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AN EXPERIMENTAL STUDY ON POLYMER IMPREGNATED CONCRETE USING STEEL WIRE MESH

*[1]Dr. G.B. Ramesh Kumar, [2]V Rishab Narayanan

ABSTRACT--*In general, there are many materials are available for enhancing the strength of the concrete. Partially polymer is used for improving the strength, but it is not commonly used. There are many researches has done for better improvement the strength of concrete by using polymer. The study inspects the compressive strength, flexural strength and split tensile strength of M20, M40, M60 with polymer impregnated concrete and steel wire mesh there will be a comparison between PCC (Plain cement concrete), (PCC, steel wire mesh and Polymer Impregnated Concrete). Polymer impregnated concrete is obtained by introducing monomer in concrete by socking at atmospheric pressure. The monomer will be replaced in air voids of concrete. Ferrocement is the combination of mortar and steel wire mesh to improve the strength of the concrete the steel wire is used. The test done in two stages of the cube, prism and cylinder conducted in 7 days and 28 days and water cement ratio is taken 0.45, cement is used OPC 53 grade. The moulds are used cube, prism, cylinders. As the compressive, flexural, split tensile strength test are conducted at two stages and compared between convectional concrete and polymer impregnated concrete with steel wire mesh as a result impact of steel wire mesh played a major role to improve the strength of concrete.*

Keywords--Steel *wire mesh, silica fume, super plasticizer, polymer, split tensile strength, compressive strength, flexural strength.*

I. INTRODUCTION

In the experimental study, determine the compressive strength, flexural strength and split tensile strength. By casting the [cube, prism, cylinder] grade of M20, M40, M60. In this experimental study the (PCC- plain cement concrete) are used commonly in construction it low cost and effective from this we can get a normal strength after 28 days of curing.

As we know the ferrocement is a composite material it is the combination of cement and steel wire mesh. Now we are comparing the steel wire mesh with PCC to improve the strength of the concrete and they are good in fire resistance, impact resistance.[10]

The Polymer Impregnated concrete was first produced in Bacookhaven national lab in 1965. [17] Now, some air voids are occurred in the concrete due to that strength of the concrete is reduced. As we know we commonly consider air voids of 2% in the bases of practical experiences. But due to steel wire mesh it can be increased strength of a structure. For avoiding this air voids, the polymer impregnated concrete is used. PIC is a hydrated

[1] *Associate Professor, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai-602105, rameshkumargb@gmail.com

[2] U.G Student, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai-602105

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Portland cement concrete that has been impregnated with monomer that is subsequently polymerized in situ. The monomer is introduced into the concrete by soaking at atmospheric pressure or above. The degree to which the available space in the concrete is filled with monomer during the socking determine whether the concrete is partially impregnated or fully impregnated that 85 percent of the available void spacing after drying is filled. Whereas partially impregnated consist of the process in which the concrete is impregnated to only a limited depth beneath in which the concrete is impregnated to only a limited depth beneath the surface. The different production methods used for full and partial impregnated procedure concrete of different physical characteristics. Therefore, full and partial impregnated produce concrete of different physical characteristics. Therefore, fully partially impregnated are treated separately.

Oranla lalaj at el 2015 has discussed about the recent perspectives of ferrocement. In chile the small prototype building is constructed and tested under seismic load. By this they are obtained better result in earthquake behaviour. Due to cost of the building is reduce by introducing the concept of ferrocement. From past ten to fifteen years the strength of concrete improvement is a major research. As we know that for a building beam, column are main parts for transferring of load to foundation and by conduct many Researches on ferrocement. The result is obtained positive and giving more strength by using ferrocement. [5

By utilising steel wire mesh thickness of slab is reduced up to 25 to 50 mm by using steel wire mesh but in Reinforced cement concrete structure minimum thickness of slab is 75mm. Due to thickness increases the dead load also get increased and comparing with RCC the steel wire mesh gives strength due to close spacing of wire.

