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Performance Assessment of M35 and M40 Grades of Concrete Prepared using Construction and Demolition Waste

Dev Anand Pandey[1], Dr. Hemant Sood[2]
[1]M.E scholar, [2]Professor & Head Department of Civil Engineering, National Institute of Technical Teachers Training and Research, Sector 26 Chandigarh, India 160019

Abstract: The world has, by now, identified the seriousness and challenges regarding the sustainability of resources amid major environmental concerns that are part of modern problems today. The construction industry all over the world has been explicitly using concrete owing to its quality, strength, and adaptability to various construction needs and situations. However, in the last few decades, increased awareness, legislation, and global initiatives to combat pollution, energy consumption, waste disposal, and global warming have pushed industries, researchers, engineers, and other stakeholders to substitute virgin materials with alternative construction materials. Construction and demolition account for about 30% of the total solid waste generated worldwide. The top ten countries including India and China which are contributing heavily to this waste stream, together generating about 2.5 billion metric tonnes every year. The C&D waste poses a significant strain on landfill sites, contributes to energy waste, and adds additional costs for its disposal. However, through careful sorting, processing, and recycling processes, a significant chunk of it can be reused and help minimise environmental impact. The work presented here involves fractional replacement of C&D waste aggregates viz., RCA and RA in amounts ranging from 05-25% as coarse and fine aggregates, respectively. Most of the previous works have not aimed at higher grades like M35 and M40, which form the subject matter of this paper. Several tests were conducted to estimate the fresh and hardened state properties of concrete, most important being compressive and tensile strength as well as slump test for workability.
Keywords: C&D Waste, Sustainability, Recycled Aggregates, Compressive Strength, Concrete, Split Tensile Strength.

I. INTRODUCTION

Concrete is by far, the most used construction material worldwide. There are so many factors which makes concrete almost irreplaceable as construction material anytime soon. Concrete is a highly durable material that can withstand heavy loads and resist the effects of weathering, erosion, and chemical attacks. Concrete is versatile material with ability to be moulded and cast in any shape and size, the local availability of constituent materials also makes it cost effective. It has high thermal mass, good fire resistance and better sound insulation and acoustic comfort. Every year, about 12 billion tonnes of concrete is produced world over, which amounts to per capita consumption of 1 m^3, hardly any material would reach anywhere near this number, in terms of production. The annual demand for concrete is expected to exceed 18 billion tonnes by 2050. With such huge demand forecast, it is vital to look for sustainable practices to balance environmental impacts associated with the extraction and manufacturing of its components, as well as carbon emissions from cement production. China is the largest producer and consumer of concrete, followed by India and the United States and unarguably these are the chief contributors to construction related waste. These wastes can be managed with sustainable mindset by incorporating recycled materials such as aggregates coming from Construction and Demolition (C&D) waste and other industrial waste by-products which causes considerable nuisance for municipal authorities and put pressure on landfill sites for disposal, such practices can relax the demand for virgin resources to a good extent and reduce carbon footprint of the associated processes.

A. Construction And Demolition Waste.

Construction and Demolition waste is largely composed of materials which comes from debris from demolished structures, waste generated from construction and renovation projects, road construction and repairs, construction of bridges and other infrastructure works. C&D materials generally include concrete, asphalt, wood, metals, gypsum, plastics, and reclaimed building materials. Rapid construction is often viewed as an indicator of improving lifestyle and economic growth.

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Recycling of waste developed as a concept in late 20th century, since then efforts are being taken to use recycled aggregates (RA) to produce recycled aggregate concrete (RAC). The absence of proper recycling facilities, inconsistent government policies and regulations, quality issues in recycled aggregates, impurities, and contamination etc. are proven limitations for the use of it on large scale, maybe this is why it has not gained popularity except in works of minor importance such as base and sub-base course in road construction, as filler in foundation work and sanitary structures. However, recent studies have shown that these recycled aggregates have enough potential to be reused in conventional concrete grades with replaced component ranging from anything between 0-100%.

B. *C&D Waste: Indian Scenario*

A detailed study was carried out to know the exact amount of C&D waste generated in India, it was done by Technology Information, Forecasting and Assessment Council, TIFAC. Overall C&D waste output was approximately 13-15 million tonnes for the year 2000. Several findings reported in this study is highlighted through the following points:

1) The total C&D waste output generated in the year of study was 14.69 million tonnes.
2) The waste generated per unit area in construction and renovation/repair work was 40-60 and 40-50 kg/m^2 respectively.
3) Out of different sources of waste generation, the waste stream from demolition of buildings, was estimated to be 425 kg/m^2 of waste.

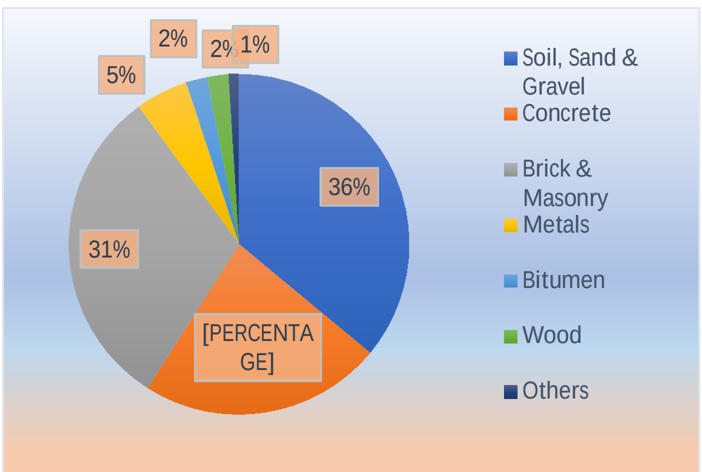

Figure 1.1 : Typical Constituents in C&D waste (TIFAC, 2001)

It also gave rule of thumb for C&D waste generation for different types of construction and repair work. However, as per C&D Waste Management Rules 2016, the C&D waste generated can be assumed to be 25% of total municipal solid waste, total output lying between 10-750 million tonnes per year as reported by different government agencies, this figure could be a gross underestimate given the absence of special measures to collect C&D waste separately. As per Annual report on Solid Waste Management 2020-2021 in conformance with *Solid* Waste Management (SWM) Rules 2016, about 50% of waste is recycled and 18.4% goes to landfills. The load on landfills seems to be decreasing due to improved collection efficiency. The policy roadblocks and economic viability are slowly giving way for better data accumulation and inclusion of C&D waste in construction industry.

