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Experimental Investigation on M25 & M30 Concrete with Construction & Demolition (C&D) Waste

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***Abstract:** Many issues confront the world today, such as increasing urbanization, population explosion, climate change and resource degradation, pollution of water, air, and land, and construction and demolition waste generation around the world, to name a few. If we consider simply construction and demolition waste output, the world's population of 7.6 billion people generated around 3 billion tonnes of waste every year. China, India, and the United States, with a combined waste output of more than 2 billion tonnes, are the most significant contributors in this scenario (Ali Akhtar et al., 2018). In recent decades, waste creation has expanded exponentially over the world, with no indications of slowing down.*

As a result, natural resources are rapidly diminishing in many countries around the world, including India. This study emphasized on utilization of construction and demolition (C&D) waste to make fresh concrete.

This research work founded on partial replacement of recycled concrete aggregate and waste marble dust replacing by 0%, 5%, 10%, 15%, 20%, and 25% as coarse and fine aggregates, respectively. Slump tests were used to evaluate fresh concrete properties, whereas compressive strength, split tensile strength, and flexural strength tests were used to determine hardened concrete strength.

Keywords: Construction & Demolition Waste, Recycled Concrete Aggregate, Waste Marble Dust, Compressive Strength, Flexural Strength, Split Tensile Strength

I. INTRODUCTION

Concrete is the leading building material since it was first used and is bound to maintain its significant role in the upcoming future due to its durability, maintenance free service life, adaptability to any shape and size, wide range of structural properties plus cost effectiveness. The concrete is one of the most extensively used construction materials around the globe which is a mixture of cement, aggregate and water. Global production of concrete is about 12 billion tons a year corresponding to almost 1m^3 per person per year, causing it to become one of the largest users of the natural resources in the world. It is predicted that concrete need will increase to more than 7.5 billion m3 (about 18 billion tons) a year by 2050. Such extensive consumption of concrete is the cause for higher use of natural aggregate and cement which eventually takes toll on the environment.

A. Construction and Demolition Waste

U.S. Environmental Protection Agency (EPA) defines construction and demolition (C & D) waste as waste materials consist of the debris generated during the construction, renovation and demolition of building, roads and bridges. C&D materials often contain materials that include: concrete, asphalt, wood, metals, gypsum, plastics and salvaged building components. Associated with the continuing increase of construction activities such as infrastructure projects, commercial buildings and housing programs, World has been experiencing a rapid increase of construction and demolition (C&D) waste.

Construction and demolition (C&D) waste is one of the largest waste flows in the world. Several research investigate that C&D waste has reached 30–40% of the total solid waste because of the large scale construction and demolition activities resulting from the accelerated urbanization and city rebuilding (Akhtar and Sarmah, 2018; Jin et al., 2017; Zhao et al., 2010)

Concrete is now the most widely used manufactured material on the planet. It has shaped so much of our built environment, but this comes at a massive environmental cost.

As per Asian institute of technology, Thailand had conducted a survey in various Asian countries and prepared a report regarding the construction and demolition waste management in May 2008.

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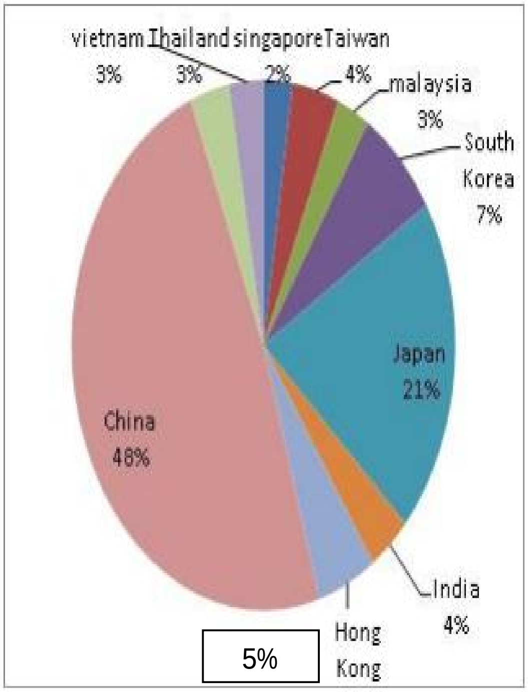	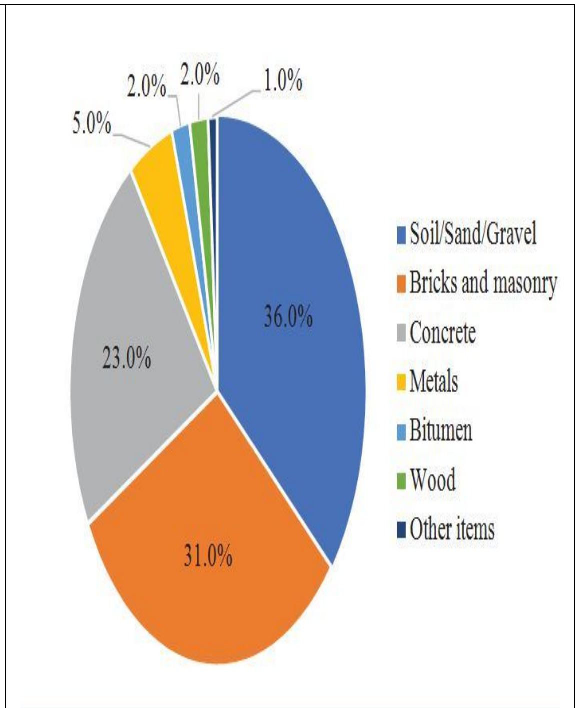
Figure 1.1: Shows the status of construction waste in Asian countries	Figure1.2 Typical Construction and Demolition (C&D) waste composition in India (CPCB, 2017)

