- Concrete made with 100% sand (control) as its fine aggregate = 52.57 MPa
- Concrete made with half sand and half quarry dust as its fine aggregate = 54.26 MPa

These outcomes demonstrate that there was 8.38% expansion in the compression quality of the concrete 3D shapes made with quarry dust as its fine aggregate when contrasted with the average compressive quality of concrete blocks made with sand as its fine aggregate.

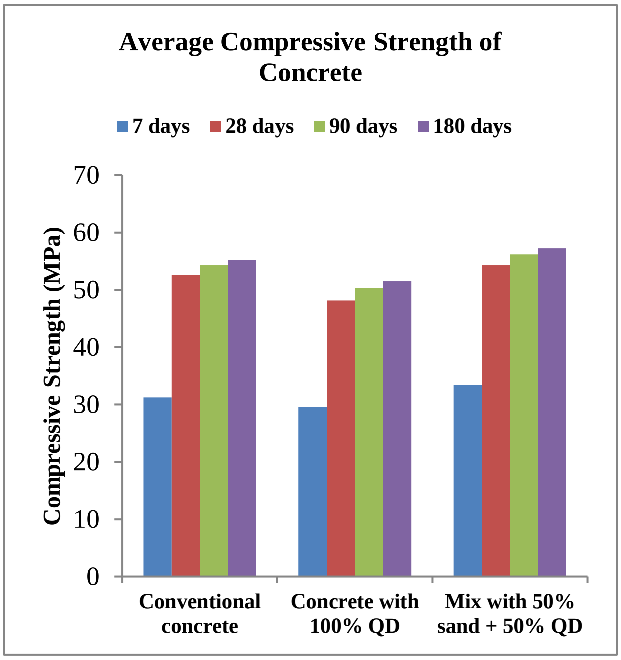

Figure 1: Variation of Compressive Strength of Concrete

Figure 2: Cube Sample

Table 2: Average compression of concrete at different ages

Specimen	Average compressive strengths for the different ages in N/mm²			
	7 days	28 days	90 days	180 days
Conventional concrete (100% sand)	31.23	52.57	54.26	55.17
Concrete with 100% quarry dust	29.54	48.16	50.34	51.52
Contrast in compression quality (MPa)	1.69	4.41	3.92	3.65
Percent alteration (%)	5.41	8.38	7.22	6.61
Mix (50% sand + 50% quarry dust)	33.41	54.26	56.18	57.24
Concrete with 100% sand	31.23	52.57	54.26	55.17
Contrast in compression quality (MPa)	2.18	1.69	1.92	2.07
Percent alteration (%)	6.52	3.11	3.42	3.62
Mix (50% sand + 50% quarry dust)	33.41	54.26	56.18	57.24
Concrete with 100% quarry dust	29.54	48.16	50.34	51.52
Contrast in compression quality (MPa)	3.87	6.1	5.84	5.72
Percent alteration (%)	11.58	11.24	10.40	9.99

5.2. Split Tensile Strength Test Results

Tensile strength for concrete specimen is characterized as the tensile stresses created due to application of the compressive load at which the concrete specimen may crack.

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Moreover, splitting tensile strength test on concrete cylinder is a technique to decide the tensile strength of concrete. The technique dependent on the ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) which similar to other codes like IS 5816 1999.

For routine testing and correlation of results, unless otherwise specified the specimens shall be cylinder 150 mm in diameter and 300 mm long.

The test specimen shall be placed in the centering jig with packing strip and/or loading pieces cautiously situating along the top and base of the plane of loading of the sample. The jig shall then be placed in the machine so that the sample is located centrally. For cylindrical specimen it shall be ensured that the upper platen is parallel with the lower platen. The load shall be applied without shock and increased persistently at an ostensible rate within the range 1.2 N/(mm^2/min) to 2.4 N/ (mm^2/min). Maintain the rate, once adjusted, until failure. The maximum load applied shall then be recorded. The appearance of concrete and any unusual features in the type of failure shall also be noted. The measured splitting tensile strength, of the specimen shall be calculated to the closest 0.05 N/mm^2.

Table 3: Average Split Tensile Strength of Concrete at different ages

Specimen	Average split tensile strengths for the different ages in N/mm^2			
	7 days	28 days	90 days	180 days
Conventional concrete (100% sand)	2.85	4.13	5.12	6.28
Concrete with 100% quarry dust	2.21	3.78	4.82	5.54
Contrast in split tensile strength (MPa)	0.64	0.35	0.3	0.74
Percent alteration (%)	22.46	8.47	5.86	11.78
Mix (50% sand + 50% quarry dust)	3.13	4.93	5.38	6.89
Concrete with 100% sand	2.85	4.13	5.12	6.28
Contrast in split tensile strength (MPa)	0.28	0.8	0.26	0.61
Percent alteration (%)	8.95	16.23	4.83	8.85
Mix (50% sand + 50% quarry dust)	3.13	4.93	5.38	6.89
Concrete with 100% quarry dust	2.21	3.78	4.82	5.54
Contrast in split tensile strength (MPa)	0.9	1.15	0.56	1.35
Percent alteration (%)	29.39	23.33	10.41	19.59

