Experimental Study of Hybrid Layer Effect for Prism under Bending, Shear and Torsion

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Abstract. The composite concrete structure by adopting varied concrete characteristics that are systematized in the layered method, described (hybrid), the principal purpose for utilizing the hybrid mixture is to enhance the load-carrying function for the segment. Hybrid concrete sections maintain high compressive strength, ductile, high absorption energy and high tensile strength, these properties can be performed by installing two or more various types or strengths of mixture layers collectively so that every layer is employed to its best benefit. The results of (flexural, shear and torsion tests) on hybrid prism composed of two layers of different types of concrete are presented and discussed with the effect of different parameters and variables. Normal concrete layer combined with a layer of (high or ultra-high-strength concrete) with the effect of fiber. The purposes of the present investigation are: find the engineering properties of three concrete types, the effect of hybrid concrete with different concrete types at different layers of prisms with different parameters and variables tested under three types of testing (flexural, shear and torsion tests).

1. Introduction

Concrete is the common extensively worked material in building construction with different characteristics and strength including normal, high and ultra-high-strength concrete. For the new demands of construction including high strength, thin sections, large space, complex forms of structure, economy, fast construction, elimination of reinforcement, and reduced maintenance special concrete with enhanced properties and characteristics are required. The cost of UH concrete is higher than the cost of conventional strength concrete except, UH concrete provides advantages including higher performance levels, impact resistance, ductility, toughness, and strength [1-4].

2. Shear, Flexural and Torsion test

The force that produces the slippage between two materials on two different surfaces parallel to the direction of force is called the shear load. The force of a materials or compounds toward the structure surface of failure when the material or compounds fail is called the shear force. The stresses in a material simply prior it yields which is a material feature is denoted flexural strength. The concrete member torsional failure is initiated by the tensile stress generated related to a category of pure shear, which is torsion sequences [5-7]. Concrete easily cracks under impact loads and tensile stress related to low tensile strength. Fibers with different shapes, types, percentage and size were used to bridging the cracks, and provide improved serviceability to the structure. The composition of steel fibers generally may enhance the tensile strength of the mold to an average level besides the toughness will be improved to a higher intensity [8-12].

Muhammad I R and Mazen A M (2007) [7] improves the toughness and the tensile strength of reinforced concrete members by steel fiber. Santhakumar R et al. (2007) [13] numerical finite elements study on coupled torsion and bending for reinforced concrete beams. Suresh R (2009) [14] study the rectangular beams SFRC torsional behavior subjected to combined torsion-bending-shear. Pant A and Parekar S (2009) [15] presented reinforced concrete beams tests with shear, bending, and torsion with the effect of steel fiber. Sable K et al. (2011) [16] investigates Fly ash as cement replacement and SFRC with different strengths under shear and torsion. Kishor S and Madhuri K (2012) [17] study of SCC and NCC shear and torsion strength with different aspect ratios with and
without fibers. Ahmed S and Khaled S (2014) [18] investigate the performance of steel fiber self-compacting high-strength reinforced concrete beams experimentally and analytically following combined torsion and bending. Babar et al. (2015) [19] investigate ductility and shear strength of non-stirrups hooked steel fiber reinforced concrete beams. Satyajeet B and Ajinkya D (2015) [20] revealed an analytical design to predict the shear, tensile strength, torsion and bending of the fiber-reinforced concrete beam. Fibers, increased load-carrying ability, ductility and toughness of high strength fiber reinforced concrete beam. Amulu C and Ezeagu C (2016) [5] investigates the impact of coupled actions of torsion, bending and shear stresses. Awadh E (2016) [6] study combined torsional moments, shear forces and bending moments for reinforced concrete beams. Karim et al. (2016) [21] improved that torsional resistance provided by fibers. Thivyja J et al. (2016) [22] study a composite beam under combined bending and torsion. Senthuran and Sattainathan S (2016) [23] study the improved torsional behavior of reinforced beams having steel fibers. Sameera K (2017) [24] investigates the behavior of cylindrical composite beams varying the percentage of fiber content under the combined state of flexure, torsion, and shear.

