2602-2052

JOURNAL OF ENERGY SYSTEMS

Volume 1, Issue 1

DOI: 10.30521/jes.323521

Research Article

Structural behaviour of ferrocement panels under radiant heating

Wail N. Al-Rifaie

Civil Engineering, Philadelphia University, Amman, Jordan, wnrifaie@yahoo.com

Ahmad K. Abdul-Rada

University of Technology, Baghdad, Iraq

Arrived: 23.06.2016 Accepted: 31.07.2017 Published: 11.08.2017

Abstract: In the present work the influence of heating on the flexural resistance of ferrocement slab specimens are carried out. One hundred and sixty eight ferrocement slab specimens 300*300 mm were cast, cured, heated, and tested under central point loads. The main parameters were 30ºC (room temperature), 100-800ºC with a graduation of 100ºC, mixing ratio of cement to sand (c: s), thickness, and number of wire mesh layers. The behavior of specimens was observed by reading the load-deflection at the central point of the specimen. In addition, the effect of heating on the compressive strength of cement mortar, and wire mesh used in casting the specimens were studied. It is concluded that the strength of ferrocement slab specimens were dropped sharply at a temperatures between 500-700ºC and the specimens were damaged at 800ºC. Also in crack stage, the slope of load-deflection curves were decreased and approaches zero at temperature 700ºC.

Keywords: *Ferrocement, Compressive Strength, Flexural Strength, Wire Mesh*

Cite this paper: *Al-Rifaie, W.N., Abdul-Rada, A.K. Structural Behaviour of Ferrocement Panels under Radiant Heating, Journal of Energy Systems 2017, 1(1): 1-9 DOI: 10.30521/jes.323521*

1. INTRODUCTION

Ferrocement is the excellent construction material due to its mechanical properties and it is considered to possess high cracking strength. Cement mortar and steel wire mesh layers are the materials used in construction of ferrocement. The growing need for eco-housing has attracted massive attention nowadays. The escalading demands of electric power due to heating and air-conditioning systems require control to make maximum reduction of the electrical energy. Prefabricated ferrocement cavity walls present a series of possibilities for the solution of building construction at maximum reduction of the electrical energy. As the use of ferrocement in building construction becomes common, the risk of exposing it to high temperatures during a fire also increases. To be able to predict the response of ferrocement structures during and after exposure to high temperature, it is essential that the strength and deformation properties be clearly understood. The thermal conductivity of ferrocement at elevated temperatures of up to 1060°C was experimentally determined based on steady-state thermal properties measurement in accordance with ASTM C177. Test results revealed that ferrocement with thermal conductivity in the range of 0.3-1.5 W/m-K can be used as fire protection material1. Al-Rifaie et al2,3,4 adopted ferrocement and nano materials for different application which demonstrated excellent properties for eco-buildings.
In order to study the structural behavior and ultimate strength of ferrocement slabs under different degrees of temperatures which can be used as precast units or cast in situ roofing system; chimneys, lining furnaces., a total of one hundred and sixty eight ferrocement slab specimens 300*300 mm were cast, cured, heated, and tested under central point loads. The main parameters were 30oC (room temperature), 100-800oC at interval of 100oC, mixing ratio of cement to sand (c: s), thickness, and number of wire mesh layers. The behavior of specimens was observed by reading the load-deflection at the central point of the specimen. In addition, the effect of heating on the compressive strength of cement mortar, and wire mesh used in casting the specimens were studied.

2. EXPERIMENTAL WORK

A total of one hundred and sixty eight ferrocement slab specimens (300x300mm) were cast, heated and tested under central point load. Full details of the specimens were given in Table 1.
The present study investigates the impact of the heat treatment on the mechanical properties of the ferrocement specimens especially the flexural characteristics. A number of slab specimens were prepared and heated up to specified temperatures and then tested under central point load. All specimens were partially fixed by restrained against rotation, horizontal and vertical translation at the ends. The main parameters were temperature, mixing ratios, thickness of slab specimens, and number of wire mesh layers. The specimens were heated under the above temperatures for one hour, then the specimens were left to cool prior to testing. The clear cover of the wire mesh was about 5 mm.

