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STUDY ON STRENGTH PROPERTIES OF FIBRE REINFORCED CONCRETE BY PARTIAL REPLACEMENT OF SAND BY COPPER SLAG

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Abstract: **The rapid rate of growth in population of India has forced the construction industry to use the building materials at a rapid rate, resulting in depletion of natural resources and also has a severe impact on the environment causing many hazards. Due to rapid growth and production, vast quantities of waste are generated in India. This thesis work is focused on making an effort to use copper slag which is an industrial by-product of Sterlite Industries Ltd (SIL), Tuticorin, Tamil Nadu, India. An experimental investigation was carried out to evaluate the effects of replacing fine aggregate by copper slag and steel fibre as an additive on mechanical properties of concrete. The whole study was done in two phases. In the first phase the feasibility of copper slag as fine aggregate was checked by preparing concrete mix of M30 grade and studying the effect of copper slag on mechanical properties of concrete. Optimum replacement percentage of copper slag was obtained as 40%. In the second phase, the properties of concrete with optimum copper slag content and various percentage of steel fibre was studied. The steel fibre reinforcement was varied from 0.50%-1.75% by weight of cement. The two types of steel fibres used are crimped fibre and hooked end fibre. The results showed that the compression strength is highest for 1% steel fibre addition for both hooked end and crimped fibre. The concrete containing the hooked end fibre shows more compressive, tensile and flexural strength compared to concrete containing crimped end fibre.**

Keywords: **Copper slag, sand replacement, steel fibres, hooked end fibre, crimped fibre, aspect ratio, compressive strength, split tensile strength, flexural strength.**

I. INTRODUCTION

Concrete is the most popular and most economical construction material. The production of concrete requires large quantities of materials. However, with the rapid growth in construction industry and fast dwindling of suitable sources, natural sand is becoming a very scarce material. Therefore, there is needed to look for alternate types of fine aggregate. As a result for the search of alternatives, copper slag is considered as one of the best options available. Copper slag is one of the by-products of smelting and refining process done during the extraction of copper. One of the main objectives of this research work is to study on the effects of incorporation on copper slag in concrete mix as a partial replacement of sand. The other objective is to study the influence of steel fibres in strength properties of the concrete mix. The research work used two types of steel fibres, hooked end fibre and crimped fibre both of aspect ratio of 60. R R Chavan et.al [1] investigated on the effect of using copper slag as a replacement of fine aggregate on the strength properties. Arivalagan [2] investigated to explore the possibility of using copper slag as a replacement of sand in concrete mixtures in various percentages ranging from 0%, 20%, 40% 60%, 80% and 100%. It was observed that, the flexural strength of concrete at 28 days is higher than design mix (without replacement) for 40% replacement of fine aggregate by Copper slag. Ranjith

Kumar.R et. al. [3] the behaviour of concrete strength by using hybrid fibre reinforced concrete (HFRC) was analyzed by adding fibres of various aspect ratios at 2% of weight of cement. Amit Rana et.al[4] carried out tests on steel fibre reinforced concrete to check the influence of fibres on flexural strength of concrete. Milind V. Mohod et.al[5] studied the effect of fibres on the strength of concrete for M 30 grade by varying the percentage of fibres in concrete. Fibre content was varied by 0.25%, 0.50%, 0.75%, 1%, 1.5% and 2% by volume of cement.

II. EXPERIMENTAL PROGRAMME

1. Materials Used: Ordinary Portland cement (ACC) of grade 53 was used for this experimental work. Coarse aggregate used was crushed angular aggregate of size 20mm and down. The fine aggregates used was river sand and copper slag. The basic material test was done as per code IS: 383-1970. The super plasticiser used was MasterGlenium SKY 8233. The steel fibres used were hooked end steel fibre and crimped steel fibre both of aspect ratio 60. The water used was available in the college laboratory.

