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# EXPERIMENTAL STUDY ON THE BEHAVIOR OF DIFFERENT TYPES OF STEEL FIBER REINFORCED CONCRETE MIX OF TWO WAY-SLABS SUBJECTED TO DIFFERENT HEAT TEMPERATURE

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**Abstract:** This research aims to study the influence of steel fibers on the behavior of eighteen reinforced concrete (RC) slabs under different temperatures. The main investigated parameters in this paper were concrete type i.e. Normal-Strength Concrete (NSC), High-Strength Concrete (HSC) and Light-Weight Concrete (LWC), the effect of various parameters such as; amount of steel fiber ratio (0% and 2%) on failure load, crack patterns, and load- deflection response, have been studied. In these slabs the amounts of reinforcements were kept constant. The study also includes the type's failure and effect of types of concrete when all specimens are exposed to several temperature levels (25C$^{o}$, 400C$^{o}$, 600C$^{o}$). It showed that, there is a reduction of strength with the increase of temperature. The test results show that as the volume of the steel fibers increase the punching shear strength increased and the presence of fibers delay the appearance of the first crack in the slab and gave less deflection than the slab without fibers.

**Keywords**: *Punching Shear, Steel fiber, Temperature, Slabs, Concrete*

# دراسة عملية على سلوك مجموعة خلطات خرسانية مسلحة بألياف فولاذية للبلاطات باتجاهين معرضة لدرجات حرارة متغيرة

**الخلاصة:** ان الغرض من هذا البحث هو دراسة تأثير الالياف الفولاذية على سلوك عدة خلطات خرسانية مسلحة تحت تأثير درجات حرارة متغيرة للبلاطات باتجاهين، حيث تم صب وفحص ثمانية عشر بلاطة خرسانية مسلحة بنسب مختلفة من الالياف الفولاذية وتم تسليط درجات حرارة مختلفة (٢٥$^{o}$س و ٤٠٠$^{o}$س و ٦٠٠$^{o}$س). تم دراسة تأثير عدة متغيرات مثل: نوع الخرسانة (خرسانة اعتيادية و خرسانة عالية المقاومة و خرسانة خفيفة الوزن) و نسبة الالياف الفولاذية (٠% و ٢%) وتأثير درجات الحرارة على الحمل الاقصى بثبوت نسبة حديد التسليح الرئيسي لجميع البلاطات. وقد وضحت نتائج هذا البحث على شكل منحنيات الحمل-الهطول و نمط التشقق وقد وجد ان مقاومة الخرسانة تقل بزيادة درجات الحرارة كما ان نتائج الفحوصات بينت ان زيادة نسبة الالياف تزيد من مقاومة القص الثاقب للبلاطات العاملة باتجاهين و تعمل على تقليل التشققات وتأخير ظهور اول تشقق التشققات وكذلك تقلل من الهطول مقارنة بالبلاطات الخالية من الالياف الفولاذية.

## 1. Introduction

The structural behavior of reinforced concrete slabs are mainly affected by the temperature by changing material properties (concrete and steel). Also, punching shear is the common failure type of the flat plate especially when subjected to high concentrated loads. However, when high elevated temperatures are exposed to the slab,

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both, the structural behavior and the material properties will change. Therefore it is very important to get a better understand for the punching shear failure of flat plate under the new conditions [1, 2]. HSC (High-Strength Concrete) is a relatively modern evolution in RC technology. HSC can be allowed constructing longer spans and more serviceable area of buildings by reduces the dead weight [3, 4]. Many main codes for concrete in the entire world are based on structural members which have compressive strength less than 41 MPa, which is commonly called NSC (Normal Strength Concrete). In recent years, most codes have containing for design of HSC members in their provisions [5].

The term LWC (Light-Weight Concrete) is generally used for concrete of density lower than 2200 kg/m$^3$. There are many types of LWC such as no-fines concrete, aerated concrete and light weight aggregate concrete [6]. Concrete is "a brittle" material with weak strength in tension and limited ductility. Incorporation of randomly distributed, discrete, short fibers in the matrix results in three dimensional crack arrest and crack control system in the matrix of concrete [5].

In 1972, Harada et al. [6] found that the residual strength (bond) between the concrete and reinforcing steel bars was 44% of the control specimen at a temperature 300°C, while the residual strength of compression strength was 60% at the similar temperature.

In 1979, Lie and Leir [1] have carried out theoretical and experimental investigations to study the influence of various slab's thickness on the fire behavior of concrete slabs. They found that the slab's thickness has a strong influence on the heat transfer mechanism, and has little to do with the thermal properties of concrete.

In 1996, Fahmi and Heid. [4], studied (analytically and experimentally) the effect of high temperature (up to 700 C$^0$) on the behavior of RC slabs then gradually cooled, the main parameters of the slabs were the steel ratio and exposure temperature that ranging (25 to 700 C$^0$). They found that, the increase in temperature lead to decrease in the residual flexural strength.

In 2008, Peter J. et al. [7], studied the fire behavior of two-way RC slabs, they found that the concrete and the steel reinforcement in the bottom layers of the slab heat up well before the concrete and the top layers reinforcement, and when the temperature reaches 300 C$^0$, the yielding stress of the reinforcements were decreases.

From above, it can be seen that very few research studied the behavior of steel fiber reinforced concrete two-way slabs (punching shear strength and related failure) exposed to high temperature. For every slab in this study (when exposure to high-temp.), the shear capacity is recorded then discussed.

## 2. Study Program

An experimental program was planned and executed to investigate the behavior of two-way slab based on 18 RC simply supported slabs specimens. The program includes 3-types of mixes; NSC, HSC and LWC with compressive strengths of (50, 90 and 36 MPa) respectively. The experimental program consists of casting and testing 18 reduced scale RC two-way slab specimens in the Lab. with dimension (500*500*50 mm) (length*width*thickness) as shown in figure (1). Varying steel fiber ratio was used for all slab groups (0 and 2%), as shown in Table (١). All slabs had the same steel reinforcement; the amount of reinforcement for all tested slabs was Φ-4 at 150 mm c/c spacing in two directions, as illustrated in Fig.1. The specimens were divided into three groups (NS, HS and LW), these groups were classified according to concrete types. All specimens were left in the Lab. for 7-days after cured for 28-days, and then exposed to different temperature levels by using electric oven. Also, each group have a slab control specimen were tested to define the general behavior for variables which were studied in this research.