2.1. Materials

2.1.1. Reinforcement

Hexagonal wire mesh with an average diameter of 0.45mm has been used. Several strands wire taken from the mesh and tested in tension to determine the average yield stress, the ultimate strength, and modulus of elasticity. The average measured values of yield stress fy, ultimate strength fu, and modulus of elasticity Es were 251.97, 330.71, and 56600 MPa respectively. In addition, a chemical test was carried out on wire mesh to determine its material properties. The values are tabulated in Table 2.
The yield strength was selected as stress corresponding to total strain of 0.005 (ASTM)5.

2.1.2. Cement

Ordinary Portland cement was used throughout the present investigation.

2.1.3. Water

Ordinary tap water was used for casting and curing the specimens.

2.1.4. Cement mortar

Three mixes were used in casting the specimens, the mixes proportion of the cement mortar as (cement; sand of 1:1, 1:2, 1:3) ratios by weight with (water: cement) ratio of (0.4, 0.45, 0.5) respectively.

2.2. Mould

The formwork of the moulds for casting the slab specimens consist of two parts (steel base, 500x500 mm, and wood edge strips). The wood edge strips were fixed to the base by means of steel bolts.

2.3. Fabrication of the Specimens

The wire mesh was cut to an appropriate size. The layers of wire mesh were placed in two phases. Each of the twin layers consists of two meshes placed one above the other in contact but with perpendicular orientation, in order to gain the best strength of the wire mesh reinforcement. After fastened the wooden strips edge in base by bolt, the wire mesh layers laid in between the mortar layers thus leaving a mortar layer of 5mm on both the top and bottom faces. The test panels were demolded after 24 hours and cured for 14 days. Then, slab specimens were air-dried for 14 days prior to be exposed to heating before testing.

2.4. Instrumentation

The instrumentation was design to provide experimental values of the central displacements of the slab specimens. The displacements were measured with dial gauges having least count of 0.01 mm.
The load from a testing machine SNAS with a rate 0.1 kN/min. Approving ring of 25 kN capacity was used for recording the applied loads accurately. The load was applied through a solid ball.

2.5. Testing Procedures

The slab specimens, as detailed in Table 1, were partially fixed on all four sides. All four sides were positioned on the spatial support so that the following criteria were satisfied:
i) The vertical and horizontal movements were prevented.
ii) The sides of the specimens were prevented from rotating about the longitudinal and transverse axes.
The support condition was detailed in Figure 1.

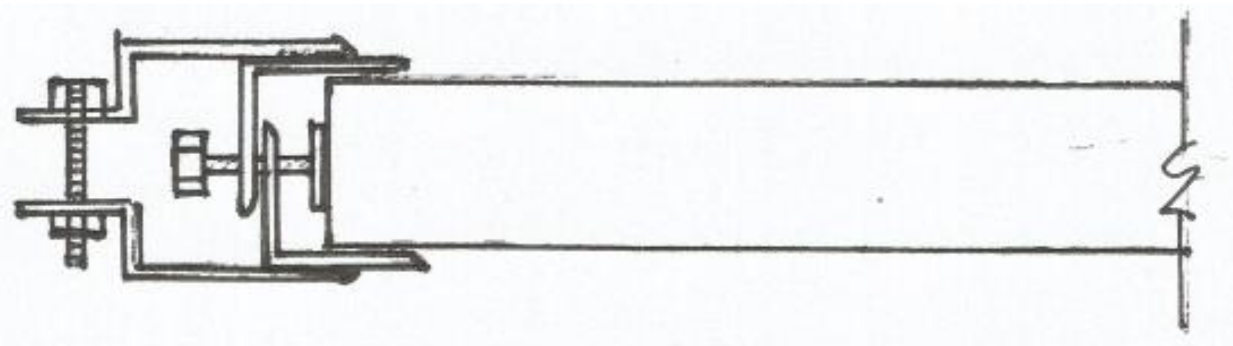

Figure *1 Testing apparatus.*

Having assembled the slab specimen, the loading system and the apparatus for measuring the deflection were set in position, the dial gauges were set to zero to represent the initial unloaded state. The test were carried out and the central point loads were applied through a ball. During the test, each (50) division of the gauge for deflection, the dial gauge in the proving ring reading were recorded, this process continued until the failure occurred.

