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An Experimental Study on the Use of Quarry Dust as a Replacement Material in Concrete

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Abstract

River sand, the most commonly used fine aggregate in concrete is very expensive now. Day by day, the cost of sand is increasing due to the scarcity and restrictions. Huge quantity of sand excavated from river bed destroys the stability of river banks. To avoid such situation and to meet the demand we have to think of an alternative or replacement material to sand. Crushed rock material, fly ash and sea sand are some of the alternatives. Different sizes of metal like 40 mm, 20mm and 10mm are obtained by crushing boulders of rock into small pieces in crushers. The residue of size less than 4.75 mm is called quarry dust which attracts various researchers as an alternative to river sand. This experimental work describes the study on the feasibility of the quarry dust for usage in concrete. To study the effect of quarry dust on the use of super plasticizer, sulphonated naphthalene based super plasticizer was added with fresh concrete of grades M20 and M25 using OPC and PPC separately. Super plasticizer was added at 1.2 lit/100 kg of cement as per the recommendation of the manufacturer. Water cement ratio was found out by conducting slump test for a constant slump of 60 mm. Tests were conducted in limited ratios of sand: quarry dust choosing one ratio each above and below the one giving maximum strength say 60:40, 50:50 and 40:60. At the age of 28 days the compressive strength, tensile strength and flexural strength were determined. From the test results it is found that the compressive strength, *tensile strength and flexural strength are maximum at 50:50 ratios. These results on strength studies give a clear conclusion that quarry dust can be used as a good substitute for natural river sand with higher strength at 50% replacement compared with control concrete.*

***Keywords**: - River Sand, Compressive strength, tensile strength, flexural strength, mechanical properties*

INTRODUCTION

Concrete is the most widely used building material. It is versatile, has desirable engineering properties, which can be moulded into any shape and it is produced with cost effective materials. It is also brittle in nature. The fresh concrete can be prepared by mixing the ingredients cement, river sand and aggregates with water to the required ratio. Cementing medium is the product of reaction between hydraulic cement and water. Concrete is made with several types of cement and also containing pozzolana, fly ash, blast furnace slag, a regulated set additive, sulphur, admixtures, polymers, fibres etc. Workability is the amount of useful internal work necessary to produce full compaction. The useful internal work is a physical property of concrete and the work or energy required to overcome the internal friction between the individual particles, formwork surface or reinforcement provided in the concrete.

Due to the hydration, the heat is liberated and so the concrete get hardened. It can be heated, steam cured, autoclaved, vacuum treated, extruded and sprayed. The concrete attains its strength with respect to its age. The quality of concrete is determined by its mechanical properties as well as its ability to resist deterioration. The mechanical properties can broadly be divided into short-term and long-term properties. Elastic modulus, Compressive strength, tensile strength and shear strength are short term properties. The long term properties are porosity, impermeability, abrasion and freeze-thaw resistance. With respect to strength, concrete is strong in compression. In addition to its compressive strength it is also to withstand against tensile and flexural strength.

The consumption of the river sand is becoming high now-a-days and so the cost also increasing rapidly. Due to this, developing countries like India are facing a lot of problems in getting of sand. Vast development of the construction industry leads to the scarcity in the supply of natural sand. Therefore the construction companies are under stress to identify alternative materials to reduce the demand for natural sand.

ALTERNATIVE MATERIALS TO SAND

Some of the alternative materials like crushed rock material; M-sand, fly ash and sea sand are found out in order to replace the natural sand. Boulders of rock are crushed to small pieces in crushers to obtain different sizes of metal like 40 mm, 20 mm, 10 mm, 4.75 mm and the powder residue of size less than 4.75 mm. The powder is the unwanted material called as quarry dust and this is dumped like heap of mountain near crusher units which creates environmental pollution. It is used as filler to spread over newly laid bituminous road surface. If it is effectively used in concrete as an alternate material to sand, it helps to reduce environmental pollution. Its cost is less when compared to river sand.

The M-sand, the manufactured sand is prepared by washing quarry dust, dried and then sieved through 4.75 mm sieve. The particles having size in between 4.75 mm to 150 microns is called as M-sand. It is costlier than quarry dust but cheaper than river sand.

Fly ash generated and sintered ash from pulverized coal burner is an important aggregate. Large quantities of this industrial by-product are derived from pulverized coal operated boilers of thermal stations. These ashes are extensively used by the building industry. Ash as pozzolana is used for cellular and other types of concrete as mineral admixtures. Fly ash also used as fine aggregate as a partly replacement material. Among the above alternative materials to sand, quarry dust is preferred for this study.

OBJECTIVE AND SCOPE

The main objective of this work is to study the behavior of concrete replacing sand by quarry dust partly. To analyze the possibility of its use, tests on workability, strength and durability are to be carried out on concrete using OPC and PPC with super plasticizer. In this study sand is replaced by quarry dust say, 60:40, 50:50 and 40:60, water cement ratio (w/c ratio) for all proportions is to be found out conducting slump cone test, to give a constant slump of 60 mm.

According to strength point of view the compressive strength of cube specimens, split tensile strength of cylindrical specimens and flexural strength of plain beams are to be determined. After the study through conducting the experiments, the intention of this work is to decide, whether quarry dust can be utilized and if so, up to which range it can be used as a good substitute for natural river sand without sacrificing strength.

LITERATURE REVIEW

General

This topic presents the literature reviewed on the effect of using crushed rock material, quarry dust in place of sand in the preparation of concrete. Some of the experimental investigations on the strength and durability behavior of concrete on the use of quarry dust in the place of natural sand are listed here. To increase the workability and strength of concrete super plasticizer may be used. These criteria viewed from different literature are listed in this chapter.

LITERATURE REVIEWED

Patagundi and Patil (2002) have conducted experiments to investigate the properties of concrete when cement was partially replaced by fly ash and natural sand by crusher stone powder simultaneously. The compressive strength and flexural strength were studied. The behavior of concrete when subjected to heat cycles was also studied. The replacement of sand was from 0- 40% at increments of 10%. Using OPC the design mix 1: 1.2: 2.4 was prepared with water cement ratio 0.30. To facilitate the flow of concrete a super plasticizer was used. In temperature resistance test, the concrete cube specimen were subjected to heat cycles say 8 hours of heating at 60°C followed by 16 hours of cooling at 25°C. Two heat cycles say 15 day cycle and 30 day cycle were adopted. From test results it was observed that 28 day compressive strength was maximum at 30% sand replacement and this was due to the fact that crusher powder fills up the maximum voids to get dense concrete and fly ash liberates strength during later periods. Similarly flexural strength was also maximum at 30% replacement itself. Due to heat cycle there will be some loss in compressive strength as well as flexural strength. The maximum resistance to heat was developed at 30% sand replacement. From the above test results it was concluded that quarry dust and fly ash may be used as replacement materials in concrete.

Selvakoodalingam and Palanikumar (2002) have analysed through experimental study the use of quarry dust as fine aggregate in cement concrete. M15 mix was considered with three proportions say 100% sand, 50% sand and 100% quarry dust. Workability and compressive strength tests were conducted. From the test results it was observed that the 28 day compressive strength was maximum at 50% sand replacement. Compared with sand, quarry dust was more workable. It was concluded that quarry dust can be utilized as replacement material in place of sand with higher strength at 50% replacement.

