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Enhancing the concrete behavior exposed to chlorides in tunnels

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Abstract: ***In terms of the importance of acquiring concrete structures with longer life span in tunnels, this research was initiated with the objective of enhancing the concrete behavior exposed to sodium chloride in tunnels. The previous literature in the field of concrete in tunnels was reviewed. Additives were proposed to improve the concrete characteristics (i.e. iron fillings, Sika and fiber). 12 columns were cast with traditional concrete to act as a reference or with different additives and immersed in 10,000 ppm salty water for 1, 12 and 18 months. Measurements were carried out and. Results were analyzed and relationships were established. They were discussed to select the most efficient additive. Conclusions were deduced and recommendations were suggested.***

I. INTRODUCTION

Corrosion of reinforcing steel is one of the most important causes of deterioration of concrete structures subjected to Chlorides (i.e. in tunnels). High permeability concrete and poor design detailing allow the ingress of salt into the concrete. High concentration of salt accelerates corrosion of reinforcing steel and significantly deteriorates the concrete structure. ***Regarding the tunnels,*** in Egypt there is a political vital tunnel exists below Suez Canal (i.e. Ahmed Hamdy Tunnel), which is faced by great challenges and is exposed to damages**.** Additionally, in the near future, more tunnels are expected to be constructed, in accordance to the **new** development plans.

II. RESEARCH OBJECTIVE

In terms of the importance of acquiring concrete structures with longer life span in tunnels, this research was initiated with the ***main objective*** of enhancing the concrete behavior exposed to sodium chloride in tunnels. The ***consequential research objectives*** were to:

- Propose additives (i.e. iron fillings, sika and fiber) to enhance the characteristics of concrete subjected to Chlorides.
- Cast12 columns with traditional concrete or with different additives and immerse them in 10,000 ppm salty water for 1, 12 and 18 months.
- Examine the response of the concrete units in order to determine the efficiency of additives to select the efficient one.
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III. RESEARCH METHODOLOGY

Accustomed to the defined objectives, the research study phases *(i.e. methodology)* were designed. The ***1st phase*** will review the previous literature in the field of concrete in tunnels. The ***2nd phase*** will propose additives to improve the concrete characteristics (i.e. iron fillings, Sika and fiber). 12columns will be cast with traditional concrete to act as a reference or with different additives and immersed in 10,000 ppm salty water for 1, 12 and 18 months. Measurements will be carried to define their characteristics.The ***3rd phase*** will analyze the undertaken measurements and establish relationships. Results will be discussed and compared. Finally, the ***4th phase*** will deduce conclusions for implementing the most efficient additive in practice. Recommendations will be suggested to the future.

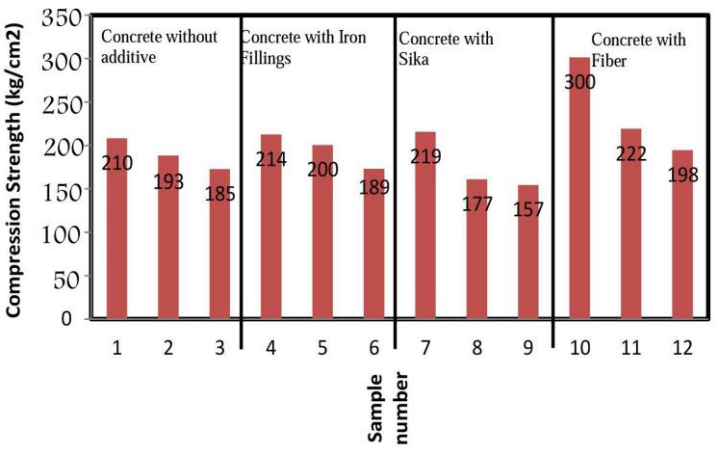

Fig (1) Cube strength at 10000ppm for concrete cast with and without additive

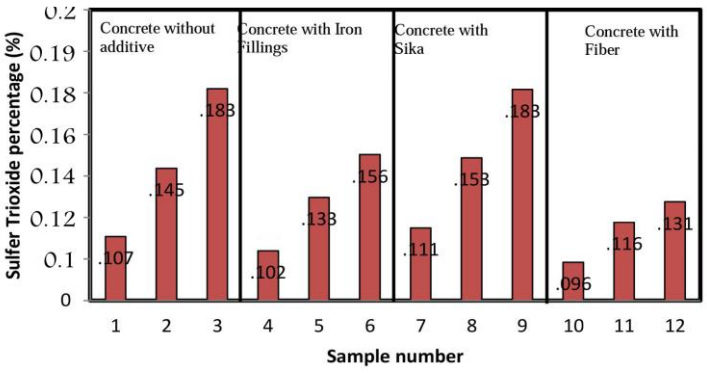

Fig (2) Sulfur trioxide percentage at 10000ppm for concrete cast with and without additive

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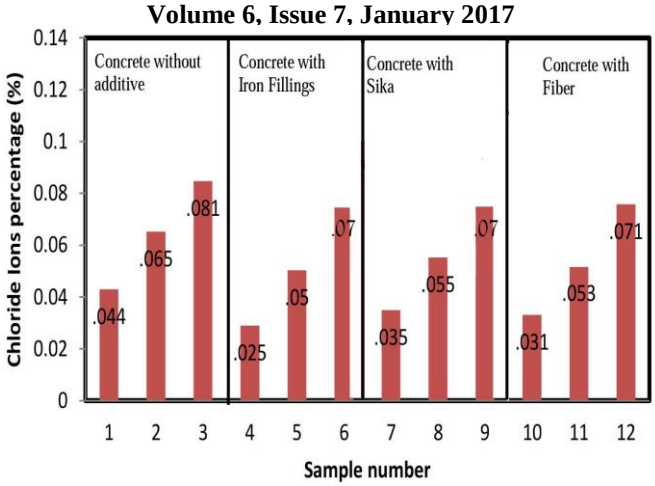

Fig (3) Chloride Ion (Cl-) % at 10000 ppm for concrete cast with and without additive

IV. EXPERIMENTAL WORK

The experimental work was carried in the Properties of Materials in Ain Shams University Laboratory.12 columns were cast (i.e. 3 were cast with traditional concrete, 3 with iron fillings additive, 3 with Sika and 3 with polymers)and immersed in tanks of salty water of 10,000 ppm concentration. They were removed from the tanks after 1 or 12 or 18 months and core specimens were extracted and tested to evaluate their compression strength, sulfur trioxide and percentage of Chloride ions.

V. RESULT ANALYSIS

Results were presented to relate the different variables of concrete characteristics; figures (1) to (3).A summary to percentage changes relative to traditional concrete is listed on table (1).

Table (1) The test program and the percentage of enhancement of concrete characteristics

Specimen No.	Concrete mix	Sodium Chloride (ppm)	Age (month)	Comp. %	So3 %	Cl %
1			1	0	0	0
2	Traditional	10,000	12			
3			18			
4			1	2.16	-14.75	-13.58
5	Iron Fillings	10,000	12			
6			18			
7			1	-15.14	0	-13.58
8	Sika	10,000	12			
9			18			
10			1	8.65	-28.4	-12.35
11	Fiber	10,000	12			
12			18			

VI. CONCLUSIONS AND RECOMMENDATION

The following conclusions were deduced:

- Fiber sheets provide the highest performance at lower concentration, in terms of Compression strength and sulfer trioxide So 3%.
- Fiber did not provide a markedly effect, in terms of Chloride ions (Cl-)%.

Therefore, it was suggested to make the decision upon the condition in hand.

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