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AN EXPERIMENTAL STUDY ON STRENGTH AND CORROSION OF CONCRETE WITH STEEL SCRAP

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Abstract:-

Steel scrap is a waste product of steel plate manufacturing industry. Every year huge quantity of steel scrap is produced from drilling the steel plates and other related works. Disposing of those steel scrap is a major issues in Oman and all over the world. Landfill is one of the method for disposing the scraps however it produces soil pollution. Also in Oman, there is no waste separation system, therefore all the waste materials are dumped in soil especially in the desert and it is harmful to the environment. In the present study, steel scrap is added with concrete and the mechanical and physical properties were studied. Three tests were conducted such as slump test to measure the workability of fresh concrete, compressive strength test and corrosion test. In total, four various mixes were prepared with and without steel scrap. The first mix was normal mix without any steel scrap and the remaining three mixes were concrete with adding steel scrap with 1%, 2% and 3%. Based on the compressive strength test results, samples of 1%, 2%, 3% of adding steel scrap shows that the strength was increased for samples with 1% and 2% steel scrap and decreased for 3% steel scrap.

Keywords:- *Steel scrap; Corrosion test; recycle; Compressive strength; Slump test*

1. INTRODUCTION:

All the countries are facing the problem of landfill. Many countries suffer from the less capacity of landfills. There are a lot of factors for this landfill problem. Increase of population, increases the waste generated from manufacturing process and construction, demolition and countries need more landfills and because of those waste materials, landfills are getting full quickly. The main problem with landfills is the waste materials are not recycled. In Oman, there is no waste separation system therefore all waste materials are dumped in open area. Lot of materials can be reused or recycled. Dumbing without recycling is a waste of materials, energy and very harmful to the environment. This present study is mainly focusing on adding steel scrap in concrete to use this waste material. The waste materials are collected from the site which is waste from steel manufacturing industry. This method will be helpful to reduce the waste which created by manufacturing steel and also construction, demolition sector. Adding steel scrap to paving block will improve the mechanical properties of paving block. The scope of this research work is testing and comparison of normal paving block with steel scrap adding to the paving block, moreover to reduce the waste generated by steel manufacturing process and construction, demolition will preserve the environment and put a good use of this type of waste material to improve mechanical properties of paving block. The aim of the project is to determine physical and mechanical properties of concrete with steel scrap. The aim of the present study is achieved by conducting experimental work. The main objectives of this work are, to determine the mix ratio of C30 grade concrete, to cast cubes with and without steel scrap, to conduct compressive and split tensile strength of concrete with and without steel scrap and to conduct corrosion test on concrete. Many researchers have done experimental work in the field of concrete with steel scrap. A study was conducted to reuse of lathe waste steel scrap in concrete pavements.

Many research works carried out in the field of concrete with steel fibre. Researchers used various techniques such as, steel slag was mixed as a coarse aggregate with concrete [1], thermal property of concrete with steel fibre was studied [2], experimental investigation was carried out on fibre reinforced concrete with waste materials [3], reuse of lathe waste steel scrap in concrete pavements [4] and pullout behavior was studied of steel fibers in self-compacting concrete [5].

2. Materials and methods

In this work, the materials used for experimental study are cement, fine and coarse aggregates, water and steel scraps. Steel scrap is a waste materials and it is a waste product of steel manufacturing industry. Every year huge amount of steel scrap is produced in Oman. Also steel scrap is available from drilling of other steel component as shown in Fig. 1.

Fig. 1 Steel scrap from drilling of steel plate

Fig. 2 Steel scrap

Steel scraps were collected from steel manufacturing company from Ghala, Sultanate of Oman as shown in Fig. 2. Also steel scraps are produced by drilling and cutting steel plates or steel sheets.

3 Materials Needed for the Experiment

3.1 Fine and coarse Aggregates

Fine aggregate size used for experimental work was less than 5 *mm*. Fine aggregate is free from chemicals, salt and other dust particles. It is produced from grinding stones from rock as shown figure 3. The size of course aggregate used for this experimental work was between 10 and 20mm as shown in figure 4.

3.2 Cement and water

Grade of concrete used for this work was C30. Ordinary Portland cement (OPC) was used as a binder. The water was used in the mixing and curing was free from salt and other chemicals.

4 Testing of mechanical and physical properties of concrete specimens

Three tests were conducted for this experiment compressive test on concrete cubes, corrosion test and slump test on fresh concrete. Slump test was conducted on fresh concrete to measure the workability and compressive strength test was conducted to find out 28 days cube compressive strength of concrete.