Chandrasekhara Reddy (2003) has conducted experiments to study the performance of concrete using stone dust as a replacement to sand. Sand was replaced by quarry dust from 0 to 100% at increment of 25%. Compressive strength and tensile strength tests were conducted using 43 grade OPC in M20 concrete. Compressive strength was computed at the age of 7 days, 28 days and 60 days. From the test results he observed that all the mixes except 50% replacement achieved the target strength. The stone dust decreases workability of concrete due to the larger portions of fine particles. At 75% of sand replacement, the percentage of increase in compressive and tensile strength were 40 and 28 compared with reference mix respectively. The unit weight increases with increase in percentage of replacement of sand. He concluded that sand can be replaced by stone dust available locally without affecting strength of concrete.

Binu Sukumar et al (2005) have investigated about the mix optimization method to develop a suitable mix proportion for self compacting concrete (SCC) with different percentage of replacement of river sand by crusher dust. They studied about the compressive strength, split tensile strength and flexural strength of OPC used concrete. They reported from their results that higher percentage replacement of crusher dust reduces the flow characteristics of SCC and hardened properties of SCC with crusher dust replacement were improved. Replacement beyond 20% greatly reduces the workability which needs addition of a super plasticizer. Mix using only stone crusher dust as fine aggregate developed higher strength than control concrete. This was due to better bonding characteristics of crusher dust compared to the rounded particles of river sand. It was concluded that use of crusher dust in place of sand may be possible to get better strength.

Safiuddin et al (2007) have conducted experiments on fresh and hardened concrete with quarry waste as fine aggregate except control concrete. Four different types of concrete were prepared using water binder ratio 0.4. The percentage of replacement of quarry waste was 20 with pit sand. Cube specimens were prepared to find compressive strength at an age of 28 and 56 days. From test results it was observed that quarry waste fine aggregate decreased the compressive strength of concrete due to deficient grading and excessive flakiness. Quarry waste fine aggregate decreases concrete's resistance to water penetration. Due to addition of quarry dust the slump value increases due to deviation in graduation of quarry waste fine aggregate. They concluded that quarry waste fine aggregate can be utilized in concrete mixture as a good substitute for natural sand.

Prachoom Khamput (2006) has conducted experiments to study the compressive strength of concrete using quarry dust as fine aggregate instead of sand. The mix used was 1: 2: 4 (by weight) with water-cement ratio 0.45. In addition to normal concrete(0% quarry dust) 70%, 90% and 100% sand replaced concrete was prepared, specimen were cast to conduct compressive strength test at an age of 7, 14, 21 and 28 days with and without admixture. From the test results it was observed that maximum compressive strength of concrete was obtained at 70% sand replacement both at 7 and 28 days. Concrete with admixture was more workable than concrete without admixture. However the compressive strength of concrete with admixture was higher than without admixture concrete in every mix ratio of quarry dust and sand. He concluded that quarry dust could be used to replace sand in general concrete structures. Ilangovan et al (2008) have conducted tests to study the feasibility of the usage of quarry rock dust as hundred percent substitutes for natural sand in concrete. Mix design has developed for M20, M30 and M40 grades for both conventional concrete and quarry dust concrete. Tests were conducted on cubes and beams to study the strength and durability of concrete made of quarry rock dust and the results were compared with natural sand concrete.

Shahul Hameed et al (2009) have conducted experiments to study the feasibility of the usage of quarry rock dust and marble sludge powder as hundred percent substitutes for natural sand in concrete. Two M20 mixes were prepared using 43 grades OPC, one with purely river sand and another with quarry dust and marble sludge powder combination. Tests were conducted on compressive strength, tensile strength, water absorption, permeability and resistance to sulphate attack. Mahendra et al (2010) have conducted experiments on steel fibre reinforced concrete with natural sand as fine aggregate (SFRNSC) and also the artificial sand the quarry dust as fine aggregate (SFRASC). Three grades M20, M30 and M40 were prepared with steel fibres. The specimens were cast and tested for compressive strength, split tensile strength and flexural strength. From the test results it was observed that SFRASC has more strength than SFRNSC. The percentage of increase in strength was less for higher grades of concrete. The increase in strength was due to sharp edges of the particles in artificial sand provides better bond with cement than the rounded particles of natural sand resulting in higher strength. It was concluded that the full replacement of natural sand by artificial sand considering technical, environmental and commercial factors.

Ramaraju et al (2011) have conducted experiments on self compacting concrete with partial replacement of quarry dust in place of sand and fly ash in place of cement. 53 grade OPC was used to prepare M30 mix. Sand was replaced by quarry dust from 0-100% at increments of 25%. Cement was replaced by fly ash by 0%, 15%, 25%, 30% and 35%. From the test results it was found that maximum compressive strength was obtained at 100% sand replacement without cement replacement. If fly ash used in place of cement then maximum compressive strength was obtained at 30% replacement. It was concluded that quarry dust can be a very good replacement for river sand fully.

SUMMARY OF REVIEW OF LITERATURE

Researchers presented various different suggestions and all are not unique in connection with the usage of quarry dust the crushed rock material as an alternative to natural sand. Most of them investigated normal mechanical properties like compressive, flexural and split tensile strength of quarry dust as fine aggregate in concrete. Due to higher strength than control concrete they suggested that the quarry dust may be utilized in place of sand up to some extent. Least number of investigations was carried out on concrete durability if sand was replaced by quarry dust. This research is planned to investigate in addition to normal mechanical properties, temperature effect, thermo shock effect and permeability with super plasticizer.

MATERIAL PROPERTIES

General

The influence on the behavior of concrete is found out from the properties of materials present in concrete. Different tests were conducted to determine the properties of cement, river sand, quarry dust and aggregates. Potable water was used to mix the materials to prepare concrete.

Cement

Two types of cement namely ordinary Portland cement and Portland pozzolana cement were used in this study. At the time of cement manufacturing, pozzolana constituent is added normally at 10% to 25% by weight to get Portland pozzolana cement. The following tests were carried out to find out the properties of cement.

FINE AGGREGATES

Sand

The river sand is sieved using 4.75 mm sieve and the particles passing through 4.75mm sieve and retained on 75 micron sieve is defined as fine aggregate. Tests were conducted to determine specific gravity, density and void ratio

Quarry dust

The crushed rock particles having size below 4.75mm is defined as fine aggregate. It is further classified into coarse, medium and fine. The size of grains from 4.75mm to 2mm is known as coarse, 2mm to 0.425mm as medium and 0.425 mm to 0.075 mm defined as fine. Tests were conducted to determine specific gravity, density and void ratio

COARSE AGGREGATE

Aggregates are the major ingredients of concrete. It constitutes the total volume, provide a rigid skeleton structure for concrete, and act as economical space fillers. Aggregates contribute to both the weight and stiffness of concrete. Generally coarse aggregate are derived from rock. Their properties depend on the mineralogical composition of rock, the environmental exposure to which the rock has been subjected and the method of crushing employed to get different sizes. The physical, chemical and thermal properties of aggregates substantially influence the performance of concrete. The dimension between 20mm to 4.75mm termed as coarse aggregate. Tests were conducted to determine specific gravity, density and fineness modulus. The various values obtained by conducting tests on cement, sand, quarry dust and coarse aggregate were presented in Table 1

Table:-1Physical Properties of the materials

Material	Properties		
Crushed granite stone	Maximum size	:	20 mm
	Specific gravity	:	2.98
	Fineness modulus	:	6.36
	Density	:	1.58 gm/cc
River sand	Specific gravity	:	2.53
	Fineness modulus	:	3.08
	Density	:	1.63 gm/cc
	Void ratio	:	0.55
Quarry dust	Specific gravity	:	2.57
	Fineness modulus	:	2.41
	Fineness modulus of		
	coarse quarry dust	:	5.00 (Phase I)
	medium quarry dust	:	3.20 (Phase I)
	fine quarry dust	:	1.95 (Phase I)
	Density	:	1.85 gm/cc
	Void ratio	:	0.42
Ordinary Portland cement	Specific gravity	:	3.05
	Initial setting time	:	30 min.
	Final setting time	:	220 min
	Fineness	:	8 % residue on IS90 micron sieve
Portland Pozzolana cement	Specific gravity	:	3.05
	Initial setting time	:	30 min.
	Final setting time	:	230 min
	Fineness	:	6 % residue on IS 90 micron sieve

Water

Water is an important ingredient to make concrete. The purpose of adding water to concrete is, to distribute the cement evenly, react with cement chemically to produce calcium silicate hydrate gel and provide workable one. Small amount of water is needed to hydrate cement. Additional water is required to lubricate the mix. Excess water leads to bleeding stage ultimately creation of pores. Quantity of water is controlled by the w/c ratio. The water used must be free from oil, acid and alkali, salts and organic material. It should be potable.