IS 383 which only allowed for 'naturally sourced' virgin materials for aggregates got revised in 2016 and allowed for usage of C&D waste in conventional concrete mix with certain limits. The latest stipulations in IS 383 allows for use of recycled aggregates with 25% replacement limit in plain concrete, 20% in RCC mixes of M25 and below grades, with up to 100% replacement in lean concretes of grades smaller than M15. Similar changes were incorporated in other technical institution such as National Building Code of India (NBC) which added a chapter on 'sustainability' and made certain provisions to allow recycled aggregates to replace natural aggregates.

II. LITTERATURE SURVEY

1) (Khatib, 2005)This study mainly focuses on replacing only the fine aggregates from normal mix and studied the effect on key properties of concrete. Recycled aggregate consisted of crushed concrete (CC) or crushed brick (CB) with particles less than 5 mm in diameter. r. The free water/cement ratio was kept constant for all mixes. The fine aggregate in concrete was replaced with 0%, 25%, 50% and 100% CC or CB.

2) (Yang et al., 2008)The author tested at least nine samples created using partial replacement of natural aggregates with recycled aggregates. The replacement levels of recycled grade I and grade III coarse aggregates and recycled grade II fine aggregate were 30, 50 and 100%, the properties of hardened concrete with different replacement level and quality of recycled aggregates were compared with design equations proposed by ACI 318-05 and others. The results indicated that properties of such concrete mainly dependent on water absorption of aggregates.
3) (Etxeberria et al., 2007)Among different types of recycled aggregates, the study utilizes crushed concrete aggregates as coarse aggregates. Four different recycled aggregate concretes were produced; made with 0%, 25%, 50% and 100% of RCA, respectively. The mix proportions of the four concretes were designed in order to achieve the same compressive strengths. The influence of the order of materials used in concrete production (made with recycled aggregates) with respect to improving its splitting tensile strength was analysed.
4) (Rao et al., 2007)This study not only focussed on development of concrete using recycled aggregates but also analysed to some detail the engineering properties of recycled aggregates and the effect of such properties on overall mix. It also gives a summary of the effect of use of recycled aggregate on the properties of fresh and hardened concrete. The paper concludes by identifying some of the major barriers in more widespread use of RA in recycled aggregate concrete (RAC).
5) (Duan & Poon, 2014)The main objective in this study was to compare the difference in properties of recycled aggregates (RAs) with different amounts of old adhered mortar procured from different sources and examining the influence of the different RAs on the mechanical and durability aspects of recycled aggregate concrete (RAC). The experimental results show that the performance of RAs from different sources varied greatly and RA of good quality can be used to produce high strength concrete with hardened properties comparable to those of the corresponding natural aggregate concrete (NAC).
6) (Andreu & Miren, 2014)Many studies were limited to normal grades with not more than 25% replacement but here, high performance concretes were produced using 20%, 50% and 100% of RCA on substitution of natural coarse aggregates. Three types of RCA were used, they were produced crushing original concrete of 100, 60 and 40 MPa of compressive strength. The results showed that considering mechanical properties, the 100% natural coarse aggregates replacement would be possible when RCA were produced from original concrete with a minimum compressive strength of 60 MPa.
7) (Bravo et al., 2015) Here, the approach was to evaluate various mixes of concrete which utilized CDW aggregates in order to understand the impact that the source point of RAs, and their composition, has on the characteristics of the mixes produced. The analysis of the mechanical performance helped in concluding that the use of RA does not improve majority of the properties under test, there is more pronounced decline in properties when fine RAs are used.
8) (Silva et al., 2014)Arising from a systematic, as opposed to narrative, literature review of 236 publications published over a period of 38 years from 1977 to 2014, the paper examines the factors affecting the physical, chemical, mechanical, permeation and compositional properties of recycled aggregates sourced from construction and demolition waste, intended for concrete production.

III. EXPERIMENTAL ARRANGEMENT

A. Materials

Cement is the most basic material in concrete production, it acts as a binder and imparts strength. In this study OPC 43 Grade cement was used which complies with IS 8112: 1989. Several properties of concrete such as setting times, fineness, consistency etc. are used to judge the quality of cement, these tests were carried out to ascertain quality of cement, properties, and test results are listed in Table I.

We have taken fine aggregates which are part of demolished concrete structure, it was subjected to cleaning with running water and manually sorted for impurities, it is labelled as recycled fine aggregate (RFA). Sieve analysis was carried out and based on fineness modulus it falls into Zone III, control mix i.e., a reference mix was designed with natural river sand having nominal size of 4.75 mm.

In this study, coarse aggregates of 10 mm and 20 mm were chosen and combined grading was done to work out the proportion in which they need to be mixed, sieve analysis was done to match the grading requirements given in IS 383:2016 and recycled concrete aggregate (RCA) was used substituted with natural coarse aggregates; the recycled aggregates were sourced from a local construction waste processing plant in Chandigarh. Physical properties of coarse and fine aggregate are listed in Table II.