TABLE I: PHYSICAL PROPERTIES OF FINE AND COARSE AGGREGATES

Particular	Natural sand	Copper slag	Coarse aggregate
Specific gravity	2.74	3.64	2.76
Water absorption (%)	1.25	0.90	0.55
Grading	Zone II	Zone II	-

2. Mix Design: The mix proportion chosen for this study is M30 grade (1:1.78:3.20) with water-cement ratio of 0.40. Cubes of standard size 150x150x150mm, cylinders of standard diameter 150mm and height of 300mm, prisms of size 100x100x500mm are casted and cured for 7 and 28 days and tested as per code IS: 516-1959 and IS: 5816-1999.

TABLE II: MIX PROPOTION FOR M30 GRADE CONCRETE

Mix	**% replacement of fine aggregate by copper slag**	**Cement kg/m^3**	**Fine aggregate kg/m^3**	**Copper Slag kg/m^3**	**Coarse aggregate kg/m^3**	**Water kg/m3**
CM	100% RS	394	705.276	-	1262.97	157.6
CS-10	90%RS+10%CS	394	634.740	70.528	1262.97	157.6
CS-20	80%RS+20%CS	394	564.22	141.050	1262.97	157.6
CS-30	70%RS+30%CS	394	492.99	211.280	1262.97	157.6
CS-40	60%RS+40%CS	394	423.16	282.110	1262.97	157.6
CS-50	50%RS+50%CS	394	352.638	352.638	1262.97	157.6

***3. Compressive Strength*:** Uni-axial compressive strength testing was done on 150 x 150 x 150 mm cubes. The procedure is the same as given in IS 516-1959. All the cubes were wet cured up to the day of testing. The cubes are tested for both 7 days and 28 days of curing. Three specimens were made for each age testing and for each mix made with partial substitution of copper slag in the order (0%, 10%, 20%, 30%, 40% & 50%).The maximum value of compressive strength was obtained for 40% replacement of sand by copper slag. The variation of the compressive strength is shown in figure 1.

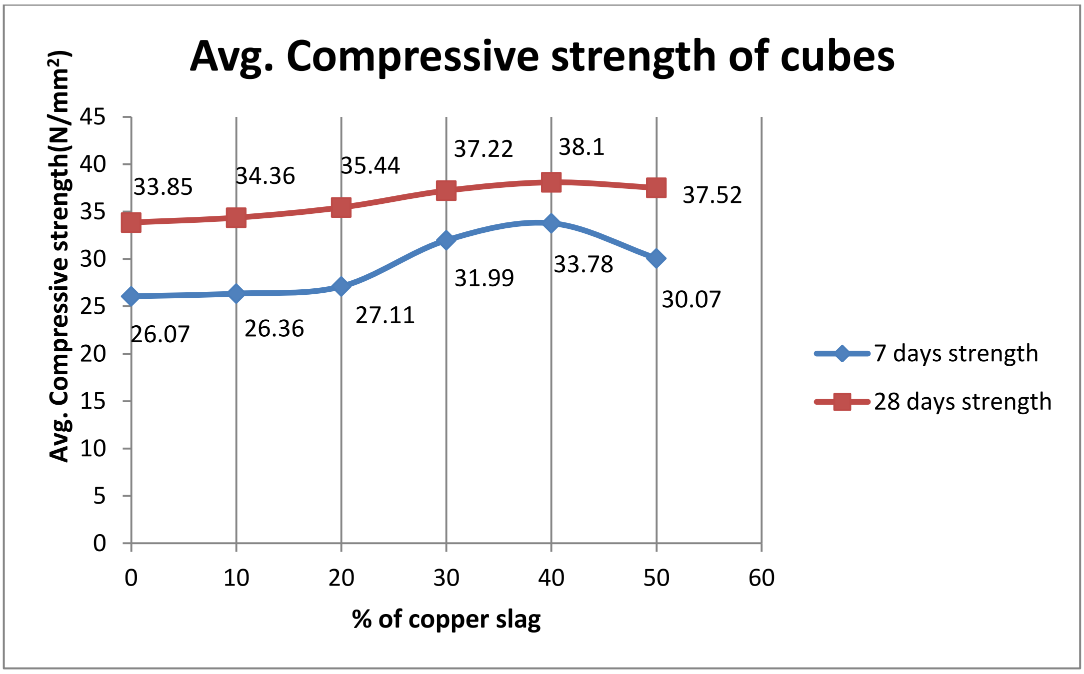

FIG. 1 COMPRESSIVE STRENGTH WITH RESPECT TO VARIATION OF COPPER SLAG (7 & 28 DAYS)

Compressive strength test was then carried out on cubes which were cast by fixing the copper slag variation as 40% and variations were carried in the quantity of steel fibres added. The two types of steel fibres used were hooked end steel fibre and crimped steel fibre, both of aspect ratio 60. The comparison of the compressive strength of cubes with the two fibres is shown in figure 2.

