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Structural behavior of ferrocement self compacting concrete using M-sand under axial and lateral pressure load

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ABSTRACT

Water Tanks are used for the collection and storage of water for drinking, washing, animal use, irrigation and agricultural purpose. The self -compacted concrete is an innovative product in the civil engineering field in India. M sand is produced by reducing large pieces of aggregate into sand-sized particles. An experimental program was designed in the current work to examine the structural behavior of ferrocement self-compacting concrete using M sand under axial and lateral pressure load. M sand is used in mixtures in an area where the natural sand is not available. The size of M sand is less than 4.75mm. The cost of construction can be controlled by the use of M and is the alternative material for construction. The ferrocement tanks have better corrosion resistance and they have lower maintenance costs than steel tanks. In this method of construction provides durable and high strength water tanks. The main objective of the project is studying the structural behavior of ferrocement self-compacting concrete using M sand under axial and lateral pressure load. The matrix was designed to have high strength, low water to binder ratio, flow characteristics and high durability. Depends a lot of factors, in SCC adding silica fume as a mineral admixture, gelinium as a chemical admixture and using M and is the alternative material for natural sand. In this present investigation, the structural behavior of the ferrocement tanks will be tested in terms of strength, cracking behavior and energy absorption.

Keywords— *Ferrocement, Self compacting concrete, Pressure load, Ferrocement tanks, Structural behavior*

1. INTRODUCTION

In many countries, ferrocement tanks are used for the collection and storage of water for drinking, washing, animal use, irrigation and agricultural purpose. Ferrocement tanks vary in capacity, size, and shape and they may be built by hand. They are usually cheaper than steel tanks or fiber reinforced plastic because of the high manufacturing cost of the other materials. M sand is produced by reducing large pieces of aggregate into sand-sized particles. M sand is used in mixtures in an area where the natural sand is not available. The size of M sand is less than 4.75mm. The cost of construction can be controlled by use of M sand is the alternative material for construction. The ferrocement tanks have better corrosion resistance and they have lower maintenance costs than steel tanks. In ferrocement tank, large amounts of small diameter mesh uniformly distributed within the concrete section are used these lead to provide a very efficient and simple form of crack control. Additionally, a number of researches investigated a method for strengthening and repairing of concrete reinforcement tanks that depend on using ferrocement technic. From their results, it was concluded that this method of construction provides durable and high strength water tanks. The main objective of the current research is studying the structural behavior of ferrocement self-compacting concrete using M sand under axial and lateral pressure load. The matrix was designed to have high strength, low water to binder ratio, flow characteristics and high durability. In the current paper, ferrocement tanks different in the reinforcement system were designed, constructed and tested under pressure loads.

2. REVIEW OF LITERATURE

Y. Shaheen, F. Aboul-Ella, "Structural performance of ferrocement tanks under pressure loads" This paper makes the study of Ferro cement tanks two types of Ferro cement tanks (RT1, RT2) internal dimensions are 800mm*800mm*400mm. wall and footing thickness 40mm and 70mm.silica fume used as a partial replacement for cement. Polypropylene fibres are added in mortar mix. Using welded mesh and expanded mesh, Steel wire meshes used under tensile load. The result from the paper is highest mechanical properties of welded wire mesh compare with expanded wire mesh.

Y. B. I. Shaheen, A. A. Elsayed, "Design and construction of Ferro cement water tanks'' This study deals with the Ferro cement is a type of thin wall reinforced concrete construction. ferrocement has better corrosion resistance and lower maintenance

cost than steel .the developed Ferro cement tanks is four times cheaper than the other constructed tanks. The optimum displacement of cement with silica fume was found to be 15%.major significance qualities of the Ferro cement, low consumption of materials, easy to be repaired, good behaviour to cracking, it can be prefabricated.