Table I : Physical Properties of OPC 43 Grade Cement

Physical Properties	Test Results	IS 8112-1989 Stipulations
% Fineness (90 µm IS Sieve)	4.25	≯10
Soundness (mm) Le Chatelier's Method	1.20	≯10
Normal Consistency (%)	31	-
Initial Setting Time (mins.)	220	≥ 30
Final Setting Time (mins.)	335	≤ 600
Specific Gravity (Le Chatelier's Method)	3.15	-

Table II : Physical Properties of Fine & Coarse Aggregates

Properties	Fine Aggregates		Coarse Aggregates		Admixture (Conplast SP430G8)
	Natural Fine Aggregate	Recycled Aggregate (RA)	Natural Coarse Aggregate	Recycled Concrete Aggregate (RCA)	
Maximum Size (mm)	4.75	4.75	20	20	-
Bulk Density (loose) in kg/m^3	1656	1435	1480	1155	-
Bulk Density (compacted) in kg/m^3	1865	1600	1570	1316	-
Specific Gravity	2.60	2.63	2.65	2.45	1.24
Free Moisture (%)	1.55	1.38	0.30	2.25	-
Water Absorption (%)	14.6	16.3	0.34	5.065	-

B. Water
The various limits of impurities to be allowed in water used for mixing the ingredients of concrete are given in IS 456:2000 and samples used in our study have been made with clean source of potable water at room temperature for mixing and curing and conforms to IS 456 limits.

C. Chemical Admixture
Conplast SP430G8 was used in the experimental investigation for both the grades. This admixture is to produce pumpable concrete and high-grade concrete of M30 & above by substantial reduction in water resulting in low permeability and high early strength. Also, it helps in producing high workability concrete requiring little or no vibration during placing. Its dosage was fixed as 0.5% by weight of cement as stipulated in the mix design.

D. Design Mix details of M35 Grade of Concrete
The mix proportions were worked out for the two grades as per IS 10262:2009 and IS 456:2000 and details are tabulated in Table III and IV.

Table III : Mix Design details of M35 Grade Concrete

Grade M35			
Cement	Fine Aggregate	Coarse Aggregate	Water
420	607.1	1222.9	159.6
1	1.45	2.91	0.38

E. Design Mix details of M40 Grade of Concrete

Table IV : Mix Design details of M40 Grade Concrete

Grade M40			
Cement	Fine Aggregate	Coarse Aggregate	Water
435	587.7	1216.2	165.6
1	1.35	2.80	0.35

F. Replacement Details-Sample Matrix

Table V : Replacement Details with Number of Samples*

% age replacement		No. of cubes for Compressive Strength Test		No. of cylinders for Split Tensile Strength Test		No. of Beams for Flexural Strength Test	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
0	Grade M35 & M40	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 Cylinders		36 Beams	

*The total number of samples as indicated in Table 2.5 is for both the grades i.e., 108 samples for M35 and same number of samples for grade M40.

IV. RESULTS AND DISCUSSION

The experimental programme was designed to determine the fresh and hardened characteristics of concrete mixes. The results obtained at the end of various tests conducted are presented here. Two control mixes of M35 and M40 were prepared and then the recycled aggregates were replaced in different percentages equally spaced from one another. The impacts of replacing aggregates on different concrete properties are studied through tests such as workability and density estimation for the fresh properties and compressive strength, splitting tensile strength and flexural tensile strength for matured state of concrete.

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A. Workability

The ease of mixing of control mix and concrete prepared with replaced recycled aggregates of both the grades are evaluated using slump test in conformance with IS 1199:1959.

Slump Test: The slump test is most used procedure for measuring the consistency or workability of fresh concrete. The test determines the degree of deformation the concrete undergoes under its own weight after being placed in a cylindrical mould and then removed. The slump test signifies the consistency of various batches of concrete. The shape of the concrete slumps provides information about the workability and quality of the concrete. Since this test is so simple to execute, right from measurement and the apparatus used, this test is being used since last 100 years . The slump cone's shape demonstrates concrete's workability and it is suitable for low to high workabilities.

Initially, the inner surface of the mould was cleaned and oiled. The non-porous base plate was then covered with a mould, which was then filled with approximately four layers of prepared concrete mixture. Each layer was tamped with 25 strokes, and excess concrete was removed by slowly lifting it upward in a vertical direction. The slump was then known by measuring the height difference between the mould and the highest point of the test specimen mixture.

There are many other tests available to check the workability of concrete such as Compaction Factor Test, Vee Bee Test, Flow Table Test etc which are relatively sophisticated and is suitable for various ranges of workability. For example, a mix with low and very low workability can be better handled and measured using Vee-Bee Test.

Table VI : Slump Variation With % Replacement for M35

SLUMP VALUE			
S. No.	Level of replacement (%)	Grade	Obtained Slump Value (mm)
1	0	M35	70
2	5		65
3	10		63
4	15		68
5	20		62
6	25		60

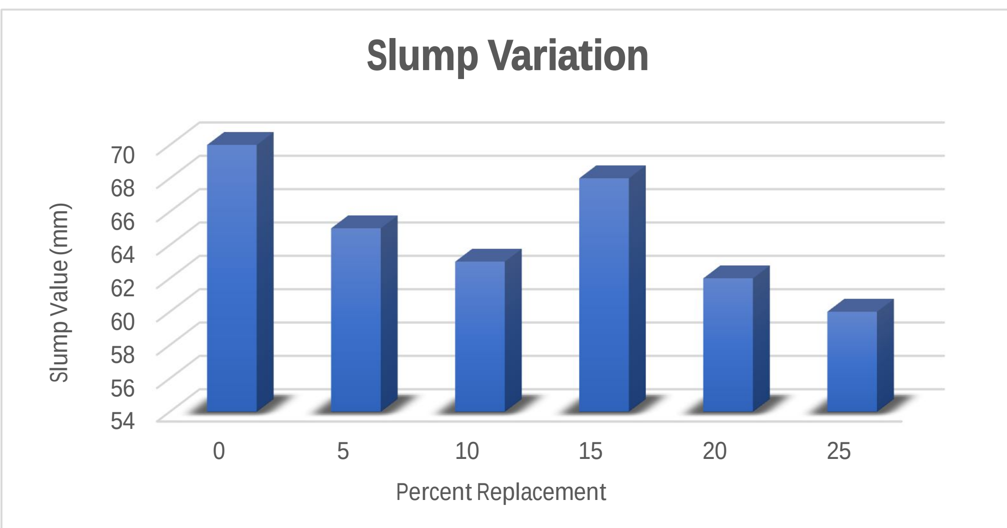

Fig. 3.1: Slump Variation with % replacement for grade M35

The percentage change in slump values of grade M35 are recorded as -7.1%, -10.0%, -2.9%, -11.4%, -14.3% from the reference value of control mix i.e., 0% RL. The above variations are depicted in Table VI and Figure 3.1 respectively.