By using high performance concrete thickness of a particular section get reduced due to dead load or self-weight get decreases. [8] By this concrete then material and time for casting can be reduced and cost of particular structure is been decreased. Especially voids are main cause to decrease the strength of concrete to fill the capillary voids the admixtures like silica fume and fly ash are replaced in cementitious material. [1]

Iyappan G R at el 2017 has done research on steel wire mesh improve the strength of RC column. In this they have casted a square column of size (150 X 150) mm and height of 600mm and the grade of concrete is M25 and they have provided and tested in 28 days. In the RCC column provided 4 numbers of 12mm diameter bars and 8mm lateral ties at the spacing of 120mm. They have wrapped with steel wire mesh in a circular shape in the column and test a column by using eccentric loading and by axial loading. The result is more obtained in the axial loading and the strength is increased by 30- 35 %. By this study it is obtained that by using steel wire improving the strength of column. [6]

By replacing 5% to 10% of silica fume it improves the compressive strength of the concrete and silica fume is 100 times finer than cement. Now maximum research is focusing on reducing the Cardon di oxide emission from cement by replacing the admixtures the greenhouse effect is been controlled.[2] by replacing silica fume in cement from 0% to 25% the workability of the concrete is been decreases to maintain the standard slump value super plasticizer has added. If water /cement ratio increases in mix strength of concrete can decreases. [3]

Abdul kadir at el 2018 has discussed about effect of steel mesh in cylindrical concrete. Size of concrete 1.67mm of diameter and spacing of 40mm. Total 6 sample has been casted and for each two sample they have increased the layer of mesh. Basically, they are obtaining the single layer, double layer and three layer and they not providing any spacings between layers. As result it is obtained that by increasing the layer the strength of the concrete increased. [7]

Sameh yehia at el. 2017 has discussed about polymer impregnated porous concrete and they have used three mix proportions for porous concrete. In this Mix A of cement content is 200 kg/m^3, Mix B of cement content is 300 kg/m^3 and Mix C is 400 kg/$m^{3.}$ Water/Cement ratio is 0.30. In this slab of thickness 100 mm, length and width of 500mm and cube of standard size of (150 X 150 X 150) mm and size of cylinder is 150 mm diameter, height of 300mm. the polymer used is [polyester resin] and it is poured in the slab nearly 75 % of voids are filled with polymer and curing has done in three stages 7, 14, 28 days and in this study the result is obtained Mix C [9]

II. METHODOLOGY

In this experiment study adopting three grades of concrete M20, M40, M60 and comparing the result with convectional concrete and steel wire mesh concrete impregnated with polymer to increase the durability and strength of concrete. Casted cubes of standard size (150 X 150 X 150) mm, cylinder of size (diameter – 100 mm) and (height – 200 mm), prism of size (500 X 100 X 100) mm. In this process steel wire mesh is provided in the concrete by giving 15mm cover around the concrete block and curing for 7, 28, 90 days. Concrete are impregnated by using a capsule method. so, nearly eight hours have to soak in polymer and heat it for $70^0\ c$ to $150^0\ c$ for five hours then it will be produced as a polymer Impregnated concrete. Before Mix design the preliminary test for material has been done.

III. MATERIALS

3.1 Cement

In the experimental work OPC 53 grade is used. it is binding material and also known as adhesive material and properties of cement have been studied in IS 2386 (PART-1) 1963. [15] Table 1 shows the properties of cement.

Table 1 properties of cement

so no	properties	values
1	Fineness (%)	3
2	soundness (cm)	2.5
3	Initial setting time (min)	35
4	final setting time (min)	450
5	specific gravity	3.13

3.2 Polymer used

As we know that the combination of two monomer is called polymer. In the experimental work polyester and styrene monomers used to produce polymer impregnated concrete. So, these types of polymer are thermoplastics because they are low viscous and it get penetrate in the voids of concrete. In this durability, strength of concrete is increased and water absorption of concrete is reduced. Properties of monomer has been adopted from ACI 548.1R-97 and shown in Table 2.

