Study On Mechanical Properties of Concrete by Using Different Size of Coarse Aggregates

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Abstract

The production of concrete requires various materials like coarse aggregate, fine aggregate, cement and water each of them is mixed with various proportions to achieve the specific strength. In order to get the optimum packing density of mix, the aggregate sizes are selected that the voids formed by larger particles are filled with smaller ones. Higher degree of particle packing leads to minimum voids and maximum density and requirement of cement and water will be less. Therefore, an alternate material used for the partial replacement of coarse aggregate in concrete. In the present study mechanical properties such as compressive strength and split tensile strength of M 20 grade of concrete with the use of 12 mm coarse aggregate (5%, 10%, 15%, 20%) and 6 mm coarse aggregate (5%, 10%, 15%, 20%) as partial replacement of 20 mm coarse aggregates were studied. The testing of concrete was done after 28 days curing according to the Indian standard specifications. The results were analysed and compared with the conventional mix made with 20 mm coarse aggregate. It is found that, 15% of 12 mm and 5% of 6 mm aggregates replacement proportion are showed better results than compare to the conventional concrete made with 20 mm aggregate.

Keywords: Coarse Aggregate, Mechanical properties, Compressive strength, Split tensile strength, optimum packing density of mix.

1. Introduction

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. The usage, behavior as well as the durability of concrete structures, built during the last first half of the century with Ordinary Portland Cement (OPC) and plain round bars of mild steel, the ease of procuring the constituent materials (whatever may be their qualities) of concrete and the knowledge that almost any combination of the constituents leads to a mass of concrete.

It is well recognized that coarse aggregate plays an important role in concrete. Coarse aggregate typically occupies over one-third of the volume of concrete, and research indicates that changes in coarse aggregate can change the strength and fracture properties of concrete. To predict the behavior of concrete under general loading requires an understanding of the effects of aggregate type, aggregate size, and aggregate content. This understanding can only be gained through extensive testing and observation.

The effects of aggregate type, size, and content on the behavior of normal and high-strength concrete and the relationships between compressive strength, split tensile strength are discussed. The concrete mixtures incorporate partial replacement of 20 mm coarse aggregate with aggregate sizes of 12 mm and 6 mm. Compressive strengths and split tensile strengths of concrete will increase by partial replacement of 20 mm coarse aggregate by sizes 12 mm, 6mm compared with conventional concrete.

2. Literature review

2.1 Chauhan Zheng et al. (2018); This experimental investigation on effect of replacement of natural coarse aggregate with either Recycled concrete aggregate(RCA) or recycled clay brick(RBA) aggregate by Construction building materials. The compressive strength of the hardened concrete replacements 0%, 25% ,50%, 75%, 100% 28 days' compressive strength was founded to be only M 25. The concrete with RCA has better performance than the concrete with RBA.

2.2 Kumar Animesh et al. (2017); they conducted tests after partial replacement of coarse aggregate with coconut shell. Cubes for their workability, compressive strength and split tensile strength for The percentage of 0%,5%,10%,15%,20% replacement with coconut shell.it found better results at 20 % replacement.

2.3 Partha Seiko et al. (2016); conducted the waste tier rubber chips in concrete as partial replacement of coarse aggregate at various percentages had been investigated. Compression and Split tensile tests were carried out for different percentages of rubber chips 0%, 4%, 8%, 12% at 7 days curing period. The test results indicated that at 4% shows replacement of rubber chips better results.

2.4 Subramanian and Shankar Ram (2015); Carried experimental investigation on concrete by partial replacement of coarse aggregate with glass powder This work examines the possibility of using glass powder partial replacement of coarse aggregate and cement. Glass powered has partial replacement as 10%, 20%, 30%, 40% tested for its compressive and tensile strength up to 28 days of age and were compared with those of conventional concrete. it is found better results at 10%.

2.5 Vignesh Kumar and Ramjet Kumar (2013); they founded that the partial replacement by coarse aggregate by Iron slag with polypropylene fiber. Hence in this study 30%, 35% of iron slag used increased compressive strength in concrete. Compressive strength of concrete is increased 4%, 5% compared than the conventional concrete.