Admixtures

Admixtures are used to modify the properties of fresh and hardened concrete. They are classified as chemical and mineral admixtures. The admixtures which have significant effect on concrete are plasticizers, accelerators, retarders, super plasticizers, waterproofing agents and mineral admixtures. Accelerators reduce the setting time. They are helpful in cold weather concreting particularly used for repair and patch work in which early removal of formwork is necessary. The most common accelerator for plain concrete work is calcium chloride. Retarders increase the setting time of the concrete mix and reduce the water cement ratio. About 10% water reduction can be achieved usually while using retarders. Plasticizer is an admixture added to fresh concrete mix to impart adequate workability properties. Super plasticizer is the recent and more effective type of water reducing admixture called high range water reducer (HRWR). The dosage levels are usually higher than the conventional water reducers and the possible undesirable side effects are considerably reduced.

Super plasticizers are used to produce very high strength concrete using normal workability with a very low water cement ratio. It reduces water to an extent of 30% without reducing the workability. Super plasticizers are not at all participating in any chemical reactions with cement and aggregates. In this experimental work Sulphonated Napthalene was used as super plasticizer.

TESTS AND TEST RESULTS

General

This chapter describes the experimental study on the feasibility of using quarry dust to replace sand in concrete. The concrete grades, M20 and M25 with nominal mix proportions 1:1.5:3, 1:1:2 respectively by weight were taken for the study by keeping a constant slump of 60 mm. Tests on concrete for compressive strength; tensile strength and flexural strength were conducted using quarry dust in the place of sand.

In this study compressive strength, tensile strength and flexural strength of concrete of M20 and M25 grades were determined using ordinary Portland cement and Portland pozzolana cement without and with the addition of super plasticizer. Super plasticizer was added at 1.2 lit/100 kg of cement. Water cement ratio was found out by conducting slump test keeping a constant slump of 60 mm. Tests have been conducted choosing three proportions of sand: quarry dust, one proportion giving peak compressive strength and two more proportions , one above and one below the above proportion to study the variation in strength developed due to the addition of super plasticizer. The temperature and thermo shock effects on concrete cubes with this super plasticizer were also determined. The co-efficient of permeability of concrete was also determined to study the effect of addition of super plasticizer in concrete

EFFECT OF SUPERPLASTICIZER IN CONCRETE WITH QUARRY DUST

The results of the experimental works on superplasticizer added concrete like workability, compressive strength, tensile strength, flexural strength and permeability using quarry dust for replacing sand for the ratios of sand with quarry dust are 60:40, 50:50 and 40:60 are presented and discussed in this portion.

Workability

To determine slump value, water was added with dry mix in addition to super plasticizer Sulphonated Napthalene at 1.2 lit/100 kg of cement and slump test was conducted. For the constant slump of 60 mm the water cement ratio was obtained for limited ratios of sand: quarry dust say 60:40, 50:50 and 40:60. From the Tables 2 and 3 it is observed that the w/c ratio was reduced nearby 5% compared with the normal concrete due to the addition of superplasticizer.

Table 2 Water cement ratio of M20 concrete with and without superplasticizer

Fine aggregate Sand: Quarry Dust	Water cement ratio					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	0.520	0.490	6.12	0.48	0.455	5.49
50:50	**0.525**	**0.500**	**5.00**	**0.49**	**0.466**	**5.15**
40:60	0.535	0.510	4.90	0.50	0.476	5.04

Table 3 Water cement ratio of M25 concrete with and without superplasticizer

Fine aggregate Sand: Quarry Dust	Water cement ratio					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	0.509	0.485	4.95	0.400	0.375	6.67
50:50	**0.512**	**0.487**	**5.13**	**0.404**	**0.380**	**6.31**
40:60	0.521	0.496	5.04	0.408	0.383	6.53