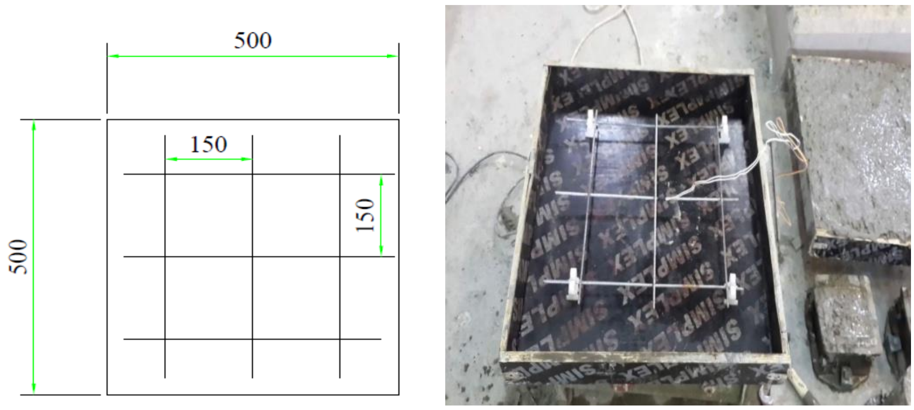



Figure 1. Slab molds, reinforcement and dimensions (mm).

## 3. Materials

The Properties of the materials used in this investigation and standard used in the tests are given below: in the following subsection.

### *3.1. Cement*

Ordinary Portland cement type I of Mass factory was used in this study. The physical analysis and chemical test results were conform to the Iraqi specification No.5/1984 [8].

### *3.2. Fine Aggregate*

Natural sand that used as a fine aggregate were brought from Al- Akhaidher. To examine the mechanical properties of this sand, series of tests have been conducted to make sure that the implement fine aggregate is following the Iraqi Specification No.45/1984 (zone 3) [9].

### *3.3. Coarse Aggregates*

Crushed gravel having maximum size of 10 mm brought from Al-Niba'ee region was used within the casting of cubes, cylinders and RC slabs (for NSC and HSC). The grading of this type of aggregate was conforming according to the Iraqi specification No.45/1984 [9].

### 3.4. Lightweight Coarse Aggregate

In this study one type of lightweight coarse aggregate used crushed thermostone. The shape of crushed lightweight coarse aggregate was normally in angular with adequate amount of elongated of and flaky particles. The maximum size of 20mm was used and satisfies the [ASTM C-330 specification] [10].

### 3.5. Steel Reinforcement

Smooth plain bars of diameter 4-mm were used as reinforcement for flexural, it is placed in the tension zone of the slab specimens. Three bars specimens were tested to get the yielding of the reinforcements which was 382 $N/mm^2$. The reinforcements were placed in 2-directions regularly at 15 cm C/C, which led to obtain the steel ratio of (0.0036) for each direction. Spacers were provided for the mesh of 1.5 cm.

### 3.6. Steel Fiber

Steel fibers produced by Chinese company (Hebei-Yusen-Metal Wire-Mesh Comp.Ltd) were used in this study. It is conformed to the standard specification of [ASTM A820/A820M- 04]. Steel fibers usually range from 0.25 to 2 percent by volume. The intended function of these fibers within RPC requires that the fibers have a very high tensile strength.

### 3.7. Superplasticizer

The superplasticizer used is known commercially as "GLENIUM-51". It is free from chlorides and conformed to the standard specification of ASTM C494-05 types A and F. Also, this type is compatible with all cement types in the entire worlds (Portland cements) that familiar with international codes.

### 3.8. Concrete Mix Proportions

Three mix proportions for NSC, HSC and LWC are selected depending on several trial mixes for each group. Six slabs are made of NSC, and designated as N1, N2, N3, NF1, NF2 and NF3. The control mix designed was (1) cement, sand/cement ratio (1.5), aggregate/cement ratio (3) and W/C ratio of 0.45 (by weight) were used. The above proportions produce average compressive strength of 50 MPa at 28 days, as shown in Table (1).

Also, six slabs are made of HSC, and designated as H1, H2, H3, HF1, HF2 and HF3. The virgin (control) mix designed was (1) cement, sand/cement ratio (1.134), aggregate/cement ratio (1.93) and W/C ratio of 0.264, and super-plasticizer content of 1.5% by weight of cement were used. The above proportions produce average compressive strength of 90 MPa at 28 days, as shown in Table (1). Finally, six slabs are made of LWC, and designated as L1, L2, L3, LF1, LF2 and LF3. Mix proportions of these slabs are 1:0.72:0.9 pocelinite by weight with W/C of 0.3 and amount of superplasticizer of 1.2% (by weight of cement). The above proportions produce average compressive strength of 36 MPa at 28 days, as shown in Table (1).

## 4. Heating and Cooling of Specimens

Three different temperatures were chosen (room temperature 25 C$^o$, 400C$^o$, 600C$^o$) for testing the slabs. For heating process, an oven (electric) was used for slabs and cubes specimens. The oven temp. was controlled by an electrical thermostat controller. While, for the cooling operation, the oven was turn off when the exposure time reaches at the end and the slabs and cubes were allowed to cool by leave the door of the oven half open for 24-hours, At last, specimens (slabs, cylinders and cubes) were furthered cooled for 24 hours prior to test, as shown in Fig.2.


Figure 2. Oven used for heating Specimens.

## 5. Compressive Strength Test

Table (1) reveals that concrete mixes for all cubes (150*150*150 mm) and cylinders (100*200), where the tests of compressive strength were carried out according to standard specification of BS-1881: part-116: 1983 [11]. Three cubes and cylinders for each group, three control samples including cubes and cylinders were tested to estimate the concrete compressive strength with heat staging.