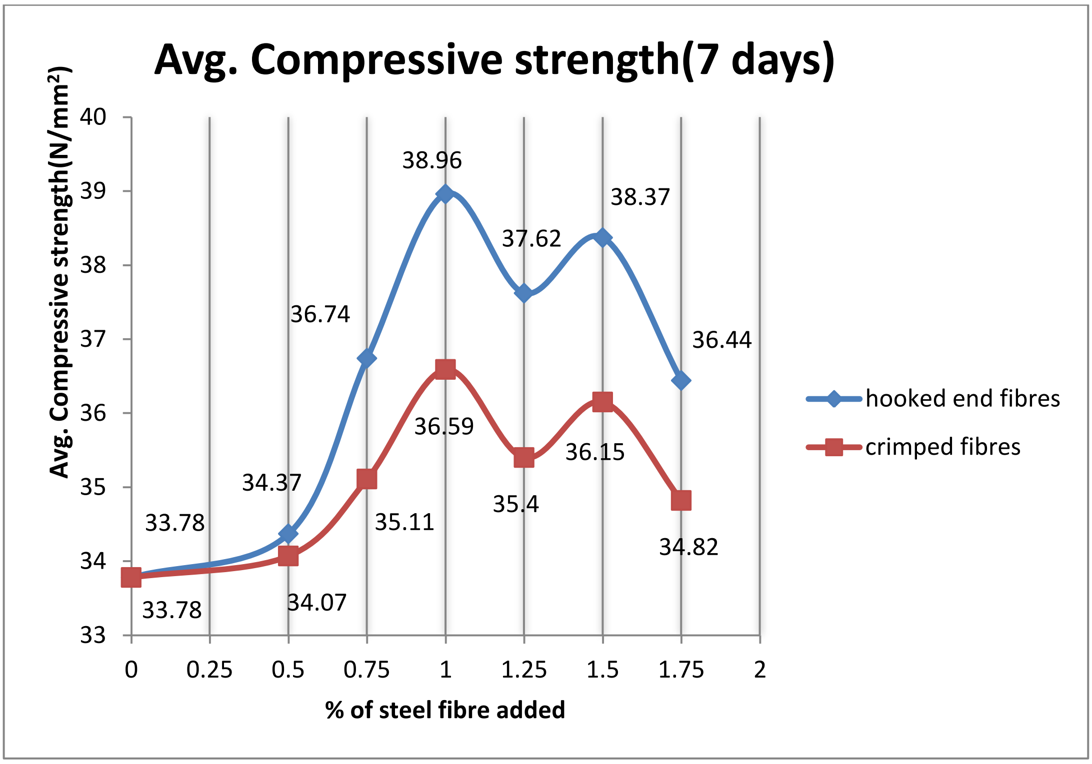

FIG. 2 COMPRESSIVE STRENGTH WITH RESPECT TO VARIATION OF STEEL FIBRE (7 DAYS)

Compressive strength test is then carried out to obtain the 28 day strength values. The values obtained and the comparison of strength is shown in figure 3.