3. Description of the Experimental Work

The experimental program is conducted to find the relation between different types of concrete in shear, flexure, and torsion. These mixes were divided into four different mixes with different concrete properties with different tests including (weight change, density, tensile splitting strength, compressive strength, and flexural strength) [1, 12]. All work was investigated over a period of 28 days. Table 1 shows the details of various types of mixes used in the present research work. (100*100*400 mm) wooden and steel molds prisms were prefabricated to cast the specimens. The experimental program includes testing 39 specimens with different concrete types tested under shear, torsion, flexure and compression as presented in Table 2.

| Concrete type                | Cement kg/m³ | Sand kg/m³ | aggregate kg/m³ | w/c   | Superplasticizer (%) by weight of cement | Silica Fume (%) | Steel fiber (%) |
|-----------------------------|--------------|------------|-----------------|-------|-----------------------------------------|----------------|---------------|
| Normal Concrete             | 420          | 650        | 1000            | 0.45  | --                                      | --             | --            |
| High Strength concrete      | 560          | 635        | 1085            | 0.27  | 1.5                                     | --             | --            |
| Ultra-high strength concrete| 1000         | 1000       | ---             | 0.2   | 6.8                                     | 25             | --            |
| Ultra-high strength concrete| 1000         | 1000       | ---             | 0.2   | 6.8                                     | 25             | 1.0           |

Table 2. The experimental program specimens with different concrete type.

| Test   | Concrete type                      | layer | Concrete position |
|--------|------------------------------------|-------|-------------------|
| Flexure| Normal High strength               | All   |                   |
| Shear  | Ultra-high strength                |       |                   |
| Torsion| Ultra-high strength with fiber     |       |                   |
| 1/4 High| 3/4 normal                         |       |                   |
| 1/4 Ultra-High | 3/4 normal          |       |                   |
| 1/4 Ultra-High with fiber | 3/4 normal |       |                   |
| 1/2 High | 1/2 normal                         |       |                   |
| 1/2 Ultra-High | 1/2 normal                   |       |                   |
| 1/2 Ultra-High with fiber | 1/2 normal |       |                   |
| 3/4 High | 1/4 normal                         |       |                   |
| 3/4 Ultra-High | 1/4 normal                     |       |                   |
| 3/4 Ultra-High with fiber | 1/4 normal |       |                   |

In the case of regular or high-performance mixtures are poured normally where dry materials are initially mixed from cement, sand, and gravel for a certain period and then added the water to obtain a homogeneous mixture. As for ultra-high-strength concrete mixes, dry materials are mixed together including of cement, sand and gray silica fume from to obtain high density and high compressive strength, then water with the Sika ViscoCrete-PC5390 superior plasticizer add to the mixture to get a homogeneous mixture and for the mixture containing fiber, the fiber is added in the end of mixing by hand to distribute evenly. After finishing the casting process, the homogeneous mixture is distributed
to the molds where it is filled with three layers and vibrate to obtain a homogeneous casting. The surface of the molds shall be modified and covered for a whole day and then taken out of the molds and placed in water containers for 28 days after which they are taken out in preparation for the day of examination. Results from tests of all mixtures were analyzed and discussed in tables and figures.

Table 3 shows the fresh and hardening properties for different concrete strength. The compressive strength test, flexural and splitting strength, density and weight change were determined according to [B.S-1881; part 116], [ASTM C39-2005], [ASTM C 348-02] [ASTM specification C496-04], [ASTM C267-89] and [ASTM C642-97] as shown in Figures from 1-6. Figures 7 and 8 show material, the experimental work and flexural and shear tests.

For torsional test special steel mold used for testing the specimens. For a prismatic prism of tubular cross-section, the angle of torsional twist ($\theta$) is conditional on the implemented torque ($T$), the length of the member ($L$), the shear modulus of the material ($G$) and a shape-dependent parameter known as the torsional inertia constant ($I_t$). Many test methods for evaluating shear strength, like FIP standard. Several researchers have reported the use of fibers to enhance the shear, torsional and flexural capacity of concrete.

| Test                | Compressive strength (MPa) | Density (kg/m$^3$) | Splitting tensile strength (MPa) | Flexural tensile strength (MPa) | Weight change (%) |
|--------------------|---------------------------|--------------------|----------------------------------|--------------------------------|------------------|
| Mix                | cylinder 100*200mm (%)    | cube 100*100mm %   | cylinder 100*200mm %             | Prism 100*100*400 mm %         |                 |
| Normal concrete    | 26 0 31 0 2369 0 3.0 0 4.5 0 | 23.3             | 116 2543 7.3 5.1 70 7.5 66.67 | 2.3 -21.7 |                 |
| High  Strength     | 46 76.9 53 71 2450 3.4 4.2 40 5.4 20 | 1.8 -21.7 |                 |                 |                 |
| Ultra high Strength| 61 134.6 67 116 2543 7.3 5.1 70 7.5 66.67 | 0.9 -60.8 |                 |                 |                 |

Figure 1. Compressive strength for different concrete type of cylinder.