Fig. 3 Fine Aggregate

Fig. 4 Coarse Aggregate

4.1 Compressive strength Tests on hardened concrete

Compressive test on concrete cubes were conducted in laboratory using 100 Tonne Universal Testing Machine as per BS 1881: Part 116: 1983 as shown in Fig. 5. The size of the cube is 150 *mm* and the cube was placed on the lower platform of UTM and load is applied at top surface of the cube. The load is increased continuously at a nominal rate within the range 0.2 N/mm^2·s to 0.4 N/mm^2·s until no greater load can be sustained and till the specimen fails. The maximum load at the point of failure (occurrence of crack) is recorded and results are obtained compressive strength from the following equation.

$$f_c = \frac{F}{A_c}$$

Where

F - The maximum load at the point of failure in N

Ac - Cross-sectional area of the cube in mm^2

f_c – Compressive strength of concrete in MPa

4.2 Slump tests on fresh concrete

Four slump tests were conducted for each mix. The tests were done laboratory while mixing and casting to check the workability of fresh concrete. The slump test apparatus consist of a cone in the form of a hollow frustum of a cone with diameter of base 200 *mm*, diameter of top 100 *mm* and height of cone 300 *mm*.

Cone is filled with fresh concrete in three layer and tamped it twenty five times in each layer using a rod of standard dimension. Lifted the cone vertically and after removing the cone measure in to the nearest 5 *mm* so that to check difference between the height of the cone and highest point of the specimen being tested as shown in Fig. 6. This slump test takes various several shapes, where based on profile of slumped concrete, the slump is termed as a true slump, which shear slump or collapse slump.

Fig. 5 Compressive strength test on cube

Fig. 6 Slump test

4.3 Corrosion Test

After the block is broken, liquid Phenolphthalein indicator was poured on the broken surface. Phenolphthalein it is a colorless liquid as shown in Fig. 7. If there is corrosion in the concrete or ingredients, then the color will be changed into pink.

Fig. 7 Phenolphthalein indicator

5 Results & Discussion

Based on the experimental work, the following results were discussed.

5.1 Slump Test Results

The slump test was conducted with four mixes the first mix is normal mix without any steel scrap and the three remaining mix are concrete with steel scrap with 1%, 2% and 3%. Results were found that the slump value was not stable. Slump values are decreasing in the mixes which contain steel scraps comparing with the normal mix. In the first mix which is normal mix the result is 15 mm, the second mix with adding 1%, the result decreased to 10 mm, in third mix of adding 2% the result decreased to 5 mm, and the fourth result of adding 3% it shows decreasing to 0 mm. Table 1 and Fig. 8 shows the slump test results.

Table 1 Slump test results

SI NO.	Cement		Steel Scrap		Slump values (*mm*)
	%	Kg	%	Kg	
1	100	3.275	0	0	15
2	100	3.275	1	0.31	10
3	100	3.275	2	0.62	5
4	100	3.275	3	0.93	0

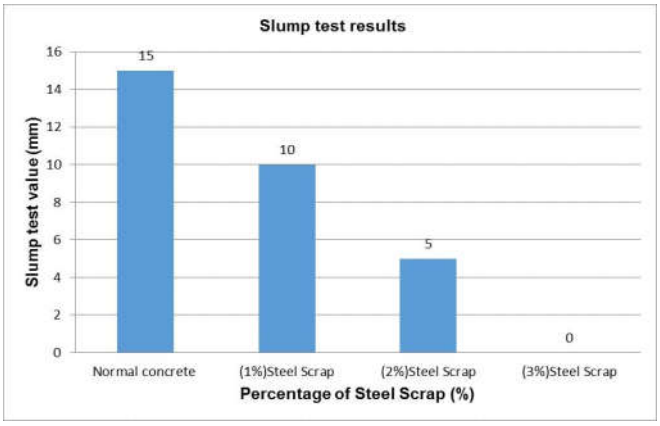

Fig. 8 Slump test results

5.2 Compressive Strength Test Results

Compromise strength tests on cubes were conducted after 28 days of curing using 100 Tonne Universal Testing Machine (UTM), and the results are shown in Table 2. Compressive strength results were plotted and shown in figures 9 and 10.

Table 2 Compressive Strength on Cube

Type of concrete	Average Compressive Strength (MPa)
Normal Concrete	30.64
Concrete with 1% steel scrap	34.34
Concrete with 2% steel scrap	32.04
Concrete with 3% steel scrap	19.48

Based on the compressive strength result test the following discussions are made,

1. Based on experimental study, 28 days cube compressive strength of concrete with steel scrap 1% and 2% are 12.08% and 4.56% more than that of normal concrete respectively.
2. However the 28 days cube compressive strength of 3% steel scrap is 57.28% less than the normal concrete.
3. Based on the test results, compressive strength of the concrete with steel scrap upto 2% was increased.