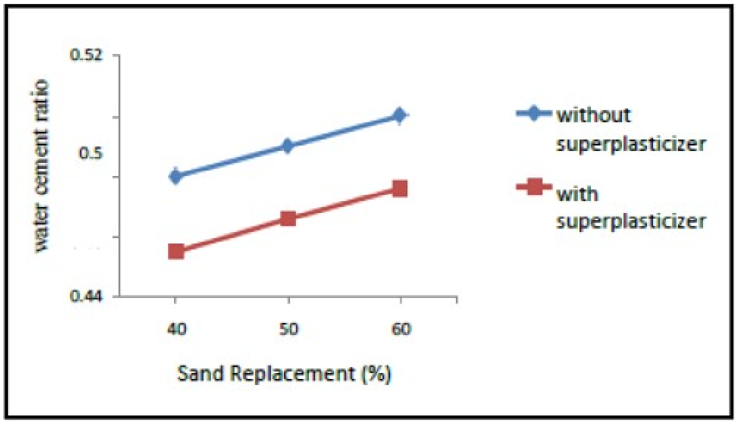

Figure 1 Water cement ratio of M20 concrete using PPC

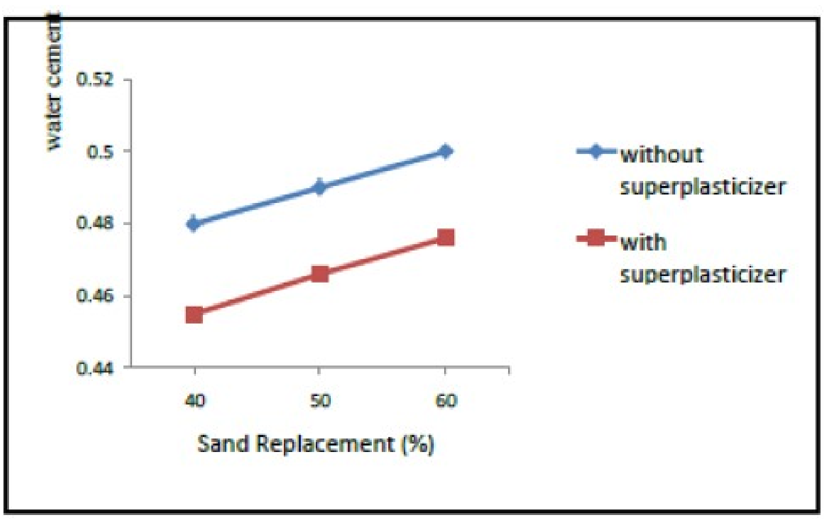

Figure 2 Water cement ratio of M20 concrete using OPC

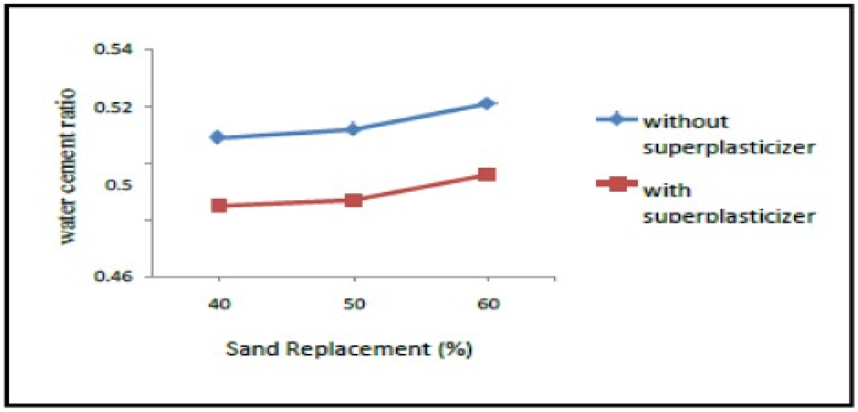

Figure 3 Water cement ratio of M25 concrete using PPC

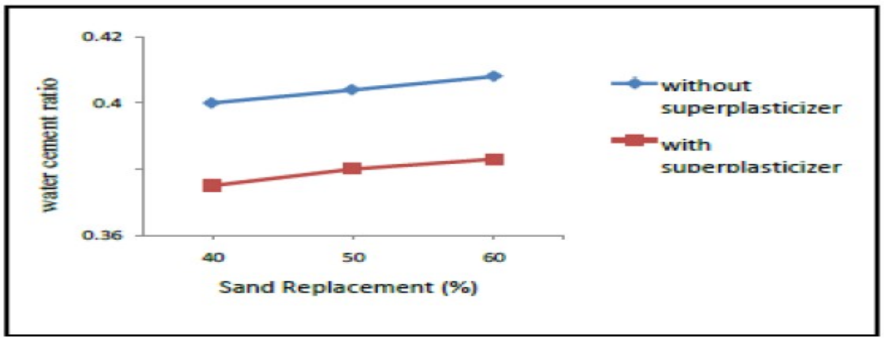

Figure 4 Water cement ratio of M25 concrete using OPC

Figures 1 to 4 represent the variation in water cement ratio with and without addition of superplasticizer. From that figures it is observed that due to the addition of superplasticizer the w/c ratio was reduced considerably when compared with the concrete without superplasticizer.

Compressive strength

Figures 5, 6 and 7 represent the variation in compressive strength of concrete at the age of 7 days with and without addition of superplasticizer. From that figures it is found that the compressive strength is increased due to the addition of superplasticizer.

Table 3 represents the compressive strength of M20 concrete due to the addition of superplasticizer at the age of 7 days. The percentage of increase in compressive strength for 50% sand replacement is 2.93 and 3.0 for PPC and OPC used concrete respectively. At the age of 7 days the concrete reached its characteristic compressive strength for 50% sand replacement.

Table 3 Compressive strength of M20 concrete with and without superplasticizer at 7 days

Fine aggregate Sand: Quarry Dust	Compressive strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	20.44	21.00	2.74	21.33	21.95	2.91
50:50	21.18	21.80	2.93	22.67	23.35	3.00
40:60	19.67	20.25	2.95	20.44	21.00	2.74

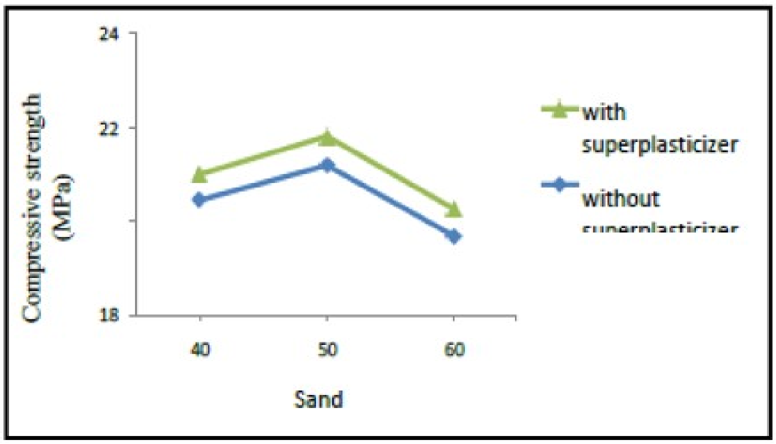

Figure 5 Compressive strength of M20 concrete using PPC at 7 days

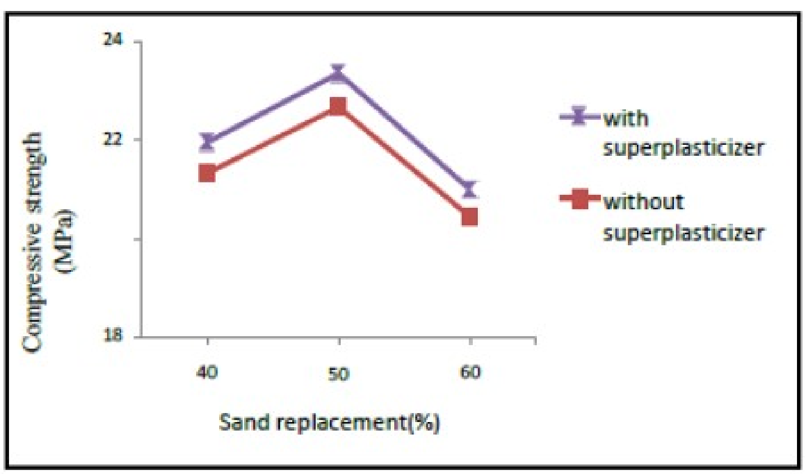

Figure 6 Compressive strength of M20 concrete using OPC at 7 days

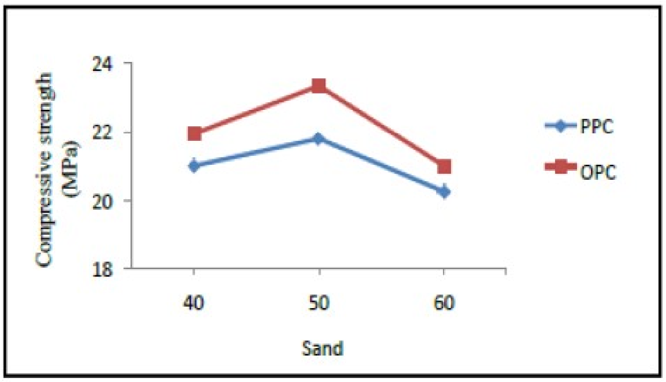

Figure 7 Compressive strength of M20 concrete with superplasticizer at 7 days

From Table 4, it is found that the increase in compressive strength of M25 concrete due to the addition of superplasticizer at the age of 7 days is 2.75 and 2.89 for PPC and OPC used concrete respectively. At the age of 7 days the concrete reached its characteristic compressive strength for 50% sand replacement.