Figure 2. Compressive strength for different concrete type of cube.

Figure 3. Density for different concrete type.

Figure 4. Splitting tensile strength for different concrete type.

Figure 5. Flexural tensile strength for different concrete type of Prism.

Figure 6. Weight change for different concrete type of cube.
4. Results and Discussion

Results of shear, flexure, and torsional tests for all molds are presented here.

4.1 Flexural stress

Table 4 shows all flexural stresses for normal and high and ultra-high concrete. Figures from 9-15 show the flexural comparison between normal, high, ultra-high-strength concrete with or without fiber with a different layer.
- When concrete change from all normal concrete casting to [all high strength concrete casting], [(1/4 high)-(3/4 normal)], [(1/2 high)-(1/2 normal)] and [(3/4 high)-(1/4 normal)] the flexural stress increased by (20, 4.0, 6.67 and 16%).
- When concrete change from all normal concrete casting to [all Ultra-high strength concrete casting], [(1/4 ultra-high)-(3/4 normal)], [(1/2 ultra-high)-(1/2 normal)] and [(3/4 ultra-high)-(1/4 normal)] the flexural stress increased by (66.67, 6.67, 26.67 and 53.33%).
- When concrete change from all normal concrete casting to [all Ultra-high strength concrete casting with fiber], [(1/4 ultra-high with fiber)-(3/4 normal)], [(1/2 ultra-high with fiber)-(1/2 normal)] and [(3/4 ultra-high with fiber)-(1/4 normal)] the flexural stress increased by (133.33, 33.33, 66.67 and 106.67%).

Table 4. All flexural stresses for normal and high and ultra-high concrete.

| Concrete type                | Concrete type | Flexural Stress (MPa) | (% Flexural Stress compared to Normal) | (% Flexural Stress compared to High) | (% Flexural Stress compared to Ultra high) |
|-----------------------------|---------------|-----------------------|--------------------------------------|-------------------------------------|-------------------------------------------|
| Normal                      | All 4.5       | 0.00                  | -16.67                               | -40.00                              |                                           |
| High strength               | All 5.4       | 20.00                 | 0.0                                  | -28.00                              |                                           |
| Ultra-high strength         | All 7.5       | 66.67                 | 38.89                                | 0.0                                 |                                           |
| 1/4 High                    | 3/4 normal 4.68 | 4.00                  | -13.33                               | -37.60                              |                                           |
| 1/2 High                    | 1/2 normal 4.8 | 6.67                  | -11.11                               | -36.00                              |                                           |
| 3/4 High                    | 1/4 normal 5.22 | 16.00                 | -3.33                                | -30.40                              |                                           |
| 1/4 Ultra-High              | 3/4 normal 4.8 | 6.67                  | -11.11                               | -36.00                              |                                           |
| 1/2 Ultra-High              | 1/2 normal 5.7 | 26.67                 | 5.56                                 | -24.00                              |                                           |
| 3/4 Ultra-High              | 1/4 normal 6.9 | 53.33                 | 27.78                                | -8.00                               |                                           |
| Ultra-high strength with fiber | All 10.5 133.33 | 94.44                | 40                                   | 0.0                                 |                                           |
| 1/4 Ultra-High with fiber   | 3/4 normal 6. 33.33 | 11.11                | 11.11                                | -20                                 |                                           |
| 1/2 Ultra-High with fiber   | 1/2 normal 7.5 | 66.67                 | 38.89                                | 0.0                                 |                                           |
| 3/4 Ultra-High with fiber   | 1/4 normal 9.3 | 106.66                | 72.22                                | 24.0                                 |                                           |

- Compare the results to the normal flexural stress, it can be seen that all model can overcome the flexural stress of normal concrete.
- Compare the results to the high strength flexural strength it can be seen that just seven model can overcome the flexural stress of high strength concrete which include the ultra-high-strength concrete.
- Compare the results to the ultra-high-strength flexural stress it can be seen that just three model can overcome the flexural stress of ultra-high-strength concrete which include the ultra-high-strength concrete with fiber.

