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STUDY OF DURABILITY PROPERTIES OF HOLLOW CIRCULAR TUBULAR SECTIONS WITH AND WITHOUT FRP

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ABSTRACT:

The present work deals with the evaluation of both fully and partially concrete filled FRP tubes to attain the durability of the specimens. To achieve this, preliminary tests was done to evaluate the properties of the materials used. From these material properties, mix design has been made. Here, two grades of concrete mixes were used (i.e.; M20 and M25). With these mixes, conventional concrete cylinders were made. After 28 days of curing the axial compressive strength was found out. Fully and partially concrete filled FRP tubes were made with the same concrete mixes. Partially concrete filled FRP tubes have centrally placed PVC pipes with different diameters. After 28 days of curing of concrete filled FRP tubes, durability tests were found out and they were graphically presented from that the compressive strength of the concrete cylinders were reduced.

KEYWORDS: Acid attack test.

I. INTRODUCTION:

There is a great appeal for columns and piles to be constructed using more durable materials in correlate to traditional construction materials. The contemporary products have to withstand destructive corrosive environments, such as the splash zone in the case of marine piles. Correspondingly, bridge columns have to possess their structural integrity in cold regions where salt is used for de-icing roads. One auspicious inventive structural system is concrete-filled Fibre Reinforced Polymer (FRP) tubes, which provide many unique advantages. The FRP tube serves as a stay-in-place structural formwork to accommodate the fresh concrete, which may save the costs of formwork and labour used by cast-in-place or pre- cast industries. In the meanwhile, the FRP tube acts as a non-corrosive reinforcement for the concrete for flexure and shear. More basically, the FRP tube arrests the concrete in compression, which somewhat enhances the strength and ductility. The FRP tubes which are filled with concrete are effective in facing the great appeal for non-corrosive and durable piles, power transmission poles, highway overhead sign structures and bridge components.

Concrete-filled steel tubes have been utilized for years as piles and columns. Abundant researches has been established in this direction [Furlong 1967, Knowles and Park 1969, and Kilpatrick and Rangan 1997]. It should be noted, nonetheless, that in addition to the rusting problems of steel tubes, the confinement capability is reduced at low levels of loading if the tube is loaded in the axial direction. This is associated to the evidence that Poisson's ratio of concrete at low levels of loading, 0.15 to 0.2, is lesser than the 0.3 assessment of steel [Prion and Boehme 1994 and Wei et al 1995]. On the other hand, Poisson's ratio of FRP tubes can be controlled through selected design of the laminate structure to provide more confinement effect [Shahawy and Mirmiran 1998].

The confining pressure affords by steel tubes is limited to a constant value once the tube yields, whereas FRP tubes affords a stable increasing confining pressure, which adds to both the ultimate confined strength and ductility [Samaan 1998].

For practical reasons, FRP tubes which are filled with concrete are used to carry axial compression loads and may also be designed to combat the case of implementing bending moments. Most of the reported experimental and analytical research in the area of concrete confinement using FRP [Mirmiran et al 1998] included FRP tubes totally filled with concrete and the fibres were mainly oriented in the hoop direction to provide maximum stiffness and strength for confinement. Other studies treated, that the case of applying the axial load to the concrete core only for an optimum use of the FRP tube in the hoop direction for confinement [Mirmiran and Shahawy 1997]. In such case, slip could take place between, the concrete and the outer tube, and consequently the member cannot resist bending. Arresting of concrete cylinders which are encased with FRP sheets and subjected to axial loading conditions was also studied by other researchers [Nanni and Bradford 1995 and Picher et al 1996]

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2 MATERIALS AND PROPERTIES:

2.1 CEMENT:

Cement acts as a dominant role in concrete. One of the important criteria tricalcium aluminate (C_3A) content, tricalcium silicate (C_3S) content, dicalcium silicate (C_2S) content etc. It is also necessary to ensure the compatibility of chemical and mineral admixtures with cement.

In this study, Zuari Cement of 53 grade Ordinary Portland Cement conforming to IS: 12269–1987 is used for the entire work. The cement was purchased from single source and was used for casting of all specimens. The physical properties of the cement are furnished in Table No.1

Table 1 Physical properties of the cement

S.No	Characteristics	Test Results	Requirements as per IS 12269 - 1987
1	Fineness (retained on 90-μm sieve)	6%	<10%
2	Normal Consistency	33%	--
3	Initial setting time of cement	90 min's	30 minutes (minimum)
4	Final setting time of cement	340 min's	600 minutes (maximum)
5	Expansion in Le-chatelier's method	4 mm	10 mm (maximum)
6	Specific gravity	3.15	3.10 – 3.25

2.2 FINE AGGREGATE:

The natural sand taken for this investigation is the local natural river sand. It was collected and cleaned for impurities, so that it is free from clayey matter, salt and organic impurities. Particles passing through IS sieve of 4.75 mm conforming to grading zone-II of IS: 383-1970 were used in this work. Properties such as gradation, specific gravity, fineness modulus, bulking, and bulk density had been assessed. The physical properties of sand are furnished in Table 2.