2.6 Walker and Bloom (1960); Studied the effects of coarse aggregate size on the properties of normal-strength concrete. Their work demonstrates that an increase in aggregate size from 10 to 64 mm results in a decrease in the compressive strength of concrete, by as much as 10 percent; however, aggregate size seems to have negligible effects on flexural strength. The study also shows that the flexural-to compressive strength ratio remains at approximately 12 percent for concrete with compressive strengths between 35 and 46 MPa.

3. Materials and methods

The various materials used in the experimental investigation include:

- Ordinary Portland Cement (OPC)
- Coarse aggregate
- Fine Aggregate (Natural River Sand)
- Water

Different experiments conducted on cement, fine aggregate and coarse aggregate are

Cement:

- Normal Consistency
- Initial setting time
- Final setting time
- Specific Gravity
- Fineness Modulus

Fine aggregate:

- Specific Gravity of Fine aggregate
- Bulk density of fine aggregate
- Sieve analysis of fine aggregate

Coarse aggregate:

- Specific Gravity of Coarse aggregate
- Sieve analysis of Coarse aggregate
- Flakiness Index and Elongation Index

3.1 Ordinary Portland Cement (53 grade)

Cement used in this experimental work is Ordinary Portland Cement (OPC) of 53 grade from ZUARI brand. Cement used was fresh, of uniform color, free from any lumps and foreign matter, and from the same batch. The various properties of cement are depicted in Table 1.

Table 1 Properties of cement

S. No.	Property	Test Value	Standard values (IS 8112:1989)
1	Specific gravity	3.13	3.15
2	Normal consistency	33%	Not Specified
3	Initial setting time (min)	42	>30
4	Final setting time (min)	350	<600
5	Fineness	6	10

3.2 Fine Aggregate

The sand used throughout the experimental work was obtained from Putter, Chittoor district, Andhra Pradesh, India. The specific particle size composition of the sand was prepared as per the IS 650:1966 and IS 383:1970. Sand was thoroughly washed with tap water to remove impurities like decayed vegetable matter, humus, organic matter and deleterious materials like clay, fine silt and fine dust and was oven dried for 24 hours and cooled to room temperature.

River sand conforming to Zone-II as per IS 383-1970 was used. The fine aggregate was clean, inert and free from organic matter, silt & clay. The fine aggregate was dried before use. The size of sand is that passing through 4.75mm and retained on 150 microns IS sieve. The various properties of fine aggregate are shown in Table 2 and sieve analysis in Table 3.

Table 2 Properties of Fine Aggregate

S. No.	Properties	Results
1	Specific gravity	2.62
2	Bulking of sand	3%
3	Fineness modulus	3.12
4	Grading zone	II

Table 3 Sieve analysis of Fine Aggregate

IS Sieve Size	Weight Retained (grams)	Percentage of total weight retained	Cumulative % of total weight retained	Percentage Passing	Permissible Values as per IS 383-1970 (Percentage)
4.75mm	15	1.5	1.5	98.5	90-100
2.36mm	30	3	4.5	97	75-100
1.18mm	355	35.5	40	64.5	55-90
600µ	325	32.5	72.5	79	35-59
300µ	210	21	93.5	93.5	80-30
150µ	65	6.5	100	0	0-10

Fineness Modulus of Fine Aggregate = 312/100 = 3.12

3.3 Coarse Aggregate (20 mm)

Conventional coarse aggregate from an established quarry was used. For most of building constructions, the coarse aggregate consists of gravel or crushed stone up to 20mm size. However, in massive structures, such as dams, the coarse aggregate may include natural stones or rock. The coarse aggregate is free from clayey matter, silt and organic impurities etc. The coarse aggregates used were of size 20mm. The coarse aggregates were tested in accordance to IS 383-1970.

The Coarse aggregate is obtained from a local quarry is used. The various properties of Coarse aggregate (20 mm) are publicized in Table 4 and sieve analysis in Table 5.