Table 2 properties of monomer

so.no	monomer type	density (gm/cm^2)	boiling point °c

1	styrene	0.91	135
2	polyester	1.38	206

3.3 Fine aggregate

In the M-sand i.e. manufactured sand is used because availability of material and cost of material. Due to using of river sand ground water depletion are the major cause to use M- sand. It economic and easily available as compare to river sand. From IS 383:1970 result has been compared for sieve analyses and Table 3 shows the properties of fine aggregate. [14]

Table 3 properties of fine aggregate

so no	properties	values
1	specific gravity	3.6
2	fineness modules	3.7
3	water absorption (%)	4.16

3.4 Coarse aggregate

The size of coarse aggregate is used is 12.5 mm because in this experimental work steel wire mesh has been used in the core of concrete the spacing between the two wires is 15mm for this reason the aggregate size is used 12.5 mm. At the initial stage the strength of the concrete is less as compared to 20 mm aggregate. After 28 days the strength is nearly equal. So, there will not be any major changes by using 12.5 mm. but the mix design will change for 12.5mm aggregate. [19] From this if the size of aggregate is decreasing the fine aggregate will be increases. For IS 383 sieve analysis result is compared with the obtained result (coarse aggregate) [14]. So, it is obtained that graded aggregate of nominal size and Table 4 shows the properties of course aggregate. Figure 1 is show the s – curve of course aggregate in that the green line denotes the observed valued done by sieve analysis and red line is the IS standard values of zone – III.

Table 4 properties of course aggregate

so no	properties	values
1	specific gravity	2.9
2	fineness modules	7.468
3	water absorption (%)	1.45

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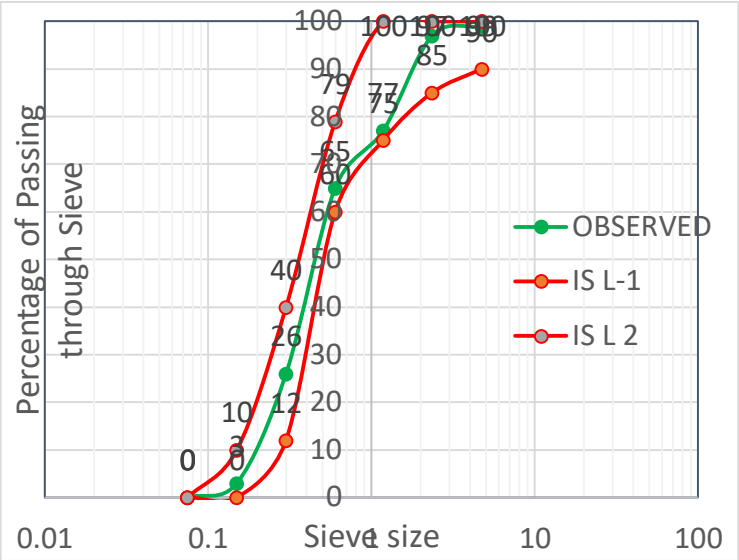

Figure 1. s – curve of coarse aggregate

3.5 Silica fume

The silica fume is mainly used in high strength concrete it uses to avoid air voids between cement particles and it is 100 times finer than cement particles. Table 5 denotes the properties of silica fume. It helps to fill in capillary pores occurred in the cement particles due to which the strength gets increases.[4]

Table 5 properties of silica fume

so.no	properties	values
1	specific gravity	2.2
2	colour	grey

3.6 Steel wire mesh

The steel wire mesh is made up of galvanised Iron material. It can easily get corroded due to thin wire usually (0.76 mm-2 mm) to avoid corrosion zinc coating is provided. Wire has different shape like rectangle, square, hexagonal and diamond. The fabricates can be welded, woven and twisted. The properties are adopted from ACI 549.1R-93 as shown in Table 6.

Table 6 properties of steel wire mesh

so no	properties	values
1	shape	square
2	fabrication	welded
3	gage	No - 19
4	wire spacing (mm)	15
5	wire thickness (mm)	1
6	No. of wire/m²	67 X 2= 134

7	wire weight (kg/m)	0.01
8	weight of mesh (kg/m²)	1.34
9	Tensile strength (Mpa)	307

3.7 Super plasticizer

In this super plasticizer is used TECH MIX 550. It acts as the water reducer agent and it is especially used in high strength concrete. [16] In this experimental work for M60 grade 1.5% of super plasticizer is used in the Cementitious material.

3.8 Preparation of wire mesh

In this steel wire mesh is provided in Cube, beam and cylinder. For cube of (150 X 150 X 150) mm the mesh is provided with 15 mm cover and the size of wire mesh for cube is (120 X 120 X 120) mm, For beam of size (500 X 100 X 100) mm the wire mesh is provided for beam is (470 X 70 X 70) mm and For cylinder of 100 mm diameter and 200 mm height the mesh is provided with 15 mm cover of size 70mm diameter and 170mm height. As in the figure 2 shows the specimen shape of steel wire mesh for cube, prism and cylinder and Figure 3. denotes the placing and size of specimens used.

