STUDY ON GLASS FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH PAPER MILL SLUDGE AND WASTE WATER SLUDGE

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Abstract – *Concrete is a weak building material in tension. Inherently, micro cracks will be present in concrete. The formation of micro cracks normally due to shrinkage of concrete. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking. In order to improve these properties, an attempt has been made to study the effect of addition of glass fibers in ordinary Portland cement concrete. In the present experimental investigation glass fibers in different percentage 0 to 0.09% has been studied for the effect on mechanical properties, stress-strain behavior and formation of cracks. The results have shown improvement in mechanical and ductility properties with the addition of glass fibers.A noteworthy issue emerging from the across the board utilization of ranger service biomass and handled timber squander as fuel is identified with the creation of huge amounts of fiery remains as a by-item from the burning of such biomass is a noteworthy bit of the wood squander slag delivered is land filled as a typical technique for transfer. In the event that it proceeds with waste results of paper plant ooze landfills require substantial measure of space would be required by 2025. A study was conducted as a result of investigations into the use of paper mill sludge as recycled material and additives in concrete mixes for use in construction projects. for produce low cost concrete by blending various ratios of cement with paper sludge & waste water sludge to reduce disposal and pollution problems due to paper sludge is most essential to develop profitable building materials from paper waste sludge and waste water sludge. The use of paper-mill pulp in concrete formulations was investigated as an alternative to landfill disposal. About 320 kg of sludge is produced for each tone of recycle paper. It is assessed that 39,315 million liters for each day (mld) of wastewater is produced in urban focuses. The bond has been supplanted by paper process slime, and waste water muck likewise in the scope of 5%, 10% and 15% set up of bond in cement for M-30 and M-40 blend and to decide the compressive, split rigidity and flexural quality of cement at 7 days and 28 days contrasted and customary cement*

1. INTRODUCTION

Glass Fiber Reinforced Concrete (GFRC) is a type of fiber reinforced concrete. Glass fiber reinforced concrete (GFRC) consists of high strength glass fiber embedded in a cementatious matrix. In this form, both fibers and matrix retain their physical and chemical identities, yet they produce a combination of properties that cannot be achieved with either of the components acting alone. In general, fibers are the principal load-carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as a load transfer medium between them, and protects them from environmental damage. In fact, the fibers provide reinforcement for the matrix and other useful functions in fiber-reinforced composite materials.

Glass fibers can be incorporated into a matrix either in continuous lengths or in discontinuous (chopped) lengths.

2. PAPER MILL SLUDGE

Paper making industries generally produces a large amount of solid waste. Over 320 million tons of industrial wastes are being produced per annum by chemical and agricultural processes are available in India. These materials possess problems of disposal along with health hazards and aesthetic problem. The paper fibers will be recycled only a limited number of times before they become too short or weak to make high quality of paper. It means that the broken, low- quality paper fibers are separated out to become like waste sludge. But Paper sludge behaves like cement because of silica and magnesium properties which improve the setting of the concrete. And the quantity of sludge varies from mill to mill. However the amount of sludge generated through a recycled paper mill is greatly dependent on the type of furnish being used and end product being manufactured. About 320 kg of sludge is produced for each tone of recycled paper. Which is relatively large volume of sludge produced each day that makes making landfill uneconomical as paper mill sludge is bulky.

3. APPLICATIONS OF PAPER MILL SLUDGE

- To provide an economical concrete.
- It should be easily adopted in field.
- Using the wastes in useful manner
- Light weight comparably with conventional concrete.
- Paper mill sludge is the cheaper substitute to OPC.
- To reduce the cost for construction

4. WASTE WATER SLUDGE

Waste water sludge also known as sewage sludge. Sewage sludge as as end-product of biological waste water treatment processes. It is estimated that about 39,315 million liters per day (mld) of wastewater is generated in urban centres comprising Class I cities and Class II towns having population of 52,000 and also 71 population of the total urban cities. The municipal wastewater treatment was developed so far is about 12,911 mld which is about 33 per cent of wastewater generation in these two classes of urban centres and high organic sludge with organic content more than 52% of sludge weight was used as an additive to concrete mixes. The density of the concrete decreased in all cases with an increasing sludge content. The reduction in density of sludge was higher when high organic sludge was used than low organic sludge. Sludge is the solid material removed during the treatment of wastewaters. There are three kinds of sludge: I - Sewage sludge from municipal treatment works II- seepage pumped from septic tanks and III industrial sludge's. Those are a growing management problem in this state, and throughout the world. Municipal sludge is supplemental energy source at treatment works.