Table 4 Compressive strength of M25 concrete with and without superplasticizer at 7 days

Fine aggregate Sand:Quarry dust	Compressive strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	23.56	24.25	2.93	24.29	25.00	2.93
50:50	**24.43**	**25.10**	**2.75**	**24.59**	**25.30**	**2.89**
40:60	22.76	23.40	2.82	23.60	24.31	3.01

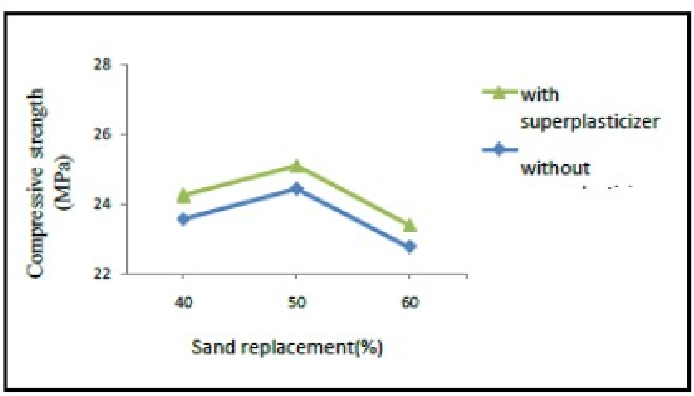

Figure 8 Compressive strength of M25 concrete using PPC at 7 days

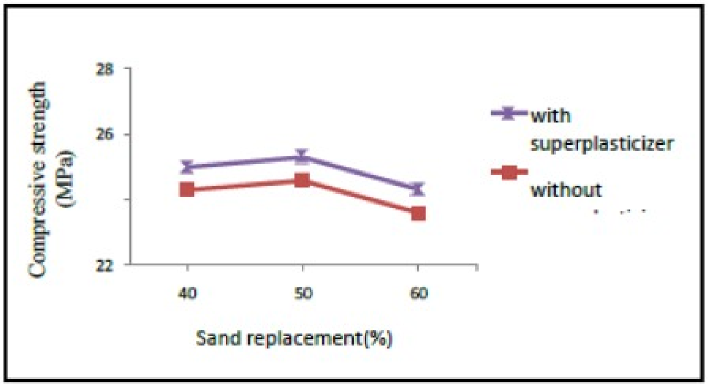

Figure 9 Compressive strength of M25 concrete using OPC at 7 days

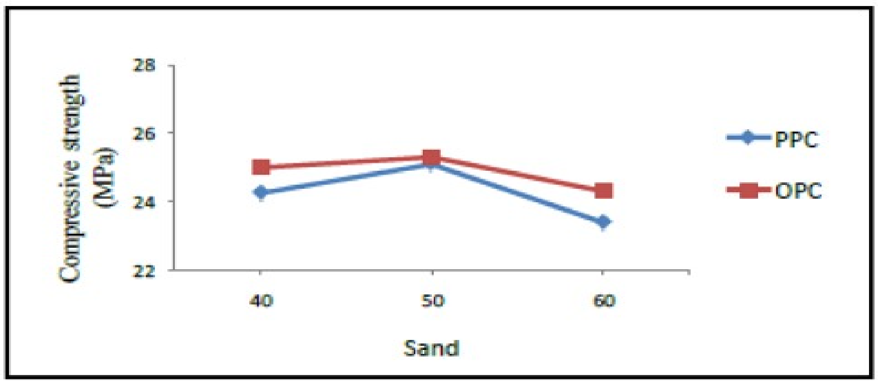

Figure 10 Compressive strength of M25 concrete with superplasticizer at 7 days

Table 5 shows the variation in compressive strength of M20 concrete at the age of 28 days due to the addition of superplasticizer. The percentage of increase in compressive strength for 50% sand replacement by quarry dust is 6.03% and 5.96% for PPC and OPC used concrete respectively.

Table 5 Compressive strength of M20 concrete with and without superplasticizer at 28 days

Fine aggregate Sand: Quarry dust	Compressive strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	24.89	26.35	5.87	25.77	27.30	5.94
50:50	**26.22**	**27.80**	**6.03**	**27.56**	**29.20**	**5.96**
40:60	24.43	25.85	5.82	26.22	27.75	5.84

Figures 11, 12 and 13 represent the variation in compressive strength of concrete at the age of 28 days with and without addition of superplasticizer. From that figures it is observed that the compressive strength of superplasticizer added concrete is higher than that of concrete without superplasticizer.

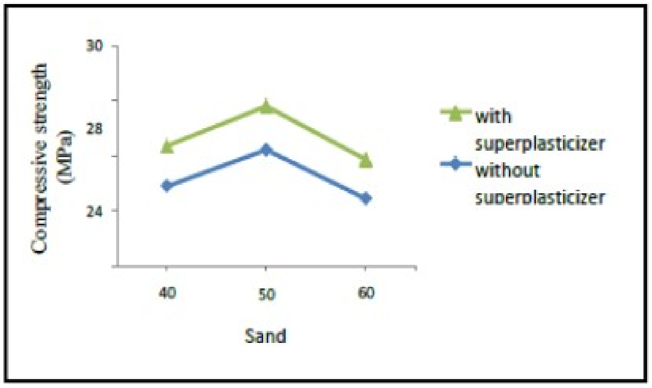

Figure 11 Compressive strength of M20 concrete using PPC at 28 days

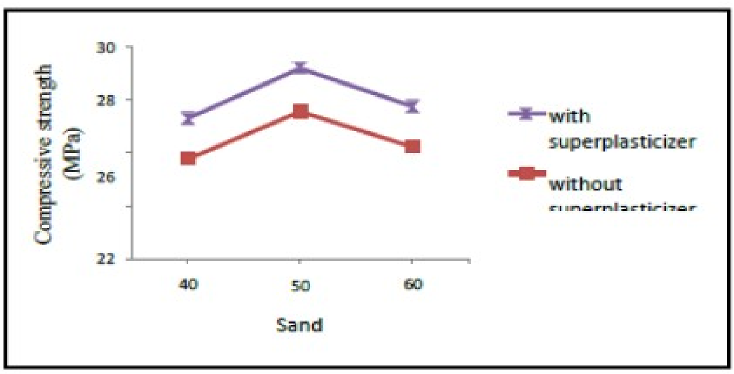

Figure 12 Compressive strength of M20 concrete using OPC at 28 days

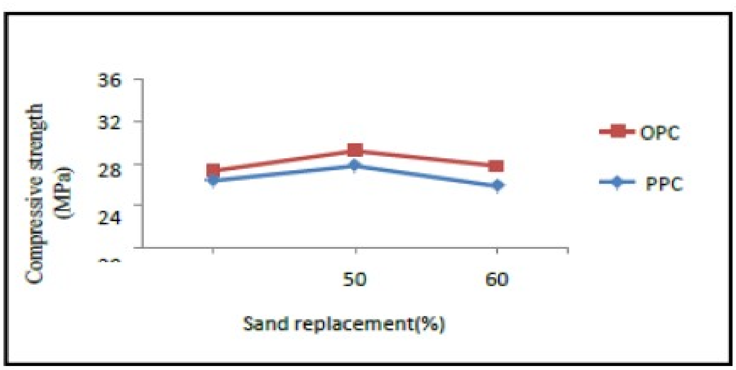

Figure 13 Compressive strength of M20 concrete with superplasticizer at 28 days

Table 4.6 shows the variation in compressive strength of M25 concrete at the age of 28 days due to the addition of superplasticizer. The percentage of increase in compressive strength for 50% sand replacement by quarry dust is 4.93 and 4.96 for PPC and OPC used concrete respectively.

