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"Research On Sustainable Development Towards Green Concrete"

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Abstract:

Sustainable Construction is the construction that focuses on mitigating the impact of the environment and making the construction economically viable for its impact. The exodus of the construction industry has a great detriment to maintain a sustainable economy overall and is a great burden to our environment. Green concrete can be considered elemental to sustainable development since it is eco – friendly itself. Green Concrete is a type of concrete which resembles the conventional concrete, but the production or usage of such concrete requires minimum amount of energy and causes least harm to the environment. Although Green concrete is nothing to do with the color, it is the concept in which the environment is incorporated into concrete, taking into account all the aspects from the production of raw materials and the composition mixture to the structure, construction and durability. The production of Green concrete is often also cost effective for example, waste products are used as a partial substance for cement, charges for disposal of waste are avoided, energy consumption during production is lower and durability is greater.

Our project target is to reduce the extra load in landfills and reduce the aggregates waste and lowers the net CO2 emission and environmental impact. The research has been conducted to make environmental-friendly/ Green concrete by partially replacing coarse aggregate by recycled concrete aggregate and fine aggregate by M-Sand and to investigate their technical benefits .The reuse of materials also contributes intensively to economy. The recycled concrete aggregate reduces the extra load in landfills and wastage of aggregates. In addition, we use M-sand which is very environmental-friendly and cost effective as compared to the river sand and is the best alternative to reduce the consumption of river sand or end the misleading mining in many areas. To achieve sustainable development, we also need to make some important changes to the existing theory of concrete technology.

***Keywords* -** Green concrete, Sustainable Development, Recycled Aggregate, CO_2 Emission, Coarse & Fine Aggregate, M-Sand

INTRODUCTION:

In order to make concrete as a sustainable material, the concept of "Green Concrete" was introduced which was first invented in Denmark in the year 1998 by Dr. W.G. Concrete made from eco- friendly concrete waste is called Green Concrete. Since it is an eco- friendly concrete its production requires less energy and produce less CO2 than conventional concrete. Therefore, its main goal is to reduce the environmental impact of concrete and should follow reduce, reuse and recycle technique or any two process in the concrete technology.

Green Concrete means that as many recycled material as possible are used in the production of concrete and leaving the carbon footprint as small as possible. It is a revolutionary issue in the history of concrete industry and refers to a concrete in whose production and installation additional measures have been taken to ensure a sustainable structure and a long - life cycle with minimal maintenance.

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REPLACEMENT MATERIAL FOR GREEN CONCRETE:

S.NO.	Traditional Ingredients	Replacement material for Green Concrete
1.	Coarse Aggregates	Recycled Demolition Aggregate
2.	Fine Aggregates	Manufactured Sand
3.	Cement	Eco- Cement

Aggregate – Aggregate falls under the broad category of materials which are formed by breaking or crushing of bigger rocks or stones into small pieces. Recycled concrete can also be used as an aggregate. It provides strength, increase volume, and provides protection against wear. Major portion in concrete is occupied by aggregates. They are divided into 2 categories according to particle size as:

- Coarse aggregate
- Fine aggregate

Particle size of greater than 4.75mm falls under a category of coarse aggregate. It means aggregate is retaining on 4.75mmsieve.eg. Gravel, boulders.

Aggregate passing through 4.75mm sieve is called as fine aggregates. E.g., Sand, clay, silts. Fine aggregates are used to fill voids in concrete generated by coarse aggregate.

Recycled Demolished Concrete Aggregate –Recycled concrete aggregate is produced by two-stage crushing of demolished concrete, screening and removal of impurities. Recycled coarse aggregates showed that physical and mechanical properties were of inferior quality and improvement in properties was observed after washing due to removal of old weak mortar that adhered to the surface.

Manufactured Sand –This is also known as M-sand or artificial sand produced by crushing of rock, quarry dust, or aggregates of larger size. M-sand is used as per I.S code 383-1970 is used.