Figure 9. Flexural comparison between normal and high concrete with different layer.

Figure 10. Flexural comparison between normal and ultra-high concrete with different layer.

Figure 11. Flexural comparison between normal and high concrete with different layer.

Figure 12. Flexural comparison between ultra-
and ultra-high concrete with and without fiber.

Figure 13. Comparison of flexural test results compared to normal concrete.

Figure 14. Comparison of flexural test results compared to high strength concrete.

Figure 15. Comparison of flexural test results compared to ultra-high strength concrete.

4.2 Shear stress

Table 5 shows all shear stresses for normal and high and ultra-high concrete. Figures from 16-22 show shear comparison between normal, high, ultra-high-strength concrete with or without fiber with a different layer.

- When concrete change from normal to [high], [(1/4 high)-(3/4 normal)], [(1/2 high)-(1/2 normal)] and [(3/4 high)-(1/4 normal)] the shear stress increased by (24.39, 4.88, 9.76 and 19.51%).
- When concrete change from normal to [ultra-high], [(1/4 ultra-high)-(3/4 normal)], [(1/2 ultra-high)-(1/2 normal)] and [(3/4 ultra-high)-(1/4 normal)] the shear stress increased by (60.98, 24.39, 36.59 and 51.22%).
- When concrete change from normal to [ultra-high with fiber], [(1/4 ultra-high with fiber)-(3/4 normal)], [(1/2 ultra-high with fiber)-(1/2 normal)] and [(3/4 ultra-high with fiber)-(1/4 normal)] the shear stress increased by (90.24, 36.58, 51.21 and 70.73%).

Table 5. All shear stresses for normal and high and ultra-high concrete.

| Concrete type                      | Shear Stress (MPa) | (% Shear Stress compared to normal) | (% Shear Stress compared to High) | (% Shear Stress compared to Ultra high) |
|-----------------------------------|--------------------|------------------------------------|-----------------------------------|----------------------------------------|
| Normal                            | All                | 4.1                                | -19.64                            | -37.88                                 |
| High strength                     | All                | 5.1                                | 0.00                              | 0                                      |
| Ultra-high strength               | All                | 6.6                                | 60.98                             | 29.41                                  |
| 1/4 High                          | 3/4 normal         | 4.3                                | 4.88                              | -15.69                                 |
| 1/2 High                          | 1/2 normal         | 4.5                                | 9.76                              | -11.76                                 |
| 3/4 High                          | 1/4 normal         | 4.9                                | 19.51                             | -3.92                                  |
| 1/4 Ultra-High                    | 3/4 normal         | 5.1                                | 24.39                             | 0.00                                   |
| 1/2 Ultra-High                    | 1/2 normal         | 5.6                                | 36.59                             | 9.80                                   |
| 3/4 Ultra-High                    | 1/4 normal         | 6.2                                | 51.22                             | 21.97                                  |
| Ultra-high strength with fiber    | All                | 7.8                                | 90.24                             | 52.941                                 |
| 1/4 Ultra-High with fiber         | 3/4 normal         | 5.6                                | 36.59                             | 9.80                                   |
| 1/2 Ultra-High with fiber         | 1/2 normal         | 6.2                                | 51.22                             | 21.97                                  |
| 3/4 Ultra-High with fiber         | 1/4 normal         | 7                                 | 70.73                             | 37.255                                 |

- Compare the results to the normal shear strength it can be seen that all models can overcome the shear stress of normal concrete.
• Compare the results to the high strength shear strength it can be seen that just eight models can overcome the shear stress of high strength concrete which includes the ultra-high-strength concrete.

• Compare the results to the ultra-high-strength shear stress it can be seen that just two models can overcome the shear stress of ultra-high-strength concrete which includes the ultra-high-strength concrete with fiber.

Figure 16. Shear comparison between normal and high concrete with different layer.

Figure 17. Shear comparison between normal and ultra-high concrete.

Figure 18. Shear comparison between normal and ultra-high concrete with and without fiber.

Figure 19. Shear comparison between ultra-high strength concrete with and without fiber.

Figure 20. Comparison of shear test results compared to normal concrete.

Figure 21. Comparison of shear test results compared to high strength concrete.

Figure 22. Comparison of shear test results compared to ultra-high strength concrete.