Table 1.1 Comparison of Construction and Demolition (C & D) in Globally and India

C &D waste produced in	
Globally	India
The volume of construction waste generated worldwide every year will nearly to exceeds 3 billion tonnes (Akhatar et al. 2018) around the world.	As per New Delhi, August 25, 2020: According to the Building Material Promotion Council (BMPTC) generates an estimated 150 million tonnes of construction and demolition (C&D) waste every year. But the official recycling capacity is a meager 6500 tonnes per day.

II. LITERATURE REVIEW

1) Ergun et al. (2011); The concrete containing 5% waste marble powder as partial replacement by weight for cement with a super plasticizing admixture had higher compressive strength than that of the control concrete specimens. Consequently, the replacement of cement with diatomite and waste marble powder separately or together could be used to improve the mechanical properties of concrete.
2) S.P. Gautam et al. (2012); It is observed that when fine aggregate is replaced by 10% glass waste, the compressive strength at 7 d is found to increase by about 47.75% on average However, it is evident that increase in compressive strength at 28 d is only 3.30% at same replacement level.
3) N. Gurumoorthy (2014) ; The Compressive strength, Split Tensile strength and Flexural strength are increased with addition of waste marble dust up to 25% replace by weight of cement..Further any addition of waste marble dust the compressive strength, Split Tensile strength and Flexural strength are decreased. Therefore, we conclude that the most suitable percentage replacement of marble dust in concrete is 25%. Thus we found out the optimum percentage for replacement of marble dust with cement and it is almost 25% cement for cubes, cylinders and prisms. Result of this investigation that marble dust could be conveniently used in making good quality concrete and construction materials

4) Malpani et al (2014); It is observed that mix containing 40% Sand, 40% Marble Sludge Powder, 20% quarry rock dust had the best compressive strength and mix containing 50% quarry rock dust, 50% marble sludge powder and 20% Sand ,40% Quarry Rock Dust, 40% Marble Sludge Powder had the best values for Split Tensile Strength of concrete.
5) A Vishkar et al (2016); In this paper, design a M25 concrete with replacing of C & D waste (RCA) 30-100% . He found at 30% replacement the compressive strength increase but the strength of RAC gradually decrease up to 100% replacement of NA by RCA using same amount of water and cement as used in controlled concrete.
6) Muhammad ali K.et al (2016); In this study recommended C&D waste is used as the coarse aggregate in new concrete. It is shows that 0 % to 40% replacement of recycled aggregate give a good comparativelly results.
7) Hiremath et al. (2018); From the investigation, the following conclusions were drawn.The RCBA are considered as comparatively less weight aggregates but not light weight aggregates.

- As increase in the percentage of replacement of RCBA the strength also gets reduces and density also reduces.
- For 25% is found to be better substitute for concrete with respect to strength.
- The 25% replacement of RCBA is considered as the best in view of strength and economy, hence we use it in moderately loaded structures.50% replacement of RCBA can be used wherever load coming chances are less.

8) Vicky Gupta et al (2018); In this paper , up to 30% replacement of fine aggregate and 20% of coarse aggregate with DCA concrete as equivalent to conventional concrete.

III. EXPERIMENTAL PROGRAMME

A. *Materials*

In this experimental programme Ordinary Portland 43 Grade cement was used. It was tested as Per Indian Standard Specification IS: 8112-1989 and its properties are shown in Table 1. Waste marble dust used as replacement of Fine Aggregate. It is a by-product of the marble manufacturing process. The waste marble dust was collected from Chandigarh's Dhanas Marble Market and WMD is zone II. Fine aggregate was natural sand having a 4.75 mm original size. The coarse aggregate used in this investigation was 20 mm nominal size and Recycled concrete aggregate also used as replacement of coarse aggregate collected from Construction and Demolition (C&D) waste processing plant, Chandigarh. Both aggregate were tested according to BIS: 383-1970.

Table 2.1 Physical Properties of Cement OPC 43grade

Physical	Test Result	BIS 8112-1989 Obtained Specification
Fineness % (90 µm I.S. Sieve)	4.15	Not more than 10
Soundness (mm) (Le Chatelier Method)	1.02	Not more than 10
Normal Consistency (%)	29	……………………
Initial Setting Time (minutes)	225	>=30
Final Setting Time (minutes)	315	<=600
Specific gravity (Le-Chatelier’s Method)	3.17	…………..