3. RESULTS and DISCUSSION

The effect of temperature on cement mortar and wire mesh are given in Tables 3 & 4. It may be seen from table 3, the measured values indicate that as the temperature increased to 100°C compressive strength is decreased for all mixing ratios but the specimens are recovered their strength when the temperature reaches 300°C. Then, the strength dropped sharply reaching the damaged state at 800°C. It may be noted that each value is the average of three measured values.

From table 4 the steel wire mesh were heated for one hour, then cooled prior to testing. It may be seen that the yield stress and ultimate stress are not affected by heating up to 300^{o}C.

Table 5 gives the measured values of initial cracking deflection, initial cracking load, ultimate deflection, and ultimate load of the tested specimens. It may be noted that all specimens were tested first at 30^{o}C as a room temperature for comparison. Specimens that exposed to the temperature as tabulated in Table (4.1) were then tested.

The behavior of slab specimens are linear up to first cracking loads. In cracked stage, the slope of load-deflection curves were decreased and approaches to zero at temperature 700^{o}C. All the specimens were cracked first at lower surface of the specimens, then the cracks growth at center toward sides of the specimens when the applied load is increased. At last, the specimens failed by punching under the point load.

Increasing temperature to 100^{o}C, the strength decreased in comparison to room temperature for all mixing ratio. It may be seen, the strength in each mixing ratio dropped sharply at temperatures ranging between 500-700^{o}C and damaged at 800^{o}C. Also, the strength of all specimens are not affected by temperature up to 300^{o}C.

It is also seen that increasing thickness of slab specimens by 5mm, the initial cracking load P_{cr} and ultimate load are increased by 10-30%.

At temperature 500^{o}C, increasing sand ratio in the mixture of cement mortar, tend to increase the values of initial cracking and ultimate loads by 5-20%. But increasing sand ratio at temperature 300^{o}C and less, the measured values of initial cracking and ultimate loads decreased by 2-18%. Increasing the temperature tend to increased the ductility as the ratio of Δ_u/ Δ_{cr} by 5-18%, increasing the number of wire mesh layers tend to increase the ductility ratio by 4-12%, increasing the thickness of slab specimens tend to decrease the ductility ratio by 3-15%, and increasing the sand ratio in the mixture tend to increase the ductility ratio by 2-17%.

Increasing number of wire mesh layers tend to increase the number of cracks and decrease cracks spacing at ultimate load stage, and increasing slab thickness tends to decrease the number of cracks.

4. CONCLUSIONS

The effect of heating on the mechanical properties of ferrocement slabs were investigated in the present work. It was noticed that cracks were occurred at the upper surface of the corner of slab specimens. It may be attributed to the maximum negative moments, which are developed at these positions. It may be noted that increasing number of wire mesh layers tend to increase the number of cracks and decrease cracks spacing and most of slab specimens were failed by punching shear.

It is concluded that by increasing number of wire mesh/ thickness of specimens, tend to increase the initial cracking and ultimate loads and by increasing the temperature up to 100% the compressive strength was decreased for all mixing ratio.

But the specimens recovered its strength at 300^{o}C and increased by 10, 6, 3% of room temperature for mixing ratio of 1:1, 1:2, 1:3 respectively. The compressive strengths are dropped sharply at a temperatures between 500-700^{o}C and the specimens were damaged at 800^{o}C. In crack stage, the slope of load-deflection curves were decreased and approaches zero at temperature 700^{o}C.

Table 1 *Details of the tested slab specimens considered in the present investigation.*