Table 2 Physical properties of the Fine Aggregate

S.No.	Tests Conducted	Results Obtained		Permissible Limits as per IS 383-1970
1	Specific gravity	2.67		2.5 to 3.0
2	Fineness modulus	3.05		--
3	Bulk density	Loose State	1450 kg/m³	1400 to 1750 kg/m3
		Compacted State	1520 kg/m³	
4	Water absorption (%)	1.09		Max 3%
5	Sieve Analysis	Zone – II		--

2.3 COURSE AGGREGATE:

Locally available machine Crushed angular granite, retained on 4.75mm I.S. Sieve of maximum size of 20mm confirming to I.S: 383-1970 was used in the present experimental investigation. It should be free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is tested for its various properties such as specific gravity, fineness modulus, elongation test, flakiness test, sieve analysis, bulk density in accordance with in IS 2386 – 1963. The physical properties of Coarse Aggregate are furnished in Table 3.

Table 3 Physical properties of Coarse Aggregate

S.No.	Tests Conducted	Results Obtained		Permissible Limits as per IS 383-1970
1	Specific gravity	2.78		2.5 to 3.0
2	Fineness modulus	7.52		--
3	Bulk density	Loose State	1480 kg/m³	1400 to 1750 kg/m3
		Compacted State	1560 kg/m³	
4	Water absorption (%)	1.09		Max 3%
5	Flakiness Index	7.52		--
6	Elongation Index	20%		Max 25%

2.4 WATER:

Water which is used for mixing and curing should be clean and free from injurious quantities of alkalies, acids, oils, salts, sugar, organic materials, vegetable growth (or) other substance that may be deleterious to bricks, stone, concrete, or steel. Convenient water is generally considered satisfactory for mixing.

Water acts as a lubricant for the fine and coarse aggregates and acts chemically with cement to form the binding paste for the aggregate and reinforcement. Less water in the cement paste will yield a stronger, more durable concrete; adding too much water will reduce the strength of concrete and can cause bleeding. Impure water in concrete, effects the setting time and causes premature failure of the structure. To avoid these problems quality water must be selected in construction works and PH value of water should be not less than 6. And also Quantity of water to be taken is important

2.5 FIBRE REINFORCED POLYMER:

FRP composite is a two phased material. It consists of fibre and matrix, which is bonded at interface. Each of these different faces, has to perform its required function based on mechanical property, so that the composite system performs satisfactorily as a whole. Here the reinforcing fibre provides FRP composite with strength and stiffness, while it gives rigidity and environmental protection.

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2.6 MIX PROPORTIONS:

Table 4 Quantities of Ingredients per Cum of M20, M25 Grade Concrete

Concrete	Cement (Kg)	Water (Lit)	Fine Aggregate (kg)	Coarse Aggregate (Kg)
M 20	330	180	744	1212
M 25	340	170	662.4	1183

3 EXPERIMENTAL INVESTIGATIONS:

3.1 CONCRETE MIX PREPARATION:

Design of concrete mix requires complete knowledge of various properties of the constituent materials. Initially the ingredients such as cement and fine aggregate were mixed, to which the coarse aggregate are added followed by addition of water and thoroughly mixed. Prior to casting of specimens, workability is measured in accordance with the code IS 1199-1959 by slump cone test

3.2 DURABILITY TEST:

In the present experimental investigation, Acid attack test was performed on concrete cylinders of size 150mm x 300mm were cast and then the specimens were kept for curing in water for 28 days. After completion of 28 days of curing, the specimens were taken out and allowed to sun dried for one day. Weights of the cylinders were taken.

For acid attack, 5% of dilute sulphuric acid (H_2So_4) by volume of the water is taken. After that, cylinders were immersed in the above said acid water for a period 28 days and then taken out and allowed to dry for one day. Weights of the cubes were taken and tested for compressive strength.