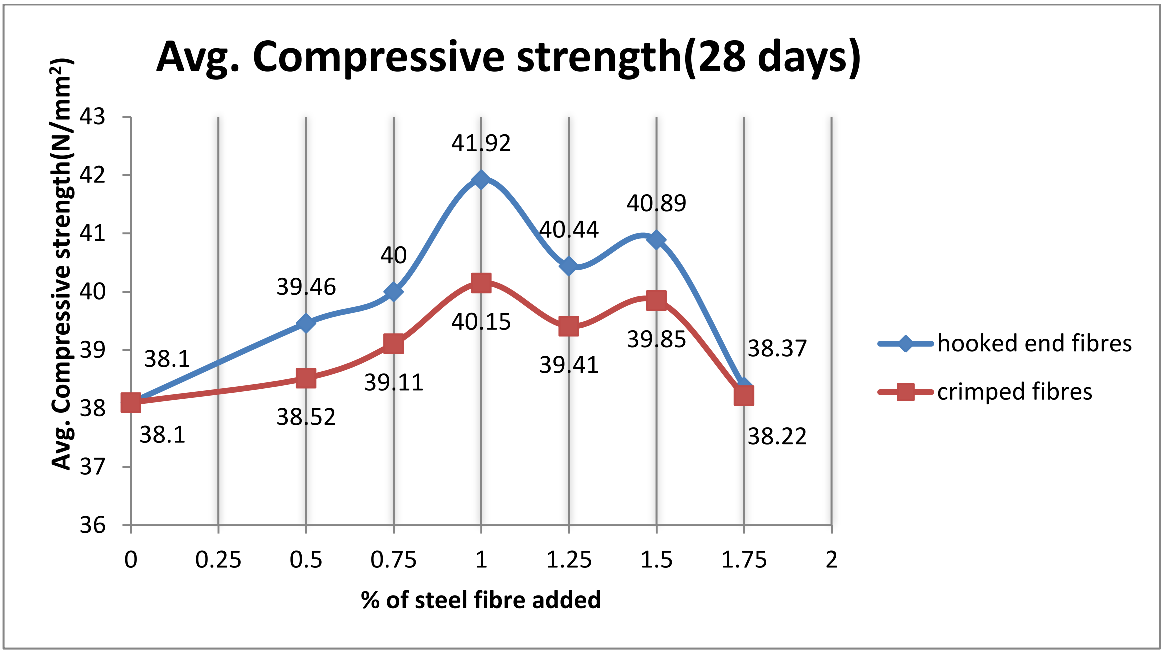

FIG. 3 COMPRESSIVE STRENGTH WITH RESPECT TO VARIATION OF STEEL FIBRE (28 DAYS)

4. Split Tensile Strength: The cylinders of size 150mm in diameter and 300mm in length are casted for various percentages of steel fibres by keeping the copper slag content constant at 40%. Total 3 cylinders are casted for each trial. Then testing was done on a compression testing machine as per code IS: 516-1959. The cylinders are cured and tested for 28 day strength. The variation in the strength is shown in fig 4.