Table 4 Properties of Coarse aggregate (20 mm)

S. No.	Properties	Results
1	Specific gravity	2.55
2	Water Absorption	0.37%
3	Elongation Index	21.20%
4	Flakiness Index	23.20%
5	Fineness modulus	7.28

Table 5 Grain Size Distribution of Coarse aggregate (20 mm)

IS sieve size	Weight of aggregate retained (kg)	% of total weight retained	Cumulative % of total weight retained	% of passing	Permissible values as per IS 383-1970
80mm	0	0	0	100	----
40mm	0	0	0	100	100
20mm	1.875	1.875	26.6	73.4	85-100
10mm	3.075	4.95	99	1.0	0-20
4.75mm	0.005	5	100	0	0-5
2.36mm	0	0	100	0	----
1.18mm	0	0	100	0	----
600µ	0	0	100	0	----
300µ	0	0	100	0	----
150µ	0	0	100	0	----
		TOTAL	725.6		

Fineness modeless = 725.6/100 = 7.26

3.4 Coarse Aggregate (12mm)

Conventional coarse aggregate from an established quarry was used. For most of building constructions, the coarse aggregate consists of gravel or crushed stone up to 12 mm size. However, in massive structures, such as dams, the coarse aggregate may include natural stones or rock. The coarse aggregates used were of size 12 mm. The coarse aggregates were tested in accordance to IS 383-1970.

The Coarse aggregate is obtained from a local quarry is used. The coarse aggregate with a maximum size 12 mm having a specific gravity 2.69 and fineness modulus of 6.72 have been used in the present study. The various properties of Coarse aggregate (12 mm) are shown in Table 6 and sieve analysis in Table 7.

Table 6 Properties of Coarse aggregate (12 mm)

S. No.	Properties	Results
1	Specific gravity	2.69
2	Water Absorption	0.39%
3	Elongation Index	19.20%
4	Flakiness Index	22.10%
5	Fineness modulus	6.72

Table 7 Grain Size Distribution of Coarse aggregate (12 mm)

IS sieve size	Weight of aggregate retained (kg)	% of total weight retained	Cumulative % of total weight retained	% of passing	Permissible values as per IS 383-1970
80mm	0	0	0	100	----
40mm	0	0	0	100	---
20mm	0	0	0	100	---
10mm	2.46	2.46	82	18	0-20
4.75mm	0.35	2.81	93.6	6.4	0-5
2.36mm	0.1	2.91	97	3	----
1.18mm	0.09	3	100	0	----
600µ	0	3	100	0	----
300µ	0	3	100	0	----
150µ	0	3	100	0	----
		TOTAL	672.6		

3.5 Coarse Aggregate (6 mm)

Conventional coarse aggregate from an established quarry was used. For most of building constructions, the coarse aggregate consists of gravel or crushed stone up to 6 mm size. However, in massive structures, such as dams, the coarse aggregate may include natural stones or rock. The coarse aggregates used were of size 6 mm. The coarse aggregates were tested in accordance to IS 383-1970.

The Coarse aggregate is obtained from a local quarry is used. The coarse aggregate with a maximum size 6 mm having a specific gravity 2.76 and fineness modulus of 5.57 have been used in the present study. The various properties of Coarse aggregate (6 mm) are shown in Table 8 and sieve analysis in Table 9.

Table 8 Properties of Coarse aggregate (6 mm)

S. No.	Properties	Results
1	Specific gravity	2.76
2	Water Absorption	0.41%
3	Elongation Index	20.20%
4	Flakiness Index	21.40%
5	Fineness modulus	5.57

Table 9 Grain Size Distribution of Coarse aggregate (6 mm)

IS sieve size	Weight of aggregate retained (kg)	% of total weight retained	Cumulative % of total weight retained	% of passing	Permissible values as per IS 383-1970
80mm	0	0	0	100	----
40mm	0	0	0	100	---
20mm	0	0	0	100	---
10mm	0	0	0	100	---
4.75mm	1.45	1.45	72.5	27.5	---
2.36mm	0.3	1.75	87.5	22.5	----
1.18mm	0.2	1.95	97.5	0.02	----
600µ	0.05	2	100	0	----
300µ	0	2	100	0	----
150µ	0	2	100	0	----
	TOTAL		557.5		

Fineness modulus = 557.5/100 = 5.57

3.6 Water

Water is an important ingredient of concrete as it initiates the chemical reaction with cement, and the mix water was completely free from chlorides and sulphates. The water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities which when present may have adverse effect on the strength of concrete. The two principal functions of water in a concrete mix are to effect hydration and improve workability. Too much of water causes a loss of strength by upsetting the water cement ratio. Ordinary potable water was used throughout the investigation as well as for curing concrete specimens.

