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Strength Properties of Concrete by Partial Replacement of Course Aggregate with C & D Waste and Fine Aggregate with Foundry Sand for M_{25} Grade Concrete

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Abstract: - Concrete is most consumption in the world after the water. Commonly concrete is composed with cement and aggregates. In now a day's aggregates is depletes in nature, cost is also high due to more consumption of concrete. On Other hand construction and demolition waste (C & D waste) and industrial by-product like a waste is produce millions of tons per year, so the disposal of waste is major problem that is dumping. So utilize some amount of waste product to make concrete. Hence in the current study an attempt has been made to minimize the cost of aggregates and effectively utilizing the C & D waste and foundry sand by utilizing with concrete mix M25 by studying the mechanical behavior of this concrete mix by partially replacing fine aggregate with foundry sand and coarse aggregate with C & D waste. In this study partial replacement5of fine5aggregate with foundry sand5and coarse aggregate with C & D waste, also adding polypropylene fiber (0.3%). Experimental study is conducted to evaluate strength characteristic of hardened concrete. The fine aggregate has been replaced with foundry sand in the range of 0%, to 30% by weight of fine aggregate and partially replacing coarse aggregate with C & D waste in the range of 0%, to 40% by weight of coarse aggregate, with and without adding polypropylene fiber. The optimum strength of concrete mix is obtained for the represent of 20% foundry sand and 30% C & D waste. Also optimum mix combination specimens are prepared and determine their mechanical property at testing dates of curing.

Key Words— foundry sand (FS), Construction and Demolition Waste (C & D Waste), polypropylene fiber (PPF).

I. INTRODUCTION

Concrete is the only major building material that can be delivered to the job site in a plastic state. The global consumption of aggregate is very high. Now a day's natural resources are depleting so it increasing extraction of natural sources like aggregates causing many problems, loosing water retaining sand strata, loss of vegetation on the bank of river etc. The sand and coarse aggregate is highly expensive and depleting. It has become very important protect the natural resources. To overcome this problem, we use other alternative materials for concrete production. So in this experiment we utilize foundry sand, foundry sand is a by-product of metal smelting and replacing with fine aggregate in varies percentage and recycled aggregate from dig of road concrete as C & D waste, replacing with coarse aggregate in varies percentage. Also polypropylene fiber is added to the concrete in less varies percentage by weight of cement. This fiber increases the ductility of the concrete. In this experimental investigation an attempt is made to study the effect of partial replacement of sand with foundry sand and coarse aggregate by C & D waste in the mechanical properties of M25 grade concrete.

1.1 *Cement*

Here, Cement is used of 43grade ordinary Portland cement (OPC) with brand name ACC is used for all concrete mixes. The cement used is fresh and without any lumps and properties of cement conforming to IS4031:1999.

1.2 Fine aggregate

Manufactured sand is used as fine aggregate. The M-sand passing through 4.75 mm size sieve is used in the preparation of specimen. Sieve analysis have zone II.

1.3 Foundry sand

Foundry sand has highly silica sand and uniform characteristics. It is the by-product of ferrous and nonferrous metal casting industries. Ferrous and non-ferrous metal castings industries highly produce the by-product of foundry sand and it is available to be recycled into other products from industry. At present in India 165-170 million tons of foundry is produced. In the process of casting, molding sands are recycled and reused many times. Moreover, the recycled sand degrades to the point that has no longer been reused in the casting process.