Cement- PPC is an eco-friendly product because it is manufactured using fly-ash, a by-product of thermal power plant. It offers better resistance to alkali-silica reaction. In addition, PPC is well compatible with all kind of admixtures. PPC is preferred in mass construction because of its low heat of hydration. PPC has high durability than OPC which means the structure last longer and has a longer service life. PPC is more resistant to attack by sulphates, alkalies , chlorides and chemicals compared to OPC.PPC is more eco-friendlier than OPC as the carbon footprints created in the production of PPC is less compared to OPC which reduces the environmental impact. PPC also has a slow hydration process so heat generation is comparatively lower than OPC.

Fosroc- Fosroc is an admixture used in concrete mix.it also help in reduction of water up to 25% conplast SPH30G8 is used in this project.

Figure 1: RCA

Figure 2: River Sand

Figure 3: M - Sand

Figure 4: Fosroc

METHODOLOGY-

The main objective of this study is to produce green concrete by partially replacing coarse aggregate with recycled concrete aggregate and fine aggregate with M-Sand. To achieve the required target strength of concrete, mix design is prepared according to IS: 10262 (2009). For the production of green concrete chemical admixture called conplast SP430G8 FOSROC is also used. Depending on the requirement some tests are performed for coarse aggregates- impact test, particle size analysis, water absorption and specific gravity and tests for fine aggregates – fineness modulus , silt content, particle size analysis, water absorption and specific gravity. Testing cement- standard consistency, initial setting time and final setting time test and compressive strength test. Testing for prepared green concrete- slump cone test, compressive strength test and flexural strength test.

Design of Green Concrete Mix for M25 grade of concrete prepared by partially replacing coarse aggregate with recycled concrete aggregate and fine aggregate with M-Sand. To determine the compressive strength of green concrete, a total of 36 cubes were made of which 12,12,12,20%, 25%, 30% respectively were tested after for curing of 3, 7, 14, 28 days. To determine the flexural strength of green concrete total of 27 beams were made of which 9,9,9, 20%, 25%, 30% respectively were tested respectively after curing periods of 7, 14, 28 days.

Green Concrete Mix

Table 1: Percentages of Coarse Aggregate replaced by RCA & Fine Aggregate by M-Sand

Mix A	M25 + (20% RCA+ 80% CA) + (50% River Sand + 50% M-Sand)
Mix B	M25 + (25% RCA+ 75% CA) + (50% River Sand + 50% M-Sand)
Mix C	M25 + (30% RCA+ 70% CA) + (50% River Sand + 50% M-Sand)

MIX A- In Mix A from one part of cement and 0.91 part of River Sand and 0.91 part of M- Sand, 0.502 part of RCA and 2.008 part of coarse aggregate.

MIX B - Mix B contains one part of cement and 0.98 part of River Sand and 0.98 part of M- Sand, 0.675 part of RCA and 025 part of coarse aggregate.

MIX C - Mix C contain M25 grade of concrete in which one part of cement (PPC 43 grade), 1.055 part of River Sand & 1.055 part of M- Sand, 0.873 part of RCA and 2.037 part of coarse aggregate (20mm+10mm). Chemical admixture was used at about 0.5% to 2% which helps in the reduction of water up to 10% and that leads to the higher strength.

TEST PERFORMED ON MATERIAL USE

Sieve Analysis - Sieve analysis is also known as Gradation test and it is performed for the use of particle size and all particles are passes through varied sizes of sieve. Sample then poured in the topmost sieve then all sieves are then place in a mechanical shaker and all particles are then retailed on varied sizes of sieve. Sieve Analysis performed to find the fineness of material.

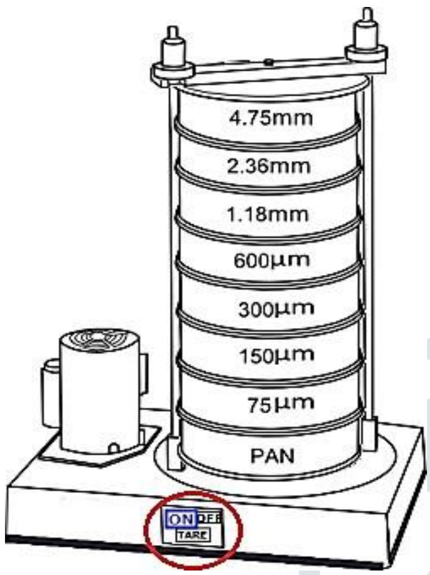

Figure 5: Arrangement of Sieves.