Prajapati Krishnapal, Chandak, Rajeev and Dubey Sanjay Kumar, "Development and properties of self-compacting concrete mixed with fly ash" The main purpose of this paper is the development and properties of SCC mixed with fly ash. Addition of fly ash in SCC increases filling and passing ability of the concrete. Increases flash, super plasticizers content in SCC reduce the water demand and compressive strength of the concrete.

M. B. Varma, M. B. Hajare, "Ferrocement: Composite material and its applications" In this paper, mostly four types of meshes used in the construction, hexagonal (or) chicken mesh, welded wire mesh, expanded wire mesh, woven wire mesh. Ordinary Portland cement (OPC) is used, application of Ferro cement are, floating marine structure, maintenance, and repair of decorating structure, water tank construction. Ferro cement is an important alternative for RCC and repair material in future, the performance of the Ferro cement depends on the properties of reinforcing mesh, it is the suitable material for repairing the defective RCC structural element to increases their performance.

Hardik Upadhyay, Pankaj Shah, Elizabeth George, "Tesing and mix design method of self-compacting concrete", this paper is discussed about the testing and mix design of SCC. Testing of SCC is passing and filling ability. The name of the testing is Slump Flow test, V-Funnel test, U-Box test.mix design is the concept of Japanese based on the method. Coarse aggregate content is fixed at 50% of the solid volume, fine aggregate content is fixed at 40% of the mortor volume. Water power ratio is depending on the properties of the powder. suoerplasticizers dosage and the final water powder ratio are determined as to ensure the self-compact ability.

N. Nandhinishree, N. Saravanakumar, "Structural behavior of self-compacting concrete confined with ferrocement under axial compression", this paper is discussed about the structural behavior of SCC confined with ferrocement under axil compression, the material used for this cement, aggregate, water, super plasticizers, reinforcement, and silica fume. Mix design of SCC aggregate size is below 12.5mm using 10mm aggregate, normally SCC means fine aggregate is more than the coarse aggregate. The result of this paper is the experiment SCC made by using silica fume as a mineral admixture, SCC with 10% replacement of cement with silica fume is given a good result both in compression and tension.

Paratibha Aggarwal, Rafat Siddique, Yogesh Aggarwal. "Self-compacting concrete-procedure for mix design", this paper is discussed about the procedure for the design of SCC. The test result for SCC is Slump cone test, v-funnel test, u-box test. Compressive strength at the ages of 7, 28, and 90 days these results are included in the paper. The test result range of slump cone test is 500-700mm, v-funnel filling ability range is 6-12 sec, u-box passing ability range is >8. The result of this paper is they do many trial method of procedure for mix design but they could not be satisfied the trial methods of SCC mix design. We do more trial and error method means the range will be satisfied somewhere.

Virendra Kumar Paul, Salman Khursheed, Siddhant Jain, "Benefit cost analysis of self-compacting concrete over conventional reinforced cement concrete", which talks about the advantage and disadvantage of SCC, the process of selection of SCC, finally the result was helped using SCC is better than convention concrete. The benefit like reduction in noise, improved durability, thinner concrete sections, and faster construction. In some places, convention concrete is difficult to pour like edges. In that place, SCC is very easy to pour. So, SCC is better than convention concrete.

Manish Hajare, Dr. M.B. Varma,"Flexural behavior of ferrocement panels with different types of meshes", this paper talks about the effects of different types of meshes select the best and suitable mesh for future work. Ferrocement ingredients are cement, sand, water and Reinforcing mesh. Based on the tested of ferrocement panels. The two tested panels are a Flexural strength at cracking load and flexural strength at ultimate load. The result of the paper is the ferrocement panels with weld mesh is the better tendency to tank load than the other two types of mesh.so, weld mesh is used for the ferrocemnt panel it gives the good result for future experimental work.