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Table VII : Slump Variation With % Replacement for M40

SLUMP VALUE			
S. No.	Level of replacement (%)	Grade	Obtained Slump Value (mm)
1	0	M40	85
2	5		75
3	10		73
4	15		78
5	20		75
6	25		70

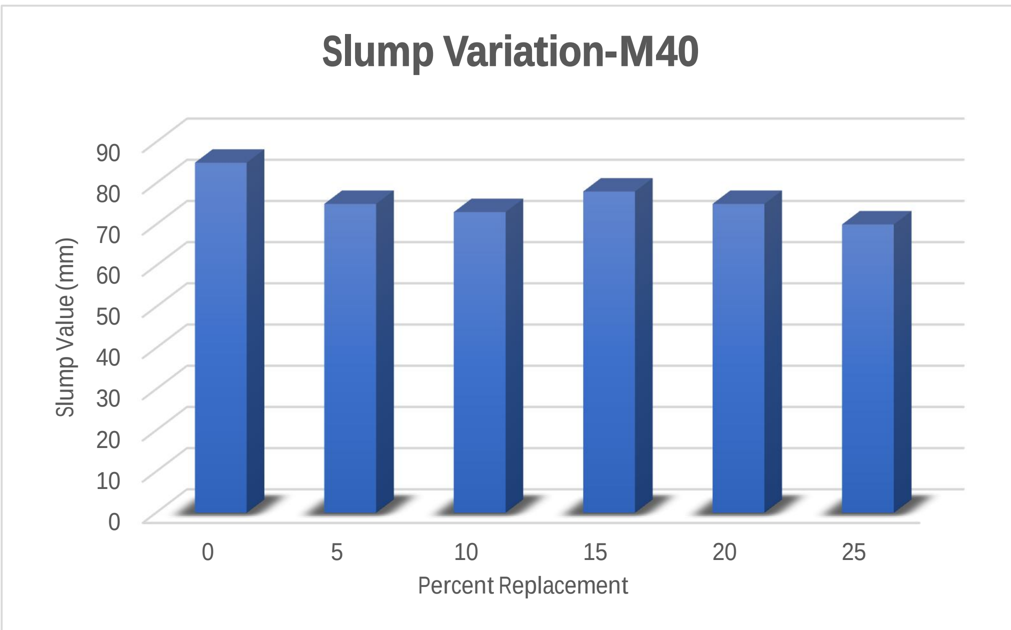

Fig. 3.2: Slump Variation with % replacement for grade M40

The percentage change in slump values of grade M40 are recorded as -11.8%, -14.1%, -8.2%, -11.8%, -17.6% from the reference value of control mix i.e., 0% RL. The above variations are depicted in Table VII and Figure 3.2 respectively.

B. Density of Concrete Mix

Density is a crucial factor in concrete's overall performance, as it affects properties such as strength, durability, workability, and shrinkage. In general, a higher density corresponds to greater strength, whereas a lower density results in diminished strength and increased porosity, which can lead to decreased durability. In addition, the density of concrete impacts its thermal and acoustic insulation properties, making it crucial to select the proper density for the intended application.

In this study, the density values are gauged at each subsequent mix sample that is created while replacing it with recycled aggregates both coarse and fine in varying percentages. For both the grades viz, M35 and M40, in general, the findings indicate that density reduces first from 0 to 5% replacement level (RL) then rises steadily up to 15% RL and falls again significantly from 20 to 25%.

Table VIII : Density Variation With % Replacement for M35

DENSITY OF CONCRETE			
S. No.	Level of replacement (%)	Grade	Obtained Density Values(kg/m^3)
1	0	M35	2470
2	5		2455
3	10		2465
4	15		2480
5	20		2460
6	25		2440

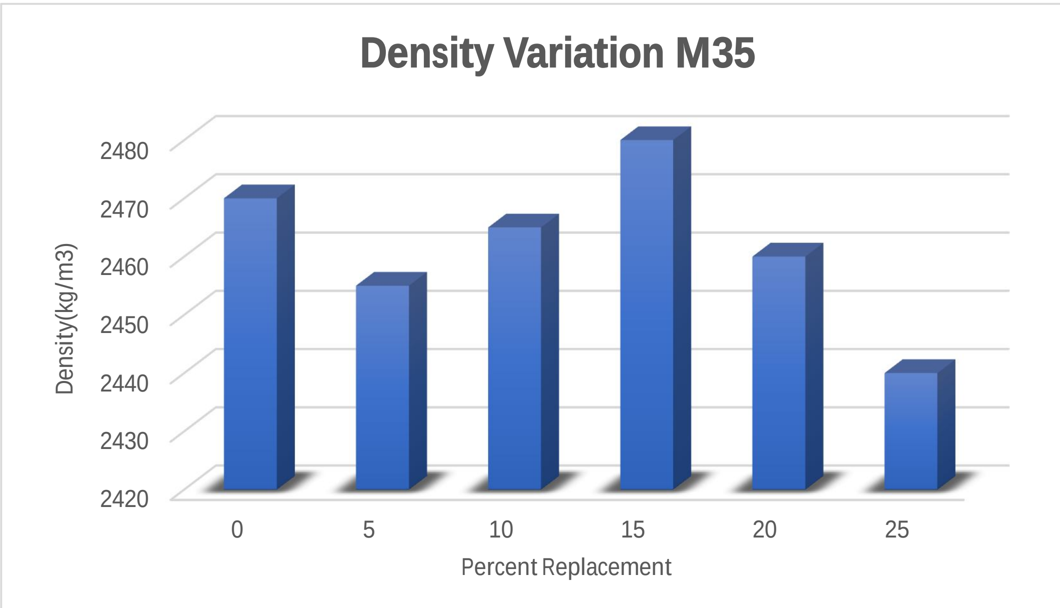

Fig. 3.3: Density Variation with % replacement for grade M35

The percentage change in density values of grade M35 are recorded as -0.6%, -0.2%, +0.4%, -0.4%, -1.2% from the reference value of control mix i.e., 0% RL. The above variations are depicted in Table VIII and Figure 3.3 respectively.

