Strength of Composite Concrete Cubes Using Different Shapes of Reinforcement

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Abstract - In this study, we have considered four different shapes of steel reinforcement in concrete cubes namely B, K, X and Σ type which comprising of a hollow steel pipe of 25.4 mm dia., 2 mm thick and 98 mm/110 mm in length along with 6 mm dia. rod of different length. Standard cubes of 150 mm x 150 mm x 150 mm are cast three for each shape. 20 mm of cover is provided from each face of cube. Both non-destructive and compression testing are carried out and results are compared with normal concrete cube.

Keywords - Compressive Strength, Cube Strength, Different Shapes of Reinforcement, Non-Destructive Tests, Comparative Study.

1. INTRODUCTION

A composite material is a material produced using two or more constituent materials with fundamentally distinctive physical or chemical properties that, when joined, produce a material with attributes unique in relation to the individual segments. The individual components stay separate and particular inside of the completed structure. The new material may be favoured for some reasons: normal illustrations incorporate materials which are more stronger, lighter, or less expensive when contrasted with traditional materials. Composite materials are commonly utilized for buildings, bridges, and structures, for example, boat hulls, swimming pool panels, race auto bodies, shower stalls, bathtubs, stockpiling tanks, impersonation granite and refined marble sinks and ledges. The most exceptional examples perform routinely are spacecraft and airplane.

2. PREVIOUS WORK

Some of the important literatures on the topic are as follows-

K. Brosens et. al (2007) observed that, for the most part steel plates and carbon fibre reinforced polymers (CFRP) are utilized as outer reinforcement. This paper deals with another material that can be utilized as outer support: steel cord reinforced polymer (SCRP). It comprises of thin high-quality steel fibres implanted in a polymer matrix. This inventive material joins the advantages of steel and carbon fibres. The material expense of SCRP is generally low and the laminate preserves the flexibility. The appropriateness of the new material as outer reinforcement is researched.

Ganjeena Khoshnaw et. al (2014) concentrated on the utilization of rubber which significantly aggravated the pervious concrete mechanical properties and its permeability however in different degrees as indicated by the rate and kind of rubber utilized. However, exchanging of normal aggregate with rubber particles brought about a noteworthy increment of toughness and ductility of concrete and additionally better damping capacity.

Ali N. Alzaed (2014) evaluated the possibility of using iron filings as one of the component of concrete mix. Four distinctive percentage of iron filing were added to concrete mix to measure the variety which may be gotten in compression and tensile concrete strength following 28 days. Total 144 standard concrete cubes and cylinders were performed and tried in this study utilizing 0% (control), 10%, 20% and 30% of iron filing in concrete mix. It is inferred that, concrete compressive strength increased steadily when iron filing added to the concrete mix where the tensile strength had a minor impact if the rate of iron filing utilized more than 10%. Two formulas represented these relations are proposed which may be utilized to expected the rate of increase comparing to every amount of iron filing added to concrete mix.

N. Manoj and N. Nandhini (2014) used polyester fibres of 0.5%, 1%, 1.5% and 2% and it's compressive, split tensile and flexural strength is determined. In this phase optimum dosage of concentration of fibres is determined. Steel slag was found to be the best replacement for aggregates of concrete. Steel slag which is originated as a waste material in the steel industry and has a negative effect on environment when methodize. Over the span of future project work by the trade of steel slag for the coarse aggregate in concrete of 25%, 50%, 75% & 100% with the expansion of optimum polyester fibres to accomplish the effective strength of concrete.

Vikrant S Vairagade et. al (2012) carried out examination for M20 grade of concrete to contemplate the compressive strength, and tensile strength of steel fibre reinforced concrete (SFRC) containing fibres of 0% and 0.5% volume proportion of hook end Steel fibres of 50 and 53.85 aspect ratio were utilized. Outcome information acquired has been broke down and compared with a control sample (0% fibre).

3. METHEODOLOGY

A. OBJECTIVES

Following are the major objective of the study:

1. Preparation of cubes using different shapes of reinforcement and normal cube of M20 grade of concrete.
2. Non destructive and destructive testing of cubes with different shapes of reinforcement.
3. Comparative study of the effect of different shapes of reinforcement on strength of concrete with the help of non destructive and compressive test results.