Figure 2. specimen shape of steel wire mesh for cube, prism and cylinder

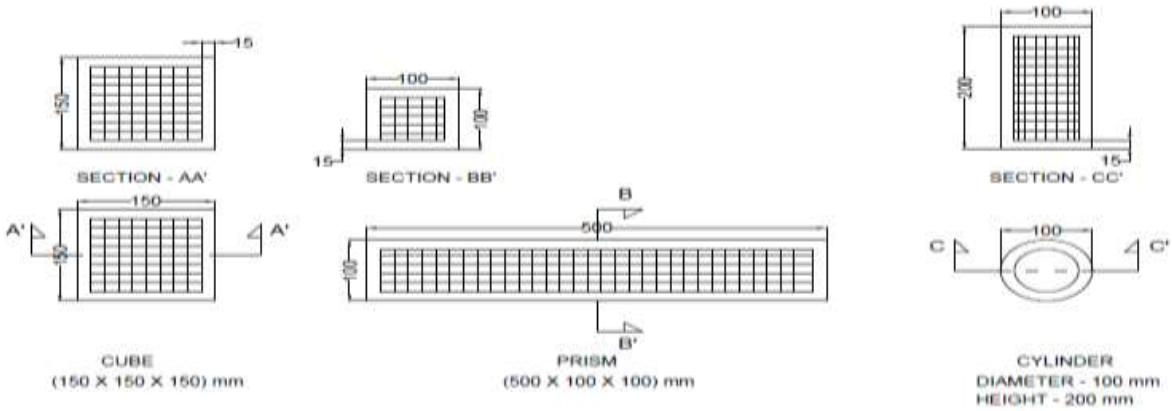

Figure 3. specimen size and placing of wire mesh in specimen

IV. MIX RATIO

Mix design is adopted for all the three grades i.e. M20, M40, M60. Design is done according to the IS method from IS 10262:2009 [12] and IS 456: 2000. For M20 grade standard mix is not obtained because 12.5 mm coarse aggregate is used for this work.[11]

Figure 4. hand mixing of concrete

For M60 grade the cement is replaced by 5% of silica fume because for high strength concrete the capillary pore or air voids are occurred due to which the strength and durability of concrete is reduces for avoiding that silica fume is used. As silica fume is finer than cement. So, void between the cement particles are occupied with silica fume and super plasticizer is used 1.5% in cementitious material. Table 7. Shows the mix proportioning. Hand mixing of concrete is done during the casting period shown in figure 4.

Table 7 mix proportioning

Grade	Mix Ratio	W/C	Admixture
M20	1:2.17:2.35	0.5	-
M40	1:1.58:1.86	0.4	-
M60	1:1.59:2.11	0.3	Silica fume (grey) and super plasticizer

V. EXPERIMENTAL WORK

In this work 18 specimens are casted for cube in that 9 specimens for convectional concrete and 9 specimens for steel wire mesh with polymer impregnated concrete for a single grade of concrete and for same number of specimens casted for beam and prism and curing is done for 7, 28 and 90 days. Tests are done in compressive strength machine and flexural strength machine shown in Figure 4 at the time of test 3 sample is tested and from that mean is taken for the result.

Figure 5. compressive strength and flexural testing machine

VI. RESULT AND DISCUSSIONS

In the test result is obtained and comparing the result with convectional concrete and wire mesh + PIC. By testing the fresh concrete and harden concrete the graph have been drawn for slump, compressive, flexural and split tensile and Figure 6 denotes the placing of concrete in mould with steel wire mesh.

Figure 6. placing of concrete in moulds with steel wire mesh.

