# Thin SCC plates behavior at high temperatures with variable steel location


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***Abstract*— This study deals with the behavior of simply supported plate under multi- effects such as distribution of reinforcement in tension and compression zones with different ratios, also the effect of various levels of temperatures on the strengths have been considered. Sixteen samples have been divided into four groups according to the distribution of reinforcement and according to the heating levels.**

**It has been noticed that increasing the temperature to about 200˚C keep the same ultimate load of group A (panels have 50% of reinforcement intension and 50% at compression zone) and increasing the ultimate load of group B (panels have equal distribution of reinforcement in full depth) and group D (panels with 75% of reinforcement in tension and 25% in compression) by 8% and 20% respectively ,but for group C (panels with 100% reinforcement in tension) at 200˚C the ultimate load decreased by 10% .For the other temperatures (400 ˚C and 600 ˚C) the ultimate load decreased .**


**Keywords— SCC Plates, Compression zones**

## I. INTRODUCTION

Thin plate is an imported construction technology which is widely adopted throughout the world (1). Ferro cement may concern as one type of thinly reinforced with cementations composite constructed of hydraulic cement mortar with closely spaced layers of continuous and relatively small size reinforcement mesh, and cast to any shape due to its easy mold ability characteristics. Since the specific surface of reinforcement in thin plate is one to two orders of magnitude higher than that of reinforced concrete, the larger bond forces are developed between the reinforcing mesh and cement matrices. The close spacing of the reinforcement meshes in rich cement sand mortar and the smaller spacing of this mesh layers imparts ductility, and leads to a better crack arresting mechanism in thin plate. The applications of thin plate are numerous including low-cost roofing/flooring on short spans and repair and rehabilitation of old/deteriorated structures [2]. "

In many countries, "the most critical components in dwelling construction are appropriate roofing, walls and floors. The use of conventional materials has not been very successful in producing durable and resistant to fire, insects, and flood or earthquake roofing materials. As a result, many developing countries import expensive galvanized iron sheets or use hazardous asbestos cement sheets as roofing material. Thin plate appears to be an economical alternative material for roofing [2]. The use of Thin plate as roofing and slab elements has been a subject of investigation by many researchers. For roofing, Thin plate has been used for channel type section, folded plates, ribbed slabs, cylindrical shells, circular domes, funicular shells etc. [3]. Also Thin plate box hollow sections have adequate strength, stiffness and other serviceability requirements for residual applications [4]. Kenai and Brooks [5] carried out extensive testing on direct tensile, four point flexural and drop impact tests on specimens reinforced with steel wire meshes, They used a simple model based on plastic analysis which was originally proposed by Mansour and Paramasivam [6]. The ultimate moment was calculated by multiplying any one of the two forces by the lever arm. "Such models cannot be used in cases where the reinforcing mesh is dispersed in the middle of the slab. This is because of the small thickness of the Thin plate slab panels (about 20mm) which makes it practically difficult to control the uniform dispersion of the wire mesh through the depth. Ahmed et al. [7] studied the shear behavior of Thin plate channel beams. Their results indicated that cracking load and ultimate shear strength increase with the increase in the volume of wire mesh and mortar strength and decrease with the increase of shear span/depth ratio. " Al-Kubaisy and Jummat [8] investigated the use of Thin plate in improving the behavior of reinforced concrete slabs. "The tension zone of each slab was covered with Thin plate layer. They studied the effects of the percentage of wire mesh reinforcement in the Thin plate cover layer, thickness of Thin plate layer and the type of connection between the Thin plate layer and the reinforced concrete slab on the ultimate flexural load, first crack load, crack width and spacing, and load-deflection relationship. They concluded that the use of Thin plate cover slightly increases the ultimate flexural load and increases the first crack load. Considerable reduction in crack widths and spacing was observed with specimen with Thin plate layers. " The performance of Thin plate panels under normal, moderate and hostile environments was investigated by Masood et al. [9]. "They concluded that the flexural capacity of the panel increases with the addition of fly ash. Considerable deterioration of wire meshes fabric was observed due to sustained exposure in saline casting and curing condition. " Hago et al. [10] conducted 6 experimental tests to study the ultimate and service behavior of Thin plate roof slab panels. The results demonstrated that the monolithic shallow edge Thin plate beams with the panels considerably improves the service and ultimate behavior, irrespective of the steel layers used. Also, slabs with channel sections supported larger ultimate loads and behaved better under service loads than their flat slabs counterparts. " Due to large deflections experienced by the thin panels, large deflection theory was adopted in the analysis.. Nine simply supported slab panels were tested for flexure. The "specimens were arranged in three categories based on the cross-section: channel section types A, channel section type B and box section. The aim was to study the effects of the shape of cross-section and the number of wire mesh layers on the behavior and ultimate capacity of the tested panels. The panels were constructed manually in a simple manner, so similar panels can be constructed and used as roofing system with almost no equipment needed. " Thorat et al [11] studied flat Ferro cement slab panels reinforced with 2 layers of chicken wire mesh. The main objective of this work is to study the effect of using 2 layers of chicken wire mesh on the flexural strength of flat Ferro cement slab panels and to compare the effect of varying the number of wire mesh layers and use of steel reinforcement the ultimate strength and ductility of Ferro cement slab panels. "Test result shows that panels with more number of layers exhibits greater flexural strength and less deflection as that compared with panels having less number of layers of mesh. Aadithiya1and Chandrasekaran [12] noticed the construction of sandwich concrete slabs is an emerging trend in the field of Civil Engineering, where a thick, low strength, lightweight core infill is encased by a thin high performance face sheet. These slabs are widely accepted due to their high strength-to-weight ratio, reduced weight, and good thermal insulation characteristics. This article reviews on journals which have considered Thin plate as the high-performance face sheets encasing aerated concrete as lightweight infill material. The thin plate panels which are known for their high bending capacity without capacity are suggested to replace the conventional rebar mat in the tension face of the slab and also used as encasements on both the sides of the slabs. "Abdul AlAziz [13] studies the using of light weight aggregate in slabs with top reinforcement and he investigated that the using of the top reinforcement increase the ultimate load and deflection.