Fig.1. Foundry sand

1.4 Coarse aggregate

The Course aggregate is replaced with construction and demolition (C&D) waste. One of the major problems being faced by cities and towns relates to the management of C&D Waste. Waste quantities are increasing and municipal authorities are not able to upgrade or scale up the facilities required for proper management of such wastes. Cities and towns, in future, will not get wastelands for the further dumping of wastes. For the replacement of coarse aggregate in some amount of percentage by demolished waste gives strength closer to the strength of plain concrete and strength retention was recorded in the range of some percentage for the recycled concrete mix. Many type of C & D waste are used such as pieces ceramic tiles, pieces of bricks, building waste concrete, dig of drainage concrete and dig of road concrete extra. In this experiment the main source for recycled aggregates is construction and demolition waste. Reuse of demolition waste appears to be an effective solution and the most appropriate and large scale use would be to use it as aggregates to produce concrete for new construction. The main source for recycled aggregates is construction and demolition waste. Most of the waste materials produced by demolishing structures are disposed by dumping them as landfill or for reclaiming land, in future will not get wastelands for the further dumping of wastes. In fact, there will be a need to go for total recycling and reuse of waste and aim for Zero Waste for landfilling. Reuse of demolition waste appears to be an effective solution and the most appropriate and large scale use would be to use it as aggregates to produce concrete for new construction. Recycled aggregate concrete utilizes demolition material from concrete and dig of road concrete as aggregate.

Fig.2. Raw material of C & D waste from Road concrete

1.5 Fiber reinforced concrete (FRC)

Fibers are grating does not corrode like steel grating and is therefore used in corrosive environments to reduce maintenances cost, in this experimental work poly propylene fibers are used. It is harder; more heat resistance. Polypropylene is the second most widely produced commodity plastic.

II. MATERIALS AND METHODOLOGY

2.1 Materials

The properties of fresh concrete and hardened concrete of M25 grade mixes are depends on the properties of the constituents used in its making. Therefore, preliminary test was conducted on the materials to determine their characteristic properties as per code of practice are reported below.

Materials Used in this Project are:

2.1.1 Cement

2.1.2 Fine aggregate

a) Manufactured sand

b) Foundry sand

2.1.3 Coarse aggregate

a) Natural aggregate

b) Construction Demolition waste

2.1.4. Water

2.1.5. Polypropylene fiber

2.1.1 Cement

Here, Cement is used of 43grade ordinary Portland cement (OPC) The specific gravity, normal consistency, initial and final setting time of cement were found as per Indian standard specifications

Basic Test on Cement:

- Grade of Cement : 43 grade (ACC)
- Specific Gravity : 3.1
- Normal Consistency : 30 %

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- Initial Setting time : 35 minutes
- Final Setting time : 600 minutes

2.1.2 Fine Aggregates (FA)

a. Manufactured sand:

Manufactured sand is used as fine aggregate. The M-sand passing through 4.75 mm size sieve is used in the preparation of specimen. The M-sand confirm to grading zone II as per IS: 383-1970. The properties of sand such as fineness modulus and specific gravity were determined as per IS: 2386-1963.

Basic Test on M-Sand:

- Specific Gravity : 2.46
- Silt content : 4%
- Bulkiness of sand : 6%
- Grading of Sand : Zone – II

b. Foundry sand:

Foundry sand has shape of semi corned or circular. Grain size of foundry sand is uniformly distributed; it is high quality silica sand. It is used in the foundry casting process. The foundry sand is passing through the 4.75 mm sieve is used in the preparation of concrete.

Basic Test on Foundry sand:

- Specific gravity : 2.47
- Water absorption : 0.45%
- Bulking of sand : 4%
- Silt content : Nil

2.1.3 Course Aggregate (CA)

The coarse aggregate used in the investigation is 20 mm down size locally available crushed stone obtained from quarries. It occupies almost of volume in concrete and hence shows influence on various properties such as strength, workability, durability and economy of concrete.

a. Natural aggregate (NA):

The aggregate having size more than 4.75 mm is termed as coarse aggregate.

Basic Test on Natural aggregate:

- Specific Gravity : 2.69
- Flakiness : 11.4%
- Water Absorption : 1%
- Shape : Angular

b. Construction Demolition waste:

It used as coarse aggregate for concrete. The demolished waste concrete coarse aggregates were obtained by crushing the waste concrete from dig of road concrete that were dismantled due to completion of their life span and it passing through 20 mm sieve and retained on12.5 mm sieve and as given in IS: 383-1970 is used for all the specimens.