Table IX : Density Variation With % Replacement for M40

DENSITY OF CONCRETE			
S. No.	Level of replacement (%)	Grade	Obtained Density Values (kg/m^3)
1	0	M40	2510
2	5		2498
3	10		2515
4	15		2535
5	20		2510
6	25		2490

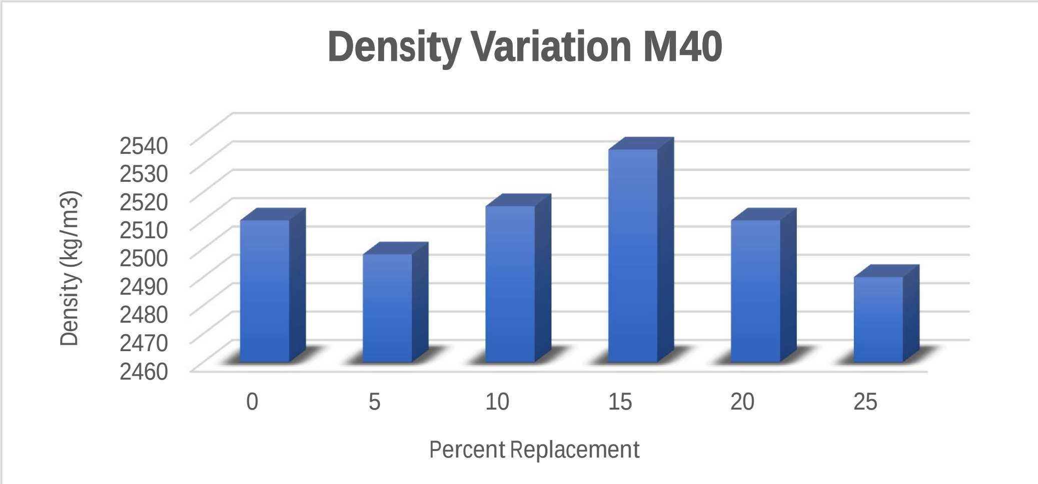

Fig. 3.4: Density Variation with % replacement for grade M40

While the percentage change in density values of grade M40 are recorded as -0.5%, +0.2%, +1.0%, -0%, -0.8% from the reference value of control mix i.e., 0% RL. The above variations are depicted in Table IX and Figure 3.4 respectively.

Table X: Results of different types of Strengths Tests conducted on M35 Grade Concrete

S. No.	% Replacement	Grade	Average Compressive Strength (in MPa)		Average Split Tensile Strength (in MPa)		Average Flexural Strength (in MPa)	
			7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1.	0	M35	34.05	39.62	2.55	4.14	3.88	6.37
2.	5		30.65	37.30	2.23	3.50	5.71	6.22
3.	10		32.95	39.90	3.02	3.66	5.82	6.48
4.	15		31.14	42.95	3.66	4.14	6.22	7.06
5.	20		30.10	40.95	3.34	3.82	6.10	6.60
6.	25		28.70	39.20	2.86	3.42	5.70	6.08

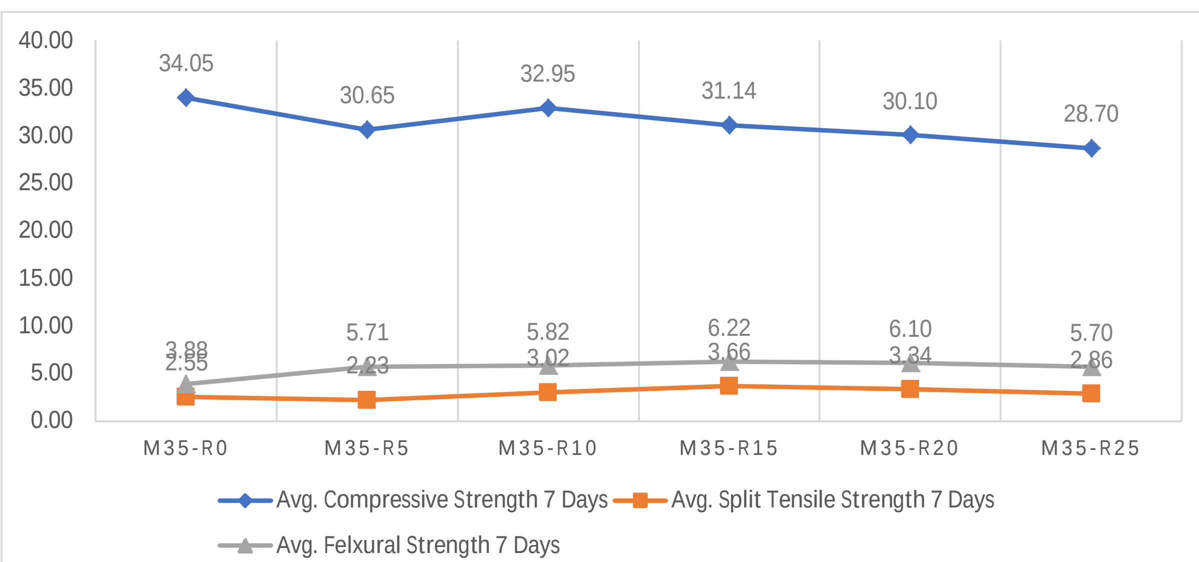

Figure 3.5 : Line Graph showing variation in Split Tensile Strength, Flexural and Compressive Strength at 7 days (M35 Grade)