6.1 Workability test (slump cone)

Slump cone test is conducted for all the three grades of concrete. As the slump value is conduced the true slump is obtained as shown in Figure 7 for the grade M 20 and M40. Figure 8 shows the slump value in mm. M60 grade more workability is obtained because super plasticizer is used but for M20 and M40 not used super plasticizer it shows less as compared with M60 grade. Workability of concrete is depending on the W/C ratio and slump by this factor we can avoid the segregation adopting a proper energy for compaction of concrete. [18]

Figure 7. slump test for M20, M40

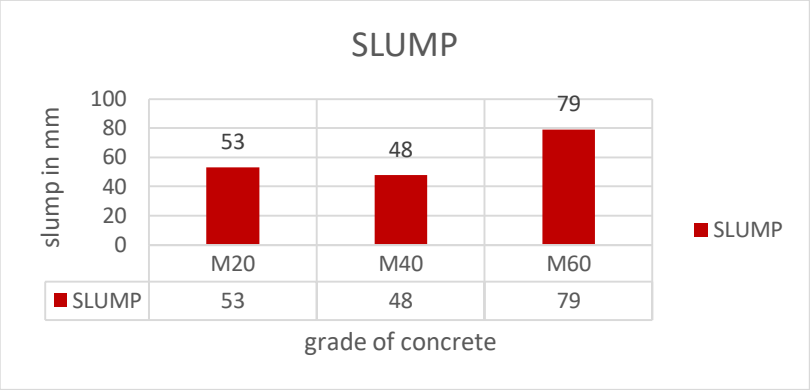

Figure 8. slump values

6.2 Compressive strength

This are the most common test to find the compressive strength concrete and it comes under distractive testing. for this process the standard size of cubes 150 X 150 X 150 mm as per IS 516 – 1959. [13] The test has been done in two stages 7 days and 28 days. In this the result has been compared with convectional concrete and steel wire mesh concrete along with polymer impregnated and tested cube specimen with steel wire mesh shown in Figure 10. The convectional concrete has fulfilled the target strength of concrete for all the three grades of concrete. At the initial stage the strength is nearly equal because of coarse aggregate impact. Comparison between steel wire mesh and convectional concrete is shown in Figure 9 and Table 8.

Table 8 comparison between steel wire mesh and convectional concrete

Grade of Concrete	specimen no.	Compressive strength in (N/mm²)		Average Compressive strength in (N/mm²)		Compressive strength in (N/mm²)		Average Compressive strength in (N/mm²)	
		Convectional concrete		Convectional concrete		Wire mesh with PIC		Wire mesh with PIC	
		7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
M20	1	15.6	21.06	15.54	22.38	15.9	31.37	16.22	28.59
	2	15.33	22.35			16.2	25.2		
	3	15.7	23.73			16.57	29.2		
sssM40	1	23.24	41.24	24.5	40.73	25.33	49.28	24.62	49.67
	2	25.73	41.11			23.91	50.93		
	3	24.53	39.86			24.62	48.8		
M60	1	42.8	61.8	52.8	65.87	55.2	70.5	58.16	72.93
	2	58.93	69.9			58.9	72.4		
	3	56.93	65.93			60.4	75.9		

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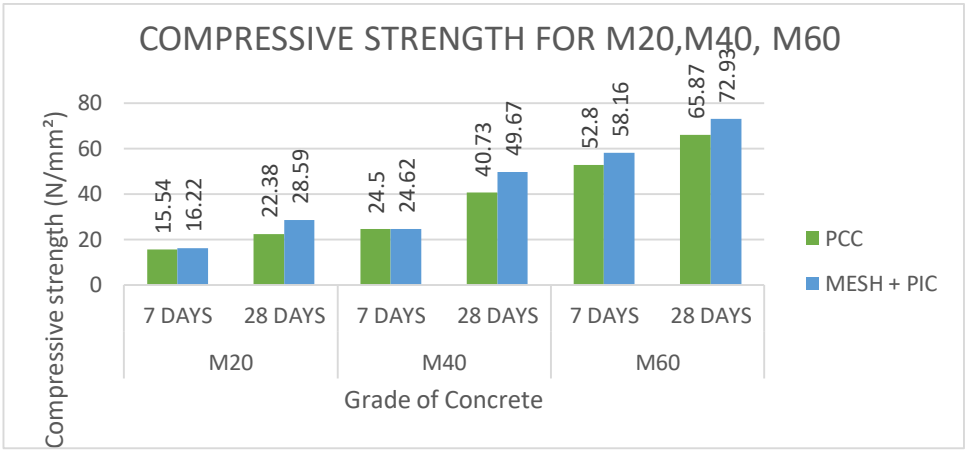

Figure 9. comparison between steel wire mesh and convectional concrete of compressive strength test.