No.	Slab spec.	T °C	c:s	t mm	No. mesh layers
1	F1202	800	1:1	20	2
2	F1202	700	1:1	20	2
3	F1202	600	1:1	20	2
4	F1202	500	1:1	20	2
5	F1202	300	1:1	20	2
6	F1202	100	1:1	20	2
7	F1202	30	1:1	20	2
8	F1204	800	1:1	20	4
9	F1204	700	1:1	20	4
10	F1204	600	1:1	20	4
11	F1204	500	1:1	20	4
12	F1204	300	1:1	20	4
13	F1204	100	1:1	20	4
14	F1204	30	1:1	20	4
15	F1252	800	1:1	25	2
16	F1252	700	1:1	25	2
17	F1252	600	1:1	25	2
18	F1252	500	1:1	25	2
19	F1252	300	1:1	25	2
20	F1252	100	1:1	25	2
21	F1252	30	1:1	25	2
22	F1254	800	1:1	25	4
23	F1254	700	1:1	25	4
24	F1254	600	1:1	25	4
25	F1254	500	1:1	25	4
26	F1254	300	1:1	25	4
27	F1254	100	1:1	25	4
28	F1254	30	1:1	25	4
29	F1302	800	1:1	30	2
30	F1302	700	1:1	30	2
31	F1302	600	1:1	30	2
32	F1302	500	1:1	30	2
33	F1302	300	1:1	30	2
34	F1302	100	1:1	30	2
35	F1302	30	1:1	30	2
36	F1304	800	1:1	30	4
37	F1304	700	1:1	30	4
38	F1304	600	1:1	30	4
39	F1304	500	1:1	30	4
40	F1304	300	1:1	30	4
41	F1304	100	1:1	30	4
42	F1304	30	1:1	30	4
43	F1352	800	1:1	35	2
44	F1352	700	1:1	35	2
45	F1352	600	1:1	35	2
46	F1352	500	1:1	35	2
47	F1352	300	1:1	35	2
48	F1352	100	1:1	35	2
49	F1352	30	1:1	35	2
50	F1354	800	1:1	35	4
51	F1354	700	1:1	35	4
52	F1354	600	1:1	35	4
53	F1354	500	1:1	35	4
54	F1354	300	1:1	35	4
55	F1354	100	1:1	35	4
56	F1354	30	1:1	35	4
57	F2202	800	1:2	20	2
58	F2202	700	1:2	20	2
59	F2202	600	1:2	20	2
60	F2202	500	1:2	20	2
61	F2202	300	1:2	20	2
62	F2202	100	1:2	20	2
63	F2202	30	1:2	20	2
64	F2204	800	1:2	20	4
65	F2204	700	1:2	20	4
66	F2204	600	1:2	20	4
67	F2204	500	1:2	20	4
68	F2204	300	1:2	20	4
69	F2204	100	1:2	20	4
70	F2204	30	1:2	20	4
71	F2252	800	1:2	25	2
72	F2252	700	1:2	25	2
73	F2252	600	1:2	25	2
74	F2252	500	1:2	25	2
75	F2252	300	1:2	25	2
76	F2252	100	1:2	25	2
77	F2252	30	1:2	25	2
78	F2254	800	1:2	25	4
79	F2254	700	1:2	25	4
80	F2254	600	1:2	25	4
81	F2254	500	1:2	25	4
82	F2254	300	1:2	25	4
83	F2254	100	1:2	25	4
84	F2254	30	1:2	25	4
85	F2302	800	1:2	30	2
86	F2302	700	1:2	30	2
87	F2302	600	1:2	30	2
88	F2302	500	1:2	30	2
89	F2302	300	1:2	30	2
90	F2302	100	1:2	30	2
91	F2302	30	1:2	30	2
93	F2304	700	1:2	30	4
94	F2304	600	1:2	30	4
95	F2304	500	1:2	30	4
96	F2304	300	1:2	30	4
97	F2304	100	1:2	30	4
98	F2304	30	1:2	30	4
99	F2352	800	1:2	35	2
100	F2352	700	1:2	35	2
101	F2352	600	1:2	35	2
102	F2352	500	1:2	35	2
103	F2352	300	1:2	35	2