Sabarish K V, Partheeba paul, S.Gowtham, "Utilization of M sand as a partial replacement for fine aggregate in concrete elements", in this paper, An experimental result shows the quality of M sand is the better than the natural sand. M sand particles are cubical in shape, finely graded, and it provides greater durability. It can be eonomical as a construction material as a river (or) natural sand. Finally, the result was, the curing method of compressive strength, split tensile strength of concrete with 50% substitute of natural sand by using M sand as a higher strength to the concrete. The result of this paper, From 7 and 28 days the rates of strength development have been found to similar for control without M sand concrete.

3. METHODOLOGY

3.1 General

The Methodology is the general research strategy that outlines the way in which research is to be undertaken and, among other things, identifies the method to be used in it. These Method described in the methodology define the means or modes of data collection or, sometimes, how a specific result is to be calculated. Methodology does not define specific method, even though much attention is given to the nature and kinds of processes to be followed in a particular procedure or to attain an objective. The methodology also define the modes of data collection is a constructive framework and as a final step the specific result is to be calculated.

Thus, the discussion for Ferrocement self-compacting concrete in a detailed manner (Naveen kumar and Murali, 2018). Figure 3.1 and figure 1 represents the methodology adopted in the entire study and methodology during phase-I duration respectively.

3.2 Literature study
A literature review summarizer a familiarity with a body of knowledge and establisher the benefits of the work.

3.3 Collection of materials
The collection of the material such as Cement, Fine aggregate, and Coarse aggregate from manufacture place in Coimbatore. And then collecting the mineral admixture (silica fume) and the chemical admixture (genilium) at civil doctor shop in vadakovai, Coimbatore.

4. PREPARATION OF MIX DESIGN
The mix design was prepared with the help of "Specification and guidelines for self-compacting concrete" (2002), EFNARC**.** For self-compacting concrete there is no detailed standard mix design. The mix design was prepared with the help of EFNARC "Specification and guidelines for self-compacting concrete" (2002). And do more and more trial and error method.

Volume of paste	-	300 - 380
Powder content (cement)	-	380 – 600
Water content	-	150 – 210
Fine aggregate in percentage	-	48 – 55
Size of coarse aggregate	-	< 20mm using (7.5mm – 10mm)

Based on this EFNARC "specification and guidelines for self-compacting concrete". From the literature study, done more and more trial and error method. Finally the fifth trial and error method was proved it is self-compacting concrete.

First Trial And Error Method = 32 sec
Second Trial And Error Method = 26 sec
Third Trial And Error Method = 22 sec
Fourth Trial And Error Method = 15.5 sec
Fifth Trial And Error Method = 10.5 sec

5. FLOW PROPERTIES TEST
The self-compacting concrete properties is filling, passing and flowing ability of L-box, U-box and V-funnel.

5.1 L-box
The L-box test is used to assess the passing ability of self-compacting concrete to flow through tight obstructions without segregation or blocking.

5.1.1 Principle: The method aims at investigating the passing ability of SCC. It measures the reached height of fresh SCC after passing through the specified gaps of steel bars and flowing within a defined flow distance. With this reached height, the passing or blocking behavior of SCC can be estimated.

Fig. 1: L-Box

5.1.2 Result

The blocking ratio H2/H1 is = 10.1/12
= 0.84

5.2 U-box
U Box test is used to measure the filing ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments an opening with a sliding gate is fitted between the two sections.