Figure. 6: Sieve Shaker

Silt content test - Material less than 150 microns is the silt content. For good bonding require less silty material. Silt content test is performed to find the percentage of silt in material. More silt content can affect the strength of the structure.

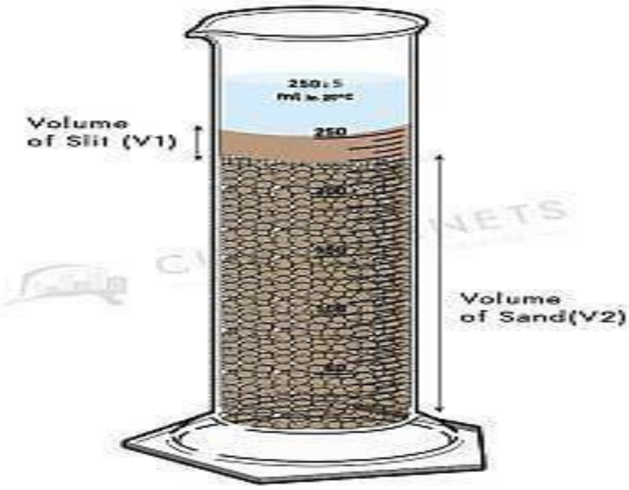

Figure 7: Measuring Jar

Figure 8: Deposit Silt

Water Absoption test - As we know we have different condition of temperature which affects the property of material. This test is performed to check the amount of water absorb by the material used in the construction. If material capability is more of absorption, then material is porous and if it absorbs less than non- porous. Ultimately is used to check the absorption capacity of material.

Aggregate Impact Value Test – The aggregate impact value test is performed to check the resistance of material by applying several impacts or shocks.

Figure 9: Aggregate impact value Mould.

Figure 10: Aggregate impact value test apparatus

Slump Cone Test – Slump cone test is performed to check the consistency of material or sample used and it also check the workiability of fresh concrete.this is the crucial factor to perform mix design.

Figure. 11 : Slump Cone test Apparatus

Figure 12 : Concrete Slump

Compressive Strength test - For the design of M25 mix design. A quantity and cost estimation were performed to meet the required conclusion. According to the data collected from above result. Mix design calculation is done for M25 grade of concrete to achieve required target strength.

***Figure 10:** Prepared cube for compressive strength test.*

***Figure 11:** Load applied by Compression Testing Machine.*

Flexural strength test – Flexural strength testing is based on IS:516-2002. Flexural strength is the ability of material to bend under various loads. It is also known as, modulus of rupture, fracture strength. Flexural strength is the mechanical parameter for brittle material. When an object made up of single material such as a steel rod or a wooden beam then its bends and experiences the stresses over its entire depth. For a rectangular specimen, the resulting stress under an axial force is given by the following formula:

$$P = f/ bd$$

This stress is not the actual stress, since the cross section of the specimen is invariant (Engineering Stress).
Where, F = Axial Load applied on the specimen B = Width
D = Depth

Figure13: Prepared beam for Flexural strength test.

Figure 14: Flexural strength testing machine.

