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Influence of Dead Sea water on Ultimate Loads of Ferro cement Composite

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Abstract: The paper investigate the performance of ferrocement, and cement mortar to be used during casting ferrocement element, exposed to Dead Sea water. Ferrocement prisms of 600x50x30 mm and 50 mm cubes were cast and cured for 28 days in tap water before exposure to Dead Sea water for different periods. It may be concluded that ferrocement was affected by Dead Sea water.

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I. INTRODUCTION

Ferrocement is an excellent construction material due to its mechanical properties, and low cost, and it is considered to possess a high cracking strength and has a number of structural applications such as earth retaining walls, swimming pools, and water tanks. In addition, the use of ferrocement in pre-fabricated buildings provides many advantages in terms of lightness of weight, ease of handling, low labor cost (skilled and non-skilled) in its production and a durable material requiring little maintenance.

The present investigation is directed to study the ultimate loads of ferrocement reinforced with square welded wire mesh when exposed to Dead Sea water and to compare the measured values with specimens of ferrocement when exposed to the tap water under the same conditions of temperature and relative humidity. The main parameters were number of wire mesh layers and period of exposure the specimens to the Dead Sea water.
The curing days both for compressive strength and ultimate loads of ferrocement prism specimens considered in the present investigation may be summarized in the following groups:

- G1: Specimens under 28 tap water curing days.
- G2: Specimens under 60 curing days (28 days tap water & 32 days Dead Sea water).
- G3: Specimens under 90 curing days (28 days tap water & 62 Dead Sea water).
- G4: Specimens under 120 curing days (28 days tap water & 92 days Dead Sea water).
- G5: Specimens under 150 curing days (28 days tap water & 122 days Dead Sea water).

The effect of Dead Sea water on cement mortar may beexamined by considering; first, the factor characteristic of the Dead Sea water exposure that can affect cement mortar. Second, the element of the specific cement mortar involve , and third; the performance that should be taken to avoid undesirable performance of the cement mortar due to its interaction with Dead Sea water.
The weather and climate of Dead Sea water are: hot and dry climate; average rainfall = 47 mm; average precipitation days = 15; average summer temperature = 27 to 40 ^oC; average winter temperature = 11 to 21 ^oC; average yearly temperature = 22 to 30 ^oz.

The morphometric data are: max length = 67km; max width = 18km; surface area = 810km^2; average depth = 118m; max depth = 377m; water volume= 147 km^3; shore length= 135km; density = 1.24kg/l.
The main aim of this research is to investigate the behavior of ferrocement elements when exposed to the Dead sea water and compare the measured values with bare specimens when exposed to tap water under the same conditions of temperature and relative humidity. It is concluded that ferrocement is highly affected by Dead Sea water.

II. EXPERIMENT

MATERIALS
The cement used in all mixes of the present investigation was ansulfates resisting ordinaryPortland cement (ASTM type II).
Limestone: Crushed limestone was used asfine aggregates.The physical and chemical properties are given in Tables1 and 2.

Table 1 Physical properties of limestone* used in the present investigation.

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Hardness	3 to 4 on Moh's scale
Density	2.5 to 2.7 kg/cm^3
Compressive strength	60-170 N/mm^2
Water absorption	Less than 1%
Porosity	Quite low
Weather impact	Resistant

*Limestone is impervious, hard, compact, fine to very fine grained calcareous rocks of sedimentary nature.

Lightweight fine crushed limestonewas used in the cement mortar for castingferrocementprisms and compressive strength cubes.The grading of the limestone as given in Table 3 was conformed to the requirements of ASTM C330.

Table 2 Chemical properties of limestone used in the present investigation*.

Chemical Composition	Percentage
Lime (CaO)	38-42%
Silica (SiO_2)	15-18%
Alumina (Al_2O_3)	3-5%
MgO	0.5 to 3%
FeO+Fe_2O_3)	1-1.5%
Alkalies	1-1.5%
Loss on lgnition (LOI)	30-32%

*Limestone is referred to as acid sensitive. Calcareous stones are readily dissolved in acid; therefore acidic products should not be used with limestone.

