Investigation on Mechanical Properties of Concrete Elements made with Partial Replacement of Cement with Card-Board Sludge

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Abstract - The rapid increase in the development of infrastructure has led to shortage of conventional materials such as cement, fine aggregate and coarse aggregate. Number of researches have started searching the alternatives for the above materials for better concrete . Now- a -days many artificial pozzalono's are found from researches such as blast furnace, slack, silica, fume, rice husk ash, fly ash etc. other than this the recent studies has shown that the waste from the card-board industries has pozzalonic properties termed as card-board sludge contains low calcium and minimum amount of silica. Card board sludge behaves like cement due to silica and magnesium properties.In this paper an attempt is made to investigate the mechanical properties of concrete elements made with M20 grade of concrete with water cement ratio 0.5 as a control specimen and card board sludge replaced in different percentages like 5% and 6% continued casting with a increase in the sludge percentage with addition of an admixture epoxy with 7.5% sludge and 0.5%of epoxy and 10% sludge and 1% of epoxy.Totally 30 cubes of dimension 15cmx15cm, 30 cylinders of dimension 15cm diameter and 30cm height and 30 beams of dimension 50cmx10cmx10cm on a overall count of 90 moulds were cast to study the properties and behavior of card board sludge in concrete. The test were conducted to study the mechanical properties of concrete such as Compressive strength, split tensile strength and flexural strength for 3 days, 7 days and 28 days.

I. INTRODUCTION

Concrete is basically made of cementitious materials which have to properly bind themselves together as well as with other materials to form a solid mass. Cement plays major role in the concrete. Cement manufacturing industries produces carbon dioxide during production of cement. To produce 1 ton of ordinary Portland cement we need about 1 to 1⅓ ton of earth resources like lime stone, etc. and from this manufacturing equal amount of carbon dioxide is released into atmosphere. Globally industry contributes 7% of green house effect gas emission to the earth's atmosphere. In order to avoid environmental effects associated with cement manufacturing and constantly depletion of natural resources, there is a need to find alternative binders to make concrete industry sustainable. Card board making industry produces large amount of solid waste. Card board sludge has properties like cement. To reduce disposal and pollution problems form these industrial waste, it is most important to develop profitable building materials from them keeping this in view, investigations were carried out to minimise the cost of production of concrete by adding paper waste with concrete mix and to determine the basic characteristics of the concrete such as compressive strength, flexural strength and split tensile strength and also to prepare mixes containing various proportioning.

II. OBJECTIVES OF THE STUDY

- To study cardboard sludge powder mixed with concrete.
- Conventional concrete (100% cement).
- Concrete made and mixed with cardboard sludge powder in various proportion. The hardening properties of the concrete mixed with cardboard sludge powder such as, Compressive strength, Split tensile strength, Flexural strength

2.1 SCOPE OF THE PROJECT

The scope of this work is to increase the mechanical strength of the concrete structure by in corporating cardboard sludge into it. The addition of paper sludge is carried out by four different proportions. Initially a concrete test specimen is mixed with cardboard. Then the cardboard sludge powder is taken in proportion with cement in two cases and two other with epoxy. Each proportion of concrete is tested two times with and without cardboard sludge powder in order to obtain average strength value of the concrete

III. LITERATURE REVIEW

Prof. Jayeshkumar Pitroda et.al (2013) have studied the properties of paper sludge. The Compressive strength reduces when cement replaced Paper sludge. As Paper sludge percentage increases compressive strength and split strength decreases. Use of Paper sludge in concrete can save the paper industry disposal costs and produces a 'greener' concrete for construction..This research concludes that Paper sludge can be innovative supplementary cementitious Construction Material but judicious decisions are to be taken by engineers.

sajad ahmad et.al (2013) studied on concrete involving use of waste paper sludge ash as partial replacement of cement concluded these 5% replacement of cement by waste paper sludge ash showed 10% increase in compressive strength at 7 days and 15% increase in compressive strength at 28 days. Splitting tensile strength decreases with increase in waste paper sludge ash content and is more than reference concrete at 5% replacement. Use of waste paper sludge ash in concrete can prove to be economical as it is non useful waste and free of cost.

abdullah shahbaz et.al (2014) experimentally tested on structural performance of concrete by partial replacement of cement with paper sludge (paper waste) concluded It is observed that in split tensile strength of M20 and M30 grade concrete. The strength of concrete has increased with 10% replacement of hypo sludge with cement as compare to conventional concrete and with 20% replacement it is slightly more or we can say it as equivalent but with 30% its start decreasing in strength. It is observed that in flexural strength of M20 and M30 grade concrete the strength of concrete has increased with 10% replacement of hypo sludge with cement as compare to conventional concrete and with 20% replacement it is slightly more or we can say it as equivalent but with 30% its start decreasing in strength