104	F2352	100	1:2	35	2
105	F2352	30	1:2	35	2
106	F2354	800	1:2	35	4
107	F2354	700	1:2	35	4
108	F2354	600	1:2	35	4
109	F2354	500	1:2	35	4
110	F2354	300	1:2	35	4
111	F2354	100	1:2	35	4
112	F2354	30	1:2	35	4
113	F3202	800	1:3	20	2
114	F3202	700	1:3	20	2
115	F3202	600	1:3	20	2
116	F3202	500	1:3	20	2
117	F3202	300	1:3	20	2
118	F3202	100	1:3	20	2
119	F3202	30	1:3	20	2
120	F3204	800	1:3	20	4
121	F3204	700	1:3	20	4
122	F3204	600	1:3	20	4
123	F3204	500	1:3	20	4
124	F3204	300	1:3	20	4
125	F3204	100	1:3	20	4
126	F3204	30	1:3	20	4
127	F3252	800	1:3	25	2
128	F3252	700	1:3	25	2
129	F3252	600	1:3	25	2
130	F3252	500	1:3	25	2
131	F3252	300	1:3	25	2
132	F3252	100	1:3	25	2
133	F3252	30	1:3	25	2
134	F3254	800	1:3	25	4
135	F3254	700	1:3	25	4
136	F3254	600	1:3	25	4
137	F3254	500	1:3	25	4
138	F3254	300	1:3	25	4
139	F3254	100	1:3	25	4
140	F3254	30	1:3	25	4
141	F3302	800	1:3	30	2
142	F3302	700	1:3	30	2
143	F3302	600	1:3	30	2
144	F3302	500	1:3	30	2
145	F3302	300	1:3	30	2
146	F3302	100	1:3	30	2
147	F3302	30	1:3	30	2
148	F3304	800	1:3	30	4
149	F3304	700	1:3	30	4
150	F3304	600	1:3	30	4
151	F3304	500	1:3	30	4
152	F3304	300	1:3	30	4
153	F3304	100	1:3	30	4
154	F3304	30	1:3	30	4
155	F3352	800	1:3	35	2
156	F3352	700	1:3	35	2
157	F3352	600	1:3	35	2
158	F3352	500	1:3	35	2
159	F3352	300	1:3	35	2
160	F3352	100	1:3	35	2
161	F3352	30	1:3	35	2
162	F3354	800	1:3	35	4
163	F3354	700	1:3	35	4
164	F3354	600	1:3	35	4
165	F3354	500	1:3	35	4
166	F3354	300	1:3	20	4
167	F3354	100	1:3	20	4
168	F3354	30	1:3	20	4

Table 2 *Chemical properties of wire mesh.*

C_r%	C_u%	M_n%	N_i%	C%	S%	S_i%
0.009	0.045	0.385	0.036	0.0536	0.0187	0.0098

Table 3 *Effect of high temperature on compressive strength of cement mortar.*

Mixing ratio(c:s)	Compression strength, MPa						
	30°C	100°C	300°C	500°C	600°C	700°C	800°C
1:1	32.76	26.21	36.04	20.71	14.90	7.07	0
1:2	28.86	21.90	30.76	21.89	16.24	8.74	0
1:3	25.47	19.11	26.41	23.03	17.96	9.83	0

Table 4 *Effect of high temperature on steel wire mesh.*

Temp.°C	30	100	300	500	600	700	800
Yield stress f_y, MPa	251.97	253.57	250.57	193.94	120.50	87.23	13.12
Ultimate strength f_u, MPa	330.71	320.93	332.13	254.65	181.19	111.36	30.38