Basic Test on C&D Waste:

- Specific Gravity : 2.45
- Flakiness : 5.36%
- Water Absorption : 2.37

2.1.4 Water:

Palatable (portable) water has been used throughout this research work.

2.1.5 Poly Propylene Fibers (PPF):

A fiber grating does not corrode like steel grating and is therefore used in corrosive environments to reduce maintenance costs. The poly propylene fibers are used in this project 0.3%. It is harder, more heat resistance.

Properties of Poly propylene fiber:

- Material : Polypropylene fiber
- Type : CT 2424
- Filament diameter : 25 Microns
- Cut length : 12mm

2.2 Methodology

2.2.1 The Following methodology is adopted for the present work:

Collection of ingredient of concrete and basic

⇩

Mix design as per IS: 10262

⇩

Mixing with specified proportion

⇩

Casting/molding

⇩

De molding after 24 hours

⇩

Curing and mechanical property tests

Fig.3. Methodology Flowchart

2.3 Experimental Details

2.3.1 Mix Design, Means, Modes and Methods:

In this experiment conducted the grades of concrete

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M-25. The mix design was carried out as per IS 10262-2009. The trials have been prepared and M-25 grade was design for this experiment having the mix proportion 1:1.51:2.58 and the water cement ratio are 0.45. All locally available materials are used during the preparation of the mix proportion.

Table.1. Mix Proportion as per IS 10262-2009

Materials	Quantity in Kg/m^3	Proportion
Cement	426	1
Fine aggregate	644.33	1.51
Coarse aggregate	1102.02	2.58
Water	191.5	0.45

2.3.2 Casting of specimens:

The cement, M-sand, coarse aggregate, foundry sand and C&D waste were weighed in a dry condition and they mixed together in a pan mixer in order to avoid cement, aggregate and water loss. As the order of M25concrete mixtures were prepared with polypropylene with foundry sand and C & D waste substitution. The foundry sand and C & D waste substitution rate was varied between 0% to 30% and 0% to 40% respectively, in increments of 10%. Similarly, without polypropylene concrete mixture has prepared. Cubes and cylinders with a size of (150×150×150) mm and (150×300) mm were prepared. Beams having a size of (100 × 100×500) mm, all the specimens were filled with concrete in three layers, and each layer of the concrete was effectively compacted by table vibrator.

Fig.4. sample of cube Casting

2.3.3 Curing of Specimens:

After casting, all the test specimens were kept at room temperature for 24hrs and thereafter were de molded and transferred to the curing tank until their test in dates. Specimen was tested for 7, 14 and 28 days

Fig.5. Curing of specimens in curing tank

2.3.4 Testing of Specimens

After completion of the curing the testing samples are dry about half an hour. Then Specimens are tested for its dates such as 7, 14 and 28 days for compressive strength, and dates 7, 28 days for split tensile, shear and flexure strength by universal testing machine (UTM).

Fig.6. Testing of specimens in UTM

III. RESULTS AND DISCUSSION

3.1. Partially replacement of foundry sand to find optimum dosage

A. With and without PPF as replace Foundry Sand for 7 days of curing:

Table.3. Without PPF as replaced Foundry Sand at 7 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	22.66
2	10%	22.51
3	**20%**	**25.77**
4	30%	23.85

Table.4. With PPF as replaced Foundry Sand at 7 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	24.29
2	10%	25.77
3	**20%**	**27.55**
4	30%	25.62

B. With and without PPF as replaced Foundry Sand for 14 days of curing:

Table.5. Without PPF as replaced Foundry Sand at 14 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	30.66
2	10%	32.88
3	**20%**	**34.21**
4	30%	33.18

Table.6. With PPF as replaced Foundry Sand at 14 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	33.03
2	10%	34.96
3	**20%**	**37.03**
4	30%	35.99