5. APPLICATIONS OF WASTE WATER SLUDGE

1. The use of sewage sludge to improve soil cannot be shown to be a zero risk proposition.
2. Pre-treatment of sewage by industries can be greatly reduce the amounts of heavy metals and toxins that enter the sludge, but these cannot be entirely eliminated.

3. As mentioned before, an important source of cadmium in Seattle is the pipes themselves.

- Some household hazardous substances will still enter the waste stream, although educating the public and providing effective ways for people to dispose of household poisons could make a difference. Finally those treatments are kill all pathogenic organisms are expensive.
- Most agricultural use of sludge especially in the Northeast states has avoided use on crops for human consumption.
- Sludge is most commonly used on forage crops and grains grown for animals.\
- There are other restrictions placed on agricultural use by most jurisdictions, and examples will be given in the next section. That food crops could be most safely grown on sludge-amended soils is tree fruits and grains which are do not take up cadmium

6. EXPERIMENTAL PROGRAM

MIX DESIGN – M30

The steps involved in the design of concrete mix as per IS: 10262-2009 is a follows,

Stipulations for proportioning:
Grade designation: M30
Type of cement: OPC 53 grade confirming to IS 12269:1987
Maximum nominal size of aggregate : 20 mm
Exposure condition: Severe (for reinforced concrete)
Degree of supervision: Good

Minimum cement content: 320 Kg/m^3
Type of aggregate: Crushed angular aggregate
Maximum cement content: 450Kg/m^3
Workability: 25-50mm

Test data for Materials:

Cement used: OPC 53 grade confirming to IS 12269:1987

Specific gravity of cement = 3.12

Specific gravity of
Coarse aggregate: 2.8
Fine aggregate: 2.6

Target mean strength for mix proportioning

f_t =fck+1.65 S ft=30+1.65(5)=38.25N/mm^2

ft = Target average compressive strength at 28 days

fck = Character compressive strength at 28 days

S =Standard deviation (taken from Table1 of IS: 10262-2009) S=5

STEP-2: Selection of Water-cement ration:- From IS: 456-2000, Table 5 by taking severe exposure condition for M30 grade, the maximum water cement ratio is 0.45 W/C = 0.45

STEP-3: Selection of water content

From IS: 10262-2009, Table 2 depending upon the nominal size of aggregate (20mm), the maximum water content is 186 litres.

- ∴ . Maximum water content per cubic meter of concrete for 20mm aggregate is 186Kg (litres)

STEP-4: Calculation of cement content

The minimum cement content required for M30 as per IS:456-2000 of table is 320Kg/m^3 (Severe exposure condition)

W/C = 0.45

186/C = 0.45

C = 413 kg

Hence we obtained cement content as 437 Kg

But, we are approximating this value of cement =380Kg

W/C = 0.45

W/380 = 0.45

W = 171 kg

380Kg/m^3 > 320Kg/m^3, hence, OK

STEP-5: Proportion of volume of coarse aggregate and fine aggregate content

Volume of coarse aggregate = 0.65

Volume of fine aggregate = 1-0.65 = 0.35

STEP-6: Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

(a) Volume of concrete = 1m^3

(b) Volume of cement = Mass of cement/specific gravity of cement ×1/1000
= 380/3.15×1/1000
= 0.120

(c) Volume of water =Mass of water /specific gravity of water ×1/1000
= 172/1×1/1000
= 0.172

(d) Volume of all in aggregate = 1-(0.120+0.172)
= 0.708

(e) Mass of coarse aggregate= Volume of all in aggregate × Volume of coarse aggregate × Specific gravity of coarse aggregate ×1000
= 0.708 × 0.65 × 2.8 × 1000
= 1288.56

(f) Mass of fine aggregate = Volume of all in aggregate× Volume of fine aggregate × Specific gravity of fine aggregate ×1000
= 0.708×0.35×2.6×1000
= 644.28
=380: 644.28: 1288.56
1: 1.695: 3.391
Cement: F.A: C.A