Table 2.2 Physical Properties of FA & CA

Properties	Fine Aggregate		Coarse Aggregate		Admixture(BASF MasterGlenium Sky 8632)
	Natural Sand	Waste Marble Dust	Natural Coarse Aggregate	Recycled Concrete Aggregate	
Maxi size	4.75 mm	4.75 mm	20 mm	20 mm	
Bulk Density loose, kg/m3	1679	1420	1473	1126	
Bulk Density compacted, kg/m3	1882	1660	1551	1293	
Specific Gravity	2.65	2.63	2.655	2.69	1.067
Free Moisture %	1.5	1.51	0	2.09	
Water Absorption %	14.6	14.6	0.34	5.43	

B. Water

The potable tap water at room temperature is conforming to the requirement of water for mixing and curing as per guidelines given in IS 456: 2000 will be used.

C. Chemical Admixture

BASF MasterGlenium Sky 8632 was used in the experimental investigation. The MasterGlenium Sky 8632, designed to impart phenomenal rheological properties fresh concrete. It ehances considerably the placing and finishing of concrete. It is vastly used for low viscosity, long workability retention and higher compressive strength.

D. Mix Design of M25 Grade Concrete

Table 2.3 Proportion of M25 Grade Concrete

M25 Grade			
Cement	Fine aggregate	Coarse aggregate	Water
371	689.97	1147.22	178.16
1	1.85	3.09	0.48

E. Mix Design of 30 Grade Concrete

Table 2.4 Proportion of M30 Grade Concrete

M30 Grade			
Cement	Fine aggregate	Coarse aggregate	Water
395	671.54	1145.59	178
1	1.7	2.09	0.45

Table 2.5 Replacement details of M25 Grade Concrete

Percentage Replacement and Number of Specimens							
% age replacement	Grade	No of cubes for compressive strength		Number of beams for flexural strength		Number of cylinders for split tensile strength	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
0	**M25 Concrete**	3	3	3	3	3	3
5		3	3	3	3	3	3
10		3	3	3	3	3	3
15		3	3	3	3	3	3
20		3	3	3	3	3	3
25		3	3	3	3	3	3
Total		36 cubes		36 beams		36 cylinders	

Table 2.6 Replacement details of M30 Grade Concrete

Percentage Replacement and Number of Specimens							
% age replacement	Grade	No of cubes for compressive strength		Number of beams for flexural strength		Number of cylinders for split tensile strength	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
0	M30 Concrete	3	3	3	3	3	3
5		3	3	3	3	3	3
10		3	3	3	3	3	3
15		3	3	3	3	3	3
20		3	3	3	3	3	3
25		3	3	3	3	3	3
Total		36 cubes		36 beams		36 cylinders	

IV. RESULTS AND DISCUSSION

The findings from the experimental work on concrete of the M25 and M30 grade are presented in this chapter. Numerous tests were carried out to determine the effects of replacing the coarse and fine aggregate with construction and demolition waste. These tests included Slump tests for the fresh state of workability and compressive strength tests, split tensile strength tests, flexural strength tests, and ultrasonic pulse velocity tests for the hardened state of concrete.

A. Workability

The consistency of reference mix and modified concrete of each mix group are determined using slump test according to IS 1199:1959.

Slump Test: - Concrete slump test or slump cone test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progresss of work. The slump test indicates the consistency of concrete in different batches. The shape of the concrete slumps reveals information about the concrete's workability and quality. A few tamping or blows with a tapping rod on the base plate can also be used to assess the features of concrete in terms of segregation propensity. Because of the simplicity of the apparatus and process, this test has been used since 1922. The Slump cone's shape demonstrates concrete's workability.

First of all internal surface of mould was cleaned and oiled. Mould was then place on the nonporous base plate, after this mould was completely filled with prepared concrete mix in about 4 layers. Each layer was tamped with 25 strokes; excess concrete was removed immediately by lifting it up slowly in vertical direction. After this slump was determined by measuring the difference between the height of the mould and that of highest point of the specimen mix being tested.

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Table 3.1 Slump Value of M25 Grade Concrete

SLUMP VALUE			
S.No.	% Replacement	Grade	Slump (mm)
1	0%	M25 Concrete	56
2	5 %		54
3	10%		53
4	15%		52
5	20%		48
6	25%		46

