The Investigation on steel bar Corrosion within self compacting concrete including Flyash and Metakaolin

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Abstract: Due to weakness of concrete in tensile strength, using the steel bars in concrete is inevitable. However, the most important problem of usage of steel bars is corrosion. Therefore, researchers have been permanently following the methods that prevent or decrease the corrosion of steel in concrete. Moreover, these methods fail to be including the negative effects on the other features. One of the proposed solutions is using the self compacting concrete with high slump and performance and without vibration. This type of concrete easily fills the structural members as well as the concreting will be facilitated in the cases in which the vibration is difficult because of high steel bars numbers. In this study the reinforced self compacting concrete beam samples with dimension of 75 *10*10 cm and 2.5 cm cover including 10% of met kaolin and 10,15,20,25 % of flay ash altered cement, in the standard conditions and Zahedan climate are simulated. Overall, five self compacting concrete mixture with met kaolin and fly ash are designed. The fresh concrete experiments consist of slump, T50, J ring, L box and V ...., are performed. To evaluate the concrete mechanical properties, the pressure strength experiment is carried out based on BS 1881 Part 116 Standard within 7, 28, 90 ages. Furthermore, The Cabera Electric strength is performed within 7, 14, 28 ages. In the end the corrosion potential ASTM G876, weight reduction of bars and pictures of existed cracks are presented. In conclusion, the simultaneous usage of met kaolin and fly ash plays an effective role in decline of corrosion content.
[Majid Ghazvini pourakbari, Dr. Reza Rahgozar, Dr. Ali Ghods. **The Investigation on steel bar Corrosion within self compacting concrete including Flyash and Metakaolin.** *N Y Sci J* 2014;7(12):85-93]. (ISSN: 1554-0200). http://www.sciencepub.net/newyork. 11

Keywords: Corrosion, self compacting concrete, Flyash and Metakaolin

1. Introduction

One of the main objectives of this project is to achieve the proper ratio to obtain a mix of materials adapted to the climate of Zahedan replaced with Metakaolin and the final design of Flyash. Therefore, the experiments were carried out to determine the engineering properties of concrete containing these two additional and accelerated conditions (electric field) are examined. Despite a poor substitute for creating an electric field is the actual corrosion, but in the laboratory to produce accelerated corrosion commonly used method. Experimental work has been done in this project consists of two phases, the first phase to obtain mix, the overall profile design of beams, calculated in section steel beams and ultimately curing concrete and concrete containing Metakaolin and Flyash and the second phase of accelerated conditions corrosion and engineering properties of concrete.

In the first phase, self-compacting concrete slump test sample density was built in 2400- 2100 kg/m^3 was examined and in the second phase of the study, five of the mix design for self-compacting concrete, replacing 10 percent Metakaolin and 0, 10, 15, 20 and 25% Flyash instead of cement to investigate the conditions of Zahedan and accelerated conditions on the properties selected. Mechanical properties of compressive strength tests (BS 1881 part 116) and the electrical resistance of concrete durability tests (Cabera) and corrosion potential (ASTM G876) is used, to create an environment of accelerated ponds containing distilled water and 5% Nacl with electric flux on the surface of the beam is used.

2-4- consuming materials

1-2-4- stone materials

During field studies have been done to prepare the concrete mix design was determined The sand stone materials produced in the factory city of Zahedan concrete foundation industrial Park Kambozia than other materials are produced from higher quality. After reviewing the results of laboratory and field results demonstrate the accuracy was and thus to build a foundation of concrete examples of materials that are virtually free of harmful substances have been used.

Table 1.4: Results of mechanical testing of materials

Mechanical fracture	Ductility coefficient	Coefficient of lengthening	Value of sandy	Type of material
%	%	%	%	**unit**
-	B.S 812	B.S 812	AASHTO T-176	Standard No.
3	20	17	-	sand mixture
-	-	-	94	Sand with a size of 0-6 mm.
-	<30	<40	>75	Approximately details

Figure 1.4. The stock solution for determination of sand and gravel materials

Figure2.4 - shaker device for determination of sandy materials

Figure 3.4: prolongation and browsing devices to test needle and flake materials

Figure 4.4: weight of the sample to determine the amount of material flake and needle

Grading of materials

Stone materials gradation is divided into a series of samples of the same size and the aim of finding a graded distribution of particles in a sample is selected.