6.3 Flexural strength of concrete

Flexural strength is also known as tensile strength even though it is weak in tension but concrete contribute its some amount of strength. As we know that reinforcement is provided to resist the tensile strength. But due to shrinkage and corrosion in reinforcement for condition the tensile test of the concrete has been conducted. Mainly flexural test is conducted because to the deflection of the beam. As per the IS 516-1950. The testing has been conducted and for finding flexural strength the formula is $PL/bd^{2,}$ in this P is load, L is length, B is breath and d is depth for the standard size of 100 x 100 x 500 mm specimen. For M20, M40, M60 flexural test is conducted in two stages 7 days and 28 days. The ratio of strength between steel wire mesh / convectional concrete for M20 7 days is 1.35 and 28 days is 2.04, for M40 of 7 days is 1.29 and 28 days is 1.45, for M60 grade 7 days is 1.28 and 28 days is 1.25. Comparison between steel wire mesh and convectional concrete is shown in Figure 11 and Table 9.

Figure 10. tested cube specimen with wire mesh

Table 9 comparison between flexural strength of steel wire mesh and convectional concrete

Grade of Concrete	specimen no.	Flexural strength in (N/mm²)	Average Flexural strength in (N/mm²)	Flexural strength in (N/mm²)	Average Flexural strength in (N/mm²)

		Convectional concrete		Convectional concrete		Wire mesh with PIC		Wire mesh with PIC	
		7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
M20	1	5.5	10	5.75	9.58	7.5	11.75	7.6	11.75
	2	5.75	9.25			8	11.5		
	3	6	9.5			7.5	12		
M40	1	6.25	9.25	7.41	10.5	9.5	15.25	9.58	15.25
	2	8.25	11.75			10	16		
	3	7.75	10.5			9.25	14.5		
M60	1	10	16.5	9.16	15.3	11.5	18.5	11.75	19.25
	2	8.5	14.5			12.5	19.5		
	3	9	15			11.25	19.75		
*Note PIC - Polymer Impregnated Concrete									

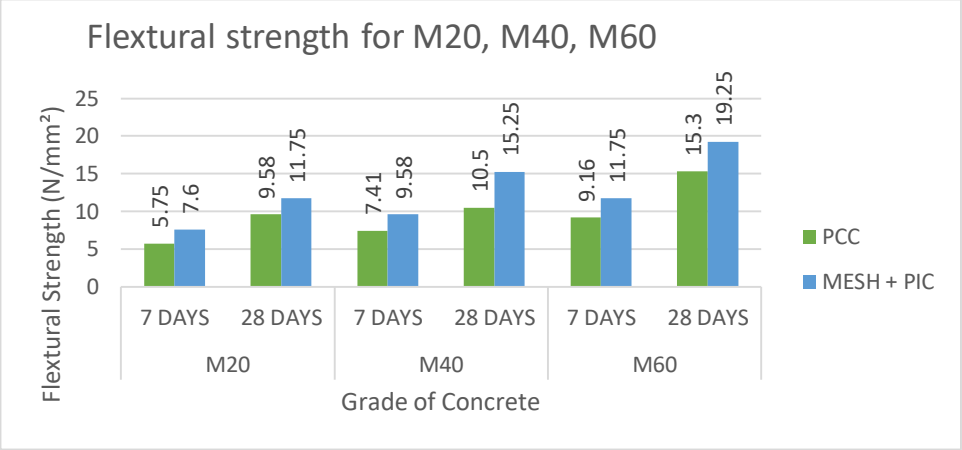

Figure 11. comparison between flexural strength of steel wire mesh and convectional concrete.

