Performance of Concrete Containing Iron Fillings

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Abstract

Non-biodegradable wastes materials pose a significant environmental hazard to living organisms and their disposal requires effort, time and money. One of the most useful processes by which this waste can be exploited is the recycling process. Iron filings are one of the wastes materials that can be recycled and used in engineering fields. One of these is the use of the process in construction. Iron filings are very small pieces of iron that look like a light powder. They are very often used in science demonstrations to show the direction of a magnetic field. The purpose of this project is to evaluate the possibility of using iron filings as one of the component of concrete mix. Three different percentage of iron filings were added to concrete mix to measure the variation, which may be obtained in compression and tensile concrete strengths after 28 days. 45 of 150mm cubes and prisms of 100x100x400mm were performed and tested in this study using 0% (control), 5%, 10% and 15% of iron filing in concrete mix.

Keywords: Concrete, Waste materials, Iron fillings.

1. Introduction

Any construction work needs several materials such as concrete, steel, brick, stone, glass, clay and so on. However, the cement concrete remains the most important construction material used in construction industries. For its suitability and adaptation with respect to the changing environment, the concrete must be such that it can save resources, protect the environment, economize and leads to proper utilization of energy. To accomplish this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The employment of recycled aggregate in fact is very promising as 75% of concrete is made of aggregates. In that condition, the aggregates considered are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, sawdust, combustor ash and foundry sand. The massive quantities of ruined concrete are available at various construction locations, which are now show a serious problem of disposal in urban regions. This can easily be recycled as aggregate and used in concrete.

One of the main challenges of the present society is the protection of environment. Some of the major elements in this respect are the decreasing of the exhaustion of energy and natural pure materials and exhaustion of waste materials. These topics are earning considerable attention under sustainable development nowadays [1] [2].

2. Materials

2.1 Cement

The type of cement utilized in this study is ordinary Portland cement (Tasolje Iraqi Portland cement type).

2.2 Coarse Aggregate

The crushed granite available in local area called (Snam Mountain) with maximum size 20 mm was used in this study. The coarse aggregate is conformed to ASTM C 33-07[3]. Shown in plate (1.1).

Plate (1.1) coarse aggregate

2.3 Fine Aggregate

Natural sand available in local area called (Juibda) with maximum size 4.75 mm was used in this study. The fine aggregate is conformed to ASTM C 33-07 [3]. Shown in plate (1.2).

Plate (1.2) Fine aggregate

2.4 Water

Tap water free of impurities, chemicals and organics available locally used in this study.

2.5 Iron Fillings

The iron fillings used in this study was obtained from the workshops located locally in the (Dakeer) area in Basrah.The iron fillings using in this work shown in plate (1.3).

plate (1.3) Iron filling

3. Experimental Work

The experiment consists of two Parts namely Part I and Part II. The primary objective of part I is to find out the properties of concrete containing iron fillings by replace the iron fillings as a part of cement. The replacement will be done with three percentages starting with 5% and 10% then end with last percentage 15%. Part II will study the properties of concrete containing iron fillings by replace the iron fillings as a part of fine aggregate (sand).

4. Concrete Mixes

In order to determine the performance of concrete containing iron fillings, 7 mixes were prepared. These mixes were designed in such way to achieve an ultimate compressive strength of 45MPa Based on B.S. The first mix will be the control mix (reference mix) concrete without any admixture. Three mixes for concrete with iron fillings replacement with cement and three mixes for iron fillings replacement with sand. The mix proportions are shown in table (1).

Table 1: The mix proportions

Mix Type	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Iron Fillings (Kg)	Water/Cement Ratio
Control	445	668	1085	185	0	0.42
P1-M1	422.75	668	1085	185	22.25	0.42
P1-M2	400.5	668	1085	185	44.5	0.42
P1-M3	378.25	668	1085	185	66.75	0.42
P2-M1	445	634.6	1085	185	33.4	0.42
P2-M2	445	601.2	1085	185	66.8	0.42
P2-M3	445	567.8	1085	185	100.2	0.42

5. Mixing

The procedure for the purpose of casting the prepared materials and weight in the laboratory and then prepare the cubes in addition to the cylinders needed for tests. The concrete mixture used in this study is shown in plate (1.4), where the concrete mixture is added into the mixer without adding water. After running the mixer and mixing the materials, the water is added gradually until the mixture is homogenized.

Plate (1.4) Mixing the materials

6. Casting Procedure

For this study, cubes 150 mm were used. Also a cylinders with 150 mm diameter and 300 mm length were used in this study. A total of 36 cubes were casted for the purpose of conducting the compressive strength test for the concrete at age 7, 28 and 56 days and the same number of cylinders were used to conduct the tensile strength of the concrete at the same ages that mentioned previously.