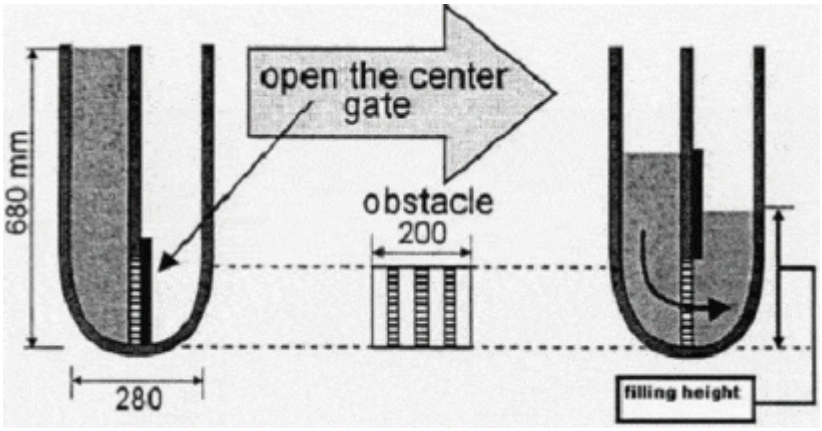

Fig. 2: U-box

5.2.1 Result

The H1-H2 of self-compacting concrete is = 28.2-27.3
= 0.9cm

5.3 V-funnel

The equipment consists of V-shaped funnel section is also used in Japan. The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm.

5.3.1 Principle: The V-funnel flow time is the period a defined volume of SCC needs to pass a narrow opening and gives an indication of the filling ability of SCC provided that blocking and/or segregation do not take place; the flow time of the V-funnel test is to some degree related to the plastic viscosity.

Fig. 3: V Funnel

5.3.2 Result

The flow time of self-compacting concrete = 10.5 sec

6. MECHANICAL TESTING

6.1 Compressive strength for 7th day testing

$$Compressive\ strength\ =\ Load/Area$$

$$Cube\ =\ 150 \times 150 \times 150$$

Cube =22500 mm2

Table 1: Compressive strength for 7th day testing

Cube	Weight of the cube	Load applied	Compressive strength
1	8.20	410	18.22
2	8.4	440	19.55
3	8.32	420	18.66

Average = 18.81 N/mm2

6.2 Compressive strength for 28th day testing

$$Compressive\ strength\ =\ Load/Area$$

$$Cube\ =\ 150 \times 150 \times 150$$

Cube =22500 mm2

Table 2: Compressive strength for 28th day testing

Cube	Weight of the cube	Load applied	Compressive strength
1	8.5	700	31.11
2	8.56	730	32.44
3	8.49	710	31.55

Average = 31.70 N/mm2

7. CONSTRUCTION OF MODEL TANK

The current experimental program concluded casting and testing of ferrocement tanks. The dimensions of ferrocement tanks are 800x800x400mm and their wall and footing thickness are 40mm and 70mm respectively.

7.1 Wire meshes (using welded wire mesh)

Two types of steel wire meshes welded and expanded wire meshes were used. From the literature study, using welded wire mesh for construct the model tank because compare to expanded wire mesh the welded wire mesh is better performance. So, using welded wire mesh in the model tank.

7.2 Construction process

- The steel reinforcement was prepared by their required dimension
- A wooden mold was manufactured and it consists of two parts. The first part was used to construct the tank base and the second part was used to construct the tank walls.
- Initially the steel reinforcement was fix in one place, the first part of the wooden mold was fix in the exterior side of the steel reinforcement. And the second part of the wooden mold was inserted interior side of steel reinforcement.
- The mix design for self-compacting concrete was already prepared for construct model tank. The concrete was porous into in between the exterior and interior wooden mold.
- After finished the concrete work, the water was sprinkled twice a day for curing purpose or the model tank were covered using a wet cloth. The model tank were stored in the laboratory atmosphere until testing after 28 days.

(a)

Fig. 4: (a) Reinforcement work

(b)

Fig. 4: (b) Welded wire mesh

(c)

Fig. 4: (c) Completed reinforcement work

(d)

Fig. 4: (d) Concrete filling side wall

(e)

Fig. 4(e) Constructed model tank

8. TEST ON SPECIMEN

8.1 Strength and quality of concrete using rebound hammer

Procedure

- Check the rebound hammer against the testing anvil, and conform the reliability of result.
- Measure the dimension of the specimen and mark grid lines on the smooth face of the specimen. Before marking the grid remove all loose adhered scales by using grinding wheel or stone.
- Rough surface resulting from incomplete compaction, loss of grout, spalled or tooled surfaces do not give reliable result and should be avoided
- Hold the rebound hammer perpendicular to the concrete surface and depress the hammer by applying a gradual increase in pressure until it impacts should be at least 20mm away from any edge or shape discontinuity.
- Find the average of the rebound index after deleting outliers as per IS 8900: 1978. Interpreter the concrete strength using calibration chart.