Table 1. Mix details for slabs

| Slab | | Cement (kg/m$^3$) | Aggregate (kg/m$^3$) | Sand (kg/m$^3$) | fiber (%) | Superplasti sizer by weight of cement % | water kg/m$^3$ | w/c | Heat Temp. | Compressive strength (MPa) | Percentage (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N1 | Normal | 410 | 1230 | 615 | 0 | --- | 184.5 | 0.45 | 25 | 50 | 0.0 |
| N2 | | | | | | | | | 400 | 41 | 18.0 |
| N3 | | | | | | | | | 600 | 27.5 | 45.0 |
| NF1 | | | | | 2 | | | | 25 | 62.5 | 0.0 |
| NF2 | | | | | | | | | 400 | 51.875 | 17.0 |
| NF3 | | | | | | | | | 600 | 35 | 44.0 |
| H1 | High | 560 | 1085 | 635 | 0 | 1.5 | 148 | 0.264 | 25 | 90 | 0.0 |
| H2 | | | | | | | | | 400 | 74.7 | 17.0 |
| H3 | | | | | | | | | 600 | 52 | 42.2 |
| HF1 | | | | | 2 | | | | 25 | 121.5 | 0.0 |
| HF2 | | | | | | | | | 400 | 102.06 | 16.0 |
| HF3 | | | | | | | | | 600 | 74 | 39.1 |
| L1 | Light | 550 | 500 (pocelinite) | 400 | 0 | 1.2 | 150 | 0.3 | 25 | 35 | 0.0 |
| L2 | | | | | | | | | 400 | 28.8 | 17.7 |
| L3 | | | | | | | | | 600 | 19.6 | 44.0 |
| LF1 | | | | | 2 | | | | 25 | 42 | 0.0 |
| LF2 | | | | | | | | | 400 | 35 | 16.7 |
| LF3 | | | | | | | | | 600 | 23.94 | 43.0 |

## 6. Crack Pattern and Mode Failure

At the time when the load is subjected on RC slabs with the presence of steel fiber or without in the concrete mix, it was observed that the beginning of the appearance of the very minor spread cracks in the middle of the slabs in the center, which started at the early loading level or steps in the area or in the surface of the tensile side, this leading to the formation of first crack on the tensile side of the concrete slabs in stages and certain proportions of the ultimate load, which depends on the level of temperature to which the slabs are exposed. Failures are almost identical to all concrete slabs where four major cracks, which begin to appear from the middle and are oriented towards the outer sides of the slabs, were observed. Few slabs were observed to that cracks generated in one direction and divided the slabs to only two parts, as shown in Fig.3. When the loading stages were increased, it was observed that these cracks began to diverge and become visible and extend towards the part of the compressive surface. As the temperature increased, cracks were increased, diffused, and obtained at lower loads compared to similar slabs but not exposed to temperature. As the effect of temperature is high on the onset of fractures and get the yield line faster and wider.

Finally, all the RC slab specimens showed the same response up to failure, the modes of failure for slabs in this study were flexural failure, as shown in Fig. 3 and Fig .4.

Figure 3. Crack pattern and mode failure for slabs.

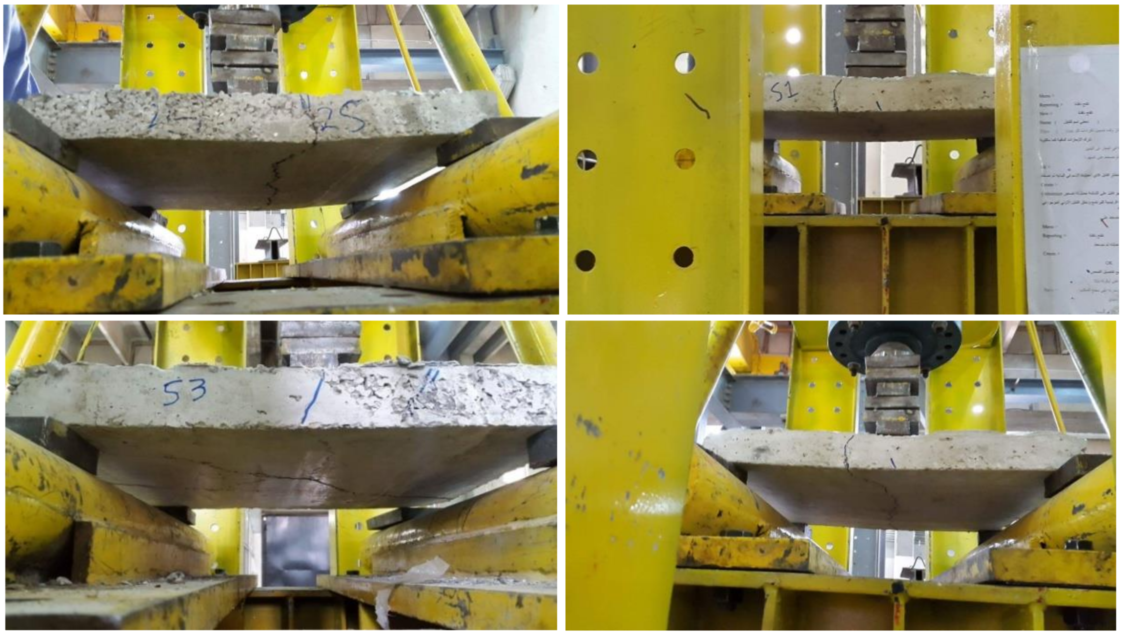


Figure 4. Mode failure for slabs after tested directly.

## 7. Test Results

### *7.1. Ultimate Load Carrying Capacity for Slabs Exposed to High Temperatures*

The influence of the load carrying capacity of two-way slabs varies over the various types of concrete panels with high temperature. Ultimate load and load deflection curve of the types of concrete (normal-strength concrete, high-strength concrete and light-weight concrete) are listed in the Table (2).