7. Workability test

To get the fresh properties for the concrete two types of tests were used the first test is the slump test and the second test is the compact factor test.

7.1 Slump test

According to (ASTM C143/C143M, 2015). This test method was originally developed to provide a technique to find the consistency of unhardened concrete. Under laboratory conditions, with strict control of all concrete materials, the slump is generally found to increase proportionally with the water content of a given concrete mixture, and thus to be inversely related to concrete strength. Under field conditions, however, such a strength relationship is not clearly and consistently shown. Care should therefore be taken in relating slump results obtained under field conditions to strength[4].

7.2 Compact Factor Test

The compaction factor test measures the degree of compaction resulting from the application of a standard amount of work [5]. The test was developed in Britain in the late 1940s and has been standardized as British Standard 1881-[6]. The results of the compaction factor test can be correlated to slump, although the relationship is not linear [6]. Table 2 relates the results of the compaction factor test to slump and the sample's degree of workability.

Table 2: Description of Workability, with slump and compact factor results.

Degree of Workability	Slump,mm	Compaction Factor
Very Low	0-25	0.79
Low	25-50	0.86
Medium	50-100	0.93
High	100-180	0.955

8. Compressive strength test

According to (ASTM C39/C38M). Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommend concrete cylinder or concrete cube as the standard specimen for the test [7].

9. Tensile Strength

According to (ASTMC39/C39M, 2015). Splitting tensile strength is generally greater than direct tensile strength and lower than flexural strength (modulus of rupture). This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores[8][9].

10. Results and Discussion

10.1 Slump and Compact Factor

Tables 3 and 4 shown the results for slump test and compact factor test. Experimental results for part I highlighted that the concrete with 15% iron fillings have the highest slump value followed by concrete with 10% iron fillings, concrete with 5% iron fillings and control sample. Overall, the slump value of the four samples indicates that the workability of these concrete in Plastic range. Part I I results show that the mix with 15% iron fillings has the highest slump compared with the other mixes. Table 4 shows the compacting factor test. It was found that the concrete with 15%iron fillings have the highest compacting factor for the two parts followed by the concrete with 10%iron fillings. Although the slump value of control sample is lower than other concrete, it has a high compacting factor that indicates the control sample is more compact than concrete with iron fillings. When control sample has a high compacting factor, the density of control sample will be high.

Table 3: Slump test

Mix Type	Slump result (mm)
Control	**30**
P1-M1	**65**
P1-M2	**70**
P1-M3	**110**
P2-M1	**38**
P2-M2	**41**
P2-M3	**48**

Table 4 Compact factor result

Mix Type	Compact factor result (%)
Control	89
P1-M1	92
P1-M2	98.4
P1-M3	99.3
P2-M1	99.2
P2-M2	99.5
P2-M3	99.6

10.2 Compressive Strength Test

The control sample designed for grade 45 shows a fairly high compressive strength as shown in Table 5. The strength development of the control sample achieved 89% the 28-day strength for age 7 days. In the Table 5, the average compressive strength of the control sample at the age of 28 days is 46.25 MPa which is higher than the design strength of 40MPa. This high strength development partly due to good quality control during the manufacturing process of the concrete. The results of the compressive strength for part **I** indicate that the strength of concrete decrease when the ratio of iron fillings increase in concrete while the compressive strength of the concrete show a good development in part **II** when the ratio of iron fillings increase as a replacement from the sand.

Table 5: results of compressive strength

Mix Type	Compressive strength (Mpa)		
	7	**28**	**56**
Control	35.7	46.25	49.7
P1-M1	30.8	38.2	45.3
P1-M2	29	36.6	43.1
P1-M3	27.2	35.2	41.7
P2-M1	37.4	49.8	52.2
P2-M2	33.97	51.5	54.7
P2-M3	38.12	53.7	55.9

10.3 Tensile Strength Test

Figure (1) shows the results of the tensile strength for concrete mixes at 28 days age. The tensile strength results of the concrete indicate that the using of iron fillings in concrete increase the resistance of the concrete to the tensile forces. The values in figure (1) show that the ratio of 15% of the iron fillings give increment by 11.6% at part **I** and 92% at part **II**.