TEST RESULTS FOR MATERIALS USED

Table 2 : Physical Properties of Cement (PPC - 43)

Physical Test of CEMENT (As per IS :4031 Part - 1,3,4,5 & 6)					
S. No.	**Test Conducted**	**Test Result**	**Units**	**LIMITS**	**Test Method**
1	Consistency	33	-	-	As Per IS:4031 (Part-4)
2	Initial Setting Time	65	Minutes	**Min.30 Minutes**	As Per IS:4031 (Part-5)
3	Final Setting Time	245	Minutes	**Max.600 Minutes**	
4	Soundness	3.33	mm	**10 mm Max.**	As Per IS:4031 (Part-3)
5	Fineness	3.1	%	**Max 10 % (By Weight)**	As Per IS:4031 (Part-1)
6	Compressive Strength After3 Days	27.75	N/mm^2	**16 N/mm^2**	As Per IS:4031 (Part-6)
7	Compressive Strength After14 Days	47.48	N/mm^2	**28 N/mm^2**	
8	Compressive Strength After28 Days	53.26	N/mm^2	**33 N/mm^2**	
9	Specific Gravity of Cement	3.15			

Table 3 : Physical properties of Materials Used

1	Specific Gravity of Admixture	1.144
2	Specific Gravity of Aggregate i) Coarse Aggregate (70% 20mm & 30% Dismental Agg.)	2.790
3	ii) Fine Aggregate (50% River Sand50% M-Sand)	2.795
4	Water Absorption of Aggregate i) Coarse Aggregate (70% 20mm & 30% Dismental Agg.)	1.96%
5	ii) Fine Aggregate (50% River Sand & 50% Crusher Sand)	1.12%
6	Bulk Density of Aggregate i) Coarse Aggregate	1.58 Kg/liter
7	ii) Fine Aggregate	1.89 Kg/liter
8	Combined Flakiness & Elongation Index	29.54%
9	Impact Value of Coarse Aggregate (70% 20mm & 30% Dismental Aggregate)	21.98%

Table 4 : Sieve Analysis of Coarse Aggregate 20mm

Particle Size Distribution of Coarse Aggregate (20 mm) (As per IS:2386, Part 1, Clause 2. 1963)					
IS Sieve's (mm)	**Weight Retained(gm)**	**Per Wt. Retained (%)**	**Cumulative Per Wt. Retained (%)**	**Percentage Of Passing**	**% Passing (As Per IS:383-2016) Table No. 7 (Clause no. 6.1 & 6.2)** **Grading (Single Size Aggregate)**
40	0	0	0	**100**	**100**
20	756	37.72	37.72	**62.28**	**90 - 100**
10	1245	62.13	99.85	**0.15**	**25 - 55**
4.75	1	0.05	99.90	**0.10**	**0 - 10**
Pan	2				**-**
Total Wt.	2004				

Table 5: Sieve Analysis of Coarse Aggregate 10mm

Particle Size Distribution of Coarse Aggregate (10 mm) (As per IS:2386, Part 1, Clause 2. 1963)					
IS Sieve's (mm	**Weight Retained(gm)**	**Per Wt. Retained (%)**	**Cumulative Per Wt. Retained (%)**	**Percentage Of Passing**	**% Of Passing (As Per IS:383-2016) Table No. 7 (Clause no. 6.1 & 6.2)** **Grading (Single Size Aggregate)**
12.5	0	0	0	100	**100**
10	154	7.70	7.70	92.30	**85 - 100**
4.75	1615	80.75	88.45	11.55	**0 - 20**
2.36	168	8.40	96.85	3.15	**0 - 5**
Pan	63				**-**

Total Wt.	2000	

Table 6: *Sieve Analysis of River Sand*

Particle Size Distribution of Fine Aggregate (River Sand) (As per IS:2386, Part 1, Clause 2.0) & (As Per IS:383-2016) Table-9 Clause 6.3							
IS Sieve's (mm)	**Retained (gm)**	**Weight Retained**	**Weight Retained**	**% Of Passing**	**Grading**		
					ZONE 1	**ZONE 2**	**ZONE 3**
10	8.00	0.80	0.80	99.20	**100**	**100**	**100**
4.75	141.00	0.14	0.94	98.26	**90-100**	**90-100**	**90-100**
2.36	239.50	23.95	24.89	74.31	**60-95**	**75-100**	**85-100**
1.18	233.50	23.35	48.24	50.96	**30-70**	**55-90**	**75-100**
0.600	162.00	16.20	64.44	34.76	**15-34**	**35-59**	**60-79**
0.300	148.50	14.85	79.29	19.91	**5-20**	**8-30**	**12-40**
0.150	36.00	3.60	82.89	16.31	**0-10**	**0-10**	**0-10**
Pan	31.50				-	-	-
Total Weight	**1000**						
Fineness Modulus		**3.01**			**Limit - (2.0 - 3.5)**		
Zone		**I**					