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Table X depicts the test results conducted on M35 grade of concrete with varying percentage of C&D waste replacement viz., recycled aggregates, both coarse and fine from 0 to 25 percent at 5% intervals to closely study the effects of such change on strength parameters of concrete. The three properties namely, split tensile strength, flexural strength and compressive strength were studied and results were mapped as shown in Fig 3.5. The effect of introducing C&D waste is analysed at 7 days and 28 days respectively. The samples were cured under constant water bath inside the curing tank, therefore there is almost negligible chance of drying shrinkage or loss of gel moisture from the body of concrete. For the design of concrete structural elements subjected to transverse shear, shrinkage, torsion, and thermal stresses, splitting tensile strength is crucial (IS 5816, 1999). The variations recorded in Splitting tensile strength values follows a similar trend as is the case with compressive strength. Flexural test is an indirect measurement of the tensile strength of concrete and hence is more practical and easier to test. It evaluates the ability of an unreinforced concrete beam or slab to resist bending failure. The results of flexural test on concrete is generally referred as modulus of rupture which is denoted as M_R. Its variation is mapped alongside the above two tests and is depicted in Fig. 3.5.

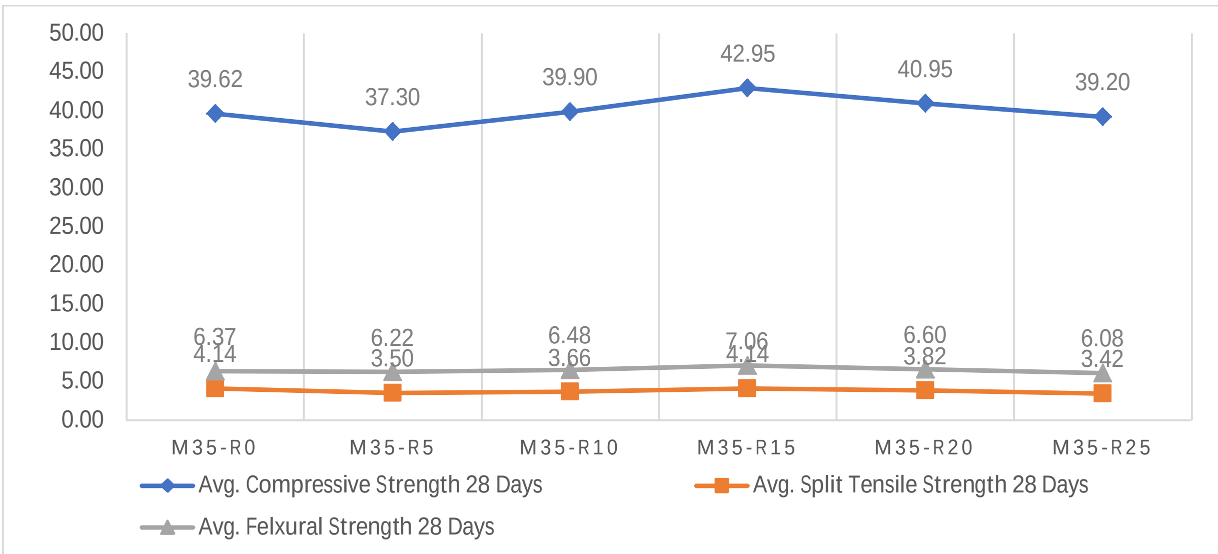

Figure 3.6 : Line Graph showing variation in Split Tensile Strength, Flexural and Compressive Strength at 28 days (M35 Grade)

At the end of 28 days, samples were tested and it was found that compressive strength dips at 5% RL as it departs from 0% RL or control mix, it rises till 15% RL and then decreases from 20 to 25%, the most significant fall was recorded from 20 to 25%. The percentage change from the level of control mix as recorded during test conducted is -5.9%, +0.7%, +8.4%, +3.4%, -1.1% corresponding to 5, 10, 15, 20, 25% RL.

Similar trend in variation in the values of splitting tensile strength was observed. The percentage change from the level of control mix as recorded during test conducted is -18.28%, -13.12%, 0.0%, -7.72%, -21.05% corresponding to 5, 10, 15, 20, 25% RL. The percentage change recorded in the values of flexural strength of the samples corresponding to replaced C&D waste as against the control mix is -2.36%, +1.73%, +10.83%, +3.61%, -4.77% respectively.

Table XI : Results of different types of Strengths Tests conducted on M40 Grade Concrete

S. No.	% Replacement	Grade	Average Compressive Strength (in MPa)		Average Split Tensile Strength (in MPa)		Average Flexural Strength (in MPa)	
			7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1.	0	M40	39.94	55.00	2.23	4.16	5.96	6.64
2.	5		39.45	47.40	2.86	3.50	5.88	6.50
3.	10		39.00	47.95	3.18	3.60	6.20	7.10
4.	15		38.60	48.45	3.50	3.82	6.36	7.40
5.	20		36.35	44.20	3.34	3.45	6.10	6.90
6.	25		34.65	39.30	3.00	3.18	5.81	6.40

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Table XI depicts the test results conducted on M40 grade of concrete with replacement of C&D waste viz., recycled coarse and fine aggregates from 0 to 25 percent at 5% intervals to study closely the effects of such change on strength parameters of hardened concrete. The effect of introducing C&D waste is analysed at 7 days and 28 days respectively. The samples were cured under constant water bath inside the curing tank.