Table 6 Compressive strength of M25 concrete with and without superplasticizer at 28 days

Fine aggregate Sand:Quarry dust	Compressive strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	29.62	31.10	5.00	32.54	34.10	4.80
50:50	**30.07**	**31.55**	**4.93**	**32.92**	**34.55**	**4.96**
40:60	28.58	30.00	4.97	31.33	32.85	4.86

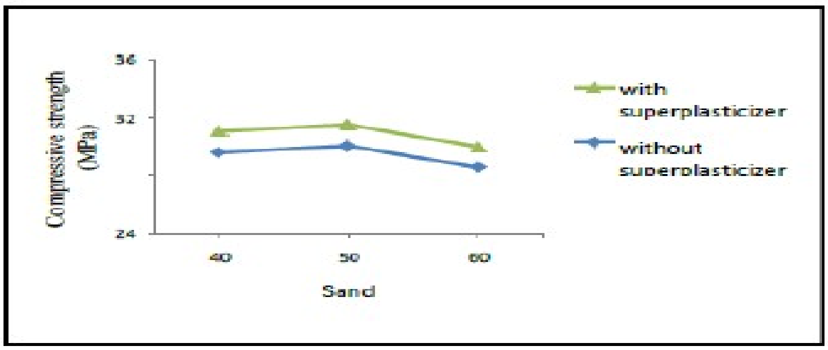

Figure 14 Compressive strength of M25concrete using PPC at 28 days

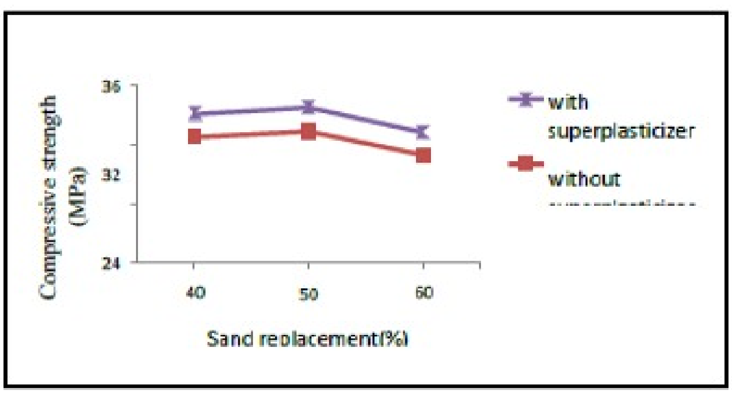

Figure 15 Compressive strength of M25 concrete using OPC at 28 days

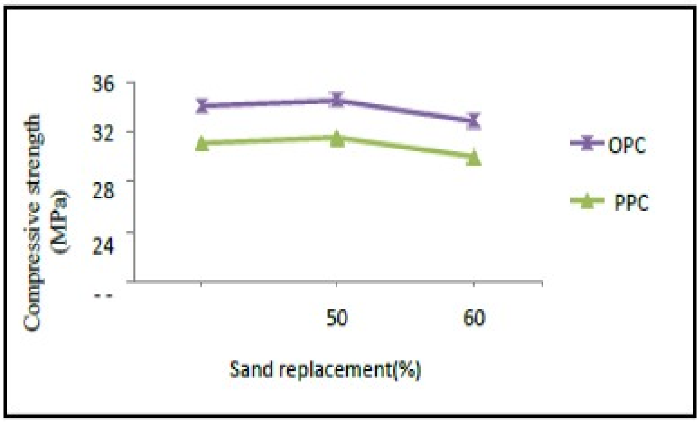

Figure 16 Compressive strength of M25 concrete with superplasticizer at 28 days

Figures 14, 15 and 16 represent the variation in compressive strength of OPC and PPC used concrete with the addition of superplasticizer. From that figures it is found that with superplasticizer, the compressive strength of OPC used concrete is higher than that of PPC used concrete.

Tensile strength

From the Figures 17, 18 and 19 it is observed that the tensile strength of superplasticizer added concrete is higher than that of concrete without superplasticizer at the age of 28 days. From the Table 7 it is observed that for M20 concrete the percentage of increase in tensile strength owing to addition of superplasticizer at 50% sand replacement by quarry dust is 1.47 and 3.77 for PPC and OPC used concrete respectively.

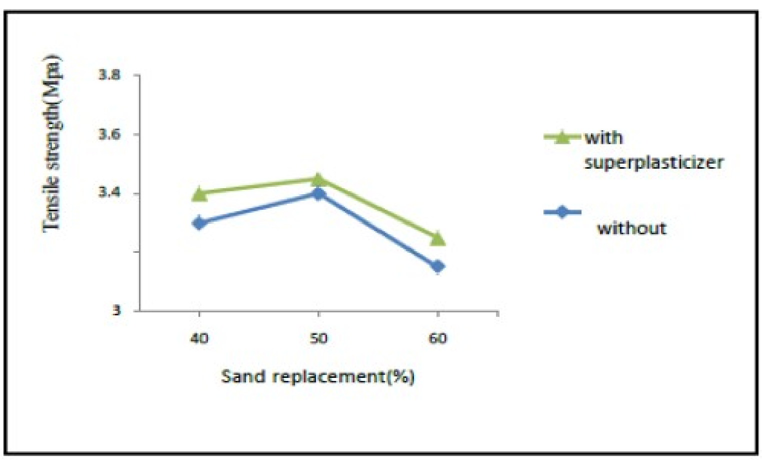

Figure 17 Tensile strength of M20 concrete using PPC at 28 days

Fine aggregate Sand:Quarry dust	Tensile strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	3.30	3.40	3.03	3.36	3.48	3.57
50:50	**3.40**	**3.45**	**1.47**	**3.45**	**3.58**	**3.77**
40:60	3.15	3.25	3.17	3.20	3.31	3.44

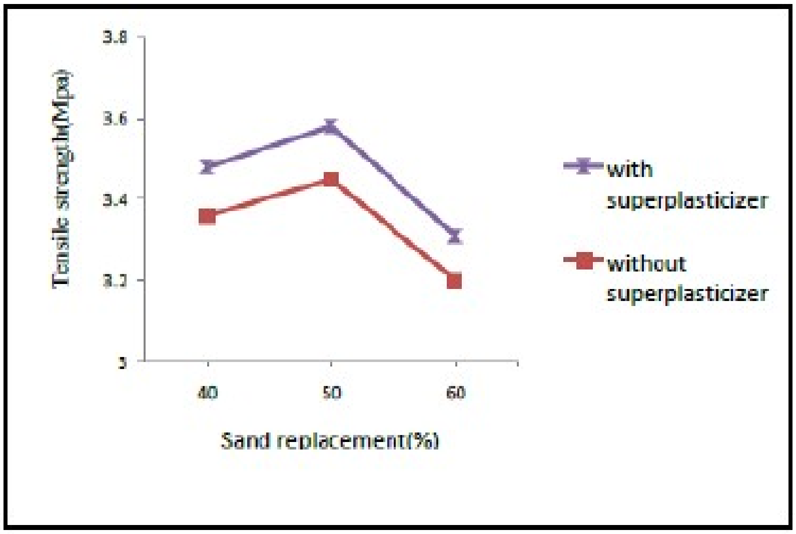

Figure 18 Tensile strength of M20 concrete using OPC at 28 days

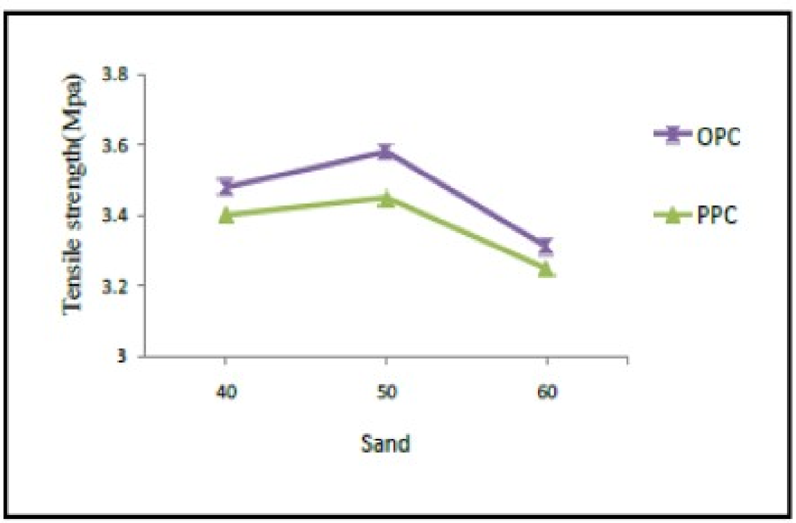

Figure.19 Tensile strength of M20 concrete with superplasticizer at 28 days

From Table 8, it is observed that for M25 concrete the percentage of increase in tensile strength due to the addition of superplasticizer at 50% sand replacement by quarry dust is 3.03 and 3.38 for PPC and OPC used concrete respectively.

