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Replacement of Natural Sand by Crushed Sand in the Concrete

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Abstract: Nowadays it is very important to make the concrete economical. Therefore the present work has initiated to make the concrete economical by replacing the natural sand by crushed sand in the concrete. From our study it is concluded that different Crushed sand gives different results for compressive strength depending on different quarries and from study of different research paper at 40% to 50% replacement of crushed sand the maximum compressive strength is obtained. The maximum tensile strength of concrete is obtain at 60% and 70% replacement of natural sand with Crushed sand. The concrete with crushed sand performed better than concrete with natural sand as the property of crush sand is better than that of natural sand.

Keywords: Natural Sand, Crushed Sand, Concrete, Compressive Strength and Tensile Strength

1. Introduction

1.1. General

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 recent years, concrete technology has made significant advances which have resulted in economical improvements in strength of concrete. This economic development depends upon the intelligent use of locally available materials. One of the important ingredients of conventional concrete is natural sand or river sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. However, due to the increased use of concrete in almost all types of construction works, the demand of natural or river sand has been increased. To meet this demand of construction industry excessive quarrying of sand from river beds is taking place causing the depletion of sand resources. Natural sand is excavated from river bed impacts on environment in many ways. Due to digging of the sand from river bed reduces the water head, so less percolation of rain water in ground, which result in lower ground water level. There is erosion of nearby land due to excess sand lifting as well as it destroys the flora & fauna in surrounding areas.

Natural or river sand are weathered and worn out particles of rock and are of various grade or size depending upon wearing. Natural sand is mainly excavated from river beds and always contains high percentages of inorganic materials, chlorides, sulphates, silt and clay that adversely affecting the strength & durability of concrete & reinforcing steel there by reducing the life of structure. Digging sand, from river bed, in access quantity is hazardous to environment and causing bank slides, loss of vegetation on the bank of rivers.

Figure 1. *Artificial Sand.*

Conventionally concrete is mixture of cement, sand and aggregate. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential

component of concrete. The most commonly used fine aggregate is natural river or pit sand. Now-a-days good sand is not available it is transported from one place to another so it is need of the time to find substitute to natural river sand. Because of limited supply the cost of natural river sand has sky rocketed and its consistence supply cannot be guaranteed. For the purpose of experimentation concrete mix are designed for M20 and M25 grade by replacing natural sand with artificial sand at different replacement levels of 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%.

Approximately 80% of total volume of concrete is made up of aggregates. Aggregates characteristics *i.e.* size, shape, texture, grading influence the workability, finish ability, bleeding, and segregation of fresh concrete and durability of hardened concrete. Fine aggregates may be one of the following types; Natural sand, crushing natural gravels, crushing hard stones *i.e.* artificial sand. Artificial sand is a process controlled crushed fine aggregate produced from quarried stone by crushing or grinding and classification to obtain a controlled gradation product that completely passes the 4.75 mm sieve. Artificial sand generally contain more angular particles with rough surface textures and flatter face than natural sand that are more rounded as a result of weathering. Some investigations have shown that angular particles rough surface of artificial sand influences the workability and finish ability in fresh concrete. The artificial sand have to satisfy the characteristics and hence it has become necessary to study the properties in order to check the suitability and appropriate replacement level of artificial sand in comparison with the natural sand for producing concretes in an economical way.

The cheapest and the easiest way of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade which would be free from all impurities. Use of crushed sand has become a good substitute for natural sand and it has become essential keeping in view of technical, commercial & environmental requirements. Crushed sand is manufactured by crushing larger stones of quarry to particular size of sand. Its chemical & physical properties such as color, size & shape, surface texture up particles depend upon types of stone & its source The artificial sand produce by machine can be a better substitute to natural river sand. The sand must be of proper gradation (it should have particle from 150 micron to 4.75 mm in proper proportion) Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar. When fine particle are in proper proportion, the sand will have fewer voids. In this situation research began for inexpensive and easily available alternative material to natural sand. Under this circumstances use of natural sand is inevitable. For the purpose of experimentation we are going design concrete mixes of M20 grades by different replacement of natural sand to artificial sand. Its mechanical properties namely cube compressive strength; flexural strength and split tensile strength are study in that experiment.