## 2. EXPERIMENTAL WORK

### *2.1 Material properties*

All materials "used in this work are conformed to the American specification (ASTM). Ordinary Portland cement has been used which is comply with the American specification (ASTM) C150/C150M -18. Normal weight fine aggregate has been used and comply with American specification (ASTM) C131/C131M -14. Tap water has been used for casting and curing the Panels. Hexagonal mesh with 0.7 mm wire diameter has been used as a steel reinforcement. "

### *2.2 Casting and curing*

Sixteen panels were casting from SCC into "four groups A, B ,C , and D as shown in Table(1), All groups have one panel tested at room temperature 25 C˚ and three panels heated to 200 , 400 and 600 C˚ respectively, details are shown at the Table (1) . All the panels casted from one mix proportion with (1:2.2:2.2) cement: sand and small crushed gravel (less than 10 mm max. size), L.S.P/c=0.52 and w/c =0.45. The average compressive strength is about 24MPa. "

Wood molds "with smooth surfaces are used to cast all the panels, the clear dimensions were (200 *500*60 mm) the molds coated with oil before casting and put the reinforcement layers. After 24 hours from casting the molds removed and the panels put in water container at the laboratory to be cured for 28 days and then the panels removed out of water and leave one day at the laboratory then they heated by electrical furnace.

### *2.3 Heating the panels*

The panels" heated by electrical furnace type Winger has the capacity of 1200C˚,one panel from each group put inside the furnace and switch on until reach the aimed temperature then kept the panels at that temperature level for 60 minutes ,then switch off the furnace and the panels cooling normally at the air. "

## 3.TEST METHOD

At a "simple supported span all panels tested with one line load at L/2 and dial gauge of (0.01mm) placed at the same position. The load start to read with the dial gauge from zero loads until the failure occurs and the results recorded with load increment. Figure (10) shows the test machine used.

## 4.RESULTS AND DISCUSSION

### *4.1"Reinforcement position effects on the ultimate load at room temperature"*

The effect of the reinforcement meshes "position appeared on the ultimate load of the panels according to the neutral axis and the distribution of the reinforcement that makes the lower part of reinforcement resist the tension stress and the upper part of reinforcement resist the compressive stress, the panels groups divided to four types A, B, C, and D, as shown in Table (1). From figure (1) it can be noted that the best case of reinforcement distribution was at the group B which carrying the maximum failure load (60 kN) and then the group C shows the second maximum load (50 kN) and the group A (45 kN), then at the last the group D (40 kN), the load deflection curve at figure (2) shows that arrangement at room temperature. The above results show that the best distribution (group B) is that when the half reinforcement under the neutral axis and the other half upper, the distance from the neutral axis to the tension reinforcement was double the distance from the neutral axis to the compression reinforcement ,on the other hand the second best distribution case (group C) when all the meshes 100% were in tension zone, then the case of (group A) which had equal distribution 50% upper and 50% lower the neutral axis, at the last the (group D) was the worst distribution result that the 75% of the reinforcement under and 25% above the neutral axis.