The average split tensile strength of concrete matured 7 days, 28 days, 90 days and 180 days were investigated and the outcomes are displayed in Table 3. From the test outcomes, it was observed that there was roughly 22.46% expansion in the split tensile strength of concrete cubes made with sand (control) when contrasted with the average split tensile strength of concrete made with 100% quarry dust at 7 days. The test outcomes further demonstrated that there was roughly 8.95% expansion in the average split tensile strength of concrete cylinders made with half sand and half quarry dust as fine aggregates when contrasted with the average split tensile quality of concrete made with sand as fine aggregates at 7 days. It was additionally uncovered from the test results at age 7 days that, there was around 29.39% expansion on the average split tensile of the solid cylinders made with half sand and half quarry dust as its fine aggregates contrasted with those made with 100% quarry dust as fine aggregates.All tests that were led at age 28 days demonstrated that, concrete cylinders made with half sand and half quarry and 100% sand (control) as their fine aggregates had 23.33% and 8.47% expansion in split tensile qualities individually when contrasted with concrete cylinders made with 100% quarry dust. There was around 16.23% expansion in split tensile quality of concrete made with half quarry residue and half sand when contrasted with that made with 100% sand (control) towards the finish of 28 days. Moreover, at 90 days, there were 5.86% and 10.4% increment on the average split tensile qualities by concrete cylinders made with 100% sand and made with half quarry residue and half sand as their fine aggregates individually. It was more than average tensile strength of concrete cylinders made with 100% quarry dust. There is around 4.83% expansion in the split tensile quality of concrete made with half quarry residue and half sand when contrasted with that made of 100% sand (control) towards the finish of 90 days. The similar trend was noticed at 180 days curing period.

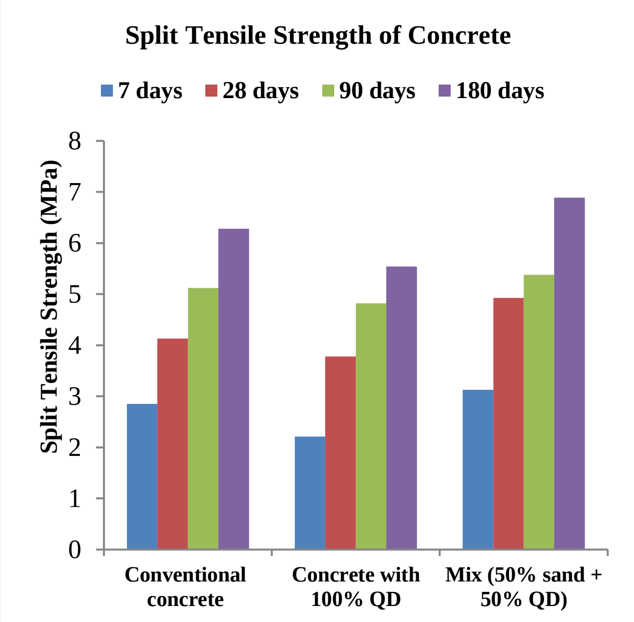

Figure 3: Variation of Split Tensile Strength of Concrete

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Figure 4: Cylindrical Sample

VI. CONCLUSIONS

The investigation infers that the quarry residue had no unfavorable impact on the compressive and split tensile qualities of concrete. Be that as it may, the workability of concrete made with 100% sand (control) was superior to anything that of 100% quarry residue and half quarry residue and half sand. There was contrast in the average compressive qualities of the different solid 3D squares with 100% sand (control), 100% quarry dust and (half sand and half quarry dust) as fine totals. The solid blocks made with half quarry residue and half sand had the most astounding average compressive quality worth, and was followed by solid 3D squares with 100% sand (control) as its fine aggregate. But it also attained a value closer to the design strength of 50 MPa.

This assessment expects to develop a concrete mix with quarry residue that has quality properties for all intents and purposes indistinguishable from that of customary concrete made with normal stream sand as fine aggregate. It is expected to displace sand with stone buildup in concrete, since fuse of higher proportions of waste stone buildup into concretes naturally benevolent and monetarily conceivable. There is no damage in using smasher dust if unadulterated by soil and other unfortunate polluting influences. Concrete attains most extraordinary increment in compressive quality at half sand substitution. The silica rate in stone buildup is above 80% which gives the high caliber as same as sand. The specific gravity of the smasher residue tests lies in the scope of 2 to 2.7 which fulfill the sand need.

Squashed stone sand can reasonably swap the regular waterway sand for concreting works. The pace of the quality addition declined as the level of quarry residue substitution expanded past 50 percent. The general expense of concrete might be diminished by expanding the level of squashed quarry dust, since expense of stone residue is insignificant when contrasted with characteristic waterway sand. As the crushed stone residue utilized is exceptionally fine, it can go about as filler between the particles of fine aggregate. Compressive and split tensile strength of concrete made with fractional and total substitution of crushed stone residue is practically identical with common waterway sand results. Stone residue contains higher level of fines than common sand and henceforth requires more water to soak the particles. Usage of quarry residue not only relieves pressure on sand but also decreases the requirement for its dumping as quarry residue is viewed as a waste item in the quarries.

Generally, every concrete needs to be cured for a maximum number of days to attain the maximum strength required. The study recommends that 100% sand and 100% quarry dust can all be used as fine aggregates in concrete production but in order to achieve a higher compressive strength in concrete, equal proportions of sand and quarry dust should be used as fine aggregates. The above determination gives an unmistakable picture that quarry buildup can be utilized in concrete mixes as a conventional substitute for natural river sand with higher quality at half substitution.

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