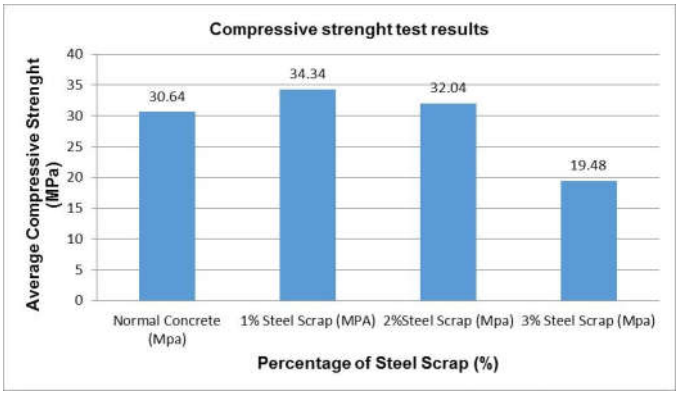

Fig. 9 Compressive strength test results

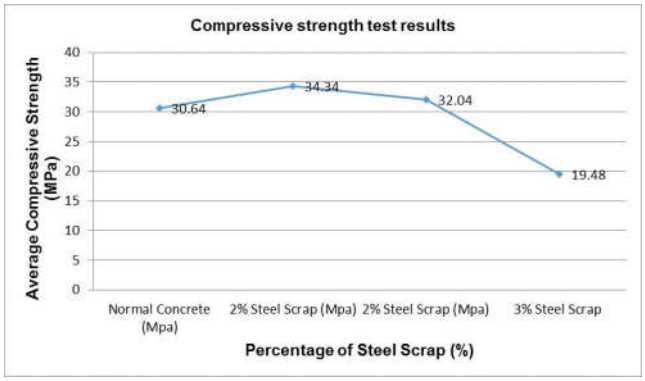

Fig. 10 Compressive strength test results

5.3 Corrosion Test

Corrosion test on concrete were conducted after the cube was split into two pieces. It was conducted on normal concrete, and in 2% of adding Steel Scrap on concrete. The procedure of this test was pouring small quantity of phenolphthalein indicator on inside surface of cube to check if there is possibility of corrosion or not compared to normal concrete. Fig. 11 and 12 show the corrosion test for normal concrete and concrete with 2% steel scrap respectively.

Fig. 11 Corrosion test-normal concrete

Fig. 12 Corrosion test-concrete with 2% Steel Scrap

Based on the corrosion test the following discussions are made,

The test results show that while pouring the phenolphthalein indicator on the surface of normal concrete, there is no change of color, which means that no corrosion is possible in control mix. But on the other hand, it was found that pouring of phenolphthalein indicator on the surface of 2% of adding steel scrap concrete, the color of the broken concrete is changed to dark pink color, which means corrosion will occur in concrete mixed with steel scrap.

According to compressive strength tests results on the samples of 1%, 2%, 3% of adding steel scrap, it shows that the strength is increasing in sample 1% and 2% but in 3% decreased caused by the corrosion inside of concrete, and it means that corrosion which happen inside is effecting the strength force of adding more than 2%. To solve the decrease of strength Zinc-rich primers must be applied to steel scrap before mixing with the concrete to prevent corrosion. This procedure will prevent corrosion to appear and the strength will increased of adding more than 2%.

6. Conclusions

The following conclusions were made based on the test results. In the present study, waste steel scraps were added with concrete to check the improvement of mechanical properties of concrete used for construction industries.

1. In Oman huge amount of steel scraps are available from industries and it is dumbed in lands. In this project work steel scraps are added with concrete and found that the mechanical properties of the concrete is improving and this method can be very helpful of reducing waste disposal in the environment.
2. Workability tests on fresh concrete using slump tests were conducted and the results show that the maximum slump value is 15 mm.
3. Compressive strength of concrete with steel scrap was more than that of normal concrete (concrete without steel scrap) and the results show that this technique is effective use of steel scrap in concrete.
4. Based on experimental study, 28 days cube compressive strength of concrete with steel scrap 1% and 2% are 12.08% and 4.56% more than that of normal concrete respectively.
5. However the 28 days cube compressive strength of 3% steel scrap is 57.28% less than the normal concrete.
6. Based on the test results, compressive strength of the concrete with steel scrap upto 2% was increased.
7. Also in this work, corrosion tests on concrete with and without steel scrap were conducted using phenolphthalein. The results show that the concrete with steel scrap will be affected quickly due to corrosion.

7 References

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