Table Mix Proportion for M30

Cement Kg/m^3	Fine aggregate Kg/m3	Coarse aggregate Kg/m3	Water l/m^3
380	644.28	1288.56	186
1	**1.695**	**3.391**	**0.45**

MIX DESIGN – M40

he steps involved in the design of concrete mix as per IS: 10262-2009 is as follows,

Stipulations for proportioning:

Grade designation: M40

Type of cement: OPC 53 grade confirming to IS 12269:1987

Maximum nominal size of aggregate : 20 mm

Exposure condition: Severe (for reinforced concrete)

Degree of supervision: Good

Minimum cement content: 320 Kg/m^3

Type of aggregate: Crushed angular aggregate

Maximum cement content: 450Kg/m^3

Workability: 25-50mm

Test data for Materials:

Cement used: OPC 53 grade confirming to IS 12269:1987

Specific gravity of cement: 3.12

Specific gravity of

Coarse aggregate : 2.8

Fine aggregate : 2.6

STEP-1: **Target mean strength for mix proportioning**

ft =fck+1.65S

ft=40+1.65(5)=48.25N/m^2

ft = Target average compressive strength at 28 days fck = Character compressive strength at 28 days

S = Standard deviation (taken from Table1 of IS: 10262-2009), S=5

STEP-2: Selection of Water-cement ration

From IS: 456-2000, Table 5 by taking severe exposure condition for M40 grade, the maximum water cement ratio is 0.38W/C = 0.38

STEP-3: Selection of water content

From IS: 10262-2009, Table 2 depending upon the nominal size of aggregate (20mm), the maximum water content is 186 litres.

∴ . Maximum water content per cubic meter of concrete for 20mm aggregate is 186 Kg (litres)

STEP-4: Calculation of cement content

The minimum cement content required for M30 as per IS:456-2000 of table is 320Kg/m^3 (Severe exposure condition)

W/C =0.38 186/C = 0.38 C = 489 kg

Hence we obtained cement content as 489 Kg But , we are approximating this value of cement =400 Kg W/C 0.38W/400 = 0.38 W = 152 kg

400Kg/m^3 > 320Kg/m^3, hence, OK

STEP-5: Proportion of volume of coarse aggregate and fine aggregate content

Volume of coarse aggregate =0.63
Volume of fine aggregate = 1-0.63 =0.37

STEP-6: Mix calculations

The mix calculations per unit volume of concrete shall be as follows:\

(a) Volume of concrete

(b) Volume of cement = Mass of cement/specific gravity of cement ×1/1000

= 400/3.12×1/1000

= 0.128

(c) Volume of water = Mass of water /specific gravity of water ×1/1000

=152/1×1/1000 = 0.152\

(c) Volume of all in aggregate = 1-(0.128+0.152)

= 0.72

(d) Mass of coarse aggregate = Volume of all in aggregate ×Volume of coarse aggregate × Specific gravity of coarse aggregate× 1000
= 0.72 ×0.63 ×2.8 ×1000=1270.080

(f) Mass of fine aggregate = Volume of all in aggregate ×Volume of fine aggregate × Specific gravity of fine aggregate × 1000= 0.72 ×0.37 ×2.6 ×1000= 692.640

400: 692.640: 1270.080

1: 1.732:3.18

Cement: F.A: C.A

Table Mix Proportion for M40

Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water 1/m^3
400	692.64	1270.08	186
1	1.732	3.18	0.38

7. RESULTS

Table: Compressive strength of concrete with paper mill sludge for M30 & M40

Mix	Compressive Strength (N/mm^2)			
	M30 Grade		M 40 Grade	
	7 Days	28 Days	7 Days	28 Days
Control. Mix (C.M)	26.5	39.4	33.7	49.7
PST 1 (5%)	34.216	42.36	39.31	54.31
PST 2 (10%)	31.4	39.4	32.13	47.28
PST 3 (15%)	26.81	32.14	30.12	43.13

Table Compressive strength of concrete with Sewage sludge for M30 & M40

Mix	Compressive Strength (N/mm^2)			
	M30 Grade		M 40 Grade	
	7 Days	28 Days	7 Days	28 Days
Control. Mix (C.M)	26.5	39.4	33.7	49.7
SST 1 (5%)	32.15	41.926	37.2	52.13
SST 2 (10%)	27.07	39.55	30.35	45.28
SST 3 (15%)	13.18	35.106	28.21	40.31