Sand smooth coefficients

Modulus of smoothness and softness coefficient as a measure of smoothness and roughness measurement of aggregate (sand) is used and the sum of ratios of sand on all coarser sieve of each standard sieve remains divided by one hundred.

Table 2-4 and 3-4 results for the remaining materials and rejected by the sieve size distribution curve in Figure 5-4 and 6-4 respectively for sand and gravel is given.

Table 2-4: details the module size and softness of the sand used

Sieve number	Screen Size (mm)	remaining weight (gr)		Remaining percentage (%)	Rejected Percentage by volume (%)
		One sieve	All sieve		
4	4.75	0	0	0	95.2
8	2.35	232	232	23.2	65.9
16	1.2	60	292	29.2	40.3
30	0.6	357	649	64.9	23.6
50	0.3	246	895	89.5	12.4
100	0.15	71	966	96.6	5.5
Tray	-	34	1000	-	0.00
Total weight		1000		303.4	
3 ~ modulus of smoothness					

Table 3-4 details of granulated sand

Screen Size (mm)	remaining weight (gr)	Remaining percentage (%)	Rejected Percentage by volume (%)
	One sieve		
22.6	0	0	100
19	13.5	1.35	98.65
16	30	4.35	95.65
12.7	30.5	7.4	92.6
9.5	310	38.4	61.6
6.3	465	84.9	15.1
4.75	132	98.1	1.9
-	19	-	0.00
Total weight	1000	234.5	-

Fine aggregate gradation

Metakaolin

Metakaolin an amorphous aluminum silicate (A2S) white with pozzolanic properties is based on the standard ASTM C618 Pvzvlanhay class category N (raw or calcined natural) is placed. Metakaolin used in this study is in powder form and has a specific gravity of 2550. Table 5-5 shows the Metakaolin particle analysis.

Determination of water-cement ratio

Since the construction of concrete specimens, in addition to corrosion resistance, high compressive strength of samples is therefore considered that the 28-day compressive strength of the concrete mix proportioning of 30 MPa is therefore considered water-cement ratio of 4% is used.

The general details the design of beams

Based on availability in the city of Zahedan and the research that has been conducted in the laboratory facilities available in the dimensions 10 × 10 × 75 cm samples were and because there is no form of this size molds were made of PVC and the number 6.

(1)

(2) $A_s = 2 \times 78.5 = 157\ mm^2$

(3) $\rho = \dfrac{157}{100 \times 70} = 0.0224$

(4) $_{max}=0.6\times0.85\times[600/(600+400)]\times(35/400)=0.0267\rho$

(5) $_{min} = \dfrac{1.4}{400} = 0.0035\ \rho$

The above relationships were minρ max ρ and the maximum and minimum percentage of tensile bars.

$_{max}$ $0.0035<0.0224<0.0267$ $\rho > \rho >_{min}\rho$

Given the high correlation between the maximum and minimum percentages in the sample as a percentage of steel rebar tensile zones, we conclude the section steel is not the need for compression fittings and soft failure occurs.

Based on the above samples of two bars in the area stretching 10 score was used.

Preparation of samples

How to mix

To make the above examples is the following procedure:

First, coarse aggregate (gravel) and fine aggregate such as sand, with a quarter of water and superplasticizer added to the mixer and mixed for 30 seconds at a time. After this period, cement and stone powder and fly ash are added Metakaolin. The two are mixed together for 60 seconds then pour the remaining water and superplasticizer in the mixer and mixed for 90 seconds at a time.