B. MATERIAL USED

Ordinary Portland cement 53 grade and specific gravity of 3.15 was used for casting of all the specimens and clean dry river sand and natural aggregates has been used. The natural river sand passing through IS 4.75 mm sieve the specific gravity of fine aggregate is 2.60. Then natural coarse aggregate with specific gravity of 2.60 and passing through IS 20 mm sieve has been used. Hollow mild steel pipes of dia. 25.4 mm, 2 mm thick and 98 mm/110 mm in length along with 6 mm dia. rod of different length are used as reinforcement. Cubes of size 150x150x150 mm were cast cured and tested for 28 days.

C. MIX DESIGN

Mix proportion ratio was arrived used IS method and given in Table 1.

Table-1: Mix Proportion Ratio

Water (litre/m³)	Cement (Kg/m³)	Fine Aggregate (Kg/m³)	Coarse aggregate (Kg/m³)
191.6	383	546	1187
0.50	1	1.42	3.09

D. PROCEDURE

The following steps are adopted during experimental work:

- First of all mix design for M20 grade of concrete is prepared according to the "INDIAN STANDARDS CODE" SP 23:1982.
- In the preparation of mix design for M20 grade of concrete various physical properties of the materials like specific gravity, nominal size, water absorption capacity, fineness modulus etc. are required, also some other conditions like type of exposure to sun and water, material mixing technique etc. are to be assumed in accordance with INDIAN STANDARD CODE SP 23:1982 and IS 456:2000.
- After working out the quality of different materials in an appropriate proportion, it's time for the selection of materials.
- Keeping in mind the "INDIAN STANDARDS" materials are selected i.e., aggregates conforming/full filling the various conditions as per IS 383:1970 and cement 53 grade OPC conforming to IS 12269:1987 are taken.
- Selected materials are mixed in a fixed proportion shown in Figure 1, as per mix design to acquire the desired strength. Sampling & analysis of concrete is done according to IS 1199:1959.

Fig. 1. Preparing Concrete Mix

Fig. 2. Casting Cubes

- IS 2386 (Part 1):1963 is used for the methods of tests for aggregates for concrete specifically for shape and size of aggregates.
- Two important tests are performed on concrete namely 1) slump cone test and 2) compaction factor test, after preparation of mix for physical properties of concrete.
- Standard moulds of size 150 mm x 150 mm x 150 mm are then cleaned and oiled. Concrete is poured in the moulds shown in Figure 2.
- Four types of reinforcements shown in Figure 3, are put in the moulds and three cubes are casted for each reinforcement. In this way total 15 cubes are cast for all the cases (B1, B2, B3, K1, K2, K3, X1, X2, X3, ∑1, ∑2, ∑3 and N1, N2, N3).

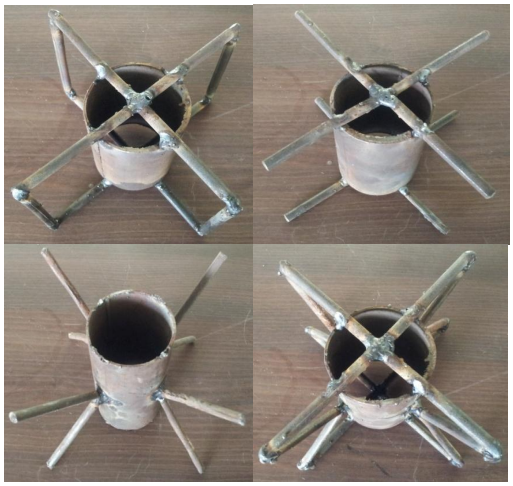

Fig. 3. Different Reinforcement Used Namely B, K, X & ∑ Respectively

- The hollow pipe is centrally placed during concreting giving 20 mm of cover from all faces of the mould.
- After 24 hrs. concrete cubes are unbolted from moulds and named with water resistant paint and placed in the curing tank filled with normal water at 27 ± 2 ^{0}C for 28 days.
- Non-destructive testing is done at 7 days, 14 days & 28 days of curing for the prediction of early strength of concrete. For surface strength of concrete cubes Rebound Hammer Test is performed and for homogeneity of the concrete cubes Ultrasonic Pulse Velocity Test is performed.
- At the end of 28 days curing it's time for the final test which gives the actual strength of concrete i.e., compression strength test in accordance with the "INDIAN STANDARDS CODE" IS 516:1959 for the test of concrete.