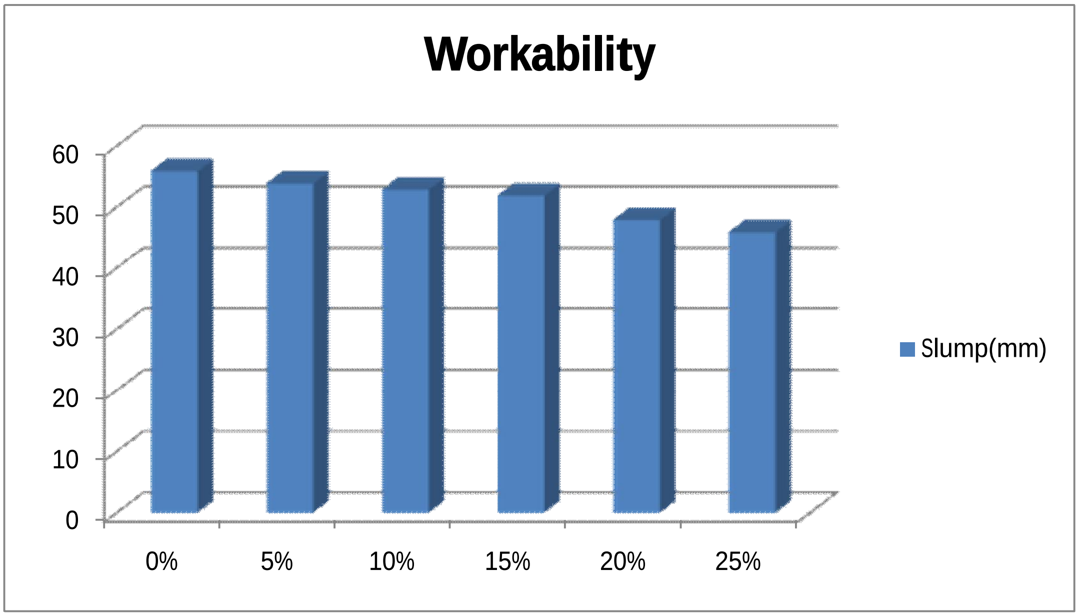

Figure 3.1 Slump Value of M25 Grade Concrete

The workability of concrete continuously decreases with increase in the percentage of construction and demolition waste. The decrease pattern value shown by slump test is by 3.57%, 5.35%, 7.1%, 14.2% and 17.8% for 5, 10, 15, 20 and 20 percentage construction and demolition waste respectively.

Table 3.2 Slump Value of M30 Grade Concrete

SLUMP VALUE			
S.No.	% Replacement	Grade	Slump (mm)
1	0%	M30 Concrete	55
2	5 %		53
3	10%		52
4	15%		49
5	20%		47
6	25%		45

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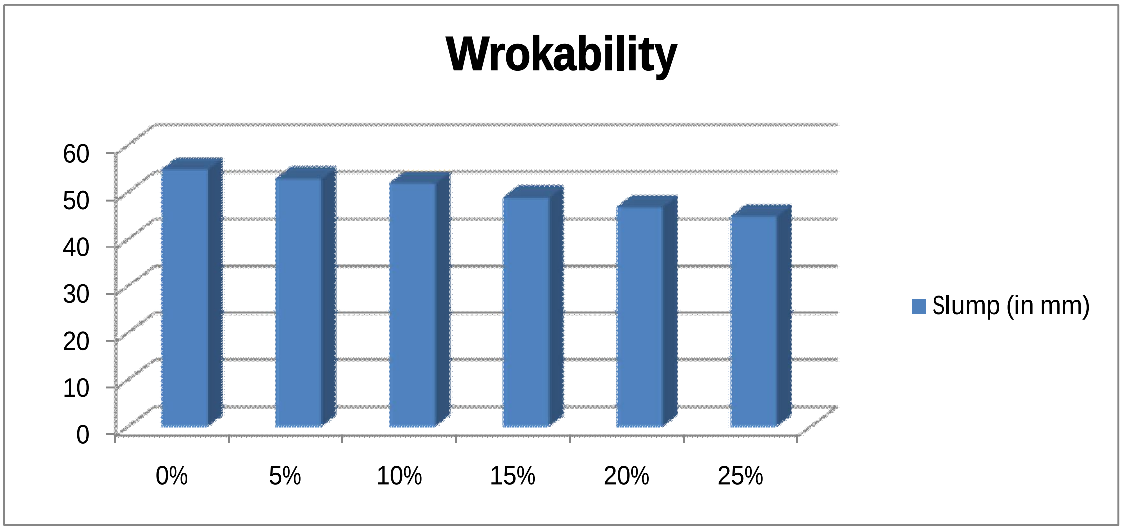

Figure 3.2 Slump Value of M30 Grade Concrete

The workability of concrete continuously decreases with increase in the percentage of construction and demolition waste. The decrease pattern value shown by slump test is by 3.63%, 5.45%, 10.90%, 14.54% and 18.18% for 5, 10, 15, 20 and 20 percentage construction and demolition waste respectively.

B. Denity Of Concrete

Concrete's density serves as a gauge for its strength. Concrete mixing can be altered to produce an end product with a higher or lower density. The Density findings at 28 days are reported in a table for concrete grades M25 and M30 that had samples partially replaced with recycled coarse aggregate and waste marble dust. Shown in table 3.3 & 3.4.