Table 8 Tensile strength of M25 concrete with and without superplasticizer at 28 days

Fine aggregate Sand: Quarry dust	Tensile strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	3.58	3.68	2.79	3.72	3.85	3.49
50:50	**3.63**	**3.74**	**3.03**	**3.85**	**3.98**	**3.38**
40:60	3.56	3.65	2.53	3.63	3.75	3.31

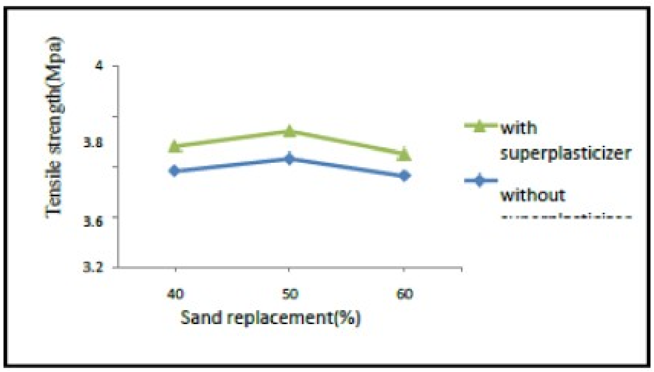

Figure 20 Tensile strength of M25 concrete using PPC at 28 days

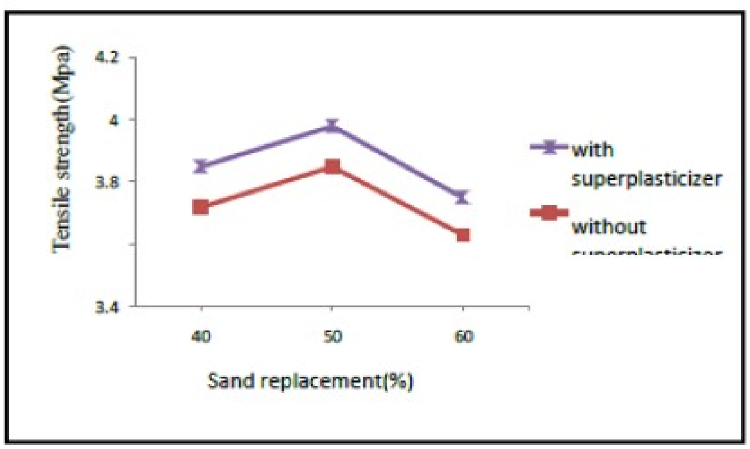

Figure 21 Tensile strength of M25 concrete using OPC at 28 days

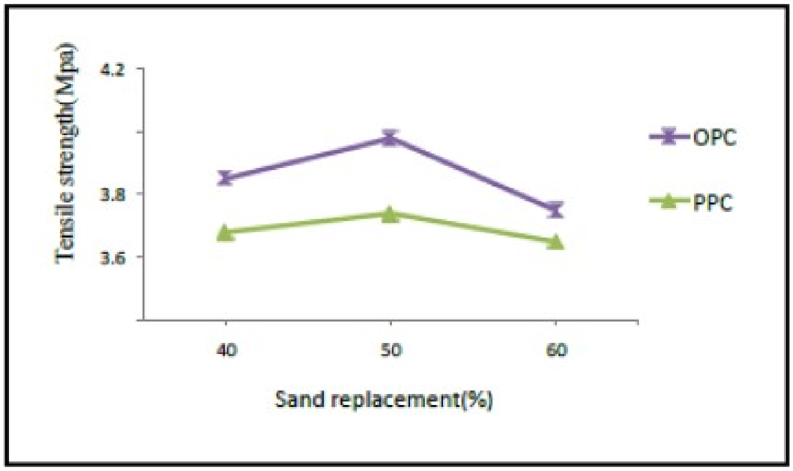

Figure 22 Tensile strength of M25 concrete with superplasticizer at 28 days

Figures 20, 21 and 22 represent the variation in tensile strength of OPC and PPC used concrete with the addition of superplasticizer. From that figures it is found that with superplasticizer, the tensile strength of OPC used concrete is higher than that of PPC used concrete.

Flexural strength From the Figures 23, 24 and 25 it is observed that the flexural strength of superplasticizer added concrete is higher than that of concrete without superplasticizer at the age of 28 days.

From the Table 9, the percentage of increase in flexural strength of superplasticizer added concrete over the concrete without superplasticizer at 50% sand replacement by quarry dust is 1.29 and 2.53 for PPC and OPC used concrete respectively.

From the Table 10, the percentage of increase in flexural strength of superplasticizer added concrete over the concrete without superplasticizer at 50% sand replacement by quarry dust is 2.44 and 2.79 for PPC and OPC used concrete respectively.

Figures 26, 27 and 28 represent the variation in flexural strength of OPC and PPC used concrete with the addition of superplasticizer. From that figures it is found that, with superplasticizer, the flexural strength of OPC used concrete is higher than that of PPC used concrete.

Table 9 Flexural strength of M20 concrete with and without superplasticizer at 28 days

Fine aggregate Sand: Quarry dust	Flexural strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	3.78	3.86	2.12	3.85	3.95	2.60
50:50	**3.88**	**3.93**	**1.29**	**3.95**	**4.05**	**2.53**
40:60	3.65	3.76	3.01	3.70	3.82	3.24