Table 2. Details of Ultimate load of slabs

| Slab | | fiber % | Heat temp | Ultimate load (kN) | Decreasing Percentage % |
|---|---|---|---|---|---|
| N1 | Normal | 0 | 25 | 11.04 | 0.0 |
| N2 | | | 400 | 9 | 18.5 |
| N3 | | | 600 | 6 | 45.7 |
| NF1 | | 2 | 25 | 13.8 | 0.0 |
| NF2 | | | 400 | 11.43 | 17.2 |
| NF3 | | | 600 | 7.68 | 44.3 |
| H1 | High | 0 | 25 | 18 | 0.0 |
| H2 | | | 400 | 15 | 16.7 |
| H3 | | | 600 | 10.5 | 41.6 |
| HF1 | | 2 | 25 | 24.3 | 0.0 |
| HF2 | | | 400 | 20.4 | 16.0 |
| HF3 | | | 600 | 14.5 | 40.3 |
| L1 | Light | 0 | 25 | 9 | 0.0 |
| L2 | | | 400 | 7.5 | 16.7 |
| L3 | | | 600 | 5 | 44.4 |
| LF1 | | 2 | 25 | 10.8 | 0.0 |
| LF2 | | | 400 | 9.2 | 14.8 |
| LF3 | | | 600 | 6.1 | 43.5 |

For the first group normal concrete for the slabs (N1, N2 and N3) without steel fiber, the increasing in the temperature from (25 to 400 and 600 C$^o$) causes a decreasing in the ultimate load of about (0%, 18.5% and 45.7%). For the first group with normal concrete for the slabs (NF1, NF2 and NF3) with steel fiber, the increasing in the temperature from (25 to 400 and 600 C$^o$) causes a decreasing in the ultimate load of about (0%, 17.2% and 44.3%), refer to fig.5 - 7.

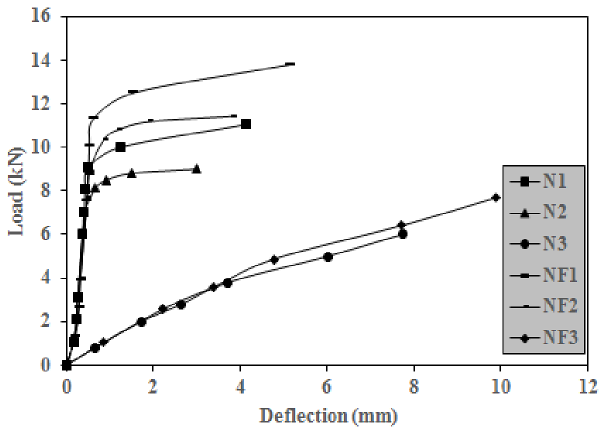



Figure 5. Load -deflection responses for NSC slabs (at different temperature) with and without fiber.

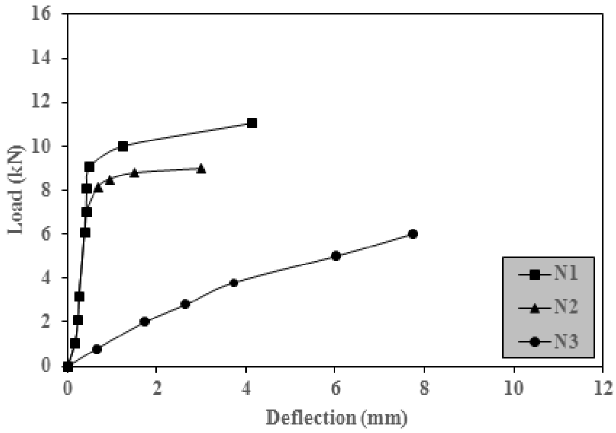



Figure 6. Load-deflection responses for NSC slabs (at different temperature) without fiber.

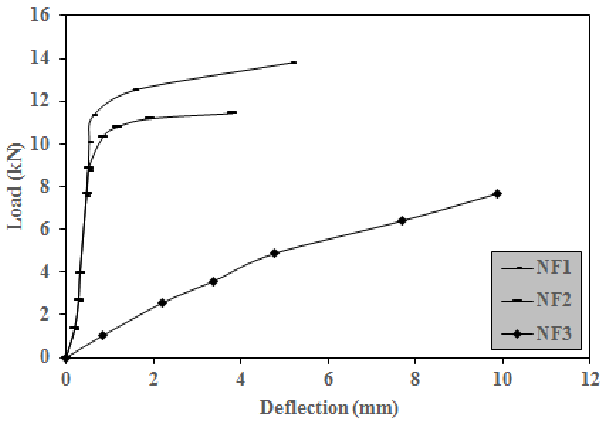



Figure 7. Load-deflection responses for NSC slabs (at different temperature) with fiber.

For the second group with high strength concrete for the slabs (H1, H2 and H3) without steel fiber, the increasing in the temperature from (25 to 400 and 600 C$^{o}$) causes a decreasing in the ultimate load of about (0, 16.7 and 41.6%). For the second group whit high strength concrete for the slabs (HF1, HF2 and HF3) with steel fiber, the increasing in the temperature from (25 to 400 and 600 C$^{o}$) cause a decreasing in the ultimate load of about (0, 16 and 40.3%), as shown in figure (8) through Fig.10.

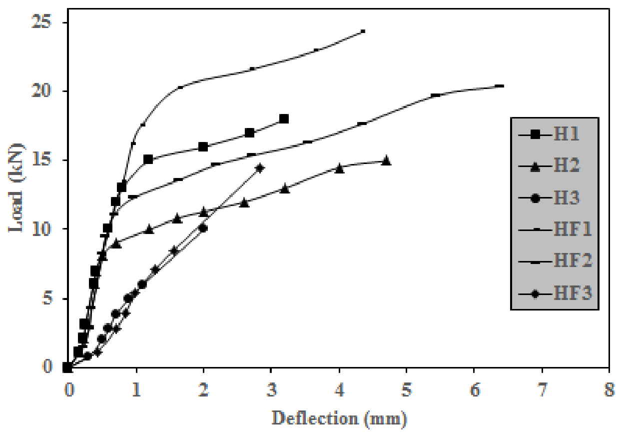


Figure 8. Load-deflection responses for HSC slabs (at different temperature) with and without fiber.