1.2. Need of Study

Concrete is widely use in making architecture structure, foundation, highway construction, runway, parking structure, pools/reservoir, pipes, concrete making, and concrete consist of mainly sand which is about 35%, It may be natural sand made from river or artificial sand there are many kinds of rocks could be used to make sand there are granite, pebbles, basalt etc. In construction industry natural sand is used as an important building material and world consumption of sand in concrete alone is around 1000 million tons per year making it scarce and limited.

Further, it has cause environment degradation like removal of mineral from top soil due to erosion and change in vegetative property leading to soil infertility problem thereby affecting agricultural productivity, hence current focus of industry should be to partly or completely replace natural sand in concrete by waste material that is obtain through recycling without promising the quality of end product. In the recent year, the construction industry has identified some waste material like fly ash, slag, lime stone powder, siliceous stone powder and crush sand for use in traditional concrete. And due to high rising of cost of natural sand there must be need to replace natural sand with artificial sand. So in that study we use artificial sand in place of natural sand so that we can minimize the cost of the construction and providing same or more strength to the our construction.

Use of Crush sand in construction is nothing new in western world. It is being used there since few decades. Crush sand is a kind of waste material that is generated from the stone crushing industry which is abundantly available to extent of 200 million tons per annum which has land fill disposal problem and health and environment hazard. The present study is an attempt to experimental hazards. The present study is an attempt to experiment on use of crush sand to replace sand in concrete.

1.3. Study Objective

- To provide background information on use of artificial sand in concrete
- To access existing concrete produce using artificial sand.
- To draw conclusion and give recommendation based on research finding and indicate areas for further study
- To study the influence of artificial sand on the compression and tensile strength of concrete
- To determine the strength of concrete for various grades
- Optimum use of artificial sand that can be use in construction
- To determine various strength of concrete, various property of concrete.
- To make our structure in an economical cost without compromising the strength.

1.4. Advantage of Crush Sand

- Crush sand is easily available in villages, and cities also

due to availability the transportation cost are low.

- Crush sand has a property same as that of Natural River sand i.e. it can be useful for construction as its size, shape is as required.
- Crush sand is cheaper than that of natural river sand. The cost of 1brass of crush sand is nearly about Rs 2200. And cost of river sand is Rs 5000.
- The concrete with crushed sand performed better than concrete with natural sand as the property of crush sand is better than that of natural sand.
- The workability of concrete manufactured with crush sand was lesser than that manufactured with natural sand.
- Compressive strength of concrete is increase when we use crush sand because it can not contain any impurity.
- Crush sand is free from chemical impurities such as sulphates and chlorides which improves the properties of concrete like strength and durability.
- Crush sand contains no organic impurities hence it gives increased strength of Concrete with same cement content.
- No wastage in crush sand since Sand is already sieved in the required size (below 4.75 mm).
- Crush sand does not harm to the environment in any way as natural sand provide harm causing bank slides, loss of vegetation on the bank of rivers etc.

1.5. Material and Their Quality Test

It is very important to know the properties and characteristics of constituent materials of concrete, as we know, concrete is a composite material made up of several different materials such as aggregate, sand, water, cement and admixture. These materials have properties and different characteristics such as "Unit weight, Specific gravity, size gradation and water content etc. We must therefore work out necessary tests on these components, and that to know the unique characteristics and their impact on the strength of concrete.

1.6. Aggregate Quality Tests

1.6.1. Dense Loose Bulk Density of Sand and Aggregate (DLBD)

Dense loose bulk density can be defined as the weight of a given volume of graded aggregate. The Dense loose bulk density effectively measures the volume that the graded aggregate will occupy in concrete and includes both the solid aggregate particles and the voids between them. The Dense loose bulk density is simply measured by filling a container of known volume with loosely filled aggregate without compaction and weighting. Dense loose bulk density of Aggregate (DLBD) tested for coarse and fine aggregate is shown in table below.

Table 1. *Dense Loose Bulk Density of Aggregates (DLBD).*

Coarse Aggregate	**1.56 kg/liter**
Fine Aggregate	g/liter

1.6.2. Specific Gravity of Sand and Aggregates

Specific gravity is defined as the ratio of the weight of a unit volume of aggregate to the weight of an equal volume of water. Specific gravity expresses the density of the solid fraction of the aggregate in concrete mixes as well as to determine the volume of pores in the mix.