Table 7: Sieve Analysis of M- Sand

Particle Size Distribution of Fine Aggregate (M- Sand) (As per IS:2386, Part 1, Clause 2.0) & (As Per IS:383-2016) Table-9 Clause 6.3							
IS Sieve's (mm)	**Weight Retained**	**% Of Wt.**	**Cum. % of Wt.**	**% Of Passing**	**Grading**		
					ZONE 1	**ZONE 2**	**ZONE 3**
10	0	0	0	100	**100**	**100**	**100**
4.75	0	0.00	0.00	100.00	**90-100**	**90-100**	**90-100**
2.36	170.5	17.06	17.06	82.94	**60-95**	**75-100**	**85-100**
1.18	380	38.02	55.08	44.92	**30-70**	**55-90**	**75-100**
0.600	188	18.81	73.89	26.11	**15-34**	**35-59**	**60-79**
0.300	129.5	12.96	86.84	13.16	**5-20**	**8-30**	**12-40**
0.150	48	4.80	91.65	8.35	**0-10**	**0-10**	**0-10**
Pan	83.5				-	-	-
Total Weight	1000						
Fineness Modulus		**3.25**			**Limit - (2.0 - 3.5)**		
Zone		**I**					

Percentage of Slit Content of River Sand = 1.20 % & Percentage of Slit Content of M-Sand = 0.90%

Table 8: Stipulations for Proportioning

Grade Designation	M-25
Cement	Ultratech PPC
Maximum Nominal size of Aggregate	20mm
Minimum Cement Content	300Kg/m^3 (As Per IS Code 456 Table No.05)
Maximum Water Cement Ratio	0.50 (As Per IS: Code 456 Table No.5)
Workablility	75 mm(Slump) (As Per IS Code 10262 By Chart-1)
Method of Concrete Placing	Manually
Degree of Supervision	Good
Type Of Aggregate	Crushed Angular Aggregate + Recycled Concrete Aggregate
Chemical Admixture	Fosroc Conplast SP4380

CALCULATIONS FOR GREEN MIX DESIG

Mix-A, Mix-B, Mix-C calculation per unit volume of concrete shall be as follow:-

1.Total Volume = $1m^3$

2.Volume of entrapped air if concrete is wet = 0.01 m^3

3. Volume of Cement for Mix A (20%) = 0.135 m^3
Volume of Cement for Mix B (25%) = 0.1283 m^3
Volume of Cement for Mix C (30%) = 0.1216 m^3

4. Volume of Coarse aggregate for 20% = 0.580 m^3
Volume of Coarse aggregate for 25% = 0.580 m^3
Volume of Coarse aggregate for 30% = 0.580 m^3

5.Volume of water for Mix A (20%) = 0.19158 m^3
Volume of water for Mix B (25%) = 0.1820 m^3
Volume of water for Mix C (25%) = 0.1724 m^3

6. Volume of Admixture For Mix-A = $0.002m^3$
Volume of Admixture For Mix-B = 0.003 m^3
Volume of Admixture For Mix-C = 0.006 m^3

7.Volume of all aggregate For Mix-A = 0.6615 m^3
Volume of all aggregate For Mix-B = 0.6767 m^3
Volume of all aggregate For Mix-C = 0.6894 m^3

8. Mass of Coarse aggregate for Mix -A = 1070.44 Kgs
Mass of Coarse aggregate for Mix -B = 1095.03 Kgs
Mass of Coarse aggregate for Mix -C= 1115.58 Kgs

9. Mass of Fine Aggregate for Mix-A = 778.38 Kgs
Mass of Fine Aggregate for Mix-B = 796.26 Kgs
Mass of Fine Aggregate for Mix-C = 811.21 Kgs