Table 3.3 Density of M25 Grade Concrete

DENSITY OF M25 GRADE CONCRETE			
S.No	% Replacement	Grade	Density (kg/m3)
1	0%	M25 CONCRETE	2436
2	5%		2454
3	10%		2459
4	15%		2471
5	20%		2488
6	25%		2466

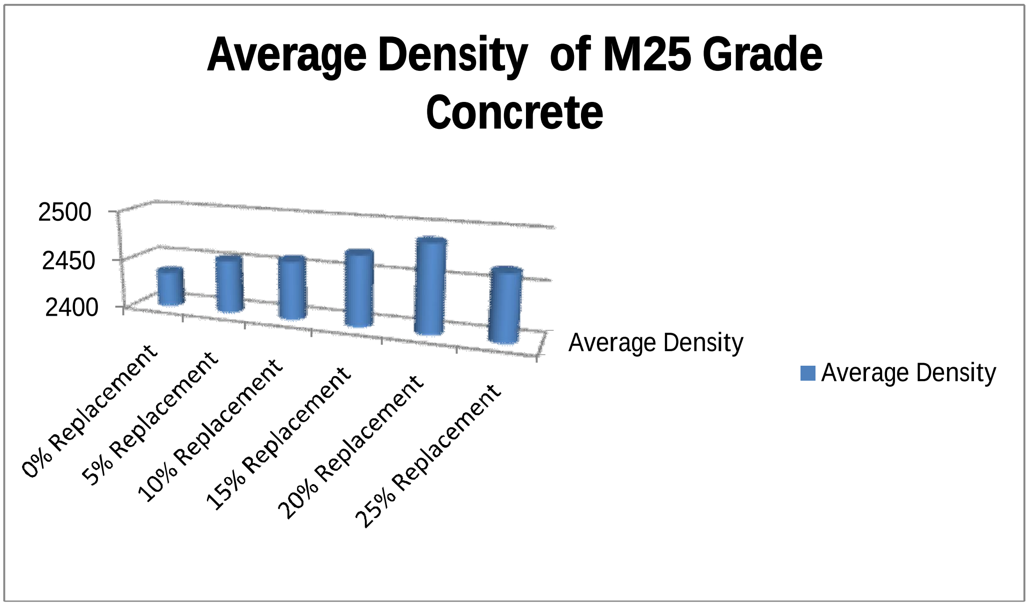

Figure 3.3 Density of M25 Grade Concrete

The density of concrete increase with increase in quantity of C & D waste. The increment pattern is by 0.57%, .81%, 1.22%, 1.46% and 0.9% for 5, 10, 15, 20 and 20 percentage construction and demolition waste respectively.

Table 3.4 Density of M30 Grade Concrete

DENSITY OF M30 GRADE CONCRETE			
S.No	% Replacement	Grade	Density (kg/m3)
1	0%	M30 CONCRETE	2441
2	5%		2448
3	10%		2460
4	15%		2463
5	20%		2510
6	25%		2489

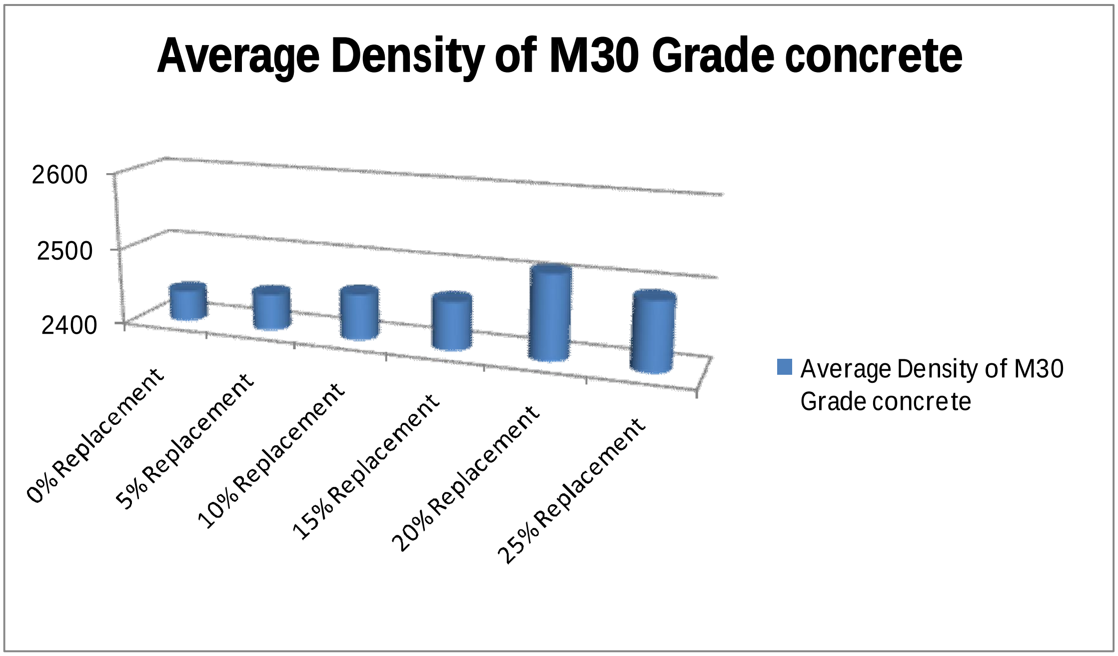

Figure 3.4 Density of M30 Grade Concrete

The density of concrete increase with increase in quantity of C & D waste. The increment pattern is by 0.20%, 0.56%, 1.26%, 1.50% and 0.89% for 5, 10, 15, 20 and 20 percentage construction and demolition waste respectively.