Electrical resistance test

Ions have penetrated into the concrete, the cracks in the concrete structure moving. Due to the movement of ions within the concrete, concrete, electrical conductivity, the electrical resistance of concrete depends directly on the permeability of concrete and concrete environmental conditions and certainly the most concrete permeability, the ions can be easily and more quickly find their way into the concrete. The concrete has a high electrical resistance, the penetration of chloride ions and the corrosion performance will be better. Therefore, the test for measuring the electrical conductivity due to the movement of ions within the concrete is concrete and output data of the experiment ohms-cm.

According Cabera, this test can be done in two ways:

1: The use of rice as two external electrodes

2. Use Chharalktrvd technique (which is known as the arrangement)

The first technique is used. The experimental apparatus is shown in Fig.

According to Table 5-10 corrosion rate of reinforcement in concrete with electrical resistivity greater than 20 kilo-ohm cm is negligible.

Table 4-9: effect of corrosion resistance of concrete on tracks based on Venère

Resistivity	Rate the likelihood of corrosion
<5	Very high
5 TO 10	high
10 TO 20	low
>20	Nearly zero

Measure the resistance of concrete specimens in vitro, using the device as a frequency of 128 kHz and a voltage of 3 V (the AC), with two copper disc located on either side of the front of the sample resistance of concrete confined to the pages of Measure. Between copper plates and surfaces with a thin layer of cement paste is filled. Samples for testing arrangement are shown in Figure 4-23. The wires connect each device to one of the plates, the electrical resistance was shown.

Armature corrosion test

In this experiment, the potential difference is measured in this way, the voltage difference between the armature and a reference electrode in contact with the concrete is measured. Method of measuring the corrosion rate by Tuesday Autolab 302N electrode polarization technique based on non-destructive method is performed. Since the device was not listed in Zahedan digital voltmeter to measure the potential difference (Figure 5-22) was performed. The method of reinforcing a weak stream and pond on the surface of the circuit (adapter) is applied. The applied current is typically 10 to 100 micro amps. The constant current at the time of exercise of the potential changes in the reinforcement and evaporation of the water in the pond is made after 6 days, once the water is completely evaporated dry period that was started 4 days, the length of the beam current and potential changes are measured with a digital device. The researchers have proved more lasting corrosion rate of drying occurs.

When water flows from a pool of samples with a series connection between the circuit and the digital ammeter is calculated and removed. (Figure 5-22)

The results of fresh concrete

Fresh concrete results are shown in Table 6-1. As you can see we try to mix all of the above settings so the lubricant, the results of fresh concrete placed in the standard range and other characteristics of the concrete in order to achieve the they are sure, let's compare.

The results show good rheological properties and demonstrate its behavior density details in all samples.

Table meters 5-1- properties of fresh SCC

J-ring		V-funnel (sec)		Box L			T_{50} (sec)	Current slump D (cm)	Name of project
(h_2-h_1) (mm)	D (cm)	T5min	T 10 sec	(h_2/h_1)	T-40 (sec)	T-20 (Sec)			
7	64	7	4.4	0.68	4	2	1	69	M0F0
8.2	62	8.15	6.8	0.7	2.9	1.3	1.3	68.5	M10F0
9.6	61	10.15	9.5	0.73	2.1	0.8	1.5	67	M10F10
8.3	63	11.2	11	0.61	3	1	3.1	65	M10F15
10	57	15	12	0.61	3.55	1.45	5	58	M10F20
10.7	64	15.7	11.8	0.61	3.7	1.65	4.9	64	M10F25

5.3 Results of hardened concrete

5-3-1- compressive strength test results

As we know, the objective of this study is to investigate the corrosion samples containing Metakaolin and Flyash. However, given that the decrease or increase of the compressive strength indirectly, can be a sign of resistance to chemical attack is destructive ions. An experiment to study the mechanical properties of concrete samples cube dimensions 15 × 15 × 15 cm at 7 days, 28 days and 90 days, with 0, 10, 15, 20 and 25 cement replacement was performed for each test three of the pressure built and mean it was presented in graphs.

Compressive strength test results in Table 1.6 and Figures 1.6 and 2.6 are presented in graphical form.