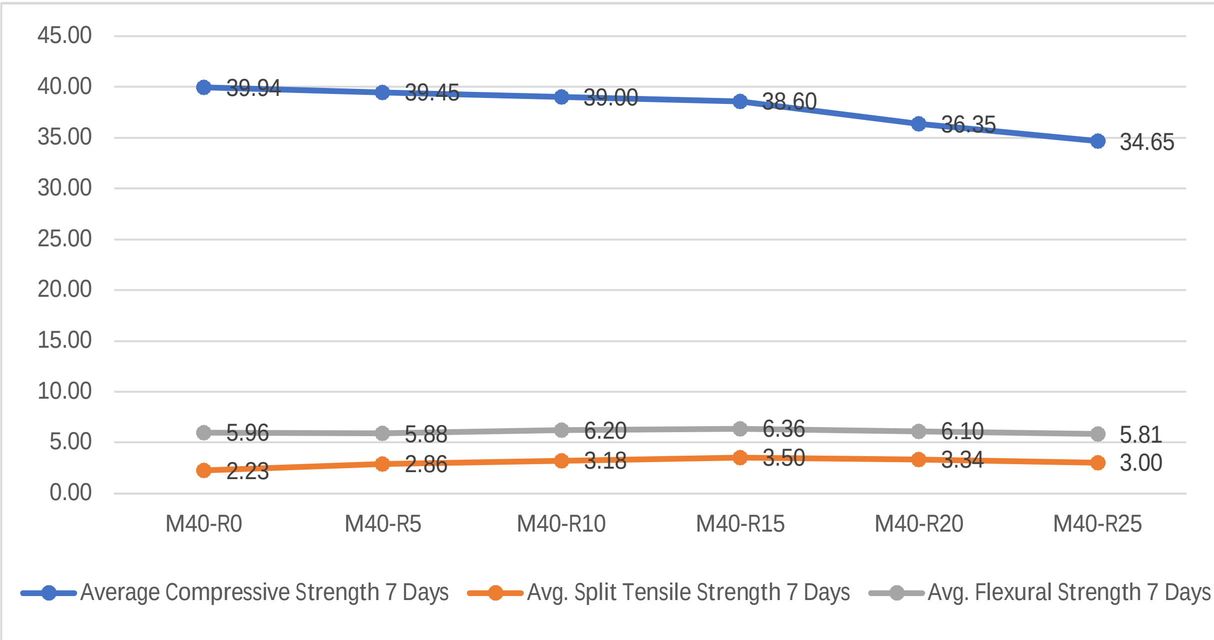

Figure 3.7 : Line Graph showing variation in Split Tensile Strength, Flexural and Compressive Strength at 7 days (M40 Grade)

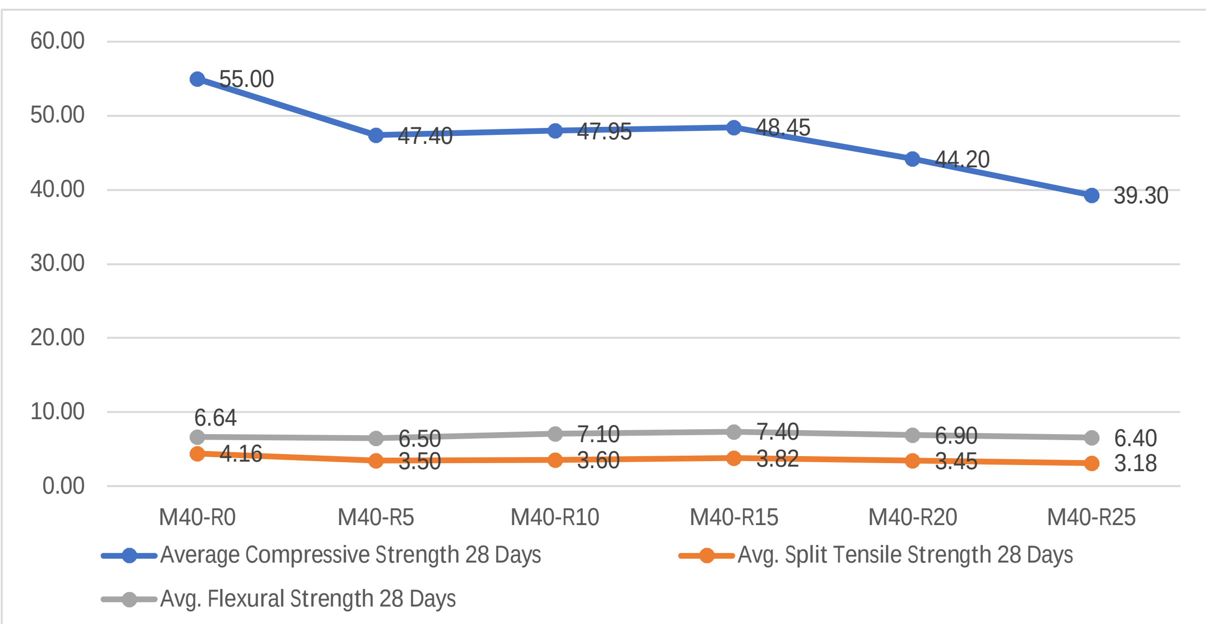

Figure 3.8 : Line Graph showing variation in Split Tensile Strength, Flexural and Compressive Strength at 28 days (M40 Grade)

At the end of 28 days, samples were tested and it was found that compressive strength dips at 5% RL as it departs from 0% RL or control mix, it rises till 15% RL and then decreases from 20 to 25%, the most significant fall was recorded from 20 to 25%. The percentage change from the level of control mix as recorded during test conducted is -16.04%, -14.70%, -13.52%, -24.43%, -39.95% corresponding to 5, 10, 15, 20, 25% RL.

Similar trend in variation in the values of splitting tensile strength was observed. The percentage change from the level of control mix as recorded during test conducted is -18.85%, -15.56%, -8.9%, -20.58%, -30.81% corresponding to 5, 10, 15, 20, 25% RL. The percentage change recorded in the values of flexural strength of the samples corresponding to replaced C&D waste as against the control mix is -2.15%, +6.48%, +10.27%, -3.77%, -3.75 % respectively.