[Specific Gravity (S. G) = (density of solid) / (density of water)]

The specific gravity of aggregate is to determine the volume of aggregates in a concrete mix as well as to determine the volume of pores in the mix. The specific gravity of coarse and fine aggregate is shown in Table below.

Specific gravity of Coarse Aggregate and Fine Aggregate is 2.84 and 2.60.

Figure 2. *Pycnometer and Sieve Analysis.*

1.6.3. Sieve Analysis of Aggregate

The size of aggregate particles differs from aggregate to another, and for the same aggregate the size is different. So in this test we will determine zone of aggregate by combined sieve analysis.

From this test aggregate was found of Zone II as per (IS 383-1970).

1.6.4. Moisture Content of Aggregates

The aggregates can absorb moisture. The water content also affects aggregate proportioning (because it contributes to aggregate weight). As the atmosphere was sunny throughout the period of casting, condition of aggregate was considered as dried.

1.6.5. Testing Program Will Include Following

- Define the properties of constitutive materials of concrete (cement, fine aggregate, coarse aggregate, crushed sand etc).
- We have to cast 132 numbers of cubes in our experimental procedure.
- Block are prepared by varying the percentage of artificial sand i.e. Crushed sand.
- We have to prepare blocks by increasing the Crushed sand by 10% i.e. the blocks contain the percentage of Crushed sand as 10%, 20%,30%, 40%, 50%, 60%, 70%, 80%,90%,100%.
- In our experiment we use 3 different types of Crushed sand so that we have to prepare 132 blocks of cubes of size 150mm x150mm x 150mm for M20 and M25 concrete grade.
- Finally performing destructive test on the all 132 prepared specimen.

2. Litrature Review

The consumption of cement content, workability, compressive strength and cost of concrete made with crush sand were studied by researchers BabuK. K. et.al, Nagaraj T. S. et.al, and Narasimahan et.al. The mix design proposed by Nagaraj et.al shows the possibilities of ensuring the workability by wise combination of rock dust and sand, use of super plasticizer and optimum water content using high percentages of manufactured sands in the aggregate blend may become a lot more common. It is seen from their studies there a variation in strength enhancement of concrete made from artificial sand to encourage the use of locally available artificial sand promotes to study to check it suitable replacement percentage in the concrete.

Sakthivel et al.[1]:- studied replacement of sand used in concrete as fine aggregates made by the crush sand. This study made an attempt to partially replace artificial sand in place of sand in M20 grade concrete. It was found that the partial replacement of sand with 10% of artificial sand has given the optimum results and concluded that if partial replacement of sand with artificial sand up to 10% in M20 grade of concrete is done. According to Sakthivel. al. study the replacement of natural sand with crush sand is economical and use of crush sand is possible without affecting the strength of structure.

Kode V. R. [2]:- Reported that concrete with stone dust as a fine aggregate yielded 10% higher compressive strength 24% higher Tensile strength 26% higher Flexural strength over the concrete with natural sand. When the cubes are test on the U. T. M machine then the above result are found which show that we can use artificial sand i.e. crush sand in place of natural sand.

B Balapgol & SA Kulkarni [3]:- investigated the hardened properties of concrete with use of crushed basalt stone fine aggregate as a substitute to natural sand. The researchers concluded that there was significant increase in compressive strength with crushed sand. The compressive strength was increased by 19.44% to 40.38% at 7 days age and increased by 8.33% to 25.9% at 28 days age as grade of increased mixes was increased. The flexural strength of concrete with crushed sand was marginally increased about 1 to 5% as compared to natural sand. According to B Balapgol & SA Kulkarni crush sand gives more strength than natural sand because of properties of crush sand i.e. shape size, strength etc. It gives higher strength than that of natural sand.

Sahu Kumar and Sachan [4]:- investigated the suitability of crushed stone dust waste as fine aggregate for concrete. Test results indicated that crushed stone dust waste can be used effectively to replace natural sand in concrete. Concrete made with this replacement can attain the same compressive strength, comparable tensile strength, modulus of rupture and lower degree of shrinkage as the control concrete.