*4.2 ‘’ Reinforcement position effects on the maximum deflection at room temperature"*

The maximum deflection appear "at the (group C) (3.1 mm) which had 100% of reinforcement at the tension zone that means more ductile behavior because the meshes carry the tension stress more than the other groups, then the two groups A and B have equal maximum deflection (2.2 mm) and at the last the (group D) (2 mm) which had the more brittle behavior than the others groups in spite of that it has 75% of meshes under the neutral axis. "

*4.3 "Effect of high temperature on the load deflection relationships for the panels with similar reinforcement distribution"*

Figures (2, 3, 4 and 5) show that the "effect of high temperatures for all panels were decrease the ultimate load and increase the maximum deflection may be excepting. when heating to the 200 C˚ the ultimate load increased at B2 by (8%) and D2 by (20%), and stay equal at A2 but decrease at C2 by (10%), also increased the maximum deflection which means that this temperature 200 C˚ made the panels more ductile than the same panels at the room temperature. At the panel C2 the ultimate load decreased by (10%) and the deflection decreased by (3%) this panel has 100% of reinforcement at the tension zone. This means that this temperature increased the compressive strength of the thin plate matrix mortar because the cement hydration completed and the water evaporated from the mix of mortar, on the other hand the effect of heating on the reinforcement meshes at all groups different from that at C2 because the meshes at this panel were to closed together than the other panels so the heating more effect on the zone between them and made it more brittle than the other part of panel so reduced the ultimate load and the deflection".

All panels "groups retreated at the highest temperature 600 C˚ and behavior more softener then the other temperature levels, all the ratios and the details shown at table (1).

*4.4 "Effect of high temperature on the load deflection relationships for the panels with different reinforcement distribution"*

Figures (6, 7 and 8) show the "load_ deflection relationships for the panels with different reinforcement distributions and different temperature levels, appeared that the (group B) still have the best behavior at 200 C˚ and 400 C˚, still have the highest ultimate load and behave more ductile than the others panels, but at 600 C˚ this group showed the second best group after the (group C) which is behave better than the other panels at this temperature levels and have the highest ultimate load. (groups D and C) showed better behave at 400 C˚ and 600 C˚ as compared with its behave at room and 200 C˚, on the other hand the (group A) have the worst behave as compared with the other groups at the different level of temperatures. "Figure (9) shows some panels after test.

Table (1) "Panels Details"

| **Reinf. Ratio Distr.** | **Panel** | **Dim. (mm)** | **Tem ( C˚)** | **Ult. Load $P_u$ (kN)** | **Max.Deflection (mm)** | **$P_{u@T^\circ}$ / $P_{u@25^\circ}$ %** | **Deflection$_{@C^\circ}$ /Deflection$_{@25^\circ}$ %** |
|---|---|---|---|---|---|---|---|
| *50% tens. 50% comp.* | A1 | 200*500*60 | 25 | 45 | 2.2 | 100 | 100 |
| | A2 | 200*500*60 | 200 | 45 | 2.6 | 100 | 118 |
| | A3 | 200*500*60 | 400 | 30 | 3.9 | 67 | 177 |
| | A4 | 200*500*60 | 600 | 17 | 7 | 38 | 318 |
| *Equal distribution* | B1 | 200*500*60 | 25 | 60 | 2.2 | 100 | 100 |
| | B2 | 200*500*60 | 200 | 65 | 2.8 | 108 | 127 |
| | B3 | 200*500*60 | 400 | 50 | 5.4 | 83 | 245 |
| | B4 | 200*500*60 | 600 | 20 | 7 | 33 | 318 |
| *100% tension* | C1 | 200*500*60 | 25 | 50 | 3.1 | 100 | 100 |
| | C2 | 200*500*60 | 200 | 45 | 3 | 90 | 97 |
| | C3 | 200*500*60 | 400 | 43 | 4.4 | 86 | 142 |
| | C4 | 200*500*60 | 600 | 22 | 9.6 | 55 | 309 |
| *75%tens. 25% comp.* | D1 | 200*500*60 | 25 | 40 | 2 | 100 | 100 |
| | D2 | 200*500*60 | 200 | 48 | 2.6 | 120 | 130 |
| | D3 | 200*500*60 | 400 | 42 | 5 | 105 | 250 |
| | D4 | 200*500*60 | 600 | 20 | 9 | 50 | 450 |