V. CONCLUSION

It is imperative to note from this study that recycled aggregates have quality issues even when sourced from highly mechanised sorting and cleaning process. The surface imperfections result in decreased strengths as we increase the percentage of replacement to the control mix, however average strength mostly lies between characteristic and target strength . The fresh and hardened properties of concrete both seems to indicate that at higher grades such as M35 and M40 which are standard grades as per IS 456 and are dense enough and needs careful supervision both during design and casting. During mix design process, effort was taken to limit w/c ratio to as low as practically feasible.

The compressive strength, split tensile strength and flexural strength have all shown a similar trend of strength variation that as soon the control mix is replaced with recycled aggregates, there is dip in values which starts rising gradually till 15% RL and it starts decreasing from 15 to 25% RL, the greatest fall recorded from 20 to 25% RL. From observations at the time of casting, such decrease at 25% RL was quite apparent as the workability, appearance and surface finish of the concrete were decreasing rapidly. From our study, it is therefore concluded that the ideal level of replacement at these grades with chosen recycled aggregates lies at 15% RL as at this point, peak strength is achieved.

It was also concluded, based on experience that coarse aggregates contribute more to strength than fine aggregates as fine aggregates have large surface area, so there should be greater cohesion and hydration reactions occurring on its surface but since the aggregate was already subjected to loads before and contains impurities on it surface hence it hampers the strength development appreciably. Also, the water absorption of recycled aggregates is higher and requires at least 10-15% more water to not hamper the workability, fine aggregates being porous absorbs most of it and this may necessitate use of admixtures. Therefore, the quality and source of recycled aggregates play a vital role in overall performance of such recycled concrete.

Use of recycled fine aggregate (RFA) can be substituted with other alternatives like Industrial by-products (IBP) such as blast furnace slag, wood ash (WA), waste foundry sand (WFS), etc. and effect of such material in conjunction with recycled coarse aggregate can be studied. Results of this study can be conveniently used for future studies on C&D waste (recycled coarse and recycled fine aggregates) concrete.

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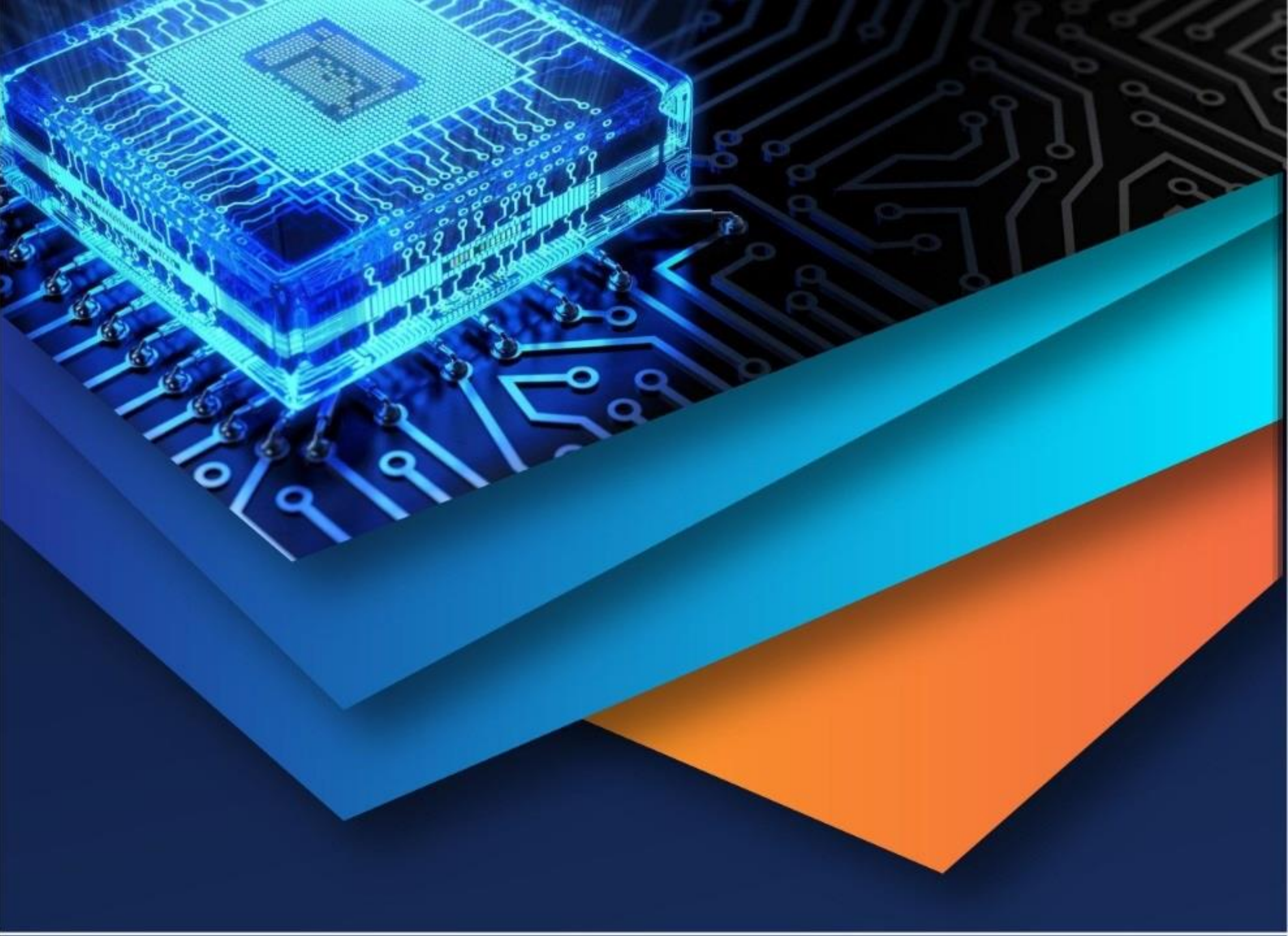

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