Table Flexural strength of concrete with paper mill sludge for M30 & M40

Mix	Flexural Strength (N/mm^2)			
	M30 Grade		M 40 Grade	
	7 Days	28 Days	7 Days	28 Days
Control. Mix (C.M)	4.21	4.7	4.43	5.04
PST 1 (5%)	4.32	4.9	4.72	5.18
PST 2 (10%)	4.25	4.78	4.51	4.85
PST 3 (15%)	3.9	4.42	4.1	4.5

Table Flexural strength of concrete with Sewage sludge for M30 & M40

Mix	flexrural Strength (N/mm^2)			
	M30 Grade		M 40 Grade	
	7 Days	28 Days	7 Days	28 Days
Control. Mix (C.M)	4.21	4.7	4.43	5.04
SST 1 (5%)	4.28	4.82	4.63	5.09
SST 2 (10%)	4.01	4.62	4.42	4.81
SST 3 (15%)	3.7	4.3	3.93	4.2

Table Split Tensile Strength of concrete with paper mill sludge for M30 & M40

Mix	Split Tensile Strength (N/mm^2)			
	M30 Grade		M 40 Grade	
	7 Days	28 Days	7 Days	28 Days
Control. Mix (C.M)	2.53	3.32	3.8	4.7
PST 1 (5%)	3.876	4.71	5.21	7.1
PST 2 (10%)	3.216	4.206	4.97	6.01
PST 3 (15%)	2.933	3.828	4.21	5.32

Table Split Tensile Strength of concrete with Sewage sludge for M30 & M40

Mix	Split Tensile Strength (N/mm^2)			
	M30 Grade		M 40 Grade	
	7 Days	28 Days	7 Days	28 Days
Control. Mix (C.M)	2.53	3.32	3.8	4.7
SST 1 (5%)	3.876	4.71	5.21	7.1
SST 2 (10%)	3.216	4.206	4.97	6.01
SST 3 (15%)	2.933	3.828	4.21	5.32

8. CONCLUSIONS

The present work consists of testing prisms and cubes understand the development of compressive strength, stress-strain behavior of concrete with different percentages of fiber contents. Based on this work the following conclusions can be drawn.

- ❖ Compressive strength of concrete increased with the increase in percentage of glass fibers

- Of the three fiber contents, i.e., 0.03%, 0.06% and 0.09%, Specimen with 0.09% gave higher increase in strength than the other two.
- It is noted that improvement in strength and strain of GFRC specimen beyond ultimate strength increased with increase in fiber content.
- Strength of GFRC specimen with fibers used in outer shell and used in complete specimen has shown that, the strength of specimen is same as in both types. This may be due to the fact that the fibers in outer shell have contributed to confinement; also confinement effect can be realized only after reaching ultimate strength. Hence it can be concluded that fibers may be used only in outer shell.
- GFRC specimens have shown improved deformation capacity after reaching ultimate load. As the percentage of fiber increased, deformation, i.e. strain at breaking hasincreased.6. Ductility of concrete specimen increased by providing GFRC outer shell.
- A paper mill sludge and waste water sludge waste is suitable for the use in small amount of concrete mixes as a replacement for the cement, but it is not appropriate for large quantities.
- The productive use of a waste material represents a way of solving some problems of the solid waste management.
- The workability is decreased because of increase in paper mill sludge and waste water sludge.
- The paper industry waste can be innovative supplementary cementatious construction material but judicious decisions are to be taken by engineers.
- Compressive strength and split tensile strength and flexural strengths are increased up to 5% replacement of cement with paper mill sludge for M30 and M40 mix.
- Compressive strength and split tensile strength and flexural strengths are increased up to 5% replacement of cement with waste water sludge for M30 and M40 mix.
- The maximum optimum level of the replacement of paper mill sludge and waste water sludge with cement is 10%.
- Use of waste paper sludge in the concrete can save the pulp and paper industry disposal costs and produce a 'greener' concrete for construction.
- With increases in the waste paper sludge content, percentage water absorption increases.
- Use of waste paper sludge in concrete can prove to be an economical as it is non-useful waste and free of cost.

8. REFERENCES

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