Table 9: Mix Proportion for Trials

S.NO.	Mass of Materials	Mix A	Mix B	Mix C
1	Water – Cement Ratio	0.45	0.45	0.45
2	Mass of Cement (Kg/m^3)	425.73	404.44	383.155
3	Mass of Water (Ltr/m^3)	191.58	182.001	172.422
4	Mass of Coarse Aggregate (Kg/m^3)	1070.44	1095.03	1115.58
5	Mass of Fine Aggregate ($Kg/m^{3)}$	778.38	796.26	811.21
6	Mass of Chemical Admixture (Ltr/m^3)	2.13	4.04	7.66

Table 10 : Recommended Mix Ratio

S.NO.	GREEN MIX	RATIO
1	**MIX A**	**1:1.82:2.51**
2	**MIX B**	**1:1.96:2.70**
3	**MIX C**	**1:2.11: 2.91**

COMPRESSIVE STRENGTH TEST RESULTS

Table11:Compressive strength Test Result for Mix-A

NO. of Days	Load KN	Area of Cube mm²	Compressive Strength N/mm²	Average Compressive Strength N/mm²	Required Compressive Strength N/mm²
3 Days	350	22500	15.55	16.30	15.80
	385	22500	17.11		
	366	22500	16.26		
7 Days	495	22500	22.00	22.62	22.12
	510	22500	22.66		
	522	22500	23.20		
14 Days	620	22500	27.95	29.56	29.05
	722	22500	32.08		
	645	22500	28.67		
28 Days	733	22500	32.78	31.90	31.60
	718	22500	31.91		
	698	22500	31.02		

Table 12 : Compressive strength Test Result for Mix-B

NO. of Days	Load KN	Area of Cube mm²	Compressive Strength N/mm²	Average Compressive Strength N/mm²	Required Compressive Strength N/mm²
3 Days	362	22500	16.09	16.62	15.80
	377	22500	16.76		
	383	22500	17.02		
7 Days	559	22500	24.84	24.28	22.12
	527	22500	23.42		
	553	22500	24.58		
14 Days	628	22500	27.91	30.51	29.05
	728	22500	32.35		
	704	22500	31.28		
28 Days	794	22500	35.29	34.10	31.60
	743	22500	33.02		
	765	22500	34.00		

Table 13: Compressive strength Test Result for Mix-C

NO. of Days	Load KN	Area of Cube mm²	Compressive Strength N/mm²	Average Compressive Strength N/mm²	Required Compressive Strength N/mm²
3 Days	355	22500	15.78	15.88	15.80
	347	22500	15.42		
	370	22500	16.44		
7 Days	500	22500	22.22	22.21	22.12
	492	22500	21.86		
	508	22500	22.57		
14 Days	642	22500	28.53	30.04	29.05
	728	22500	32.35		
	652	22500	29.24		
28 Days	725	22500	32.22	32.21	31.60
	708	22500	31.46		
	742	22500	32.97		