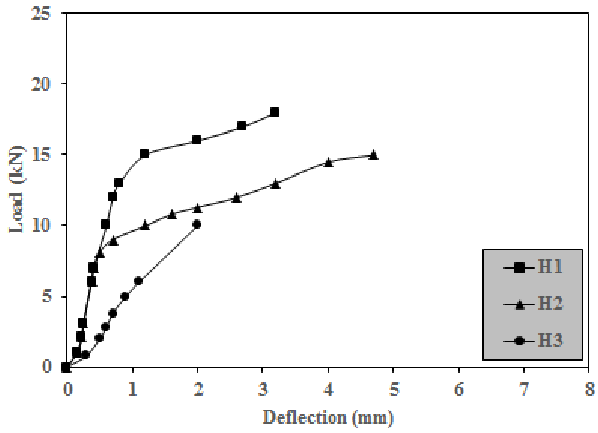


Figure 9. Load-deflection responses for HSC slabs (at different temperature) without fiber.

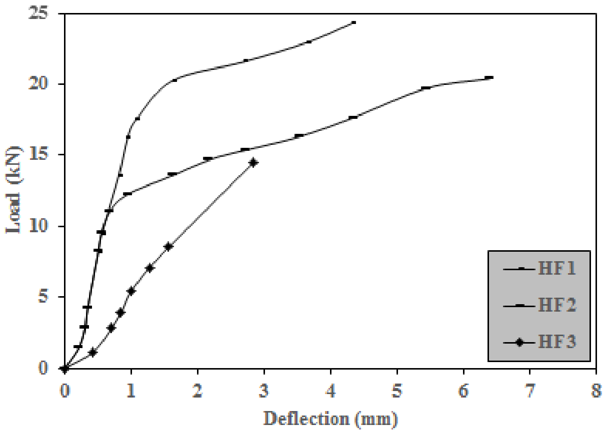


Figure 10. Load-deflection responses for HSC slabs (at different temperature) with fiber.

For the third group which light weight concrete for the slabs (L1, L2 and L3) without steel fiber the increasing in the temperature from (25 to 400 and 600 C$^{o}$) cause a decreasing in the ultimate load of about (0, 16.7 and 44.4%). For the third group which light weight concrete for the slabs (LF1, LF2 and LF3) with steel fiber the increasing in the temperature from (25 to 400 and 600 C$^{o}$) cause a decreasing in the ultimate load of about (0, 14.8 and 43.5%), as shown in Fig. 11 through Fig. 13.

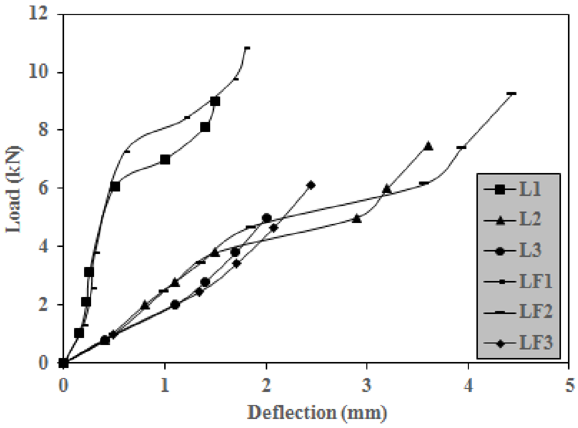



Figure 11. Load-deflection responses for LWC slabs (at different temperature) with and without fiber.

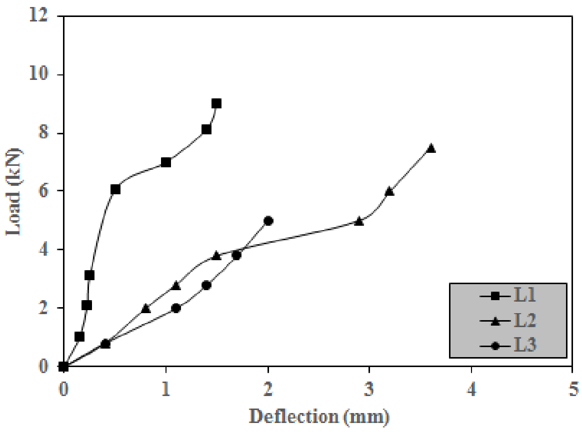



Figure 12. Load-deflection responses for LWC slabs (at different temperature) without fiber.

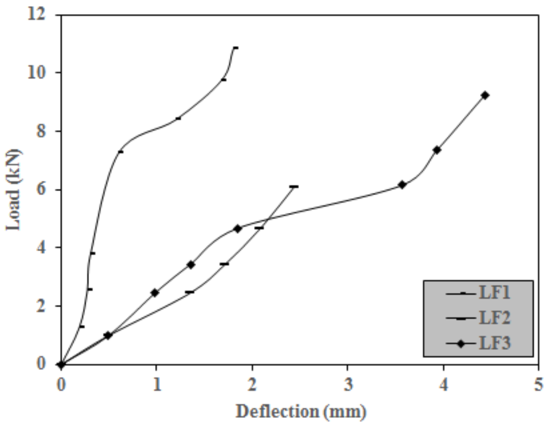



Figure 13. Load-deflection responses for LWC slabs (at different temperature) with fiber.