Table 5 *The measured values of the tested slab specimens*

Slab Spec.	T °C	Δ_{cr} mm	P_{cr} kN	Δ_u mm	P_u kN
F1202	800	0	0	0	0
F1202	700	1.11	0.365	5.25	0.639
F1202	600	0.90	0.405	3.60	1.313
F1202	500	0.82	0.725	3.00	2.311
F1202	300	0.72	1.712	2.40	3.173
F1202	100	0.63	1.569	1.90	2.887
F1202	30	0.55	1.964	1.40	3.442
F1204	800	0	0	0	0
F1204	700	1.30	0.411	6.30	0.662
F1204	600	1.01	0.770	4.20	1.429
F1204	500	0.90	1.073	3.50	2.622
F1204	300	0.82	2.139	2.90	4.137
F1204	100	0.76	1.997	2.30	3.395
F1204	30	0.68	2.334	1.90	4.002
F1252	800	0	0	0	0
F1252	700	1.27	0.459	5.12	0.735
F1252	600	0.98	0.612	3.56	1.355
F1252	500	0.86	1.029	2.92	2.551
F1252	300	0.76	1.979	2.28	3.655
F1252	100	0.66	1.841	1.79	3.594
F1252	30	0.56	2.307	1.36	4.055
F1254	800	0	0	0	0
F1254	700	1.35	0.878	5.98	1.226
F1254	600	1.13	0.967	4.56	1.679
F1254	500	0.92	1.564	3.53	3.231
F1254	300	0.84	2.414	3.00	4.691
F1254	100	0.77	2.228	2.38	4.254
F1254	30	0.69	2.591	1.84	4.842
F1302	800	0	0	0	0
F1302	700	1.34	0.596	4.95	0.831
F1302	600	1.10	0.785	3.80	1.395
F1302	500	0.90	1.326	2.85	2.788
F1302	300	0.77	2.279	2.20	4.163
F1302	100	0.68	2.183	1.66	4.119
F1302	30	0.51	2.539	1.20	4.568
F1304	800	0	0	0	0
F1304	700	1.40	1.000	5.61	1.666
F1304	600	1.22	1.200	4.71	1.935
F1304	500	0.96	1.968	3.60	3.795
F1304	300	0.87	2.668	3.12	5.251
F1304	100	0.75	2.454	2.3	5.137
F1304	30	0.63	2.857	1.81	5.686
F1352	800	0	0	0	0
F1352	700	1.44	0.676	6.60	0.959
F1352	600	1.22	1.144	3.69	1.440
F1352	500	0.94	1.875	2.76	3.076
F1352	300	0.79	2.656	2.11	4.808
F1352	100	0.71	2.610	1.56	4.783
F1352	30	0.59	2.911	1.10	5.317
F1354	800	0	0	0	0
F1354	700	1.47	1.388	4.95	2.577
F1354	600	1.34	1.535	4.42	2.727
F1354	500	1.08	2.784	3.40	4.643
F1354	300	0.94	2.997	2.90	5.958
F1354	100	0.80	2.729	2.20	5.793
F1354	30	0.65	3.176	1.74	6.880
F2202	800	0	0	0	0
F2202	700	1.25	0.422	6.10	0.689
F2202	600	1.05	0.659	4.50	1.525
F2202	500	0.88	1.369	3.50	2.511
F2202	300	0.76	1.655	2.80	2.887
F2202	100	0.70	1.484	2.10	2.574
F2202	30	0.61	1.893	1.80	2.991
F2204	800	0	0	0	0
F2204	700	1.33	0.614	6.60	0.707
F2204	600	1.21	0.885	5.41	1.984
F2204	500	0.93	1.326	4.11	2.991
F2204	300	0.86	1.898	3.30	3.766
F2204	100	0.77	1.687	2.70	3.339
F2204	30	0.68	1.989	2.00	3.895
F2252	800	0	0	0	0
F2252	700	1.31	0.515	5.85	0.793
F2252	600	1.09	0.761	4.42	1.543
F2252	500	0.89	1.428	3.26	3.134
F2252	300	0.79	1.768	2.67	3.528
F2252	100	0.73	1.685	2.05	3.233
F2252	30	0.64	1.941	1.65	3.530
F2254	800	0	0	0	0
F2254	700	1.41	0.833	6.44	1.651
F2254	600	1.24	1.075	5.34	2.028
F2254	500	1.02	1.717	4.29	3.695
F2254	300	0.88	2.187	3.39	4.479
F2254	100	0.50	1.970	2.78	4.181
F2254	30	0.72	2.301	2.11	4.748
F2302	800	0	0	0	0
F2302	700	1.38	0.611	5.60	0.912
F2302	600	1.14	0.882	4.31	1.489
F2302	500	0.92	1.495	3.00	3.726
F2302	300	0.84	1.912	2.50	4.052
F2302	100	0.78	1.897	2.02	3.989

F2302	30	0.66	1.986	1.52	4.327
F2304	800	0	0	0	0
F2304	700	1.50	1.052	6.30	1.883
F2304	600	1.28	1.270	5.26	2.066
F2304	500	1.10	2.111	4.5.	4.405
F2304	300	0.90	2.497	3.30	5.193
F2304	100	0.83	2.226	2.70	5.024
F2304	30	0.75	2.635	2.20	5.524
F2352	800	0	0	0	0
F2352	700	1.45	0.747	5.2	1.059
F2352	600	1.18	1.031	4.00	2.106
F2352	500	0.94	1.563	2.85	4.627
F2352	300	0.88	2.180	2.25	4.868
F2352	100	0.82	2.161	1.88	5.085
F2352	30	0.68	3.034	1.41	5.690
F2354	800	0	0	0	0
F2354	700	1.59	1.420	6.11	2.415
F2354	600	1.31	1.543	5.00	2.508
F2354	500	1.20	2.735	4.3	5.440
F2354	300	0.92	2.891	3.1	6.176
F2354	100	0.86	2.582	2.50	5.887
F2354	30	0.78	3.064	2.10	6.683
F3202	800	0	0	0	0
F3202	700	1.38	0.571	6.90	0.708
F3202	600	1.12	0.995	5.00	1.867
F3202	500	0.93	1.445	4.20	2.561
F3202	300	0.88	1.600	3.60	2.851
F3202	100	0.78	1.410	3.00	2.568
F3202	30	0.68	1.793	2.60	2.618
F3204	800	0	0	0	0
F3204	700	1.49	0.705	7.45	0.891
F3204	600	1.35	0.914	6.70	2.084
F3204	500	1.15	1.589	5.55	3.132
F3204	300	0..93	1.811	4.20	3.517
F3204	100	0.81	1.632	3.40	3.211
F3204	30	0.75	1.927	2.80	3.778
F3252	800	0	0	0	0
F3252	700	1.40	0.654	6.56	0.896
F3252	600	1.17	0.997	4.89	1.929