Yousuf (2014) experimentally studied on sustainable use of paper wastes (hypo sludge) in concrete mix design and obtained the following from the experiments, Compressive strength initially increases when cement replaced Paper sludge as we gradually increase the percentage from 0% up to 15%. As Paper sludge percentage increases compressive strength and split strength decreases after 15% replacement of cement. Use of Paper sludge in concrete can economize the paper industry by minimizing cost of disposal and forms a greener' concrete for construction. (Sajad Ahmad et. Al,2013)This research concludes that Paper sludge can be innovative supplementary cementitious Construction Material but judicious decisions are to be taken by engineers.

Lodhi Ravindra Singh et.al ,(2015) experimentally studied on paper waste in cement concrete. Concrete mixes containing 10% and 15% of paper waste, have shown an increase of 3.0% and 1.4% in compressive strength respectively when compared to control mix and there was a decrease of 1.9% on addition of 20% of paper waste

Mehtab Alam et.al (2015) investigated on experimental study on use of paper sludge in cement concrete. Experiments reveal that as the percentage of Paper sludge in the mix increases the slump decreases.

IV. MATERIALS USED

4.1 CEMENT:

Cement is the most important ingredient and acts as a binding material .Cement is obtained by pulversing clinkers formed by calcining raw materials primarily comprising of liming (CaO) , silica (SiO_2) , alumina (Al_2O_3) and ferric oxide (Fe_2O_3) along with some minor oxides. Joseph AspDin, a brick layer in England, developed Portland cement in 1824. Further development leads to the present form Portland cement exhibiting the variety of properties and suitable for variety of functional requirement of strength, durability, impermeability, and other dimensional constrains, cement when mixed with water forms a paste which sets and hardens under water and binds the aggregate together to produce a continuous compact mass. The characteristics behaviour of this concrete mass in a given condition depends on the type, quality and quantity of cement.

4.3 AGGREGATES:

Aggregate is an important ingredient of concrete since it occupies about 70-75% volume concrete, relatively cheap as its quality affects the durability and structural behaviour of concrete members. Its said that the strength of the concrete is the strength of its aggregate . its correct to considerable extent as this is the chief material that gives strength to the concrete. This statement also gives the idea about importance of aggregate in concrete.

But it must be added that a good aggregate will not ensure good concrete, the possible variation in grading, quality of cement, mixing and placing of concrete and its curing are various other factors and these may overweight the initial advantage presented by an unusually sound and strong aggregate.

4.4 FINE AGGREGATE:

Sand is an inert occurring material of size less than 4.75mm. It is used as a material of construction not only as filling and as a porous foundation blanket (As for roads) but also to a wide extent as a filtering medium and as

constituents of mortars and concrete.Locally available river sand conforming to grading zone-II as per IS:383-1970 was used. The sand was screened at site to remove deleterious materials. Sieve analysis and specific gravity test results of sand were given in table below.

4.2.2 COURSE AGGREGATE:

Aggregate of size more than 4.75mm, is called as coarse aggregate and is one of the most important ingredient of concrete. It gives strength to the concrete and constituents about 70 to 75 percent volume of concrete. Crushed stone in general used as coarse aggregate which is black in colour, angular and local name known as black metal or "gitti".

In the present study a locally available coarse aggregate from quarry was used. The specific gravity of coarse aggregate is given in table below,

4.5WATER:

Portable water was used for concrete.

4.6 CARDBOARD SLUDGE POWDER AND ITS COMPOSITION:

The waste from the cardboard industries is taken as a partial replacement material due to its cementitious properties and economic value.

SLUDGE PROPERTIES

- Cellulose fibre- 12%
- Alum-37%
- Lime-47%
- Silica-9.6%
- Magnesium-3.38%
- Alumina-4.32%

Fig 4.1 Sludge powder

4.5 EPOXY:

Epoxy resin has found a position in the concrete construction field because of its high compressive and tensile strengths as well as excellent adhesive properties. In recent years most of the applications have been in bonding concrete to concrete in repairing damaged or deteriorated construction. Therefore, studies and applications have been concentrated on its adhesive properties.