Villanovan et al., 2006 [5]:- studies the strength and behavior of concrete by using crushed rock dust as fine aggregate, they investigated the possibility of using crushed rock as 100% replacement for sand, with varying compacting factors.

Dan Ravina [6]:- investigated the use of crushed sand as fine aggregates along with Fly. He mentioned that the particle shape of crushed sand is more angular with a rougher surface texture, and usually flakier and more elongated than of natural sand. Moreover the crushed sand, unless suitably treated, contains much more fines (particles smaller than 75 mm). As a result the workability of the fresh concrete is impaired with the corresponding need for higher water requirement which in turn makes for lower concrete strength and higher drying shrinkage. By contrast, the fly' ash particle has a round shape and a smooth surface. He says that a combination of fly ash and crushed sand yield a far superior concrete mix than crushed sand alone' and obviates the disadvantage of partial or total replacement of natural sand with crushed sand. According to' Dan Ravina' we can use crush sand as a replacement in place of natural sand which is the cheapest way for replacement and having no drawbacks.

Thaniya Kaosol (2010) [7] has made study on the reuse of concrete waste as crushed stone for concrete masonry units. The main objective was to increase the value of the concrete waste, to make a sustainable and profitable disposal alternative for the concrete waste. Attempts were made to utilize the concrete waste as crushed stones in the concrete mix to make concrete blocks. Various percentages of crusted stones have been tried the amount (i.e. 0%, 10%, 20%, 50% and 100%). From the results they found concrete waste can used to produce concrete block masonry units. Suitability of Crushed sand to replace river sand in concrete production was investigated Manaseeh Joel [2010] [5]. Slump, compressive and indirect tensile strength tests were performed on fresh and hardened concrete. Twenty eight days peak compressive and indirect tensile strength values of 40.70 N/mm^2 and 2.30 N/mm^2 respectively were obtained with the partial replacement of river sand with 20% crush sand, as against values of 35.00N/mm^2 and 1.75N/mm^2 obtained with the use of river sand as fine aggregate.

Karan Verma 1, P. S. Pajgade 2 [8] The effect of partial

replacement of natural sand (NS) by crushed sand (CS) and partial replacement of cement by supplementary cementing material have been investigated. All the trials have been taken at actual construction site and tested at site laboratory. Supplementary Cementing materials (SCM) Fly Ash and GGBS have been used and cement has been replaced by three combination of Fly ash (15%, 20%, and 25%) and two combinations of GGBS (40% & 50%). In both the cases, 50% natural sand have been replaced by crushed sand. Both the materials have shown good compatible results when used and it is found that use of SCM gives better result in terms of compressive strength and workability due to reduction in w/c ratio. This paper puts forward the applications of crushed sand and supplementary cementing materials as an attempt towards sustainable development. It will help to find viable solution to the declining availability of natural sand to make eco-balance.

3. Experimental Program

3.1. Material Used

In our experiment we use Ordinary Portland Cement of 53 grades available in local market of standard brand. We use fine aggregate as locally available natural Sand and artificial sand**.** We use water is preparation of mortar which is least expensive but most important ingredient of concrete. The water which is used for making concrete should be clean and free from harmful impurities such as Oil, Alkalies, Acids, etc. In general the water which is fit for drinking should be used for making concrete. And crush sand use in that of size less than 4.75mm.

3.2. Curing & Casting

For the casting, the cast iron moulds are clean of dust particles and applied with oil on all sides before concrete is poured in the moulds. The moulds are place on a level platform. The well mixed concrete is filling, allow to flow and settle itself in the moulds. Excess concrete was removing with trowel and top surface is keep level and smooth. In this Total number of 198 cubes we have to cast. In that from 3 different crusher the crush sand is use i.e. we have to made 3 blocks of each, And start from 0% then increment of 10% is carry out such that up to 100% replacement of natural sand with artificial sand. it means that we have to prepare 99 block for compression test, 99 blocks for tensile strength. After that the specimens are cured in mould for 24 hours. After 24 hours, all the specimens are demoulded and kept in curing tank for 28 days. After 28 days all specimens are kept in atmosphere for 1day for constant weight. And then testing is carrying out on them.