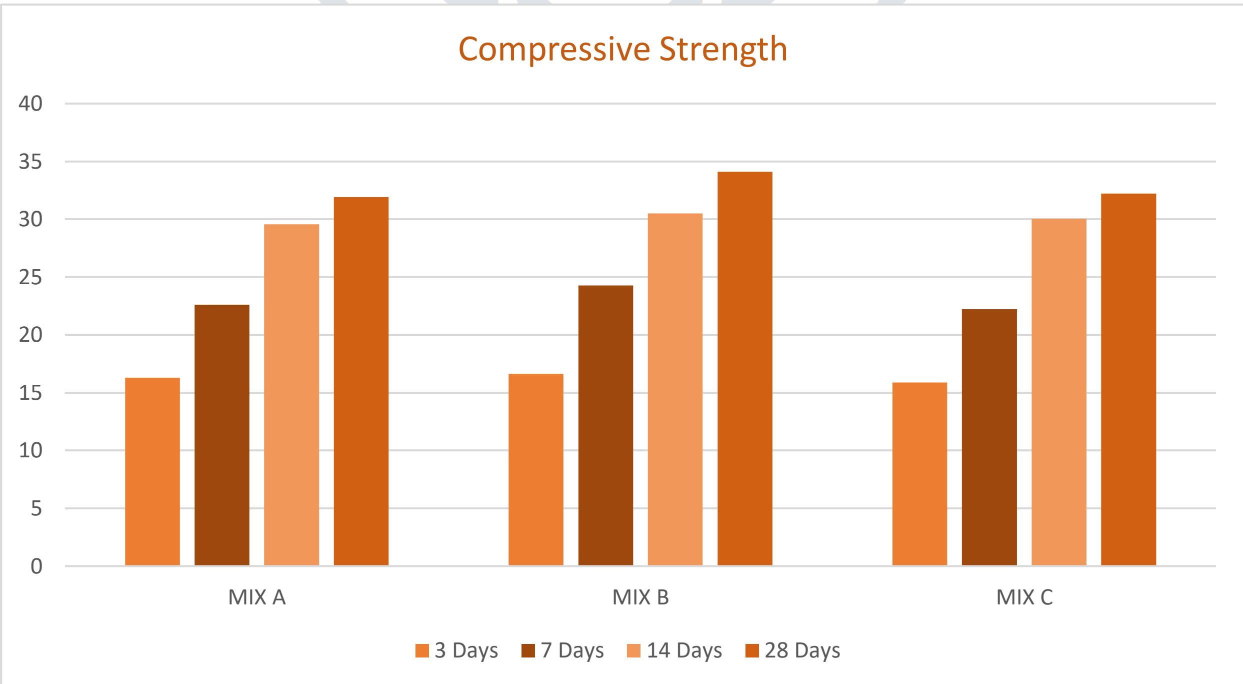

Chart 1: Chart for Compressive Strength Test for 3,7,14 and 28 days

FLEXURAL STRENGTH TEST RESULTS

Table 14: Flexural Strength Test Result for Mix-A

NO. of Days	Failure Load KN	Length mm	BD^2 mm	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2	Required Flexural Strength N/mm^2
7 Days	13.20	600	3375000	2.34	2.23	2.45
	12.80	600	3375000	2.27		
	12.00	600	3375000	2.10		
14 Days	20.20	600	3375000	3.59	3.38	2.80
	19.50	600	3375000	3.46		
	17.50	600	3375000	3.11		
28 Days	18.00	600	3375000	3.32	3.81	3.50
	25.20	600	3375000	4.48		
	20.50	600	3375000	3.64		

Table 15: Flexural Strength Test Result for Mix-B

NO. of Days	Failure Load KN	Length mm	BD^2 mm	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2	Required Flexural Strength N/mm^2
7 Days	18.50	600	3375000	3.20	3.16	2.45
	15.80	600	3375000	2.80		
	19.60	600	3375000	3.48		
14 Days	21.20	600	3375000	3.77	3.63	2.80
	21.50	600	3375000	3.82		
	18.70	600	3375000	3.32		
28 Days	19.00	600	3375000	3.38	4.33	3.50
	32.00	600	3375000	5.69		
	22.00	600	3375000	3.91		

Table 16: Flexural Strength Test Result for Mix-C

NO. of Days	Failure Load KN	Length mm	BD^2 mm	Flexural Strength N/mm^2	Average Flexural Strength N/mm^2	Required Flexural Strength N/mm^2
7 Days	17.40	600	3375000	3.09	3.09	2.45
	18.00	600	3375000	3.20		
	16.80	600	3375000	2.98		
14 Days	19.40	600	3375000	3.44	3.40	2.80
	18.60	600	3375000	3.30		
	19.50	600	3375000	3.46		
28 Days	20.20	600	3375000	3.59	3.87	3.50
	23.50	600	3375000	4.17		
	22.60	600	3375000	3.86		