The mass loss due to depreciation of concrete was calculated after 28 days of immersion by using the following formula

$$\text{Mass loss} = \left[\frac{(M_i - M_f)}{M_i}\right] \times 100$$

where,

M_i = Initial mass of concrete specimen before immersion

M_f = Final mass of concrete specimen after immersion

4 RESULTS AND DISCUSSIONS:

4.1 TEST RESULTS FOR M20 GRADE OF CONCRETE:

4.1.1 ACID ATTACK TEST:

From the Fig 1 & fig.2, The Loss of Weight (%) is minimum for Concrete with FRP Shell with central hole diameter of 75mm when compared to Concrete with PVC Shell. It can also be observed that Concrete with FRP Shell with central hole diameter of 75mm has lesser percentage Loss of Compressive Strength compared to others

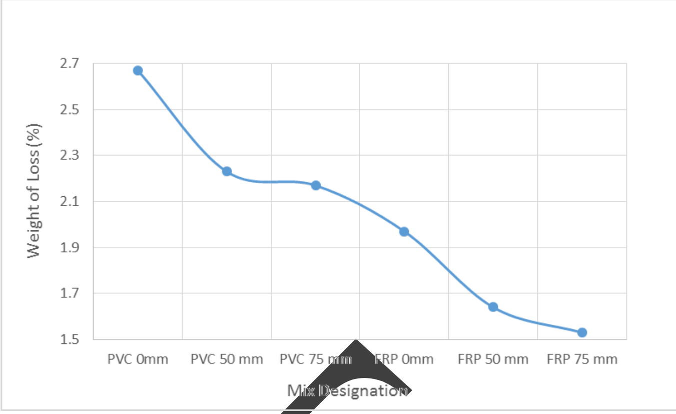

Fig.1. Comparison of Loss of Weight (%) of M20 Grade of Concrete with FRP Shell and with PVC Shell with Central Holes with diameter 50mm & 75mm

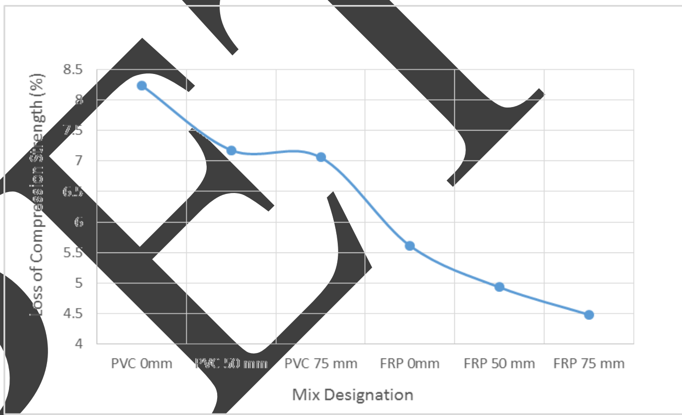

Fig.2 Comparison of Loss of Compressive Strength (%) of M20 Grade of Concrete with FRP Shell and with PVC Shell with Central Holes with diameter 50mm & 75mm

4.2 TEST RESULTS FOR M25 GRADE OF CONCRETE:

4.2.1 ACID ATTACK TEST:

From the Fig 3 & 4, The Loss of Weight (%) is minimum for Concrete with FRP Shell with central hole diameter of 75mm when compared to Concrete with PVC Shell. It can also be observed that Concrete with FRP Shell with central hole diameter of 75mm has lesser percentage Loss of Compressive Strength compared to others.

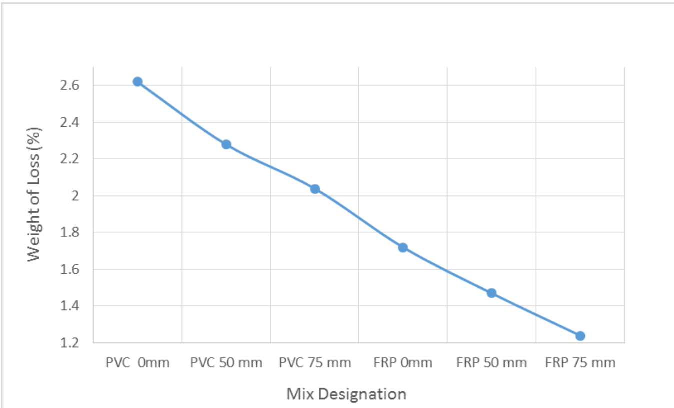

Fig.3 .Comparison of Loss of Weight (%) of M25 Grade of Concrete with FRP Shell and with PVC Shell with Central Holes with diameter 50mm & 75mm