3.7 Workability Test

Workability is carried out by conducting the slump test and compaction factor test as per IS 1199-1959 on ordinary concrete and fiber reinforced concrete.

3.8 Compressive Strength Test

Compression test is the most common test conducted on hardened concrete, partly because it is easy test to perform and partly because most of desirable characteristic properties of concrete are qualitatively related to its compressive strength. Compression test is carried out on specimens of cubical shape. The size of specimen is 15×15×15 comes were cast for M30 grade of concrete. After curing, these cubes were tested on compression testing machine AS per I.S. 516- 1959. The failure load was noted. In each category two cubes were tested and their average value is reported. The compressive strength was calculated as fallows, compressive strength (Map) = failure load/ cross sectional area. Experimental set up to find compressive strength of concrete is shown in Fig.1.

Fig. 1 Experimental set up to find compressive strength of concrete

3.9 Split Tensile Test

The split tensile test was conducted as per IS 5816:1999. The size of cylinder is 300mm length by 150mm diameter. The specimens were kept in water for curing for 28, 60 and 90 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter. The maximum load applied to the specimen was then recorded and the appearance of the concrete for any remarkable features in the type of failure was noted. Average of three values was taken as the representative of batch. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter. Experimental set up to find split tensile strength of concrete is shown in Fig.2.

To find split tensile strength following equation has used.

Split tensile strength = $2P/(\pi DL)$

Where P=split tensile load, D=diameter of the cylinder.

Fig. 2 Experimental set up to find split tensile strength of concrete

4. Results and discussions

Compressive strength after 28 days curing was obtained for totally 17 mix proportions. Conventional concrete represented with MS0 and remaining mix proportions from MS1 to MS16. The corresponding compressive strengths were presented in Table 10 and respective graph shown in Fig. 3.

Table 10 Compressive strength after 28 days curing

Mix. No.	20 mm aggregates (%)	12 mm aggregates (%)	6 mm aggregates (%)	Compressive strength (N/mm^2)
MS0	100%	0%	0%	28.96
MS1	90%	5%	5%	29.74
MS2	85%	5%	10%	30.02
MS3	80%	5%	15%	31.64
MS4	75%	5%	20%	33.27
MS5	85%	10%	5%	34.65
MS6	80%	10%	10%	35.92
MS7	75%	10%	15%	38.74
MS8	70%	10%	20%	40.19
MS9	**80%**	**15%**	**5%**	**42.68**
MS10	75%	15%	10%	41
MS11	70%	15%	15%	39.88
MS12	65%	15%	20%	37.24
MS13	75%	20%	5%	35.45
MS14	70%	20%	10%	32.12
MS15	65%	20%	15%	31.23
MS16	60%	20%	20%	29.12