V. EXPERIMENTAL PROGRAM

5.1. Tests on cement and card-board sludge powder

The following experiments were conducted to find out the properties of cement as per IS-4031:1988,

i.Fineness of Cement

Fig. 5.1 90μ Sieve

ii. Consistency of Cement

iii. Initial and Final setting time of Cement

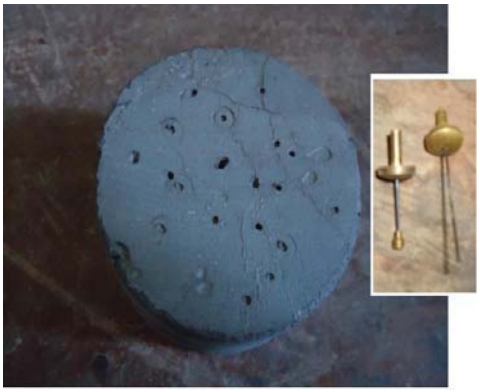

Fig. 5.2 Tested Cement Cube Along With Final & Initial Setting Time

iv. Specific gravity of Cement

Fig.5.4 Mortar cube

5.1.2. TESTS ON FINE AGGREGATE

The following experiments were conducted to find out the properties of fine aggregate as per IS-2386:1963,

i. Sieve Analysis

Fig.5.5 Fine aggregate Sieves

ii. Specific Gravity of Fine Aggregate

iii. Water absorption Test

5.1.3.TESTS ON COARSE AGGREGATE

The following experiments were conducted to find out the properties of coarse aggregate as per IS-2386:1963, Sieve Analysis

FRESH CONCRETE TESTS:

WORKABILITY TEST:

There is no unique test which can directly measure the workability. However, there are numerous methods of determining certain physical quantities which try to correlate workability to some extent. None of this methods is fully satisfactory although this provides useful guidance regarding various in workability with certain limits. Since the workability of concrete plays an important role in controlling of hardened concrete, its measurement and controlling is of great significance. Following are the methods of measuring workability.

Slump test

Fig 5.10 Slump Cone Test

1. Compaction factor
2. Vee bee consistometer.

5.3 HARDENED CONCRETE TESTS:

MOULDS PREPARED:

Fig 5.11 Cube, Cylinder & Beam Casted Element

5.3.1 COMPRESSIVE STRENGTH TEST:

This tests were carried out in accordance with IS 516-1999 standards conducted on concrete specimen size 150 mm x 150mm x 150mm. The specimens which are submerged in clean fresh water is taken out after 14 days and 28 days for testing and kept in dry place so that the water is drained well to get better results. The specimen is loaded in the compression testing machine as shown in figure. The load is continuously applied until it fails.

The compressive strength calculated by using formula

$$Fc = P / A$$

Where, Fc - compressive strength (N/mm^2)

P -ultimate load (N) and

A -loaded area (150 mm x 150 mm)

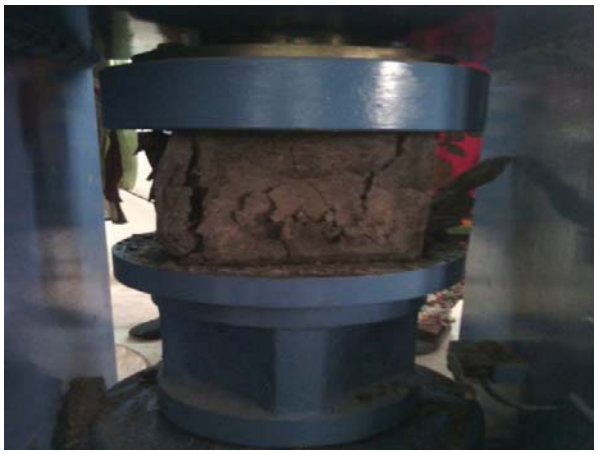

Fig 5.12 Compression Test On Cube Element

5.3.2 SPLIT TENSILE STRENGTH TEST:

Split tensile strength at 28 days of curing test of three 150 x 300mm cylinders is indirect measurement of tensile strength of concrete which were conducted according to the requirements of ASTM C496 [35]. In the split tensile strength test, cylindrical concrete specimen is placed on diametrical compressive force along its length. The load is applied continuously at a constant rate until failure of cylinder along its vertical diameter. To allow the uniform distribution of applied compressive load, strips of plywood are placed between the specimen and loading platens of the testing machine.
Splitting tensile strength of a specimen can be evaluated from below equation,

$fct = 2P/\pi DL$

Where, fct is tensile strength,
P is compression load at failure,
L is length of cylinder and d is diameter of the cylinder,

D is the diameter of the cylinder

Fig 5.13 Split Tensile Test On Cylinder Element

5.3.3 FLEXURAL STRENGTH:

Flexural strength at 28 days of curing test was conducted according to the requirement of ASTM C 1609 [33] using three 100 x 100 x 500 mm beams under third- point loading on a simply supported span of 400 mm. According to ASTM standard, the results of flexural strength test are interpreted by calculating flexural stress as following:

$R = PL/bd2$

Where, R is flexural strength (modulus of rupture).
P is maximum indicated load,

Fig 5.14 Flexural Test Test On Beam Element

x) MIX RATIO:

Cement: Fine Aggregate: Coarse Aggregate

394 :737.6 :1114.6

1 :1.87 :2.82

VI. TEST RESULTS

Table 10: Compressive Strength Of Cube Elements

S No	SPECIMEN	COMPRESSIVE STRENGTH (N/mm^2)		
		3 Days	7 Days	28Days
1.	control	12	22.85	27.75
2	5% of sludge	16.41	26.6	28.3
3	6% of sludge	15.8	22.2	26.2
4	7.5% of sludge& 0.5 of epoxy	8.8	14.2	19.17
5	10% of sludge& 1% of epoxy	16.67	25.2	27.2

S. No.	SPECIMEN	SPLIT TENSILE STRENGTH (N/mm^2)		
		3 Days	7 Days	28 Days
1.	control	1.1	1.6	2.3
2	5% of sludge	1.85	2.5	2.8

3	6% of sludge	1.2	2.2	2.5
4	7.5% of sludge& 0.5 of epoxy	1.1	1.6	1.8
5	10% of sludge& 1% of epoxy	0.28	0.42	0.6

S.No.	SPECIMEN	FLEXURAL TENSILE STRENGTH OF CYLNDER ELEMENT (N/mm^2)		
		3 DAYS	7 DAYS	28DAYS
1.	control	5.06	6.16	6.5
2	5% of sludge	1.9	3.3	3.6
3	6% of sludge	5.2	6.4	6.5
4	7.5% of sludge& 0.5 of epoxy	4	4.25	5.6
5	10% of sludge& 1% of epoxy	3.5	4.4	5.2

VII. CONCLUSION

- The maxmimum compressive strength obtained after 28 days of curing is 28.3 N/mm2 (5% of sludge) and 27.2 N/mm2(10% of sludge and1% of epoxy)
- The maximum split tensile strength obtained after 28 days of curing is 2.8 N/mm2 (5% of sludge) and 1.8N/mm2(7.5% of sludge and0.5% of epoxy)
- The maximum flexural strength after 28 days of curing is 6.5 N/mm2 (6% of sludge) and 5.6 N/mm2(7.5% of sludge and0.5% of epoxy)
- The use of cardboard sludge in concrete can reduce the harmful effects that it will cause to the environment in its disposal and hence it can be called as Green concrete.
- Workability of this concrete is lesser than the normal concrete and thus requires more water. 8. By using cardboard sludge powder the weight of the conctere is reduced.
- Environmental effects from wastes and residual amount of cement manufacturing can be reduced through this research.
- This concrete is highly flame resistance due to the presence of 37% of alum in it.

REFERENCES

[1] Prof. Jayeshkumar Pitroda et al, "Innovative Use Of Paper Industry Waste (Hypo Sludge) In Design Mix Concrete", Pitroda et al., International Journal of Advanced Engineering Technology ,E-ISSN 0976-3945, (2013)

[2] Sajad Ahmad et al, IUST Kashmir, "Study of concrete involving use of waste paper sludge ash as partial replacement of cement" IOSR Journal of Engineering vol.3, Issue 11(November, 2013).

[3] V. Mymrin, A.M.C. Ferreira, et. al. (September 2009). Paper production sludge application for producing of new construction materials. In: Symposium on Infrastructure Development and the Environment, September 2009, Bath, UK. pp. 6-9Concrete, Pitroda et al., International Journal of Advanced Engineering Technology ,E-ISSN 0976-3945

[4] "Structural Performance of Concrete by Partial Replacement of Cement with Hypo Sludge (paper waste)". International Journal of Emerging Technologies and Engineering (IJETE) volume 1 Issue 7, august 2014.

[5] . L Ravindra Singh et al. Int, Journal of Engineering Research and Applications, vol.5, Issue 4, (Part - 7) April 2015

[6] Y. Chun, T.R. Naik, and R.N. Kraus (July 11 – 13, 2005). Durable concrete through use of pulp and paper mill residuals, composites in construction. In: Third international conference, July 11 – 13, 2005, Lyon, France. pp. 6-9.

[7] R.S. Gallardo, Mary Ann Q Adajar, "Structural performance of concrete with paper sludge as fine aggregates partial replacement enhanced with admixtures," Symposium on Infrastructure Development and the Environment, University of the Philippines, December 2006.

[8] Ganesan K., Rajagopal K., Thangavelu K., "Effects of the Partial Replacement of Cement with Agro Waste Ashes on Strength and Durability of Concrete." Proc.of Internat. Conf. on Recent Adv. in Concrete a. Constr. Technol., organised by Dept. of Civil Engng , S.R.M. Engng. College, Chennai, Dec. 7-9, 2005.