*Table symbols: tens. (tension zone), comp (compression zone), Dim (dimension), Temp(temperature), Ult (ultimate), Max (maximum)

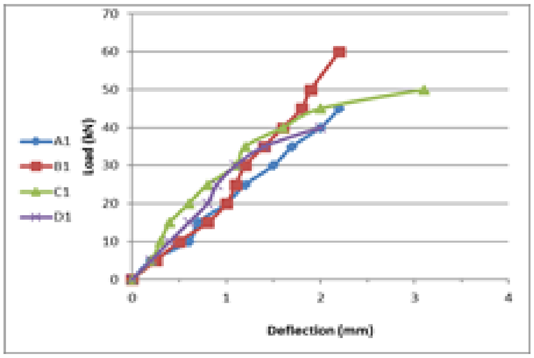


Figure (1) "Mid-Span Load _ Deflection relationship for panels at 25 ˚C room temperature"

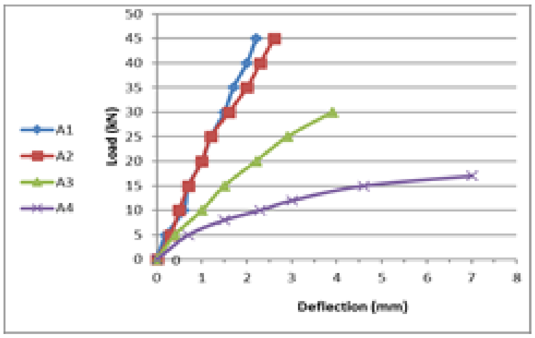


Fig. (2) "Mid-Span Load _ Deflection relationship for group A panels at different temperature"

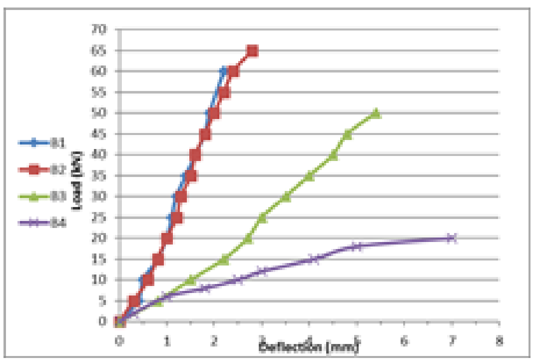


Fig. (3) "Mid-Span Load _ Deflection relationship for group B panels at different temperature

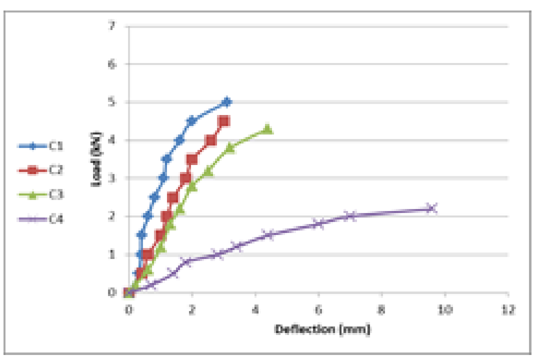


Fig. (4) "Mid-Span Load _ Deflection relationship for group C panels at different temperature

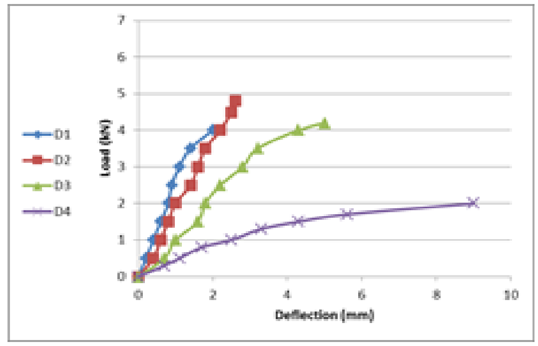


Figure (5) "Mid-Span Load _ Deflection relationship for group D panels at different temperature