6.4 Split tensile strength

It is on other way to find the tensile strength of concrete. In this the specimen is placement horizontally in the machine and applied load. As per IS 516 and IS 5816 method of testing is been obtained for the strength size of diameter of 100mm and height of 200 mm cylinder has been casted and cured in 2 stage 7 days and 28 days, comparison between convectional concrete and steel mesh along with PIC is shown in figure 12 and Table 10. Difference in strength between convectional concrete and steel mesh concrete for M20 grade of concrete 7 days is 0.35 N/mm^2 and 28 days is 0.96 N/mm^2 , for M40 grade of concrete 7 days is 0.58 N/mm^2 and 28 days is 0.98 $N/mm^{2,}$ for M60 grade of concrete of 7 days is 0.14 N/mm^2 and 28 days is 0.96 N/mm^2. It is obtained that by using steel wire mesh and Figure 12 shows that tested sample of cylinder. Its increase's strength and reduces crack as compared with convectional concrete. [20]

Figure 12. tested samples of cylinder

Table 10 comparison between split tensile strength of steel wire mesh and convectional concrete

Grade of Concrete	specimen no.	Split tensile strength in (N/mm²)		Average Split tensile strength in (N/mm²)		Split tensile strength in (N/mm²)		Average Split tensile strength in (N/mm²)	
		Convectional concrete		Convectional concrete		Wire mesh with PIC		Wire mesh with PIC	
		7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
M20	1	2.1	2.83	2.14	2.82	2.42	3.78	2.49	3.78
	2	2.26	2.73			2.48	3.59		
	3	2.07	2.9			2.57	3.98		
M40	1	2.57	4.58	2.55	4.28	3.08	4.49	3.13	4.53
	2	2.38	4.17			3.21	4.61		
	3	2.7	4.1			3.12	4.51		
M60	1	4.87	6.1	4.53	6.21	5.55	7.1	5.67	7.17
	2	4.14	6.25			5.98	7.32		
	3	4.59	6.3			5.49	7.11		
*Note PIC - Polymer Impregnated Concrete									

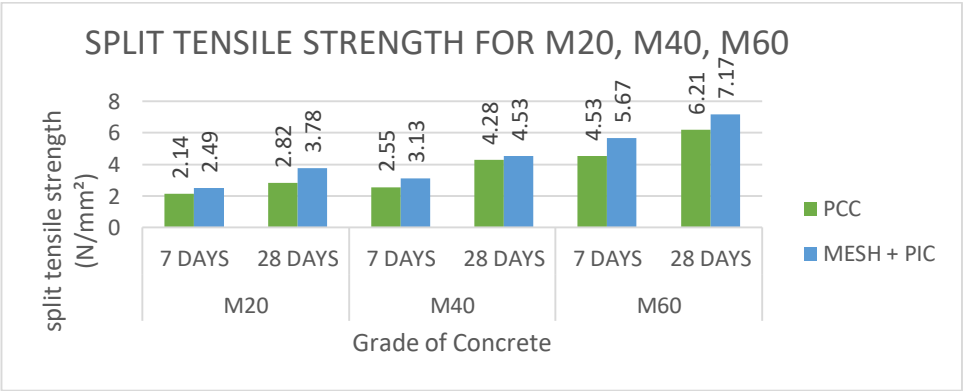

Figure 13. comparison between split tensile strength of steel wire mesh and convectional concrete

VII. CONCLUSION

- Comparison of compressive strength of concrete for all the three grade at the initial stage at 7days test 3 – 4 % of strength is been increased because for this case size of coarse aggregate is used is 12.5 mm for that reason initial strength is not gained more. Compressive strength at 28 days for M20 grade as comparing with PCC and (Steel Wire Mesh with PIC) strength is increased by 27%, For M40 grade of concrete strength is increased by 21 % and for M60 grade of concrete it is increased by 10.7 %. For this result by using steel wire mesh with polymer impregnated concrete on an average strength increases by 10 – 27 % as compared with convectional concrete.
- For split tensile strength for all the three grade of concrete at the stage of 7 days test for M20 grade of concrete strength is increased by 16 % and at 28 days 34 % is increasing. For M40 grade of concrete the strength is increased by 6 % and at 28 days. And for M60 grade of concrete the strength is increased by 15 % at 7 Days and for 28 days it is increased by 20 % by this condition of by using wire mesh in concrete it improves the strength because steel is more resist the tensile strength. It can be used as the rehabilitation work.
- For flexural strength of concrete M20 grade of concrete for comparing with convectional concrete strength is increased by 22 % by using wire mesh in concrete. for M40 grade of concrete it is increased by 34 % and for M60 grade it increased by 28 %. For this result the average strength is increased by 30 %.
- By using steel wire mesh, we can improve the tensile strength of concrete and by polymer impregnation concrete the durability of concrete is been increases and void are been reduces.
- As the grade of concrete is increase's the dead load of the structure can be reduced by minimizing the size of structure. By this cost and time of construction came reduced.
- If the fire accident is taken place in the structure main skeleton is columns, beams and slabs. It louses strength by using the steel wire mesh as a jack around the beam and column. Due to which crack can be arrested and strength of a structure can be increased and to avoid the collusion of structure.