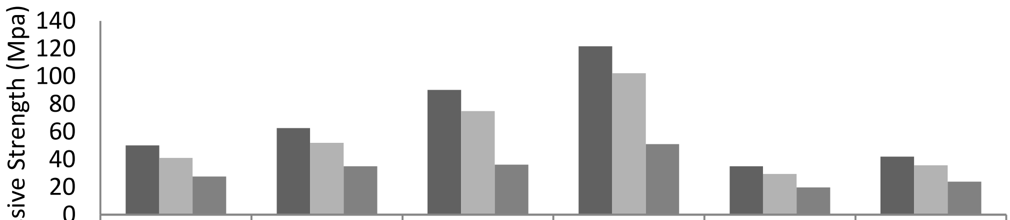
All results above show that the group of high strength concrete increases the ultimate load capacity better than the other groups.

## *7.2. Effect of Steel Fiber*

### *7.2.1. Compressive strength*

It has been observed that the compressive strength of concrete for the cubes and cylinders with steel fibers 2% is more than that of cubes and cylinders without steel fibers (at room temperature). This may be due to fact that the steel fibers will effectively hold the micro cracks in concrete mass. The percentage increase in the compressive strength for the cubes and cylinders with steel fibers 2% compared to the cubes and cylinders without steel fibers for NSC, HSC and LWC are 12.5%, 36.0% and 22.0% respectively.

The effect of steel fiber for RC slabs at temperature (400 C$^o$), the percentage increase in the compressive strength for NSC, HSC and LWC slabs with steel fiber 2% compared to the slabs without steel fibers are 26.5%, 36.6%, and 21.4% respectively.
The effect of steel fiber for RC slabs at temperature (600 C$^o$), the percentage increase in the compressive strength for NSC, HSC and LWC slabs with steel fiber 2% compared to the slabs without steel fibers are 27.3%, 41.8%, and 22.1% respectively.
It can be seen from the observations that the maximum percentage increase in compressive strength can be obtained for the HSC, as shown in Fig.14.




| | 0% fiber normal | 2.0% fiber normal | 0% fiber High-strength | 2.0% fiber High-strength | 0% fiber Light-weight | 2.0% fiber Light-weight |
|---|---|---|---|---|---|---|
| 25 C | 50 | 62.5 | 90 | 121.5 | 35 | 42 |
| 400 C | 41 | 51.875 | 74.7 | 102.06 | 29.4 | 35.7 |
| 600 C | 27.5 | 35 | 36 | 51.03 | 19.6 | 23.94 |

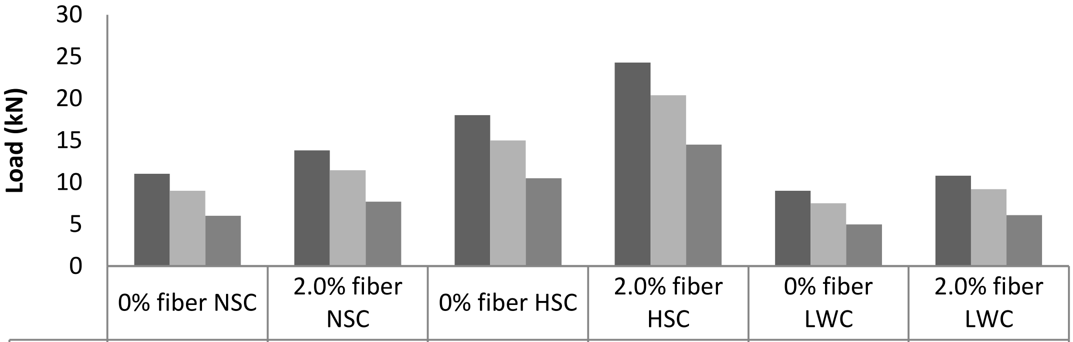
Figure 14. Effect of steel fiber on the compressive strength at temperature (25, 400 and 600 C$^o$).

### *7.2.2. Ultimate Load Capacity for Slabs*

It has been observed that the ultimate load capacity of RC slabs with steel fiber 2% is more than that of RC slab without steel fibers (at room temperature). The percentage increase in the ultimate load capacity for NSC, HSC and LWC slabs with steel fiber 2% compared to the slabs without steel fibers are 25.0%, 34.0%, and 20.0% respectively, as shown in Fig.15 to Fig.18.

The effect of steel fiber for RC slabs at temperature (400 C$^o$), the percentage increase in the ultimate load capacity for NSC, HSC and LWC slabs with steel fiber 2% compared to the slabs without steel fibers are 27.0%, 36.0%, and 22.7% respectively, as shown in Fig .15 and Fig .19 to Fig. 21.

The effect of steel fiber for RC slabs at temperature (600 C$^o$), the percentage increase in the ultimate load capacity for NSC, HSC and LWC slabs with steel fiber 2% compared to the slabs without steel fibers are 28.0%, 38.1%, and 22.0% respectively, as shown in Fig. 15 and Fig .22 to Fig. 24.




| | 0% fiber NSC | 2.0% fiber NSC | 0% fiber HSC | 2.0% fiber HSC | 0% fiber LWC | 2.0% fiber LWC |
|---|---|---|---|---|---|---|
| 25 C | 11.04 | 13.8 | 18 | 24.3 | 9 | 10.8 |
| 400 C | 9 | 11.43 | 15 | 20.4 | 7.5 | 9.2 |
| 600 C | 6 | 7.68 | 10.5 | 14.5 | 5 | 6.1 |

Figure 15. Effect of steel fiber on the ultimate load capacity of slabs at temperature (25, 400 and 600 C$^o$).

It can be seen from the observations that the maximum percentage increase in ultimate load capacity can be obtained for the HSC slabs with different temperature values (room temperature, 400 and 600 C$^o$).

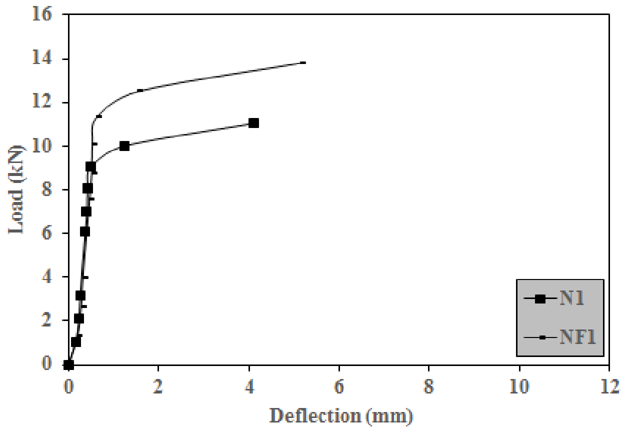



Figure 16 Load-deflection responses for NSC slabs (at room temperature) with and without fiber.