F3252	500	1.00	1.489	3.93	3.186
F3252	300	0.89	1.670	3.36	3.435
F3252	100	0.81	1.532	2.79	3.248
F3252	30	0.71	1.809	2.45	3.532
F3254	800	0	0	0	0
F3254	700	1.58	0.918	7.64	1.884
F3254	600	1.38	1.125	6.60	2.171
F3254	500	1.20	1.800	5.46	3.838
F3254	300	1.04	2.073	4.18	4.182
F3254	100	0.88	1.898	3.49	3.933
F3254	30	0.79	2.231	2.84	4.617
F3302	800	0	0	0	0
F3302	700	1.43	0.721	6.20	1.089
F3302	600	1.24	1.000	4.81	1.992
F3302	500	1.06	1.536	3.85	3.813
F3302	300	0.90	1.741	3.10	4.021
F3302	100	0.83	1.663	2.60	3.897
F3302	30	0.72	1.825	2.30	4.228
F3304	800	0	0	0	0
F3304	700	1.67	1.131	7.7	1.988
F3304	600	1.43	1.337	6.50	2.254
F3304	500	1.26	2.165	5.40	4.539
F3304	300	1.13	2.336	4.5	4.763
F3304	100	0.96	2.164	3.60	4.678
F3304	30	0.84	2.562	2.9	5.435
F3352	800	0	0	0	0
F3352	700	1.45	0.795	5.86	1.323
F3352	600	1.31	1.099	4.72	2.057
F3352	500	1.12	1.585	3.75	4.563
F3352	300	0.91	1.815	2.88	4.707
F3352	100	0.85	1.805	2.41	4.675
F3352	30	0.77	1.841	2.15	5.061
F3354	800	0	0	0	0
F3354	700	1.76	1.393	7.52	2.097
F3354	600	1.48	1.588	6.40	2.341
F3354	500	1.32	2.604	5.36	5.368
F3354	300	1.22	2.632	4.35	5.424
F3354	100	1.04	2.467	3.47	5.564
F3354	30	0.89	2.942	2.80	6.397

REFERENCES

[1] Nimityongskul, V.P., Tanchaisawat, T., Parichartpreecha, R. "Thermal conductivity of ferrocement." 11th East Asia-Pacific Conference on Structural Engineering and Construction, EASEC-11, Taipei, Taiwan. pp. 19-21 November. 2008.

[2] Al-Rifaie, W.N., Mahdi, O.M., Ahmed, W.K. "Development of Nanocement Mortar as a Construction Material." Advanced Materials Research. 795, pp. 684-691. 2013. DOI: 10.4028/www.scientific.net/AMR.795.684

[3] Al-Rifaie, W.N., Ahmed, W.K., Mahdi, O.M. "Experimental Investigation of Nano-Polymercement Composite." Study of Civil Engineering and Architecture. 3. pp. 29-35. 2014. http://www.seipub.org/scea/PaperInfo.aspx?ID=17597

[4] Al Rifaie, W.N., Ahmed, W.K., Ibraheem, L.E., Al-Samarraie, H.Y. "The Use of Renewable Energy in Ferrocement Eco-Housing System." International Journal of Renewable Energy Research. 4(1). pp. 151-158. 2014. http://www.ijrer.org/ijrer/index.php/ijrer/article/view/1051/0

[5] ASTM Standards A 82-85."Steel Wire, Plain, for Concrete Reinforcement", Vol. 0 1.04.