Table 5-2 Results of compressive strength (MPa)

90 days	28 days	7 days	Name of project
45.1	38.5	28.1	M0F0
47.3	40.3	29.6	M10F0
43.3	38.1	27.4	M10F10
42.4	37.2	26.6	M10F15
40.3	35.5	23.5	M10F20
32.4	29	23	M10F25

As can be seen in Table 5-2 Typical compressive strength at ages 7, 28 and 90 days decreased with increasing Flyash and control samples, which showed the highest resistance Flyash negative effect over time.

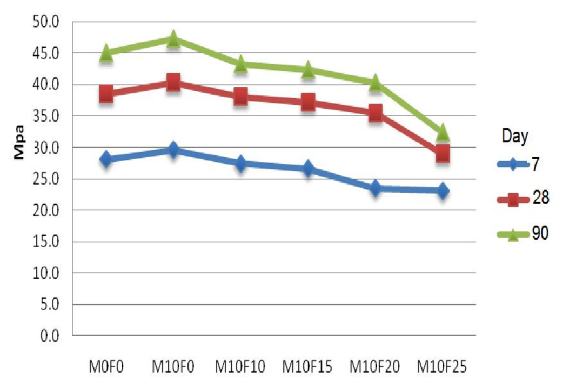

Fig. 5.1: compressive strength of fly ash samples with increasing substitution of different ages

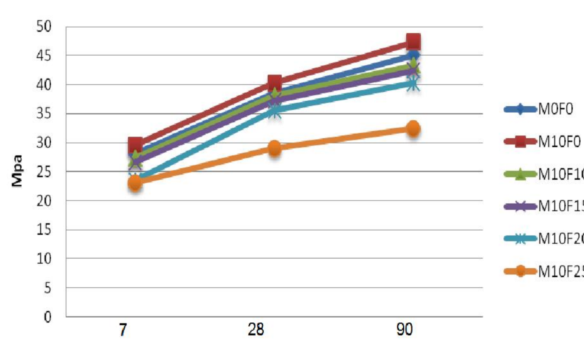

Fig 5.2: compressive strength of samples over time

By comparing the change in resistance of 7 days and 28 days were observed, the increasing resistance of 28 days with 10, 15, 20 and 25% fly ash, respectively, 39.40, 51, 26%, and resistance at 14.14, 90 to 28 days, 14 percent.

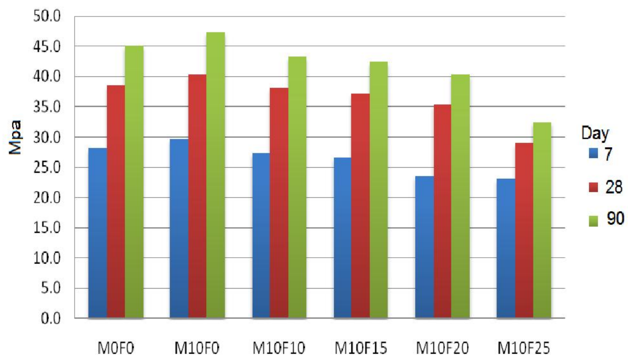

Fig 5.3: compressive strength of samples

The electrical resistance test

A result of the electrical resistance between the ages of 3 to 28 days is provided in Table 6-2.

Table 5-4- results of electrical resistance (kilo ohm-cm)

28 days	14 days	7 days	3 days	Name of project
15.1	13.98	11.3	7.9	M0F0
16.3	12.98	12.06	8.35	M10F0
17.1	14.57	12.31	6.37	M10F10
23.71	15.7	12.43	9.57	M10F15
24.8	17.31	11.32	8.13	M10F20
24.6	17.1	11.45	8.18	M10F25

As can be seen in Table 5-4 with increasing fly ash samples increases the electrical resistance, so concrete with 25% fly ash increases the electrical resistance of 28 days was 63% compared to control samples has shown itself. The compressive strength of 14, 7 and 3 days before the test in order to increase the strength of 22, 2 and 3.5 percent of the sample has no pozzolan.

Accelerated corrosion test results

Accelerated corrosion test results for concrete containing fly ash Metakaolin and the 90-day period in Table 6.3 and graphically presented in Nmvdar6-6. The numbers are read every 3 days.