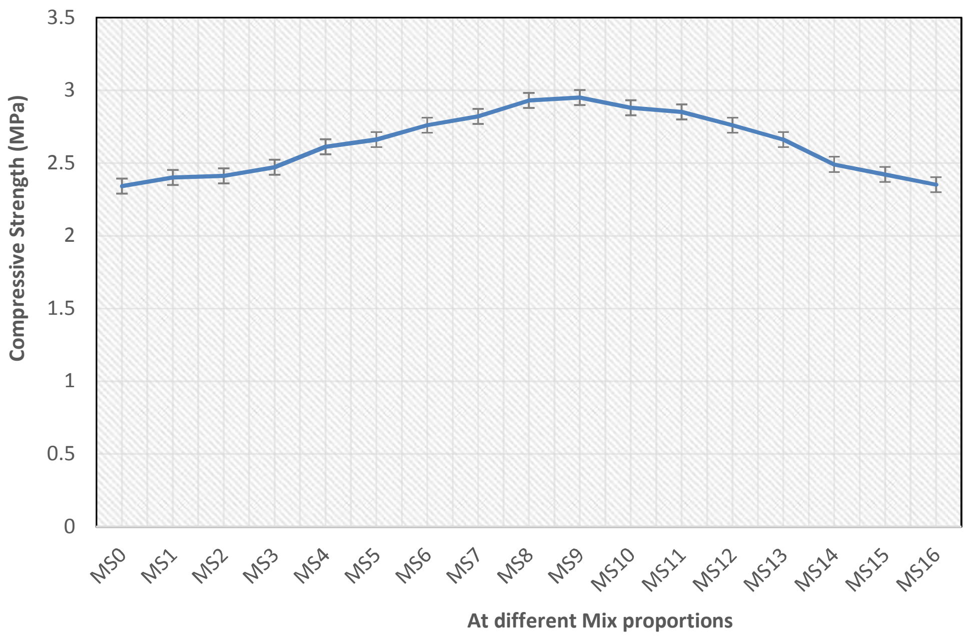

Fig. 3 Compressive strength after 28 days curing

Split Tensile strength after 28 days curing was obtained for totally 17 mix proportions. Conventional concrete represented with MS0 and remaining mix proportions from MS1 to MS16. The corresponding Split Tensile strengths were presented in Table 11 and respective graph shown in Fig. 4.

Table 11 Split Tensile strength after 28 days curing

Mix. No.	20mm aggregates (%)	12mm aggregates (%)	6mm aggregates (%)	Split Tensile strength (N/mm^2)
MS0	100%	0%	0%	2.34
MS1	90%	5%	5%	2.40
MS2	85%	5%	10%	2.41
MS3	80%	5%	15%	2.47
MS4	75%	5%	20%	2.61
MS5	85%	10%	5%	2.66
MS6	80%	10%	10%	2.76
MS7	75%	10%	15%	2.82
MS8	70%	10%	20%	2.93
MS9	**80%**	**15%**	**5%**	**2.95**
MS10	75%	15%	10%	2.88
MS11	70%	15%	15%	2.85
MS12	65%	15%	20%	2.76
MS13	75%	20%	5%	2.66
MS14	70%	20%	10%	2.49
MS15	65%	20%	15%	2.42
MS16	60%	20%	20%	2.35

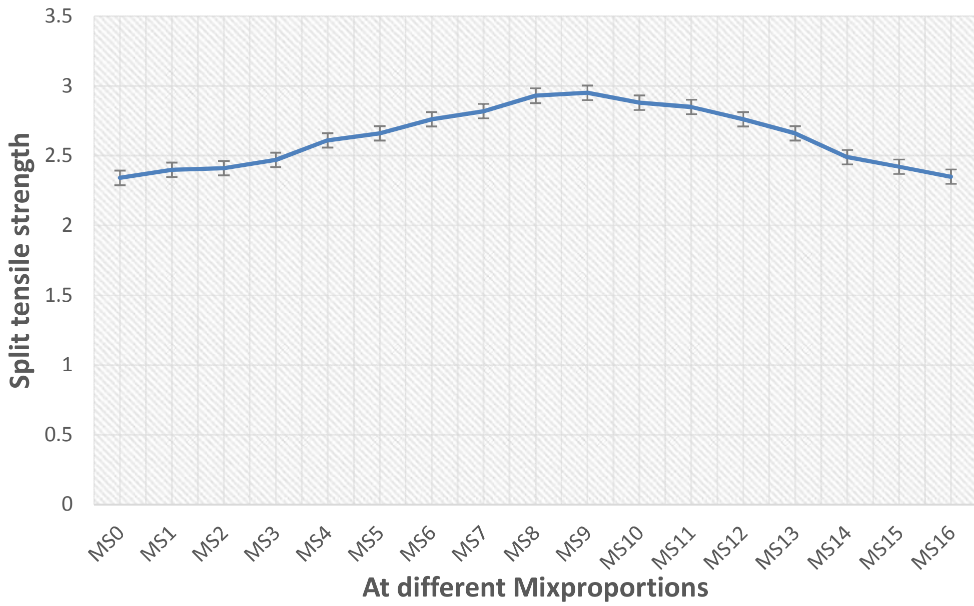

Fig. 4 Split tensile strength after 28 days

5.Conclusions

- The mechanical properties of M 20 grade concrete with the use of 12 mm coarse aggregate (5%, 10%, 15%, 20%) and 6 mm coarse aggregate (5%, 10%, 15%, 20%) as partial replacement of 20 mm coarse aggregate were studied.
- The results observed that 20 mm coarse aggregate has been partially replaced by 12 mm and 6 mm aggregates, strength goes on increasing up to certain limits compare to conventional concrete.
- 20 mm coarse aggregate partially replaced by 15% of 12 mm and 5% of 6 mm aggregates shown the higher Compressive and split tensile strengths.

6.References

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