Hollow pipe is horizontally placed in the cubes considered for compression tests.

4. EXPERIMENTAL RESULTS

A. ULTRASONIC PULSE VELOCITY

Comparative results of Ultrasonic Pulse Velocity test for all the cases are given in Table 2 and shown in Figure 4.

Table 2: Ultrasonic Pulse Velocity Values (km/sec)

Sample No.	Normal Cube	B Type R/F	K Type R/F	X Type R/F	∑ Type R/F
1	4.356	4.222	4.595	4.419	4.052
2	4.652	4.198	4.406	4.433	4.222
3	4.567	4.234	4.294	4.282	4.258
Average	**4.525**	**4.218**	**4.432**	**4.378**	**4.177**

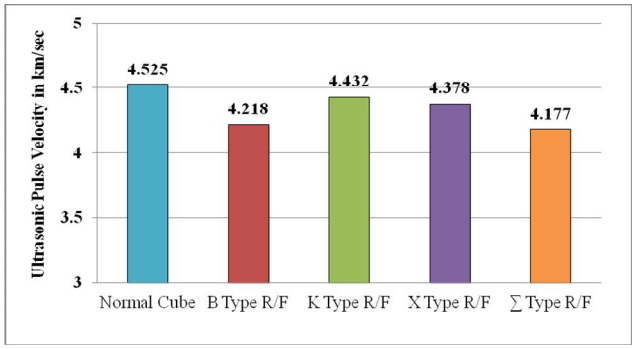

Fig. 4. Comparison of UPV Results of All Cases

Above comparison of UPV test result shows that normal cubes shows higher reading overall but, if we talk about reinforcement then K type shows maximum reading and ∑ type shows minimum reading of UPV test. This indicate that compaction with reinforcement is not achieved fully.

B. REBOUND HAMMER STRENGTH

Comparative results of Rebound Hammer Strength test at 7 days for all the cases are given in Table 3 and shown in Figure 5.

Table 3: Rebound Hammer Strength (MPa) at 7 Days

Sample No.	Normal Cube	B Type R/F	K Type R/F	X Type R/F	∑ Type R/F
1	21.0	19.0	20.0	19.0	20.0
2	22.9	19.0	27.4	21.5	22.9
3	22.9	21.4	27.4	25.8	20.0
Average	**22.3**	**19.8**	**24.93**	**22.1**	**21.0**

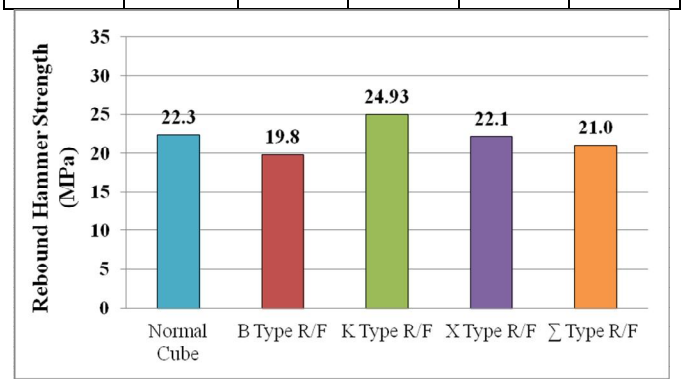

Fig. 5. Comparison of Rebound Hammer Strength Results of All Cases at 7 Days

Above comparison of RH test result shows that K type shows higher reading overall but, if we talk about reinforcement then K type shows maximum reading and B Type shows minimum reading of RH test at 7 days.

Comparative results of Rebound Hammer Strength test at 14 days for all the cases are given in Table 4 and shown in Figure 6.