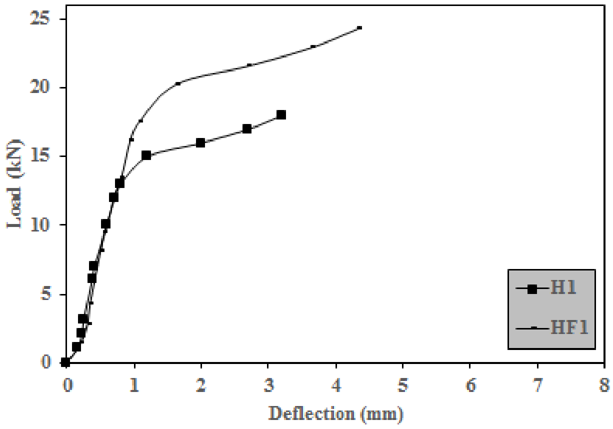



Figure 17 Load-deflection responses for HSC slabs (at room temperature) with and without fiber.

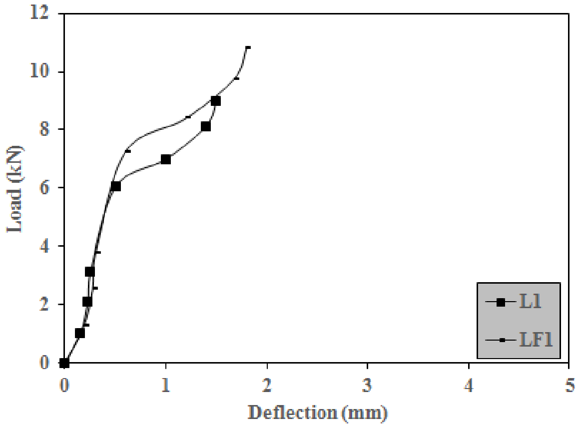



Figure 18 Load-deflection responses for LWC slabs (at room temperature) with and without fiber.

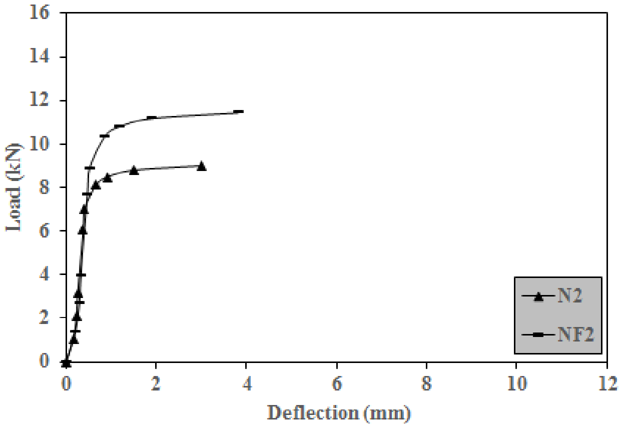



Figure 19 Load-deflection responses for NSC slabs (at 400 $C^{o}$) with and without fiber.

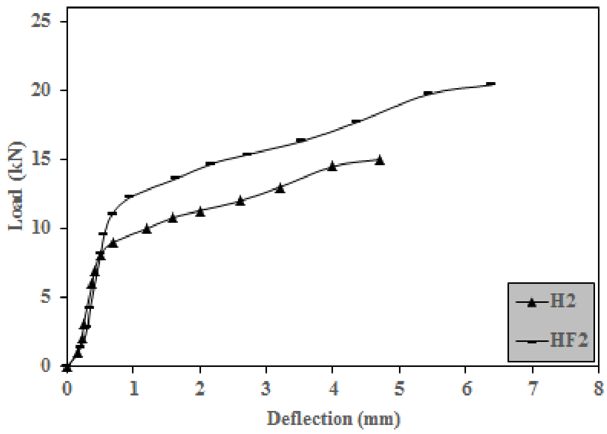



Figure 20 Load-deflection responses for HSC slabs (at 400 C$^{o}$) with and without fiber.

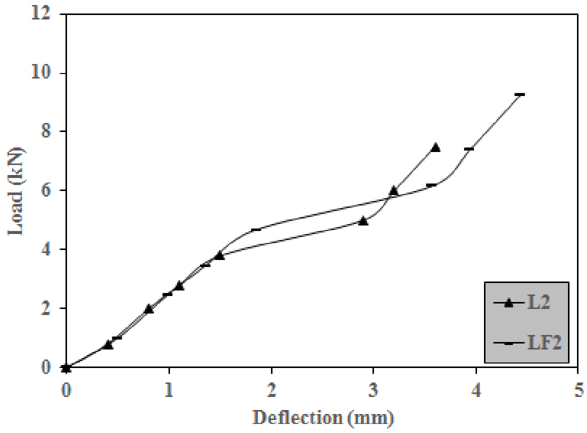



Figure 21 Load-deflection responses for LWC slabs (at 400 C$^{o}$) with and without fiber.

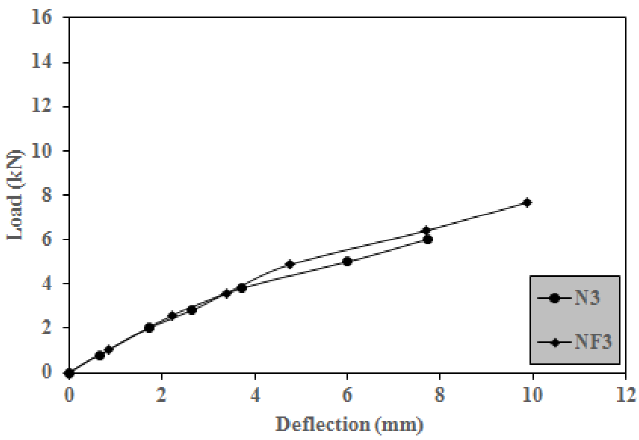



Figure 22 Load-deflection responses for NSC slabs (at 600 C$^{o}$) with and without fiber.