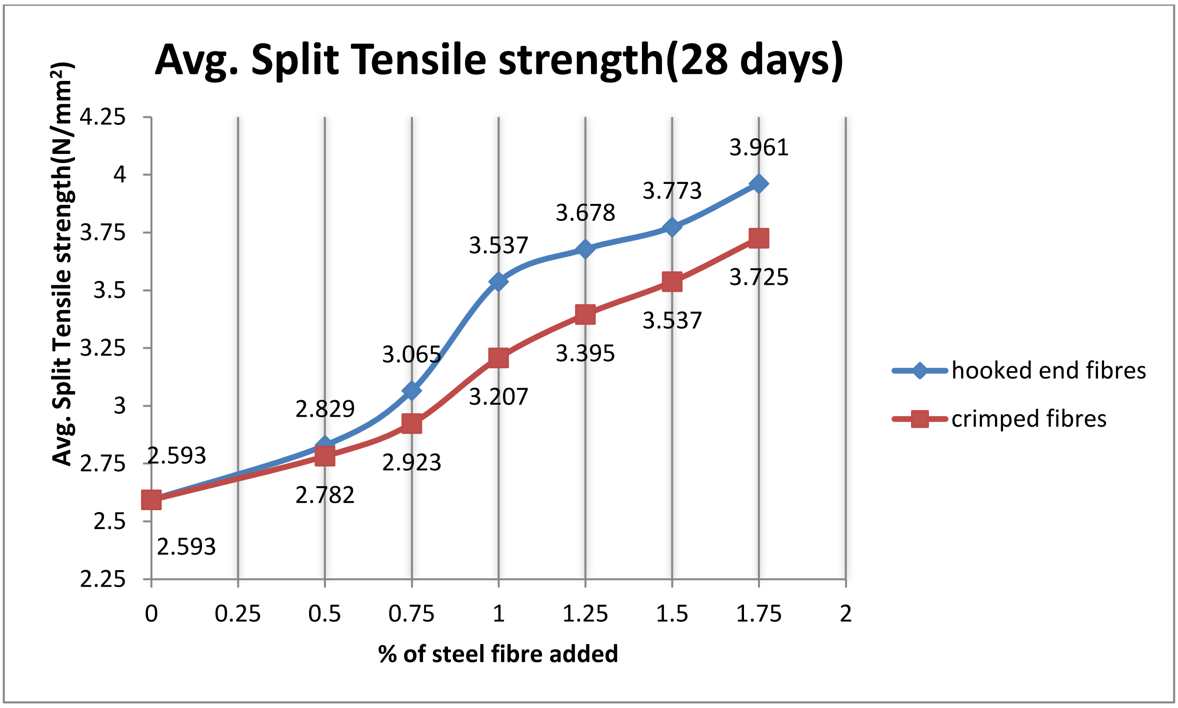

FIG. 4 SPLIT TENSILE STRENGTH WITH RESPECT TO VARIATION OF STEEL FIBRE (28 DAYS)

5. Flexural Strength: The prisms of size 100mm x 100mm and 500mm in length are casted for various percentages of steel fibres by keeping the copper slag content constant at 40%. Total 3 cylinders are casted for each trial. The prisms are cured and tested for 28 day strength. The specimen is mounted on the testing platform of universal testing machine. The specimen is subjected to 2 point loading as per code IS: 516-1959. The variation in strength is shown in figure 5.

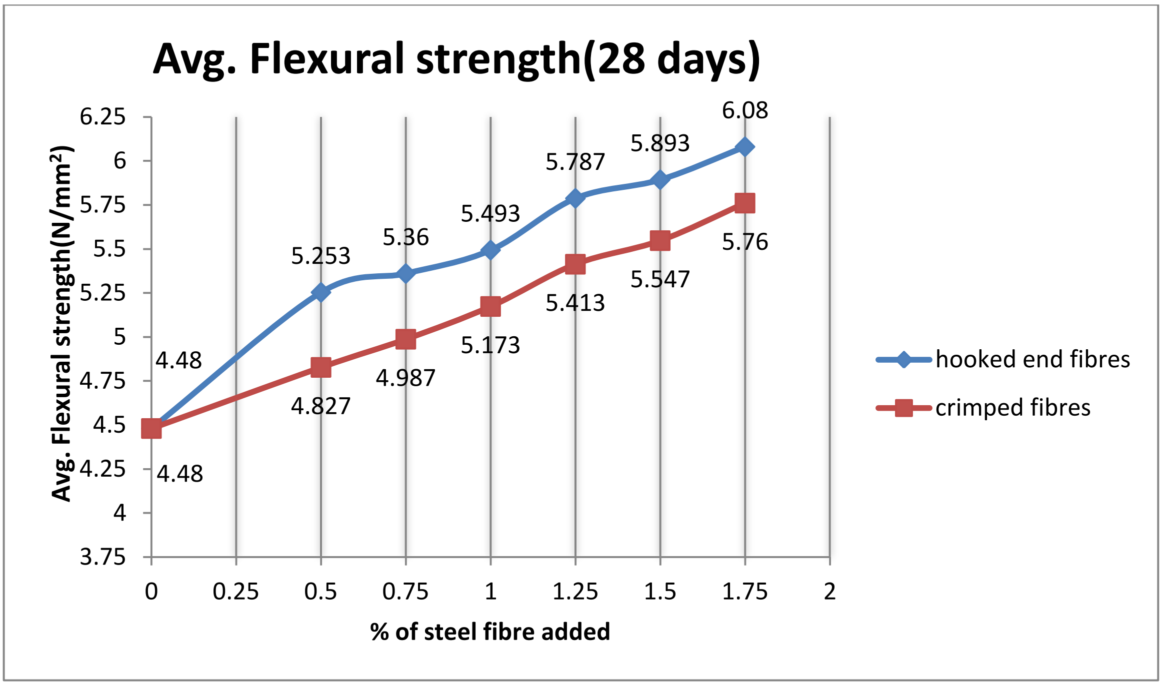

FIG. 5 FLEXURAL STRENGTH WITH RESPECT TO VARIATION OF STEEL FIBRE (28 DAYS)