REFERENCE

1. Jayesh Gosavi, U. R. Awari, "A Review on High Performance of concrete", International Research Journal of Engineering and Technology (IEJET), Vol.5, Issue-5, May-2018, pp 1963-1968, e-ISSN: 2395-0072.
2. N. K Amudhavalli, Jeena Mathew, "Effect of Silica fume on Strength and durability parameters of concrete", International Journals of Engineering Sciences and Emerging Technology, Vol.3, Issue -1, pp 28-35, Augest-2012, ISSN: 2231-6604.
3. Pranita S bhardari, "Influence of silica fume on concrete", IOSR Journals of Mechanical and Civil Engineering, pp 44-47, e-ISSN: 2278-1684.
4. G Venkatesn, T. Tamizhazhagan, "Ultra high Strength Concrete", International Journal of Innovative Research in Science Engineering and Technology. Vol.5, Issue.3, March-2016, pp 4412-4418.
5. Ornela lali, Yavuz yardim, "Recent perspectives for ferrocement", Research on Engineering Structures & Materials, Vol.1, Issue-1, pp 11-23.
6. Iyyappan G R, Dr D.Elango, "strengthening of RC square column using stainless steel wire mesh", International Journal of Constructive Research in Civil Engineering

7. Abdul kadir, Baso Mursidi, "The Effect of Wire Mesh Confinement to Compressive strength and deformability of cylindrical concrete", International Journal of Multi-Disciplinary Research and Development, Vol.5, Issue-4, April-2018, pp 110-113, e-ISSN 2349-4182.
8. Revanm jagana, Chintada. Vinod kumar, "high strength concrete", International Journal of Engineering Sciences and Research Technology, Feb-2017, e-ISSN 2277-9653.
9. Samen yehia, Mona M. Fawzy, "The impact of using polymer impregnated porous concrete in Structure Engineering application", International Journal of Current Engineering and Technology, Vol.7, Issue-1, April-2017, e-ISSN 2277-4106.
10. WRD hand book chapter no – 1, "Ferrocement Technology", Maharashtra Engineering Research Institute Nashik.
11. IS 456:2000, Indian Standards, "plain and reinforced concrete", Bureau of Indian Standard, (2005).
12. IS 10262:2009, Indian Standards, "Concrete mix proportioning – guidelines", Bureau of Indian Standard, (2009).
13. IS 516:1959, "Methods of tests for strength of concrete", Bureau of Indian Standard, (2006).
14. IS 383:1970, "specification for coarse aggregate and fine aggregate for natural source for concrete", Bureau of Indian Standard, (2011).
15. IS 2386 part-I 1963, "Methods of testing for Aggregate of concrete", Bureau of Indian Standard, (2011).
16. Evangeline. K, Dr. M. Neelamegam, "Effect of superplasticizer on workability and mechanical properties of self- compacting concrete", IOSR Journal of Mechanical and Civil Engineering, e-ISSN 2278-1684, pp 19-29.
17. David W. Fowler, Donald R. paul, "durability, strength and method of application of polymer impregnated concrete for slabs", Jan-1976.
18. D B Eme, C Nwao Bakata, "Effect of coarse aggregate gradation workability and flexural strength of concrete", International Research Journal of Advanced Engineering and Science, Vol.4, Issue-1, 2019, e-ISSN 2455-9024, pp128-132.
19. Kanwade, Kulkarni, Mehetre A.J, "Compressive and split tensile strength of concrete containing different aggregate", International Journal of Engineering Research Technology, Vol.3,Issue-3, March-2014, e-ISSN: 2278-0181.
20. Umesh sharma, Richa Ahuja, "Evaluation of workability and crack pattern in flexural of steel fibre reinforcement concrete (SFRC)", Journal of Civil Engineering and Environmental Technology, Vol.2, Issue-9, June – 2015, e-ISSN 2349-879x, pp 18-21.