Figure 3. *Showing casting and curing of cube.*

3.3. Testing

We perform following test for prepare blocks.

3.3.1. Compressive Strength Test

Out of many test applied to the concrete, this is the important test which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test specimens cubes of 15 cm X 15 cm X 15 cm are prepared. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. These specimens are tested by compression testing machine after 28 days curing.

Figure 4. *Compressive strength test on CTM.*

3.3.2. Procedure for Forming the Specimen

We have to prepare total 132 blocks by varying the percentage of Crushed sand and by using two different quarries Crushed sand. So that total 132 specimens from both quarry Crushed sand for M20 and M25 grade of concrete are prepare for a testing of 28 days.

Table 2. *Specimen prepared with different variation of Crush sand for different.*

Crush sand	Percentage	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	total
KASAT	M20	3	3	3	3	3	3	3	3	3	3	3	33
	M25	3	3	3	3	3	3	3	3	3	3	3	33
KHATRI	M20	3	3	3	3	3	3	3	3	3	3	3	33
	M25	3	3	3	3	3	3	3	3	3	3	3	33
Total No. of block=132													

4. Scrutiny of Results

Table 3. *Quantity of material for M20 grade concrete mix.*

Sr. No.	% Of Crush Sand	Water In Lit.	Cement	Aggregate	Natural Sand	Crush Sand
1	0	2.67	4.67	15.24	10.538	0
2	10	2.67	4.67	15.24	9.485	1.0538
3	20	2.67	4.67	15.24	8.432	2.114
4	30	2.67	4.67	15.24	7.379	3.167
5	40	2.67	4.67	15.24	6.326	4.22
6	50	2.67	4.67	15.24	5.273	5.273
7	60	2.67	4.67	15.24	4.22	6.326
8	70	2.67	4.67	15.24	3.167	7.379
9	80	2.67	4.67	15.24	2.114	8.432
10	90	2.67	4.67	15.24	1.0538	9.485
11	100	2.67	4.67	15.24	0	10.538

Table 4. *Quantity of material for M20 grade concrete mix.*

Sr. No.	% Of Crush Sand	Water In Lit.	Cement	Aggregate	Natural Sand	Crush Sand
1	0	2.45	4.67	27.3	18.98	0
2	10	2.45	4.67	13.65	8.540	0.949
3	20	2.45	4.67	13.65	7.591	1.898
4	30	2.45	4.67	13.65	6.642	2.847
5	40	2.45	4.67	13.65	5.693	3.796
6	50	2.45	4.67	13.65	4.745	4.745
7	60	2.45	4.67	13.65	3.796	5.693
8	70	2.45	4.67	13.65	2.847	6.642
9	80	2.45	4.67	13.65	1.898	7.591
10	90	2.45	4.67	13.65	0.949	8.540
11	100	2.45	4.67	13.65	0	9.489

Table 5. *Compressive strength of concrete block for M20 grade (kasat).*

Sr. no.	% of replacement	Curing period	Compressive strength(N)			Average strength (N/mm^2)
			Sample 1	Sample 2	Sample 3	
1	0	21	678	553	742	28.94
2	0	28	579	692	502	26.00
3	10	28	551	454	709	25.14
4	20	28	224	354	373	13.95
5	30	28	394	530	530	21.33
6	40	28	390	486	543	20.81
7	50	28	404	337	464	17.67
8	60	28	349	404	353	16.22
9	70	28	356	563	475	20.63
10	80	28	408	530	480	20.98
11	90	28	635	603	625	27.57
12	100	28	454	508	548	22.34

Table 6. *Compressive strength of concrete block for M20 grade (khatri).*

Sr. no.	% of replacement	Curing period	Compressive strength(N)			Average strength (N/mm^2)
			Sample 1	Sample 2	Sample 3	
1	0	21	678	553	742	28.94
2	0	28	579	692	502	26.00
3	10	28	530	443	441	20.74
4	20	28	432	491	400	19.40
5	30	28	634	626	701	28.76
6	40	28	420	548	501	21.55
7	50	28	302	356	404	15.58
8	60	28	569	518	472	22.87
9	70	28	483	448	501	21.00
10	80	28	445	461	587	21.90
11	90	28	486	423	325	18.10
12	100	28	324	518	515	19.90