III. RESULTS AND DISCUSSION

1. Load Vs. Deflection Graphs: The variation of load versus deflection was recorded during the flexural strength test of the prisms. The deflection is recorded using the dial gauge. Figure 6 shows the load versus deflection curve for prism containing 1.00% hooked end steel fibre, 40% of sand being replaced by copper slag.

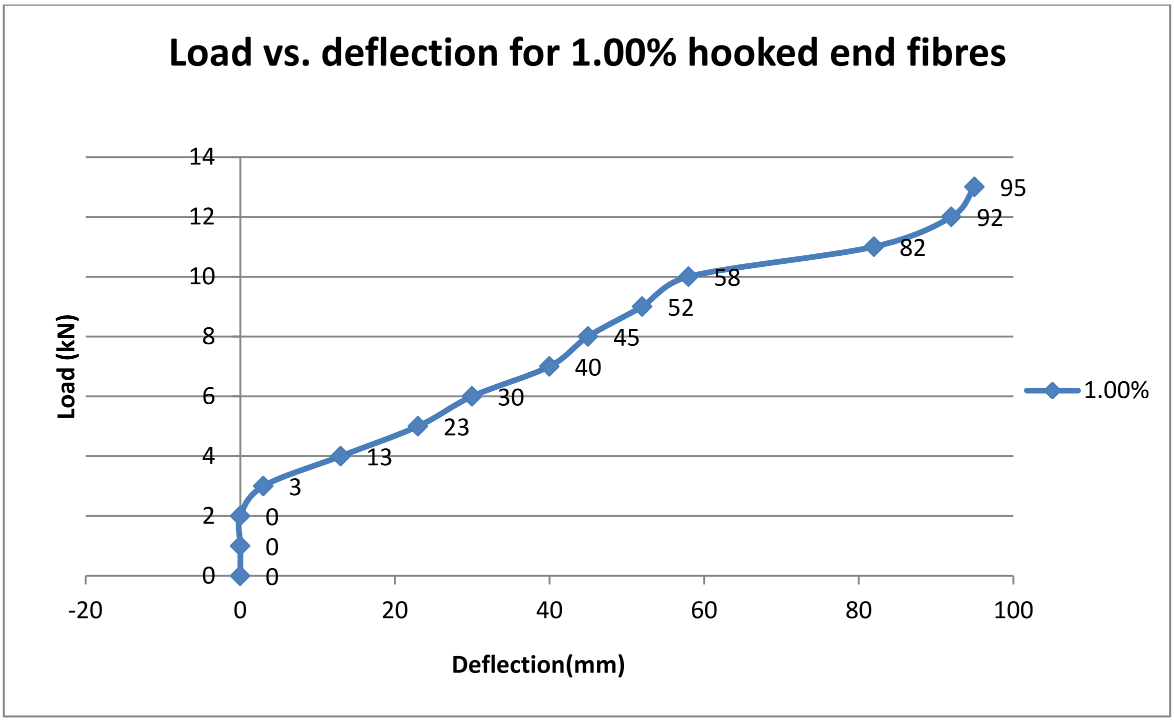

FIG. 6 LOAD VERSUS DEFLECTION OF PRISM WITH 1.00% HOOKED END STEEL FIBRE

Figure 7 shows the load versus deflection curve for prism containing 1.00% crimped steel fibre, 40% of sand being replaced by copper slag.