Table 3 Sieve analysis of crushed limestone considered in the present work

Size	Wt, rt	% rt	Cum % rt	% pass
4.76mm	13	1.3	1.3	98.7
2.36mm	130.2	13.02	14.32	85.68
1.19mm	203.8	20.38	34.7	65.3
600µm	158.2	15.82	50.52	49.48
300µm	154.5	15.45	65.97	34.03
150µm	157.1	15.71	81.68	18.32
75µm	115.2	11.52	93.2	6.8
Pan	38.5	3.85	97.05	2.95
Total	970.5			

Mild steel galvanized wire meshes of square welded typewere used throughout the present investigation. The average wire diameter and aperture of 0.9mm and 12.7x12.7mm respectively.Several strands of wires were taken from the mesh and tested in tension. The average value of the yield stress F_y , ultimate stress F_u , and the modulus of elasticity, E_s , calculated from the tests are *310 N/mm²*, *610 N/mm²*, and *120 kN/mm²* respectively. The yield strength was selected as the stress corresponding to a total strain of 0.005.

Curing Water

The chemical compositions of both tap water and Dead Sea water are given in Table 4.

Table 4 Chemical composition of tap water and Dead Sea water.

Chemical element	Tap water Mg/l	Dead Sea water Mg/l
Na	45.9	36110
SO_4	65.4	420
TDS	438	341
CL	62.1	226900

It may be noted that the ratio of concentration of salt in the Dead Sea water is (34.2%).

Mould Preparation

The mould of ferrocementprismspecimens consists of plywood as a base and pieces of plywood sections with thickness of *30 mm* to form prisms *(600x50x30 mm).* Cubic moulds *50 mm*made of play wood were considered for compression tests.

Testing of Specimens

For the ferrocementprism specimens,the mesh was cut to the required number of layers and to the appropriate size. All materials required for each specimenwere weighed and mixed by mechanical mixer. The crushed limestone and cement were first mixed for one minute, and then the water was added and mixed for two minutes. It may be noted that the cement: crushed limestone mix proportion used in casting the specimens was 1:2 by weight withwater: cement ratio for all mixes was 0.4.After cleaning and oiling the mould, the mortar layer was first spread at the base of the form work and on top of this base layer, the first mesh was laid. The mesh layer was then covered by another layer of mortar and so on to the required number of layers and thickness. The surface of ferrocement specimens were covered with nylon sheeting.

To establish mortar compressive strength f_{cu}, a number of cubes, forty five 50 mm cubes cement mortar with cement: sand ratio of 1:2 and water: cement of 0.4 were cast and tested.After 24 hours, the prism specimens and cubes were demolded,then moist cured throughout the days of groups *G1, G2, G3, G4*, and *G5*. The cubes were tested on the same day of testing the flexural prism specimens. The average of three cubes was considered for each testing age and the compressive strength f_{cu} is given by *(P/A)*, where *P(N)* is the maximum applied load and A is the surface area (50x50 mm^2). The tests were carried out according to B.S: 1881: part 116.

All prism specimens have been tested with their edges simply supported over a span of 500mm.

III. RESULTS AND DISCUSSIONS

Compressive Strengthf_{cu}:

Table 5 givesthe outcome of compressive strength tests. Forty five50 mm cubes were cast and tested after the curing days as given in the table. The loading was applied at a rate of *15 MPa* per minute. The average of three specimens was considered for each testing age and the compressive strength f_{cu} is given by *(P/A)*, where *P(N)* is the maximum applied load and *A* is the surface area (50x50 mm^2). The tests were carried out according to B.S: 1881: part 116.

Table 5 The measured values of cube compressive stresses.

Curing days	Cube 1 N/mm^2	Cube 2 N/mm^2	Cube 3 N/mm^2	Average N/mm^2
G1	20	16	18	18
G2	19	19	18	18
G3	15	15.4	16	15.47
G4	13.3	13.5	14	13.83
G5	10.2	9.4	10.5	10.03

Ultimate Loads Of Ferrocement Prisms Pu:

Table 6 Ultimate loads of ferrocement prism carriedout in the present work

Curing days	Ultimate loads Pu, N		
	2-layers of wire mesh	4-layers of wire mesh	6-layers of wire mesh
G1	1667	1995	2417
G2	1622	1950	2363
G3	1392	1500	1670
G4	1063	1320	1363
G5	840	908	1005

The results of the test specimens have been analyzed and presentedin tabular forms. Table 6 present the measured values of ultimate loads for different number of wire mesh layers.

IV. CONCLUSION

Based the tests carried out in the present work Dead Sea water has a significant deterioration on compressive strength of cement mortar and in turn has a significant effect on ultimate loads of ferrocement prisms.

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