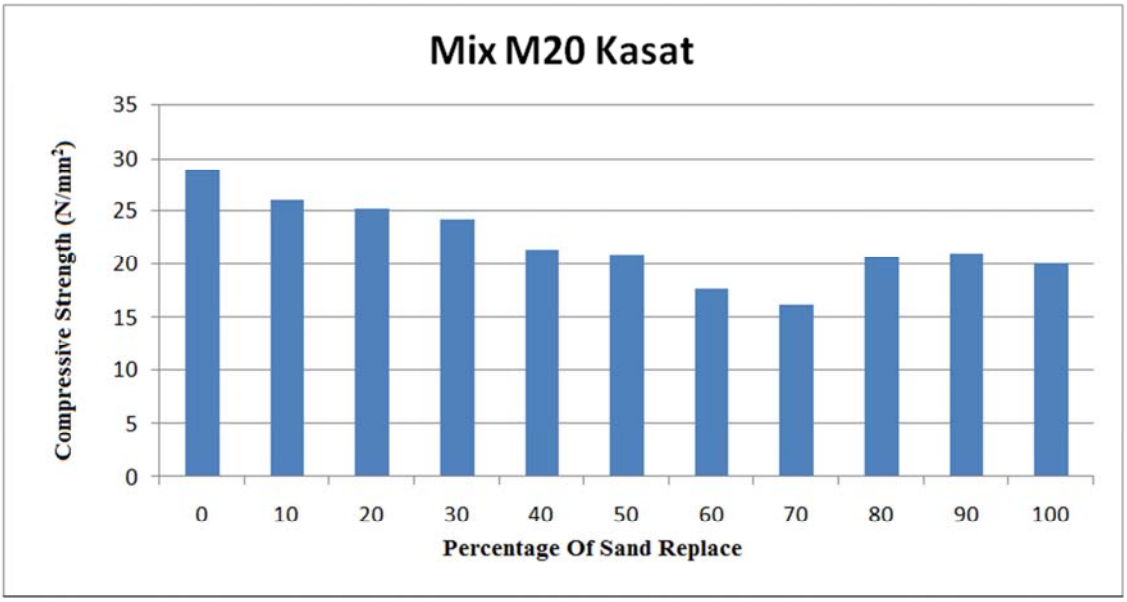

Figure 5. *Compressive strength of cubes (M20).*

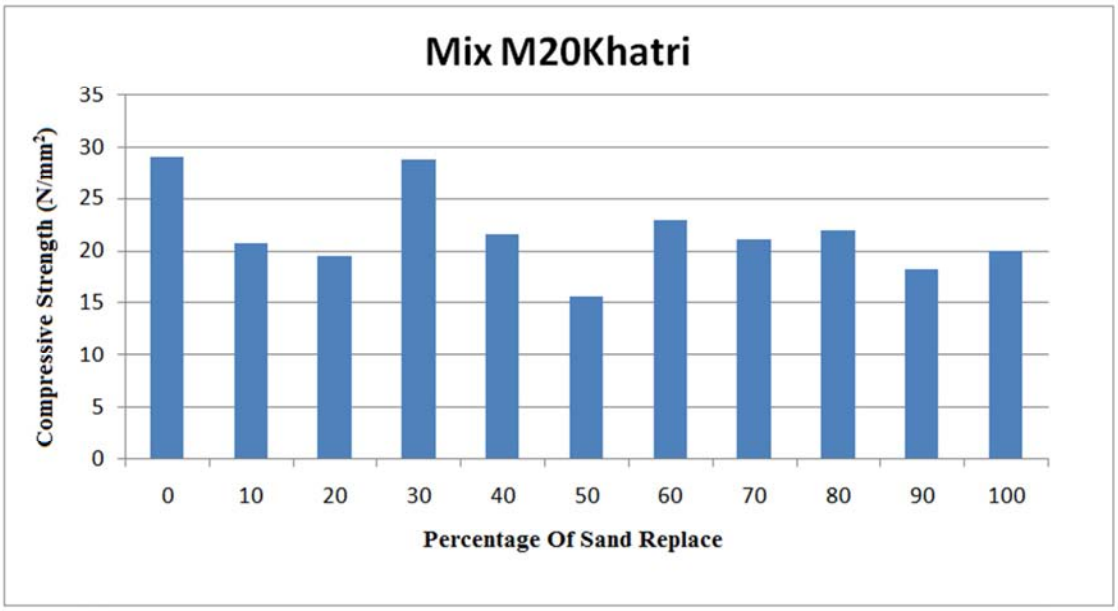

Figure 6. *Compressive strength of cubes (M25).*

Table 7. *compressive strength of concrete block for M25 grade (kasat).*

Sr. no.	% of replacement	Curing period	Compressive strength(N)			Average strength (N/mm^2)
			Sample 1	Sample 2	Sample 3	
1	0	21	732	758	685	32.22
2	0	28	862	872	840	37.58
3	10	28	648	744	749	31.40
4	20	28	797	754	708	33.13
5	30	28	803	847	901	37.42
6	40	28	715	771	638	31.15
7	50	28	725	785	830	34.32
8	60	28	750	798	634	32.00
9	70	28	703	806	745	33.06
10	80	28	679	749	587	29.55
11	90	28	719	585	610	28.07
12	100	28	552	554	587	24.83

Table 8. *Compressive strength of concrete block for M25 grade (khatri).*

Sr. no.	% of replacement	Curing period (days)	Compressive strength(N)			Average strength (N/mm^2)
			Sample 1	Sample 2	Sample 3	
1	0	21	732	758	685	32.22
2	0	28	862	872	840	37.58
3	10	28	419	739	787	28.53
4	20	28	824	779	836	35.77
5	30	28	897	777	685	34.60
6	40	28	784	975	1019	40.74
7	50	28	968	836	660	36.14
8	60	28	746	772	759	33.39
9	70	28	786	615	590	29.21
10	80	28	602	683	635	28.17
11	90	28	695	648	549	27.75
12	100	28	555	676	629	27.28