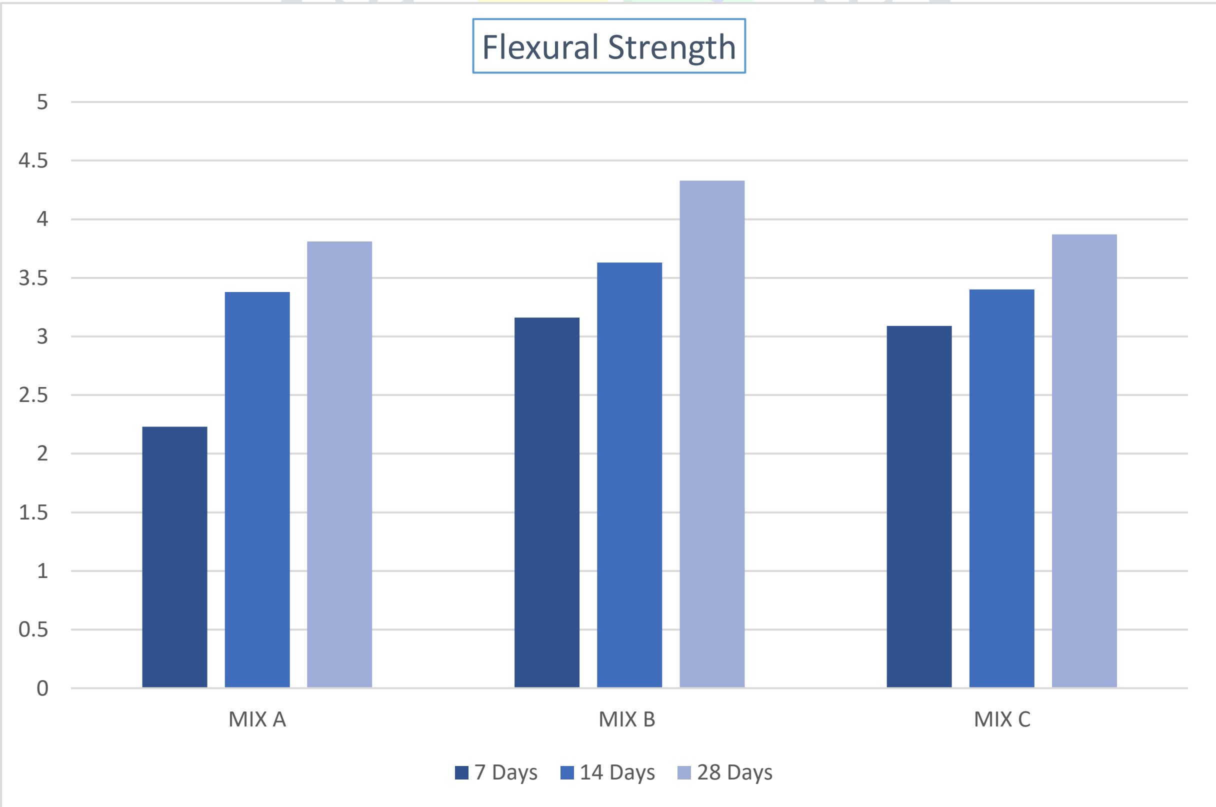

Chart 2: Chart for Flexural Strength Test for 7,14 and 28 days

Conclusion - Main objective of this study was to make Green concrete economical and to make it possible three trials were tested by replacing coarse aggregate percent at about 20%, 25% and 30% partially by recycled concrete aggregate.

- Mix A or 20% coarse aggregate replaced by recycled concrete aggregate and 50% fine aggregate replaced by 50% M-sand, required target strength achieved is 31.90 in compression and 3.81 in flexural.
- Mix B or 25 % coarse aggregate replaced by recycled concrete aggregate and 50% fine aggregate replaced by 50% M-sand, required target strength achieved is 34.10 in compression and 4.33 in flexural.
- Mix C or 30% coarse aggregate replaced by recycled concrete aggregate and 50% fine aggregate replaced by 50% M-sand, required target strength achieved is 32.21 in compression and 3.87 in flexural.
- According to the rate comparison Mix B has achieved higher economy.
- According to strength Mix B achieved Higher strength in compression and flexural.

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