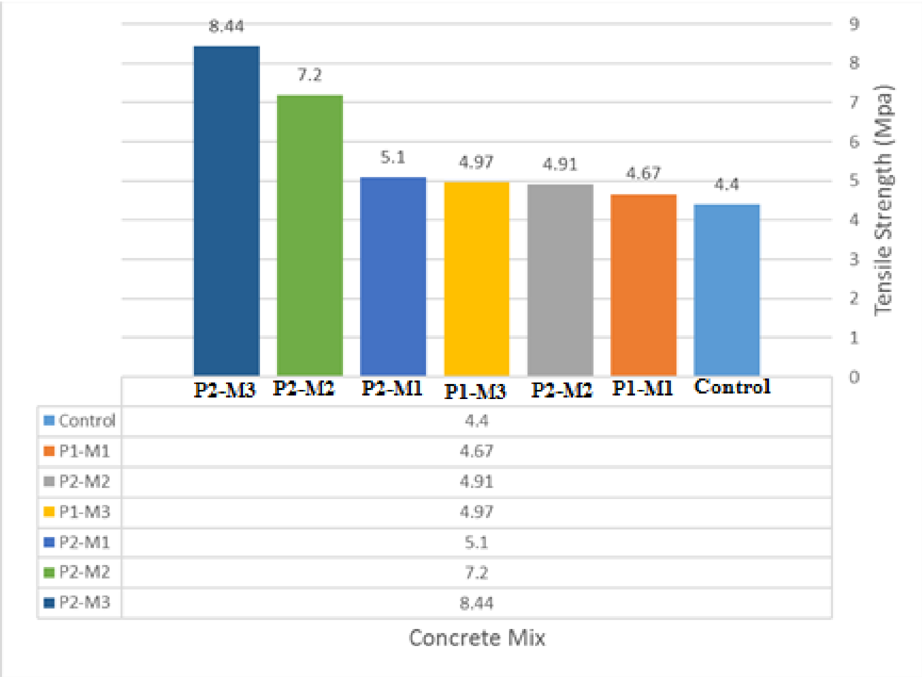

Figure (1) the results of the tensile strength for concrete mixes at 28 days age.

11. Conclusion

The conclusions that can be drawn from this study are as follows:

i) Workability

Concrete with iron fillings has the highest workability followed by control concrete. The result achieved from the slump test indicates that the use of iron fillings will increase the workability of concrete. In the concrete, iron fillings will effect on the consistency of the concrete that makes the concrete more workable furthermore the iron fillings cannot react with water so the quantity of water will increase in concrete. However, concrete with iron fillings has higher compacting factor compared to control sample.

ii) Strength

The compressive strength tests outcome for the concrete mixes are presented in tables. The results at 28 days demonstrate that as the waste iron fillings content increases in mixes P1-M1, P1- M2, and P1-M3, the tendency of the strength values decrease above that for the control mix by 8.05, 9.65, and 11.05 mpa, respectively. This tendency could be because the replacement the amount of cement by not intractable waste material, justified the decrement in compressive strength due to the low density and strength of the iron content. But the results in table 4 indicate that the increase in iron fillings in mixes P1-M1,P1- M2, and P1-M3 gives increase in compressive strength by 7.7%, 11.3% and 16.1% , respectively at age 28 days and this increment as a result from filling the voids in the concrete by the iron fillings which make the concrete more dense and more durable which led to increase the compressive strength. Also the results of the tensile strength in figure 5 show an increment by tensile strength value due to increase the ratio of the iron fillings The increase in tensile strength could be attributed to the strength and toughness of iron filings as well as its pozzolanic properties. Also, the ductility of iron filings could have led to the increase in the tensile strength.

12. References

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اداء الخرسانة الحاوية على برادة الحديد

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الخلاصة

تشكل المخلفات الصناعية الغير قابلة للتحلل البيولوجي خطرًا بيئيًا كبيرًا على الكائنات الحية ويتطلب التخلص منها بذل الجهد والوقت والمال. ومن بين العمليات الأكثر فائدة التي يمكن استغلال هذه المخلفات هي عملية إعادة تدويرها واستخدامها في المجالات الهندسية. برادة الحديد هي واحدة من المخلفات التي يمكن إعادة تدويرها واستخدامها في المجالات الهندسية. واحد من الاستخدامات هو استخدامها في عملية البناء. برادة الحديد هي قطع صغيرة من الحديد التي تبدو وكأنها مسحوق ناعم. وغالبا ماتستخدم في الاثباتات والبراهين العلمية لاضهار اتجاه المجال المغناطيسي. والغرض من هذا المشروع هو تقييم إمكانية استخدام برادة الحديد كأحد مكونات الخرسانة. تمت إضافة ثلاث نسب مؤية مختلفة من برادة الحديد إلى خليط الخرسانة لقياس التباين الذي يمكن ان يحدث في مقاومة الانضغاط والشد بعد 28 يومًا. تم اجراء واختبار 45 مكعب بأبعاد 150*150*150 مم والعتبات الموشورية بأبعاد 100*100* 400مم في هذه الدراسة باستخدام 0 ٪ (السيطرة)، 5 ٪، 10 ٪ و15 ٪ من برادة الحديد في خليط الخرسانة.

الكلمات المفتاحية: الخرسانة، المحلفات، برادة الحديد.