Table 3.5 Compressive, Flexural and Split Tensile Strength Test result of M25Grade Concrete

M25 GRADE TEST REPORT								
S.No	% Replacement	Grade	Average Compressive Strength (in MPa)		Average Flexural Strength (in MPa)		Average Split Tensile Strength (in MPa)	
			7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0%	M25 CONCRETE	23.03	33.92	4.3	5.8	1.91	4.1
2	5%		24.24	35.7	4.5	6	2.2	4.5
3	10%		25.54	37.76	4.7	6.5	2.5	4.9
4	15%		27.21	39.86	4.8	6.6	2.7	5.2
5	20%		28.82	41.99	5	6.8	2.8	5.4
6	25%		27.89	40.91	4.9	6.7	2.64	5

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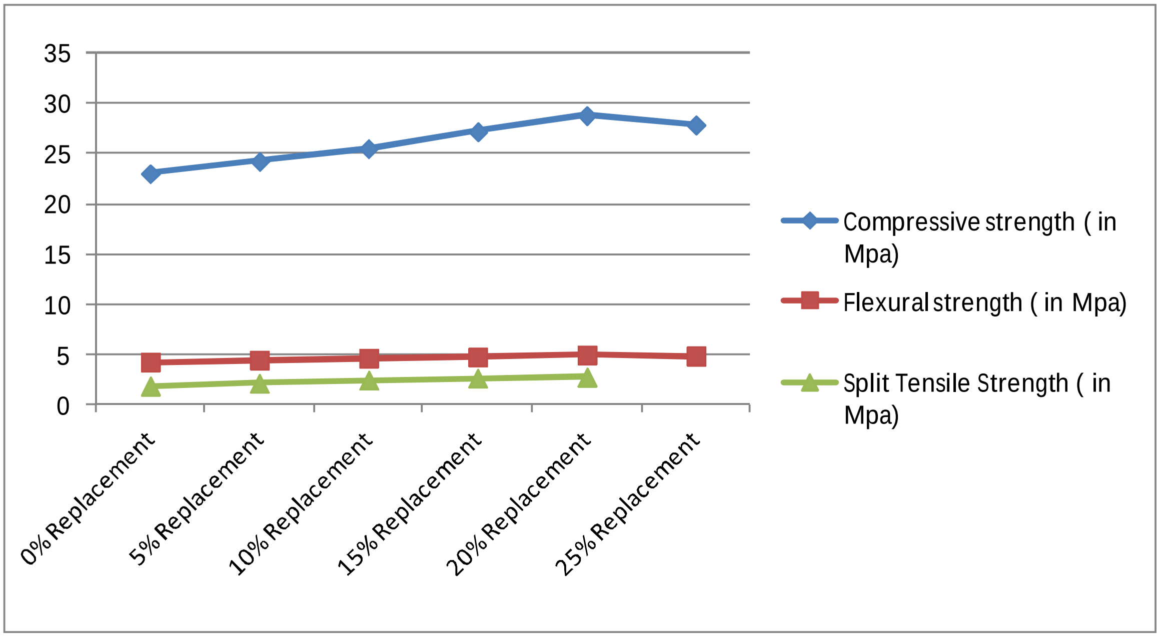

Figure 3.5 Comparison of Compressive, Flexural and Split Tensile Strength at 7days (M25 Grade)