Table 4: Rebound Hammer Strength (MPa) at 14 Days

Sample No.	Normal Cube	B Type R/F	K Type R/F	X Type R/F	∑ Type R/F
1	30.4	27.4	28.9	25.8	20.0
2	21.4	33.6	22.9	20.5	33.6
3	20.5	23.2	28.9	35.2	32.0
Average	**24.1**	**28.07**	**26.9**	**27.2**	**28.53**

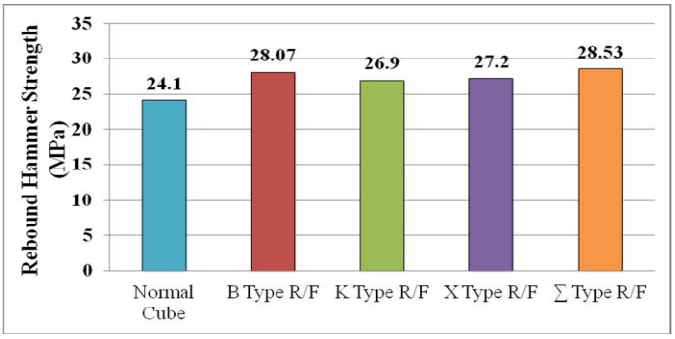

Fig. 6. Comparison of Rebound Hammer Strength Results of All Cases at 14 Days

Above comparison of RH test result shows that ∑ type shows higher reading overall but, if we talk about reinforcement then ∑ type shows maximum reading and K Type shows minimum reading of RH test at 14 days.

Comparative results of Rebound Hammer Strength test at 28 days for all the cases are given in Table 5 and shown in Figure 7.

Table 5: Rebound Hammer Strength (MPa) at 28 Days

Sample No.	Normal Cube	B Type R/F	K Type R/F	X Type R/F	∑ Type R/F
1	30.4	33.6	33.6	35.2	33.6
2	30.4	33.6	27.4	33.6	35.2
3	28.9	32.0	32.0	33.6	33.6
Average	**29.9**	**33.07**	**31.0**	**34.13**	**34.13**

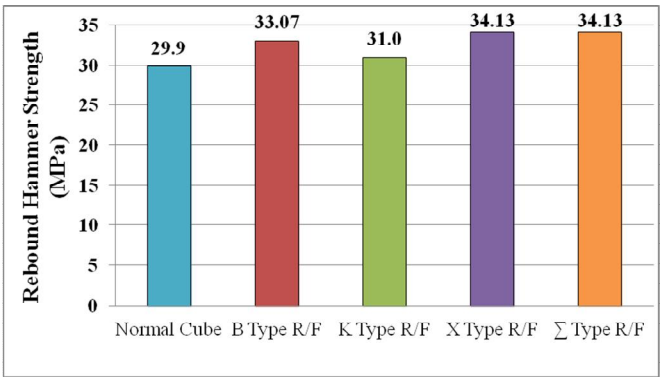

Fig. 7. Comparison of Rebound Hammer Strength Results of All Cases at 28 Days

Above comparison of RH test result shows that X type and ∑ type shows higher reading overall but, X type and ∑ type shows maximum reading and K Type shows minimum reading of RH test at 28 days.

C. COMPRESSIVE STRENGTH

Comparative results of Compressive Strength test at 28 days for all the cases are given in Table 6 and shown in Figure 8.

Table 6: Compressive Strength (MPa) of Concrete Cube Sample after 28 days

Sample No.	Normal Cube	B Type R/F	K Type R/F	X Type R/F	∑ Type R/F
1	22.77	31.32	25.18	29.70	27.72
2	20.85	31.92	30.37	30.93	25.06
3	22.15	34.62	31.55	35.06	31.64
Average	**21.92**	**32.62**	**29.03**	**31.9**	**28.14**

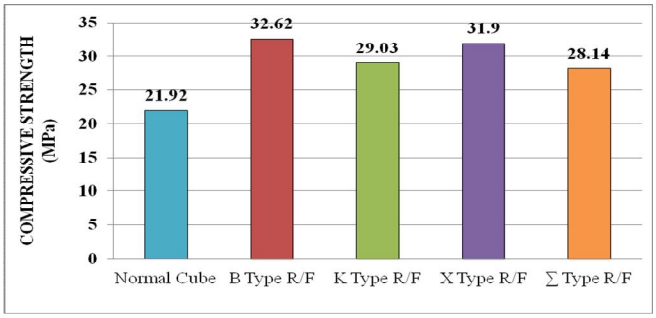

Fig. 8. Comparison of Compressive Strength Results of All Cases at 28 Days

Above comparison of Compressive Strength test result shows that B type has highest reading and ∑ Type shows minimum reading of compressive strength test at 28 days. Reinforced cubes have higher strength than normal cubes.