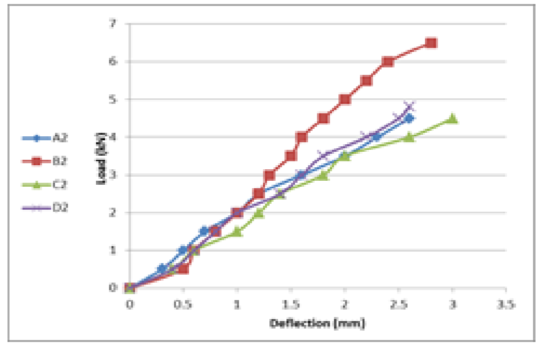


Fig. (6) " Mid-Span Load Deflect relationship for at200 C˚.

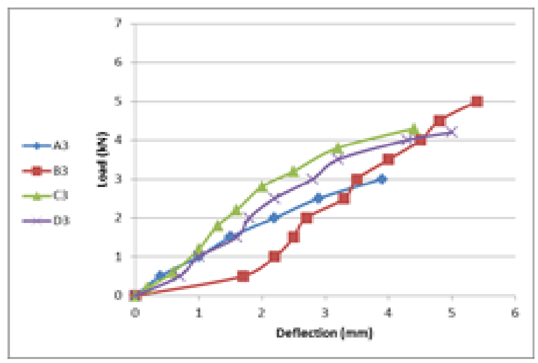


Fig. (7) Mid-Span Load-Deflection relationship for Panels at 400 C°.

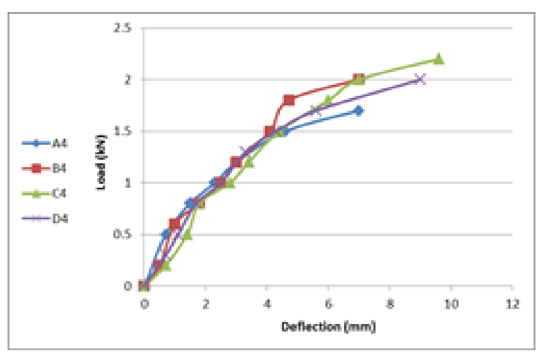


Fig. (8) "Mid-Span Load-Deflection relationship for panels at 600 C°

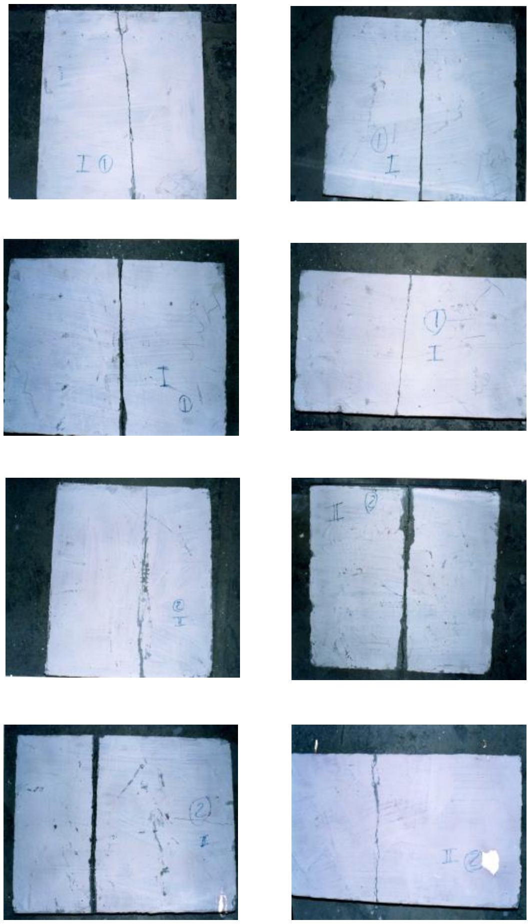

Fig. (9) some panels after test.

Fig. (10) Set – up of Test Machine

## CONCLUSIONS

From the experimental study it can be concluded some point such as:

1- Using equal disruption of reinforcement give the best ultimate load capacity at room temperature.

2- At room temperature, maximum deflection appears when using all reinforcement at tension zone.

3- Heating panels to about 200 C almost increase the ultimate load capacity by about (10-20%)

4- Heating panels to about 600 C decrease the ultimate load capacity about (30-50%)

4-Using equal disruption of reinforcement at different levels of temperature almost give the best ultimate load capacity"

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