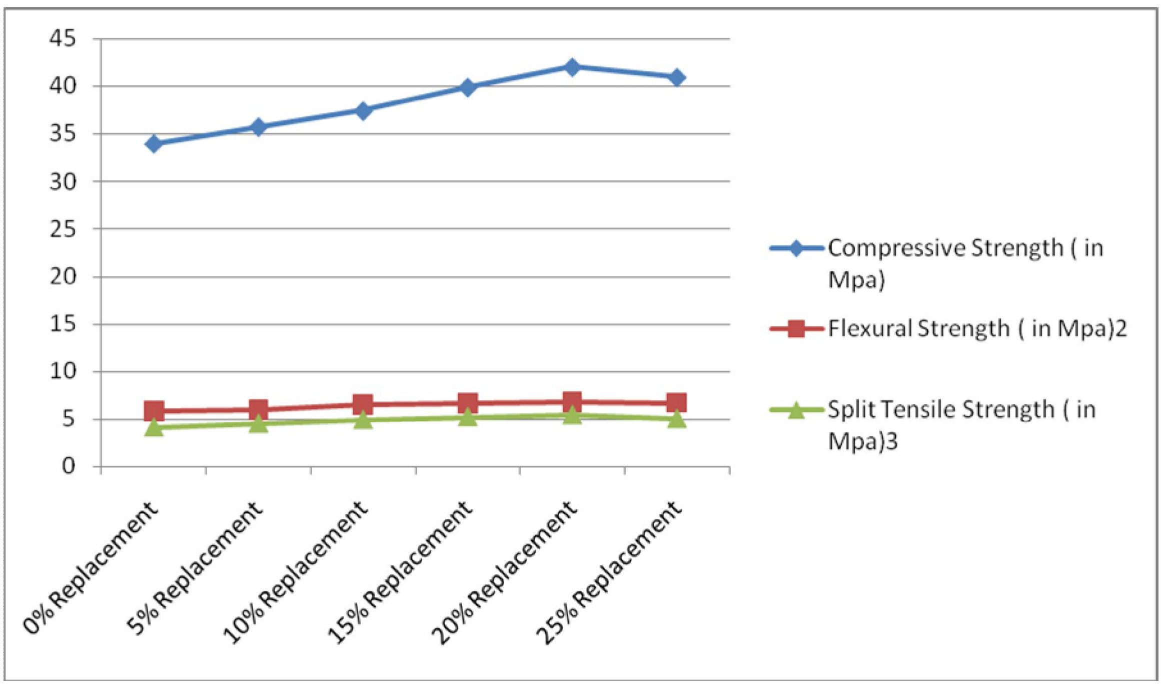

Figure 3.6 Comparison of Compressive, Flexural and Split Tensile Strength at 28 days (M25 Grade)

After curing of 28 days the increment in compressive strength as compared to controlled concrete mix is at 5, 10, 15 and 20 percentage construction and demolition waste by 5.25%, 11.10%, 17.87%, and 24.46% and decrement at 25% C &D waste by 20.8% respectively. Compressive strength of C&D concrete increase up to 20% replacement and start slightly decrease at 25% replacement.

After curing of 28 days the increment in flexural strength as compared to controlled concrete mix is at 5, 10, 15 and 20 percentage construction and demolition waste by 4.6%, 10.68%, 12.69%, and 16.75% and decrement at 25% C &D waste by 14.73% respectively. Flexural strength of C&D concrete increase up to 20% replacement and start slightly decrease at 25% replacement.

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After curing of 28 days the increment in split tensile strength as compared to controlled concrete mix is at 5, 10, 15 and 20 percentage construction and demolition waste by 9.8%, 22.25%, 30.91%, 36.5% and decrement at 25% C &D waste by 26.5% respectively. Split tensile strength of C&D concrete increase up to 20% replacement and start slightly decrease at 25% replacement.

Table 3.6 Compressive, Flexural and Split Tensile Strength Test result of M30Grade Concrete

M30 GRADE TEST REPORT								
S.No	% Replacement	Grade	Average Compressive Strength (in MPa)		Average Flexural Strength (in MPa)		Average Split Tensile Strength (in MPa)	
			7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	0%	M30 CONCRETE	28.64	40.65	6.2	7.4	2.8	5
2	5%		30.42	42.68	6.4	7.7	3.1	5.2
3	10%		31.5	44.61	6.8	8.1	3.5	5.5
4	15%		33.51	47.55	7	8.5	3.9	5.7
5	20%		35.24	49.98	7.3	8.6	4.1	6.2
6	25%		34.33	48.66	7.2	8.2	3.8	5.9

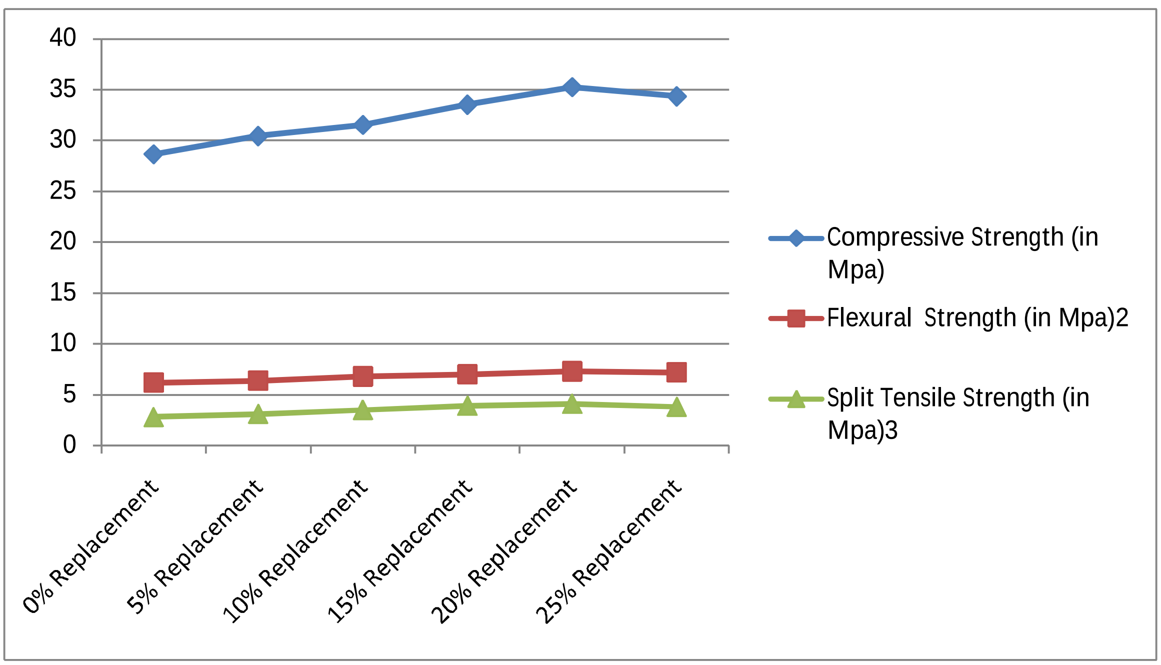

Figure 3.7 Comparison of Compressive, Flexural and Split Tensile Strength at 7days (M30 Grade)