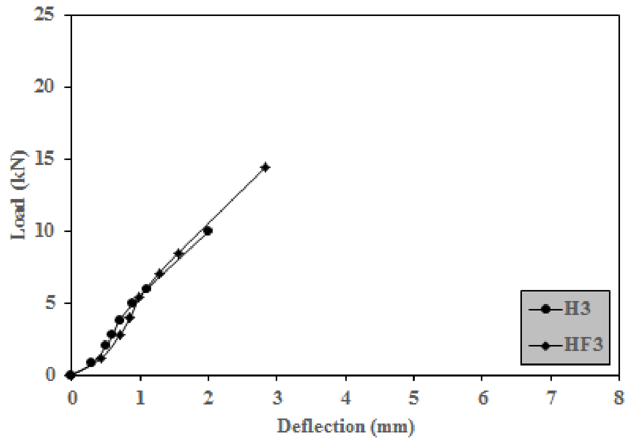



Figure 23 Load-deflection responses for HSC slabs (at 600 C$^{o}$) with and without fiber.

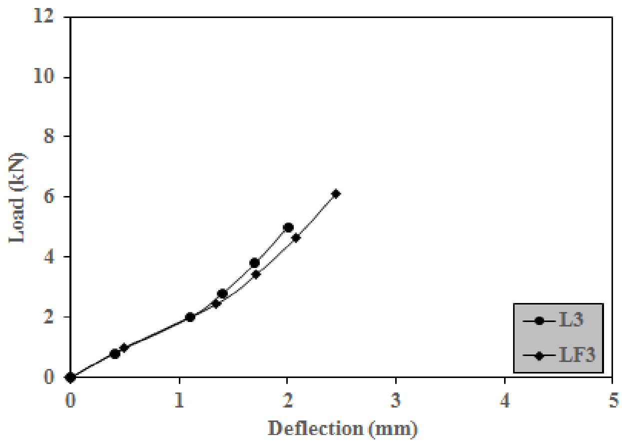



Figure 24 Load-deflection responses for LWC slabs (at 600 C$^{o}$) with and without fiber.

Finally, it can be noted from the above results for the considered type of concrete, when all tested groups were compared together, the effect of steel fiber on the ultimate load capacity were very slightly when temperature increased from 25 to 400 and 600 C$^{o}$, where, the same simple effect is observed when temperatures increased in slab specimens that do not include steel fiber.

## 8. Conclusions

According to the results of this research, the following conclusions are drawn:

1. The strength of concrete for normal-strength concrete, high-strength concrete and light-weight concrete reduce when exposure to high temperature.
2. The percentage decreases in compressive strength for normal-strength concrete when exposures to (25, 400 and 600 C$^{o}$) are about (0, 18 and 45%) respectively with mixes without fiber.
3. The percentage decreases in compressive strength for normal-strength concrete when exposures to (25, 400 and 600 C$^{o}$) are about (0, 17 and 44%) respectively with mixes with fiber.

4. The percentage decreases in compressive strength for high-strength concrete when exposures to (25, 400 and 600 $C^o$) are about (0, 17 and 42.2%) respectively with mixes without fiber.
5. The percentage decreases in compressive strength for high-strength concrete when exposures to (25, 400 and 600 $C^o$) are about (0, 16 and 39.1%) respectively with mixes with fiber.
6. The percentage decreases in compressive strength for light-weight concrete when exposures to (25, 400 and 600 $C^o$) are about (0, 17.7 and 44%) respectively with mixes without fiber.
7. The percentage decreases in compressive strength for light-weight concrete when exposures to (25, 400 and 600 $C^o$) are about (0, 16.7 and 43%) respectively with mixes with fiber.
8. The use of steel fiber improves the behavior resistance and allowing higher forces. The cracking load depends essentially on concrete strength. While, the effect of steel fiber slightly increased the ultimate load when slabs exposure to high temperature where, the same simple effect is observed when temperatures increased in slab specimens that do not include steel fiber.
9. For NSC slabs without fiber the increasing in the temperature from (25, 400 and 600 $C^o$) causes a decreasing in the ultimate load of about (0, 18.5 and 45.7%).
10. For NSC for the slabs with fiber the increasing in the temperature from (25, 400 and 600 $C^o$) causes a decreasing in the ultimate load of about (0, 17.2 and 44.3%).
11. For HSC slabs without fiber the increasing in the temperature from (25, 400 and 600 $C^o$) cause a decreasing in the ultimate load of about (0, 16.7 and 41.6%).
12. For HSC slabs with fiber the increasing in the temperature from (25, 400 and 600 $C^o$) cause a decreasing in the ultimate load of about (0, 16 and 40.3%).
13. For LWC slabs without fiber the increasing in the temperature from (25, 400 and 600) cause a decreasing in the ultimate load of about (0, 16.7 and 44.4%).
14. For LWC slabs with fiber the increasing in the temperature from (25, 400 and 600 $C^o$) cause a decreasing in the ultimate load of about (0, 14.8 and 43.5%).
15. The compressive strength of concrete with steel fibers 2% is more than that without steel fibers (at room temperature). The percentage increase in the compressive strength for NSC, HSC and LWC are 12.5%, 36.0% and 22.0% respectively.
16. The percentage increase in the compressive strength for NSC, HSC and LWC slabs with steel fiber 2% at temperature (400 $C^o$), were 26.5%, 36.6%, and 21.4% respectively compared to the slabs without steel fibers.
17. The percentage increase in the compressive strength for NSC, HSC and LWC slabs with steel fiber 2% at temperature (600 $C^o$), were 27.3%, 41.8%, and 22.1% respectively compared to the slabs without steel fibers.

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