Fig. 5: Rebound hammer test

8.1.1 Tabulation and Calculation

Size of specimen	Rebound Number- Observed	Average	Compressive strength (N/mm2)
800×800×400 mm	22 24 24 24 22	23.2	23.2
800×800×400 mm	28 28 28 28 26	27.6	27.6
800×800×400 mm	24 26 22 30 28	26	26
800×800×400 mm	32 28 32 34 30	31.2	31.2
800×800×400 mm	28 26 28 26 28	27.2	27.2
800×800×400 mm	28 28 28 30 26	28	28

Average = 32.64 N/mm2.

Result

The compressive strength of the given specimen is = 32.64 N/mm2.

8.2 Strength and Quality of Concrete Using UPV Tester

8.2.1 Procedure

- Remove the wet cured test specimen from wet storage and keep it in the laboratory atmosphere for about 24 hours before testing. Since presence of moisture content of concrete increase the pulse velocity the specimen shall be tested under dry condition.
- In order to ensure proper acoustical contact the surface of the specimen shall be smoothened by removing loose adhered scales and also use coupling medium such as petroleum jelly, grease, liquid soap and kaolin glycerol paste on the surface of specimen.
- Switch on the testing instrument which contains electrical pulse generator, transducer, amplifier and electronic timing device. Then set the mode and feed the measured path length. Now the instrument is ready.
- Place the transducer on one place of the cube and place the receiver on the other side such that both transducer and receiver are in one line. This is called as cross probing or direct transmission.
- Now press the start button in the instrument, after few seconds the velocity of the pulse and time taken is displayed in the electronic display.
- Now calculate pulse velocity and compare with velocity criterion for concrete quality grading specified in the table 2 of IS 13311(part I) and grade the concrete as excellent, good, medium, doubtful.
- In case of "doubtful" quality it may be necessary to carry out further tests.

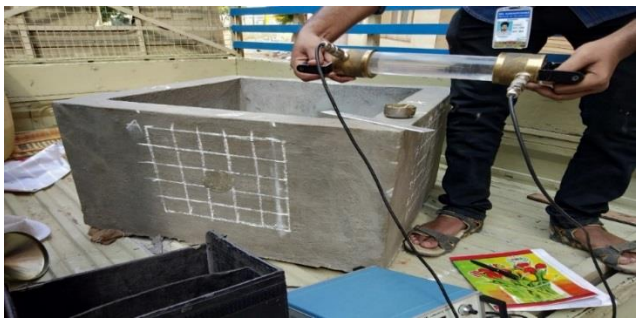

Fig. 6: UPV test

8.2.1 Tabulation and Calculation

Size of specimen	Length of specimen (L) mm	Actual transit time (Sec)	Pulse velocity (V=L/T)mm/sec
800×800×400 mm	400	24.6	16.26
800×800×400 mm	400	22.8	17.54
800×800×400 mm	400	31.5	12.69
800×800×400 mm	400	26.3	15.20

Average = 15.42 mm/sec

Result

The in situ strength of concrete specimen is **Excellent.**

9. RESULT AND DISCUSSION

Experimental result of tested tank with the objective of structural behavior of ferrocement self-compacting concrete using M-sand under axial and lateral pressure load. From the literature review, using ferrocement self-compacting concrete can be more effective than conventional concrete is observed. I have tested and constructed model tank with the ferrocement self-compacting concrete. From the test result, I conclude that ferrocement self-compacting concrete is better behavior than the conventional concrete.

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