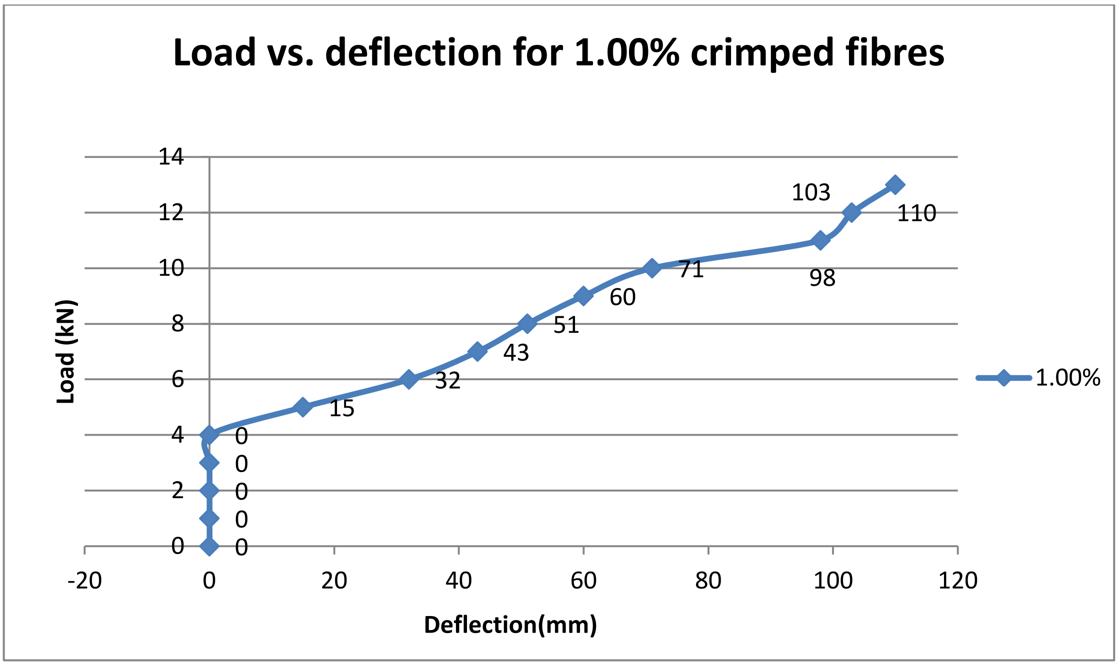

FIG. 7 LOAD VERSUS DEFLECTION OF PRISM WITH 1.00% CRIMPED STEEL FIBRE

2. Compressive Strength:- From both the compression test results (7 days and 28 days), it is clearly evident that the maximum strength of the cube is achieved at 40% replacement of sand by copper slag. Hence the copper slag content is fixed at 40%. From both the compression test results (7 days and 28 days), it is clearly evident that the maximum strength of the cube is achieved at 1% addition of steel fibres to the concrete mix. The strength increases on addition of 1.50% of hooked end steel fibres but it reduces again for 1.75% for both hooked end steel, crimped steel fibres.

3. Split Tensile Strength: From the results, it is clearly evident that the split tensile strength increases with the addition of hooked end steel fibre or crimped steel fibre content.

4. Flexural Strength: The results show that the flexural strength goes on increasing with the increase in the hooked end steel fibre or crimped steel fibre content.

IV. CONCLUSION

The results of the experimental investigations lead to the following conclusion:-

1. The compressive strength of the cube increases up to 40% of sand replacement by copper slag, and then starts decreasing.
2. The compressive strength of the cube with 40% copper slag is 12.55% more than the compressive strength of conventional concrete cube when checked for 28 day strength.
3. The split tensile strength of the cylinder with 40% copper slag is 9.97% more than the cylinder of conventional concrete mix when checked for 28 day strength.
4. The flexural strength of the prisms with 40% copper slag is 12.76% more than the prism of conventional concrete mix when checked for 28 day strength.
5. The compressive strength increases linearly and is highest for the cube containing 1.00% hooked end steel fibres. The compressive strength then shows decrease in strength for the remaining mixes.
6. The compressive strength increases linearly and is highest for the cube containing 1.00% crimped steel fibres. The compressive strength then shows decrease in strength for the remaining mixes.
7. The split tensile strength of the cylinder containing 1.75% hooked end fibres is 6.34% more than the split tensile strength of the cylinder containing 1.75% crimped fibres.
8. The flexural strength of the cylinder containing 1.75% hooked end fibres is 5.56% more than the flexural strength of the cylinder containing 1.75% crimped fibres.

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