5. CONCLUSION

Following are the salient conclusions of the study:

(A) Ultrasonic Pulse Velocity Test

1. Ultrasonic Pulse Velocity reading for the cubes with different shapes of reinforcement are lower than the normal cubes for M20 grade of concrete after 28 days. Hence compaction is maximum in case of normal reinforcements.
2. Maximum value of Ultrasonic Pulse Velocity test is recorded for cubes having 'K type' reinforcement along with 'X type', 'B type' and minimum value is recorded in '∑ type' reinforcement. All values are lower than the normal cubes value for M20 grade of concrete after 28 days.

3. It is concluded that homogeneity of concrete is affected by the different shapes of reinforcements.

(B) Rebound Hammer Test

1. Rebound Hammer strength of cubes with different reinforcement is lower than the normal cubes for M20 grade of concrete after 7 days. But as duration of curing increases the rebound hammer strength in the cubes with different reinforcement gains the strength.
2. Maximum value is recorded in 'K type' at 7 days, '∑ type' at 14 days and '∑ type' and 'X type' at 28 days and minimum value is recorded in 'B type' at 7 days, 'K type' at 14 days and 'K type' at 28 days.
3. Rebound Hammer strength is more affected in case of '∑ type' reinforcement.

(C) Universal Testing Machine

Maximum value of compression strength is obtained in 'B type' reinforcement and minimum value is recorded in '∑ type' reinforcement and overall, reinforced cubes have the higher strength than normal cubes.

6. FUTURE SCOPES OF STUDY

1. The study deals with effect of different shapes of reinforcements on cube strength, the same may be extended to other specimen like flexural, cylindrical etc.
2. This study is restricted to only four shapes of reinforcements; the same may be extended with other shapes.
3. This study is restricted to static loads; the same may be extended to impact load.

REFERENCES

[1] Ali N. Alzaed **"**Effect of Iron Filings in Concrete Compression and Tensile Strength**"**, International Journal of Recent Development in Engineering and Technology, Volume 3, Issue 4, October 2014.

[2] Bureau of Indian Standards: IS- 10262-1982, **"**Indian Standard Recommended Guidelines for concrete mix design**"**, 1982.

[3] Bureau of Indian Standards: IS- 1199: 1959, **"**Indian Standard Method of Sampling and Analysis of Concrete**"**, 1959.

[4] Bureau of Indian Standards: IS- 12269: 1987, **"**Indian Standard Specification for 53 grade ordinary Portland Cement**"**, 1987.

[5] Bureau of Indian Standards: IS- 2386-1963 (Part-I), **"**Indian Standard methods of test for aggregates for concrete**"**, 1963.

[6] Bureau of Indian Standards: IS- 383-1970, **"**Indian Standard Specification for coarse and fine aggregates from natural sources for concrete (second revision)**"**, 1970.

[7] Bureau of Indian Standards: IS- 456-2000, **"**Indian Standard Plain and reinforced concrete code of practice (fourth revision)**"**, 2000.

[8] Bureau of Indian Standards: IS- 516: 1959, **"**Methods of Test for Strength of Concrete**"**, New Delhi, 2003.

[9] Mehmet Gesoğlu, Erhan Güneyisi, Ganjeena Khoshnaw, Süleyman İpek **"**Investigating properties of pervious concretes containing waste tire rubbers**"** Construction and Building Materials, Volume 63, July 2014.

[10] M.L. Gambhir, **"**Concrete Technology**"**, The McGraw-Hill Company, Third Edition 2004.

[11] N.Manoj, N.Nandhini, **"**Experimental Investigation of Fibre Reinforced Concrete with Partial Replacement of Coarse Aggregate by Steel Slag**"**, International Journal of Innovative Research in Science, Engineering and Technology Volume 3, Special Issue 2, April 2014.

[12] Vikrant S Vairagade, Kavita S. Kene, Tejas R Patil, **"**Comparative Study of Steel Fiber Reinforced Over Control Concrete**"**, International Journal of Scientific and Research Publications, Volume 2, Issue 5, May 2012.

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