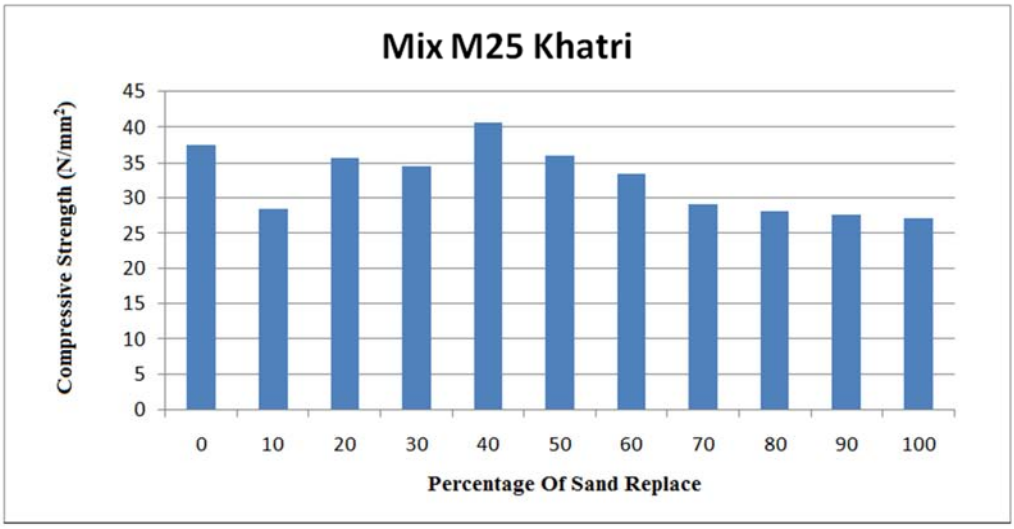

Figure 7. *Compressive strength of cubes (M20).*

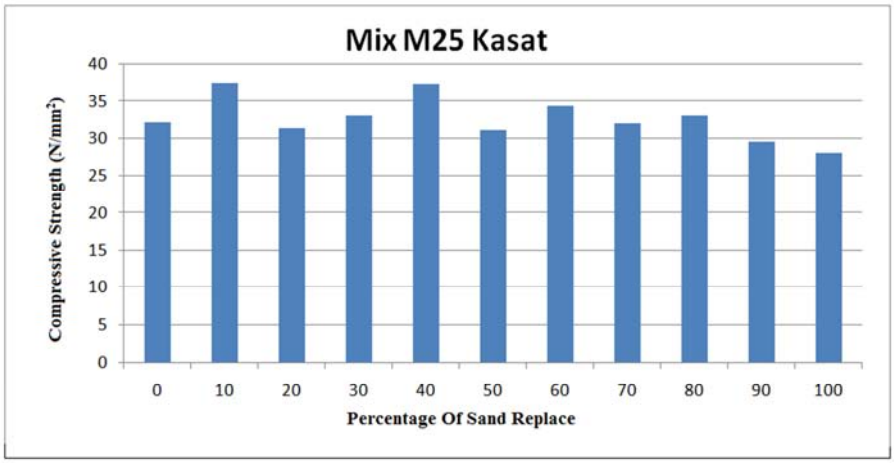

Figure 8. *Compressive strength of cubes (M25).*

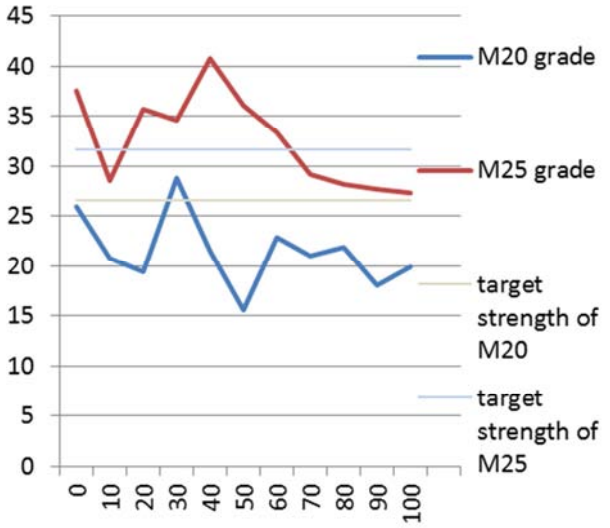

Figure 9. *Graphical representation of compressive strength of Crushed sand (khatri).*

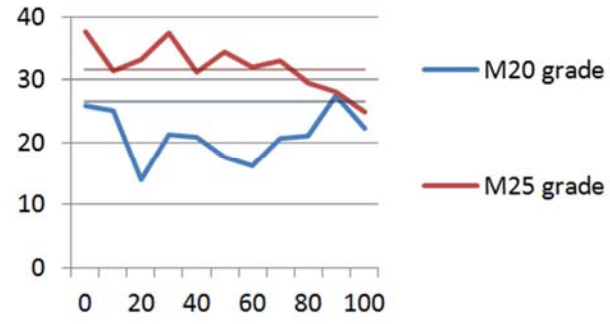

Figure 10. *Graphical representation of compressive strength of Crushed sand (kasat).*

We had used khatri and kasat type of artificial sands with varying percentage 0 to 100% for both M20 and M25 grade mix.

After testing of specimen it was found that for M25 grade of concrete, replacement of natural sand with artificial sand (kasat) maximum compressive strength was found to be 37.42 N/mm^2 at 30% replacement and for khatri sand, it was found to be 40.74 N/mm^2 at 40% replacement.

Also for M20 grade of concrete, replacement of natural sand with crushed khatri sand, maximum compressive strength was found to be 28.76 N/mm^2 at 30% replacement.

5. Conclusion

A review of different experimental studies performed by various researchers have been carried out to examine various operational parameters like workability, compressive strength, tensile strength of concrete with crushed sand as replacement to the natural sand in that total investigation. I think that following conclusion are made

- The concrete with crushed sand performed better than concrete with natural sand as the property of crush sand is better than that of natural sand.
- From our study it is concluded that different Crushed sand gives different results for compressive strength depending on different quarries and from study of different research paper at 40% to 50% replacement of crushed sand the maximum compressive strength is obtained.
- The maximum tensile strength of concrete is obtain at 60% and 70% replacement of natural sand with Crushed sand.

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