C. With and without PPF as replaced Foundry Sand for 28 days of curing:

Table.7. Without PPF as replaced Foundry Sand at 28 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	34.21
2	10%	36.73
3	**20%**	**37.92**
4	30%	37.03

Table.8. With PPF as replaced Foundry Sand at 28 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	35.85
2	10%	39.40
3	**20%**	**42.66**
4	30%	37.47

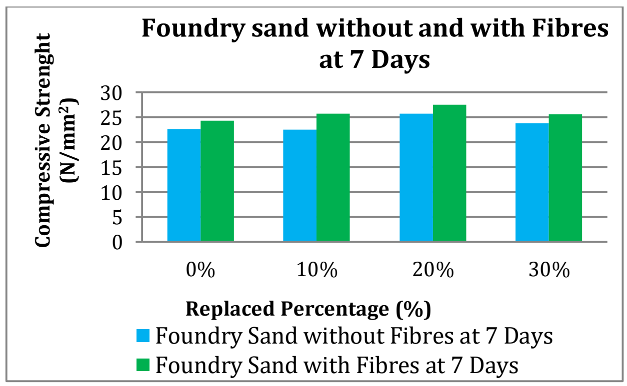

Chart.1. Graphical Representation of Foundry sand with and without fiber for 7days

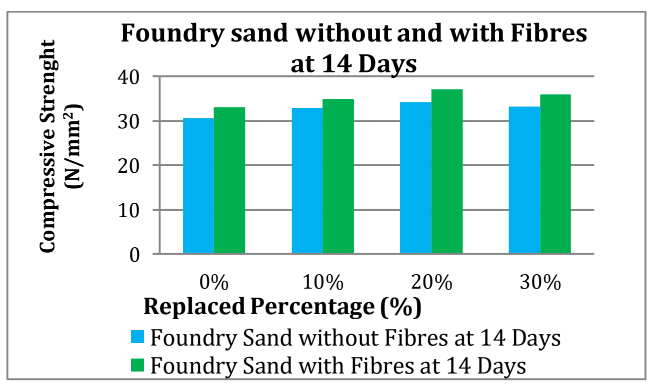

Chart.2. Graphical Representation of Foundry sand with and without fiber for 14 days

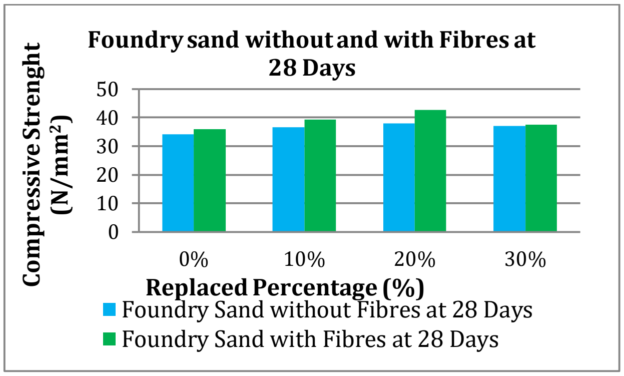

Chart.3. Graphical Representation of Foundry sand with and without fiber for 28 days

Inference:

From the above Tables 3,4,5,6,7 and 8 represents the compressive strength of concrete with partially replacement of foundry sand for 0%, 10%, 20%and 30% by weight of fine aggregates for both with and without poly propylene fibers and above graph represents the **20%** optimum percentage of foundry sand by comparing with and without fibers. For all the tables shows increase in compressive strength then without fiber at 7, 14 and 28 days of curing.