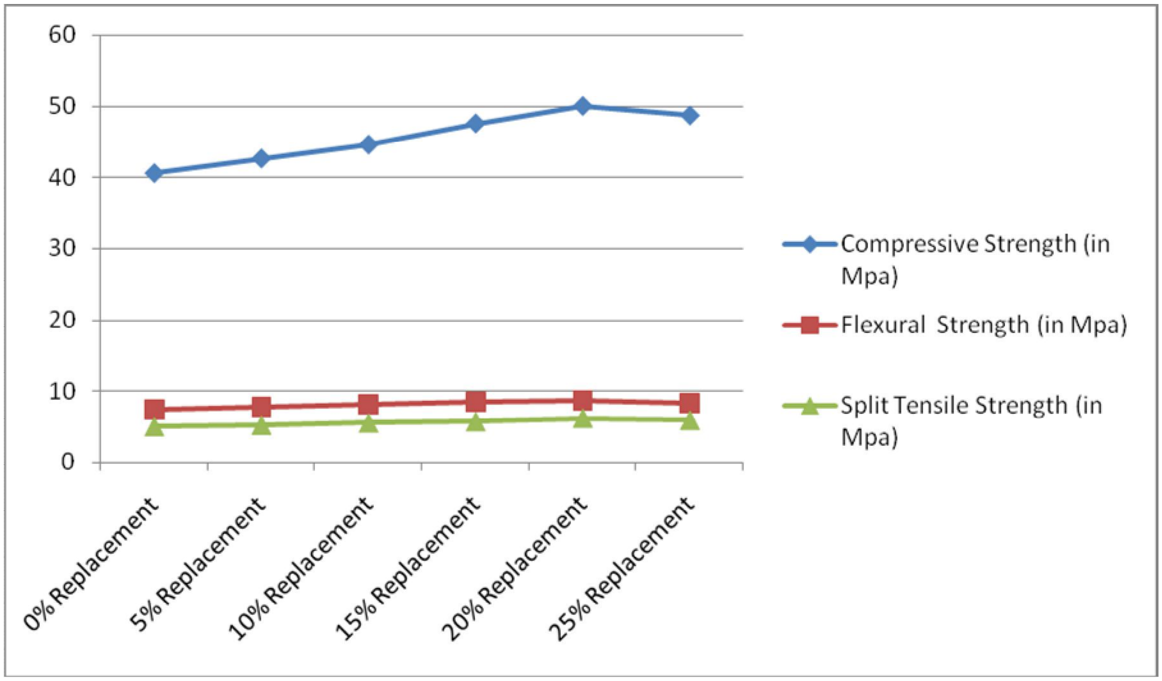

Figure 3.8 Comparison of Compressive, Flexural and Split Tensile Strength at 28 days (M30 Grade)

After curing of 28 days the increment in compressive strength as compared to controlled concrete mix is at 5, 10, 15 and 20 percentage construction and demolition waste by 5.6%, 9.82%, 16.98%, 22.93% and decrement at 25% C &D waste by 19.78% respectively. Compressive strength of C&D concrete increase up to 20% replacement and start slightly decrease at 25% replacement.

After curing of 28 days the increment in flexural strength as compared to controlled concrete mix is at 5, 10,15 and 20 percentage construction and demolition waste by 3.61%,9.5%, 13.88%, 16.97% and decrement at 25% C &D waste by 13.45% respectively. Flexural strength of C&D concrete increase up to 20% replacement and start slightly decrease at 25% replacement.

After curing of 28 days the increment in Split tensile strength as compared to controlled concrete mix is at 5, 10, 15 and 20 percentage construction and demolition waste by 9.5%, 22.5%, 26.64%, and 35.21% and decrement at 25% C &D waste by 26.5% respectively. Split tensile strength of C&D concrete increase up to 20% replacement and start slightly decrease at 25% replacement.

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V. CONCLUSION

The Compressive strength, Split Tensile Strength and Flexural strength are increased with addition of waste C & D waste (Recycled concrete aggregate and waste marble dust) up to 20% replace by weight of coarse and fine aggregate respectively. Further any addition of C & D waste (Recycled concrete aggregate and waste marble dust) the compressive strength, Split Tensile strength and Flexural strength are start slightly decreased.

Therefore, we conclude that the most suitable percentage replacement of C & D waste (Recycled concrete aggregate and waste marble dust) in concrete is 20%.

Thus we found out the optimum percentage for replacement of C & D waste (Recycled concrete aggregate and waste marble dust) with coarse and fine aggregate respectively and its almost 20% CA and FA for cubes, cylinder and beam. Result of this investigation that C & D waste (Recycled concrete aggregate and waste marble dust) could be conveniently used in making good quality concrete and construction materials.

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