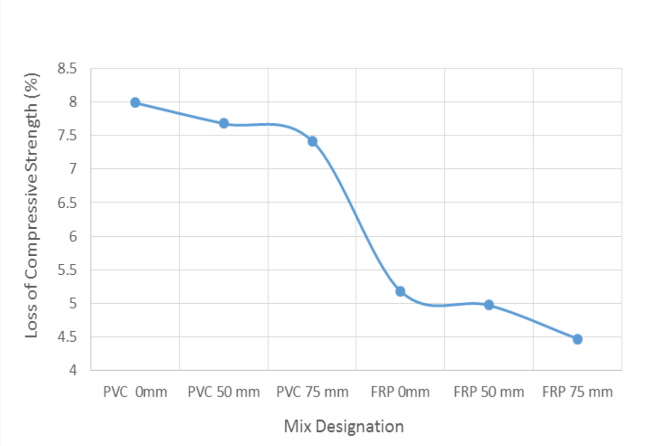

Fig .4 Comparison of Loss of Compressive Strength (%) of M25 Grade of Concrete with FRP Shell and with PVC Shell with Central Holes with diameter 50mm & 75mm

5 CONCLUSIONS:

1. Totally filled FRP tubes provide the most effective confinement. Although an inner hole offers material saving and reduced self-weight, it reduces the confinement effect, even though, high level of ductility is maintained.
2. Compared with conventional concrete cylinders, FRP tubes filled with concrete attains a compressive strength, which is 87 % higher that of conventional concrete cylinders
3. Strength and ductility are greatly improved by filling the tubes with concrete. FRP tubes were more efficient than steel tubes in this regard.
4. Concrete in the compression zone is partially confined as evident by the lateral tensile strains measured on the shell.
5. If the hole is maintained by an inner PVC pipe, the confinement effectiveness is improved and could approach that of a totally filled tube
6. For M20 & M25 Grade of Concrete, The Loss of Weight (%) is minimum for Concrete with FRP Shell with central hole diameter of 75mm when compared to Concrete with PVC Shell. It is also observed that Concrete with FRP Shell with central hole diameter of 75mm has lesser percentage Loss of Compressive Strength compared to others

REFERENCES:

1) Mirmiran, Amir "*Concrete Composite Construction for Durability and Strength,"* Symposium on Extending Life span of Structures, International Association for Bridge and Structural Engineering (IABSE), San Francisco, CA, Aug. 1995, pp. 1155-1160.
2) Slusarek.J, Kostrzanowska.A, *"Durability and repair problems of reinforced concrete columnar structure",* Accepted on 18.02.2010 in Architecture civil engineering environment
3) Mirmiran, A., Shahawy,M, M., Michel, S.(1998), El Echary,H.,Mastrapa, J.C., and Pico, O. *"Effect of Column Parameters on FRP-Confined Concrete".* Journal of Composites for Construction, ASCE, Vol.2, No.4, Nov., pp. 175-185.
4) Robert, M. and Fam, A. *Filled with Concrete and Subjected to Salt Solution."* J. Compos. Constr., 16(2), 217–224(2012). "Long-Term Performance of GFRP Tube
5) Kilpatrick, A. E. and Rangan B. V. "*Tests on High-Strength Composite Concrete Columns*," Research Report No. 1/97, School of Civil Engineering, Curtin University of Technology, Perth, Western Australia, March 1997.
6) Kilpatrick, A. E. and Rangan B. V. "*Deformation-Control Analysis of Composite Concrete Columns,"* Research Report No. 3/97, School of Civil Engineering, Curtin University of Technology, Perth, Western Australia, July 1997
7) Knowles, Robert B. and Park, R. "*Strength of Concrete Filled Steel Tubular Columns,"* Proceedings of the ASCE, Vol. 95, No. STI2, Dec. 1969, pp. 2565-2587
8) Mirmiran, Amir and Shahawy, Mohsen "*A new concrete-filled hollow FRP composite column,"* Composites Part B: Engineering, Special Issue on Infrastructure, Elsevier Science Ltd., Vol. 27B, No. 3-4, June 1996, pp. 263-268.
9) Picher, F., Rochette, P., and Labossiere, P. "*Confinement of Concrete Cylinders with CFRP,"* Proceeding of the First International Conference on Composites in Infrastructure (ICCI'96), Tucson, Arizona, Jan. 1996, pp. 829-841
10) Samaan, M., Mirmiran, A., and Shahawy, M. *"Model of Concrete Confined by Fiber Composites,"* Journal o/Structural Engineering, Sept. 1998, pp. 1025-1032
11) Rizkalla.S, Lucier.G, Daud.M, "*Innovative use of FRP for precast concrete industry*", American Concrete Institute Farmington Hills,USA.
12) Guades. E, Aravinthan.T, Islam. M, "*An overview on the application of FRP composites in piling systems*", Southern Region Engineering Conference 11-12 November 2010.

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