3.2 Partially replacement of c & d waste to find optimum dosage:

A. With and without PPF as replaced C & D waste for 7 days of curing:

Table.9. Without PPF as replaced C & D waste at 7 days of curing

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	22.66
2	10%	23.70
3	20%	23.99
4	**30%**	**24.73**
5	40%	22.66

Table.10. With PPF as replaced C & D waste at 7 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	24.29
2	10%	24.14
3	20%	25.92
4	**30%**	**26.33**
5	40%	22.66

B. With and without PPF as replaced C & D waste for 14 days of curing.

Table.11. Without PPF as replaced C & D Waste at 14 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	30.66
2	10%	31.55
3	20%	32.44
4	**30%**	**33.03**
5	40%	31.99

Table.12. With PPF as replaced C & D Waste at 14 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	33.03
2	10%	33.33
3	20%	34.36
4	**30%**	**36.14**
5	40%	33.03

C. With and without PPF as replaced C & D waste for 28 days of curing.

Table.13. Without PPF as replaced C & D waste at 28 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	34.21
2	10%	34.22
3	20%	34.51
4	**30%**	**35.40**
5	40%	34.66

Table.14. With PPF as replaced C & D waste at 28 days of curing.

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	0%	35.85
2	10%	35.85

3	20%	37.77
4	**30%**	**39.70**
5	40%	36.43

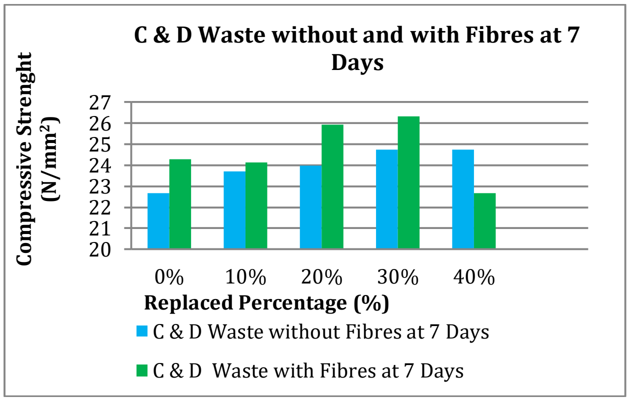

Chart.4. Graphical Representation of C &D waste at 7 days of curing

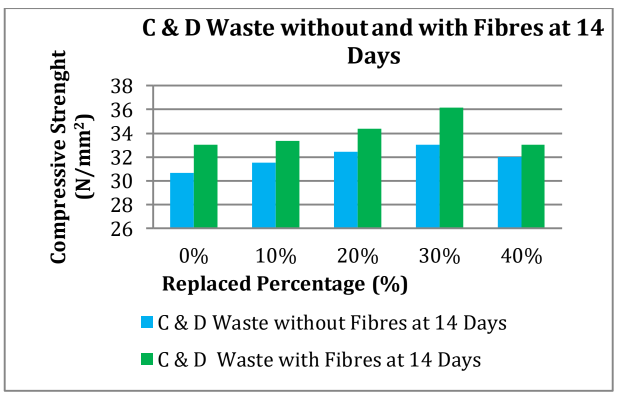

Chart.5. Graphical Representation of C &D waste at 14 days of curing

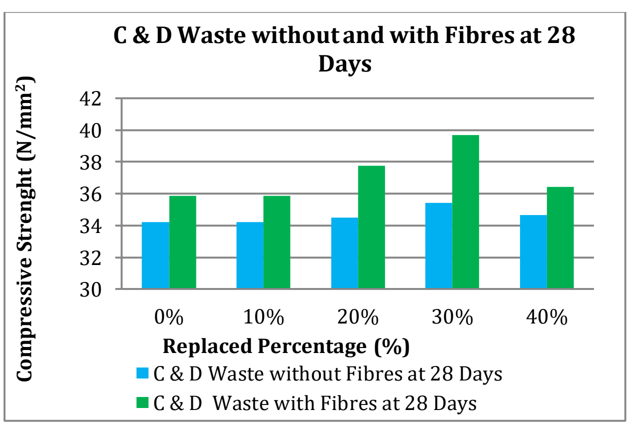

Chart.6. Graphical Representation of C &D waste at 28 days of curing

Inference: -

From the above Tables 3.7, 3.8, 3.9, 3.10, 3.11 and 3.1214 represents the compressive strength of concrete with partially replacement of construction and demolition waste for 0%, 10%, 20%, 30% and 40% by weight of coarse aggregates for both with and without poly propylene fibers and above graph represents the10% optimum percentage of construction and demolition waste by comparing with and without fibers. For all the tables shows increase in compressive strength then without fiber at 7, 14 and 28 days of curing.