Table 5-5- results of accelerated corrosion test specimens

M10F25	M10F20	M10F15	M10F10	M10F0	M0F0	زمان
-35	-21	-23	-50	-101	-148	1
-142	-121	-161	-189	-165	-197	2
-187	-168	-198	-194	-135	-265	3
-321	-175	-190	-502	-65	-136	4
-401	-21	-230	-83	-183	-305	5
-214	-184	-190	-223	-293	-283	6
-491	-213	-202	-174	-154	-301	7
-81	-81	-302	-221	-201	-326	8
-243	-248	-208	-186	-196	-431	9
-236	-215	-221	-248	-208	-421	10
-345	-387	-235	-207	-247	-487	11
-301	-265	-245	-241	-223	-492	12
-243	-291	-293	-42	-92	-393	13
-289	-389	-409	-263	-163	-263	14
-387	-222	-189	-297	-207	-394	15
-312	-324	-296	-301	-301	-493	16
-378	-365	-301	-326	-336	-501	17
-369	-347	-304	-374	-394	-523	18
-102	-325	-325	-360	-389	-533	19
-394	-365	-307	-281	-395	-612	20
-360	-364	-436	-274	-374	-591	21
-412	-324	-389	-464	-490	-580	22
-418	-436	-365	-381	-302	-601	23
-461	-351	-378	-402	-412	-603	24
-473	-394	-398	-464	-452	-607	25
-452	-361	-456	-481	-482	-621	26
-452	-372	-432	-465	-503	-623	27
-461	-381	-496	-458	-521	-632	28
-432	-394	-486	-499	-593	-632	29
-451	-401	-461	-501	-487	-609	30

According to the results, and potential changes on the diagram in Figure 6-6, effective role in reducing Metakaolin and Flyash in combination with lateral reinforcement corrosion in reinforced concrete specimens realized.

As the survey was previously described as the extent of the corrosion potential difference is greater than the figures shown in this part, Pozzolan samples did Badr in the accelerated corrosion in concrete, Molemba (2010), Shekarchi et al. (2009), Baleem and Reed (2003), Minh (2007), Lachemi (2009), Al-Dulaijan (2002), Aveldano (2011), also conducted similar experiments.

Conclusion:

According to the results obtained from experiments and observations and survey results can be summarized as stated below:

With increasing age, the compressive strength increases as the percentage increase in resistance from age 7 to 28 days of age 28 to 90 days is much higher. So, it can speed up the reaction of cement hydration at early ages.

By increasing the amount of fly ash in concrete density Metakaolin and can have significantly save on the amount of cement. But this increase is due to the concrete at early ages Pozzolanic reaction-strength leads to a reduction projects that need to be quick in vector format by adding different amounts of active largely compensated by a decrease in resistance.

At the age of 90 days maximum compressive strength of the sample Metakaolin ten per cent and ten per cent, with 25 per cent of least resistance for Metakaolin and Flyash were planned.

With the percentage of Pvzlan, electrical resistance increases. Flyash increases the electrical resistance is increased by the greatest impact on the sample containing 20% Flyash. It can be seen that the corrosion test specimens containing Pvzlan, corrosion is less than the control sample. M10F20 mix is the lowest corrosion.

In general, according to the results of this research can be concluded that Metakaolin of 10% with 20% ash in concrete compressive strength, density, and had the best results. The compressive strength at an early age, but is expected to decline at an older age (180 days) this resistance is improved.

Suggestions:

According to the results obtained in this study and the observations and experience from working in the laboratory of this article, the following recommendations are offered:

1. Study of Mechanical Properties of Self-consolidating concrete with periods of freezing and thawing Flyash and Metakaolin
2. Effect of inhibitors on corrosion of concrete containing Metakaolin and Flyash
3. Condition of sea water on the concrete containing Metakaolin and Flyash
4. Flyash combination with other pozzolan and characterization of mechanical and corrosion in concrete
5. Evaluation of Neural Network cracks in concrete containing Metakaolin and Flyash

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12/13/2014