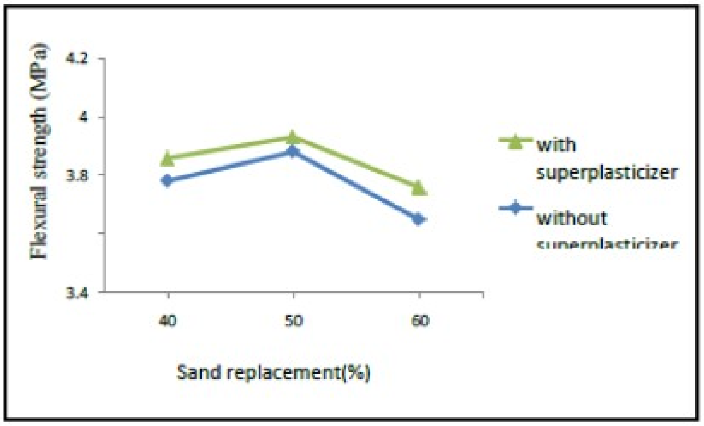

Figure 23 Flexural strength of M20 concrete using PPC at 28 days

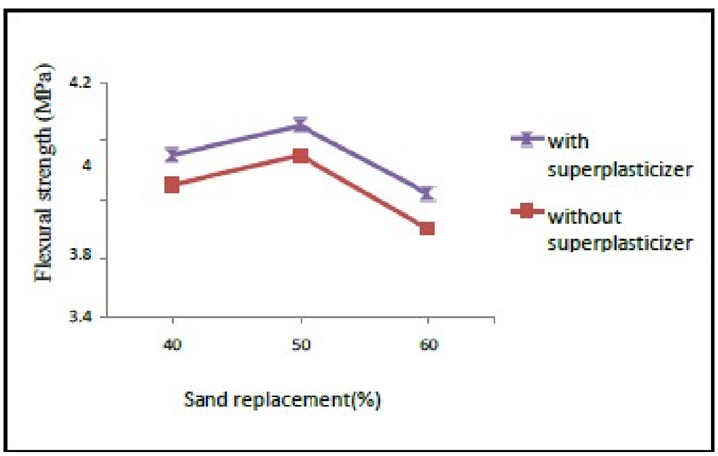

Figure 24 Flexural strength of M20 concrete using OPC at 28 days

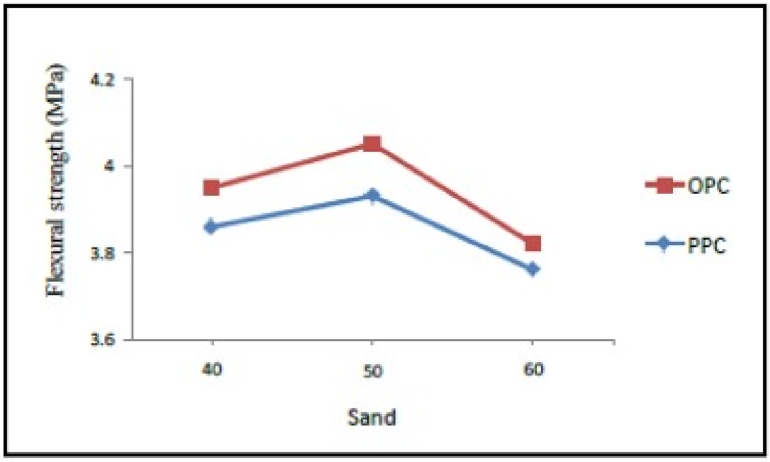

Figure 25 Flexural strength of M20 concrete with superplasticizer at 28 days

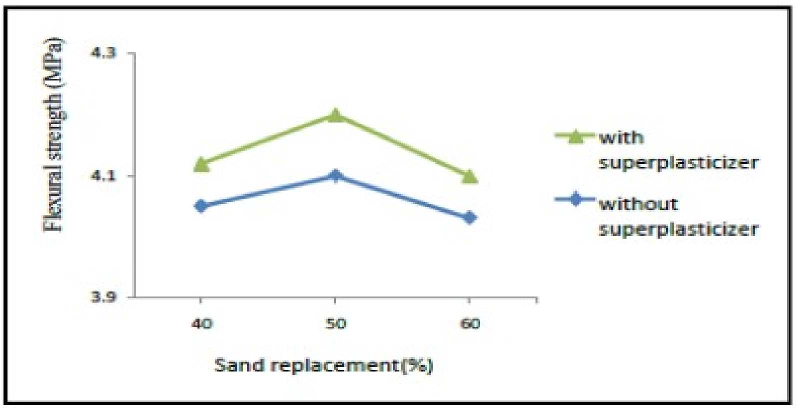

Figure 26 Flexural strength of M25 concrete using PPC at 28 days

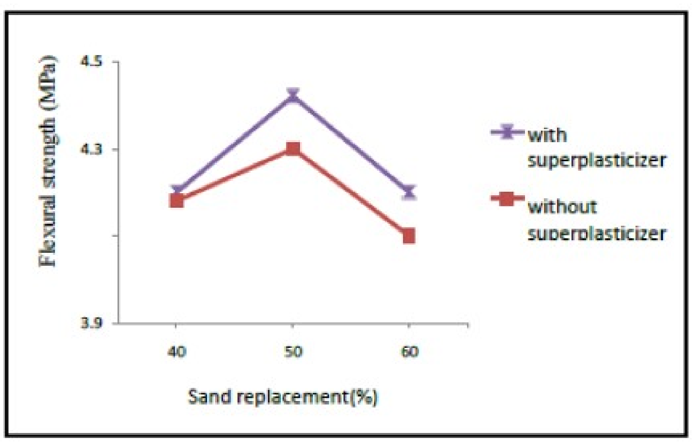

Figure 27 Flexural strength of M25 concrete using OPC at 28 days

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Table 10 Flexural strength of M25 concrete with and without superplasticizer at 28 days

Fine aggregate Sand: Quarry dust	Flexural strength (MPa)					
	PPC			OPC		
	Without SP	With SP	% of variation	Without SP	With SP	% of variation
60:40	4.05	4.12	1.73	4.18	4.20	0.48
50:50	**4.10**	**4.20**	**2.44**	**4.30**	**4.42**	**2.79**
40:60	4.03	4.10	1.74	4.10	4.20	2.44

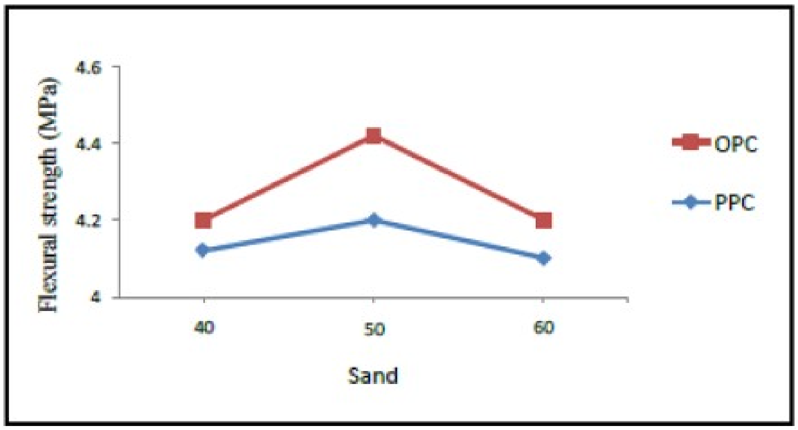

Figure 28 Flexural strength of M25 concrete with superplasticizer at 28 days

CONCLUSIONS

General

The present investigation is concerned with the evaluation of the performance of quarry dust in place of sand in concrete. Experimental investigation was carried out to study the various parameters of strength.

CONCLUSIONS FROM THE EXPERIMENTAL INVESTIGATION

The following conclusions were arrived at from the experimental investigation:

- Addition of quarry dust decreases workability. To maintain the workability constant, addition of more cement to maintain same water cement ratio (or) same quantity of cement with higher water cement ratio is to be followed. In this work, keeping the cement quantity constant the w/c ratio is varied. Rough textured, angular, elongated particles require more water to produce workable concrete than do smooth, rounded compact aggregate. PPC used concrete need more water than OPC used concrete because PPC is finer than OPC having more specific surface requiring more water to wet.

- The percentage of variation in compressive strength compared with control concrete is more for lower grade and less in higher grade of concrete due to reduction in quarry dust quantity. Sharp edges of quarry dust particles provide better bond with cement than the rounded particles of natural sand resulting in higher strength.

- The increase in tensile strength was due to the bond between cement paste and aggregate. This is due to particle shape change from smooth and rounded to rough and angular in the case of quarry dust.

- The reduction in compressive strength due to temperature effect is minimum at 50% sand replacement by quarry dust. Maximum compressive strength at lower temperature was due to stronger interfacial bonding between matrix and aggregates. Strength loss at higher temperature may be due to change in the texture of the sample into coarse and due to several micro cracks, which gradually worsen the strength character of the sample.

- Due to the addition of superplasticizer at 1.2 lit/100kg of cement, the percentage of reduction in w/c ratio is nearly 5%. The increase in strength is nearly 5%, 3.5%, 2.5% and 10% in compressive strength, tensile strength, flexural strength respectively. Superplasticizer occupy the voids reduces voids ratio leading to dense concrete which gives better strength.

- These results on strength studies give a clear conclusion that quarry dust can be used as a good substitute for natural river sand with higher strength at 50% replacement, saving in cost of concrete and reducing the demand for sand.

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