3.3 Tests on Hardened Concrete

3.3.1 Compressive Strength

3.3.2 Split Tensile Strength

3.3.3 Flexural Strength

3.3.4 Shear Strength

3.3.1 Compression strength test:

Table.15. Compression strength test for 7 days

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	Conventional	24.29
2	FS 20% + C&D 30%	29.03

Table.16. Compression strength test for 14 days' results

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	Conventional	33.03
2	FS 20% + C&D 30%	35.84

Table.17. Compression strength test for 28 days' results

SL	Replacement of Materials	Avg. Compressive Strength in MPA
1	Conventional	35.85
2	FS 20% + C&D 30%	38.81

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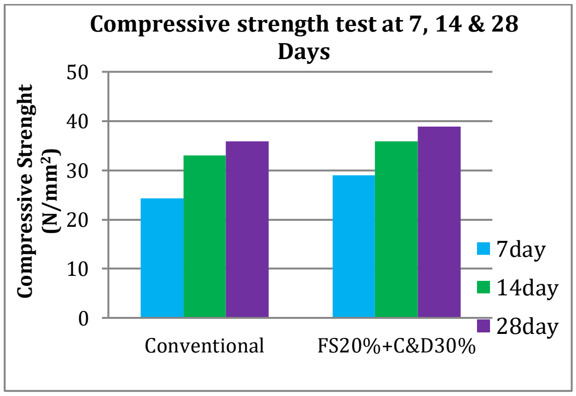

Chart.7. Comparison of compressive strength between conventional and optimum concrete cubs for 7, 14 & 28 days

3.3.2 Split tensile strength test.

Table.18. Split tensile strength test for 7 days

SL	Replacement of Materials	Avg. Split Tensile Strength in MPA
1	Conventional	2.17
2	FS 20% + C&D 30%	2.45

Table.19. Split tensile strength test for 28 days

SL	Replacement of Materials	Avg. Split Tensile Strength in MPA
1	Conventional	2.97
2	FS 20% + C&D 30%	3.49

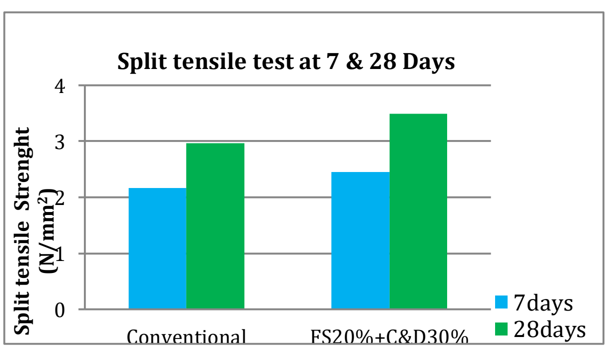

Chart.8. Comparison of split tensile strength between conventional and optimum concrete for 7& 28 days

3.3.3 Flexural tensile strength test.

Table.20. Flexural tensile strength test for 7 days results

SL	Replacement of Materials	Avg. Flexural Strength in MPA
1	Conventional	2.82
2	FS 20% + C&D 30%	3.10

Table.21. Flexural tensile strength test for 28 days results

SL	Replacement of Materials	Avg. Flexural Strength in MPA
1	Conventional	3.29
2	FS 20% + C&D 30%	3.92

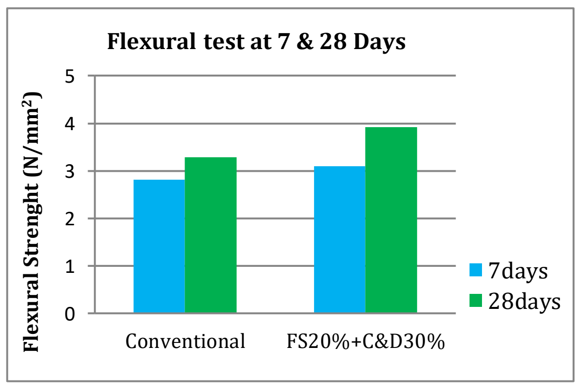

Chart.9. Comparison of flexural strength between conventional and optimum concrete for 7 & 28 days

3.3.4 Shear Strength test:

Table.22. Shear Strength test for 7 days results

SL	Replacement of Materials	Avg. Shear Strength in MPA
1	Conventional	5.92
2	FS 20% + C&D 30%	7.78

Table.23. Shear Strength test for 28 days results

SL	Replacement of Materials	Avg. Shear Strength in MPA
1	Conventional	9.62
2	FS 20% + C&D 30%	12.23

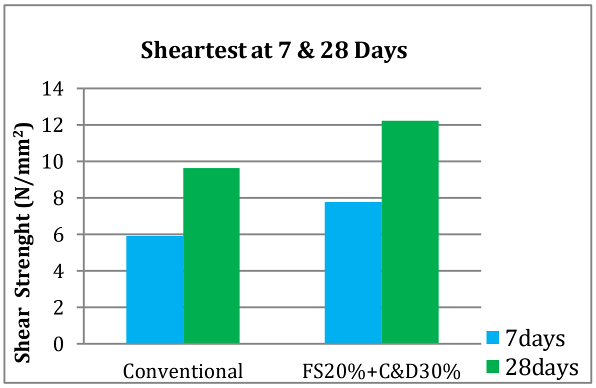

Fig.10. Comparison of shear strength between conventional and optimum concrete for 7, 14 & 28 days

IV. CONCLUSION

In this study, the mean target strength of M25 grade concrete is achieved combined effect of using foundry sand and C & D waste as partial replacement for fine aggregate and coarse aggregate respectively. We observe from the experimental result that it is clear that the concrete made with 20% foundry sand replacement with fine aggregate and 30% C & D waste replacement with coarse aggregate, with 0.3% polypropylene fiber shows higher compressive strength than other mixes so it concludes that 20% foundry sand replacement with fine-aggregate and 30% C & D waste replacement with coarse aggregate is optimum value of compressive strength results. Mechanical properties such as compressive strength, split tensile strength, flexural strength and shear strength were increased with replaced foundry sand and C &D waste (optimum20%+30%) with polypropylene fiber than conventional concrete.

- The compressive strength of conventional concrete cubes is 35.85 Mpa at 28days, whereas compressive strength of optimum amount of partially replaced both foundry sand as 20% and C & D waste 30% at 28 days found to be 38.81Mpa. Also it found that the compressive strength partially replaced concrete have 7.63% higher strength than the conventional concrete respectively.
- The split tensile strength of conventional concrete cylinder is 2.97 Mpa at 28 days, whereas split tensile strength of optimum amount of partially replaced both foundry sand as 20% and C & D waste 30% at 28 days found to be 3.49 Mpa. Also it found that the split tensile strength partially replaced concrete have 14.9% higher strength than the conventional concrete respectively.
- The flexural strength of conventional concrete beam is 3.29 Mpa at 28 days, whereas compressive strength of optimum amount of partially replaced both foundry sand as 20% and C & D waste 30% at 28 days found to be 3.92 Mpa. Also it found that the flexural strength partially replaced concrete have 16.07% higher strength than the conventional concrete respectively.
- The shear strength of conventional concrete cube is 9.62 Mpa at 28 days, whereas shear strength of optimum amount of partially replaced both foundry sand as 20% and C & D waste 30% at 28 days found to be 12.23 Mpa. Also it found that the shear strength partially replaced concrete have 21.34% higher strength than the conventional concrete respectively.

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