4.3 Torsional stress
Table 6 shows all torsional stresses for normal and high and ultra-high concrete. Figures from 23-29 show a torsional comparison between normal, high, ultra-high-strength concrete with or without fiber with different layers.
When concrete changes from normal to high, [(1/4 high)-(3/4 normal)], [(1/2 high)-(1/2 normal)] and [(3/4 high)-(1/4 normal)] the torsional stress increased by (28.57, 4.76, 9.52 and 19.05%).

When concrete changes from normal to ultra-high, [(1/4 ultra-high)-(3/4 normal)], [(1/2 ultra-high)-(1/2 normal)] and [(3/4 ultra-high)-(1/4 normal)] the torsional stress increased by (42.86, 14.29, 28.57 and 42.86%).

When concrete changes from normal to ultra-high with fiber, [(1/4 ultra-high with fiber)-(3/4 normal)], [(1/2 ultra-high with fiber)-(1/2 normal)] and [(3/4 ultra-high with fiber)-(1/4 normal)] the torsional stress increased by (80.95, 33.26, 52.27 and 76.13%).

Table 6. All Torsional stresses for normal and high and ultra-high concrete.

| Concrete type                          | Torsional Stress (MPa) | (%) torsional Stress compared to normal | (%) torsional Stress compared to High | (%) torsional Stress compared to Ultra high |
|----------------------------------------|------------------------|----------------------------------------|--------------------------------------|--------------------------------------------|
| Normal                                 | All                    | 10.10                                  | 0.00                                 | -22.22                                    |
| High strength                          | All                    | 12.98                                  | 28.57                                | 0                                          |
| Ultra-high strength                    | All                    | 14.42                                  | 42.86                                | 11.11                                     |
| 1/4 High                               | 3/4 normal             | 10.58                                  | 4.76                                 | -18.52                                    |
| 1/2 High                               | 1/2 normal             | 11.06                                  | 9.52                                 | -14.81                                    |
| 3/4 High                               | 1/4 normal             | 12.02                                  | 19.05                                | -7.41                                     |
| 1/4 Ultra-High                         | 3/4 normal             | 11.54                                  | 14.29                                | -11.11                                    |
| 1/2 Ultra-High                         | 1/2 normal             | 12.98                                  | 28.57                                | 0.00                                      |
| 3/4 Ultra-High                         | 1/4 normal             | 14.42                                  | 42.86                                | 11.11                                     |
| Ultra-high-strength with fiber         | All                    | 18.27                                  | 80.95                                | 40.755                                    |
| 1/4 Ultra-High with fiber              | 3/4 normal             | 13.46                                  | 33.33                                | 3.688                                      |
| 1/2 Ultra-High with fiber              | 1/2 normal             | 15.38                                  | 52.38                                | 18.490                                    |
| 3/4 Ultra-High with fiber              | 1/4 normal             | 17.79                                  | 76.19                                | 37.057                                    |

Compare the results to the normal torsional stress it can be seen that all models can overcome the torsional stress of normal concrete.

Compare the results to the high strength torsional stress it can be seen that just seven models can overcome the torsional stress of high strength concrete which includes the ultra-high-strength concrete.

Compare the results to the ultra-high-strength torsional stress it can be seen that just four models can overcome the torsional stress of ultra-high-strength concrete which includes the ultra-high-strength concrete with fiber.
5. Analytical modeling

An acceptable concordance was found between the experimental test conclusions and the finite element program. The analytical study includes the modeling of normal, high and ultra-high-strength molds tested under different types of loadings, with the dimensions and properties corresponding to the actual experimental data. The specimen will be modeled using an eight-node three-dimensional concrete brick element [25-27]. The theoretical work is applied to verify the finite element programs can examine many structural elements. Table 7 shows a comparison between experimental and analytical stress. Figure 30 shows a 3-D view and dimensions of the shear molds. Figures 31, 32 and 33 shows shear stress for normal, high and Ultra-high strength concrete mold. Figure 34 shows the brick element for the flexural test. Figures 35, 36 and 37 show flexural stress for normal, high and Ultra-high strength concrete mold. Figure 38 shows a 3-D view and dimensions of the torsional molds. Figures 39, 40 and 41 show torsional stress for normal, high and Ultra-high strength concrete mold.

Table 7. Comparison between experimental shear stress, flexural stress, torsional stress and analytical stress.

| Details         | Experimental shear stress (MPa) | Analytical shear stress (MPa) | Exp/Analytical | Experimental flexural stress (MPa) | Analytical flexural stress (MPa) | Exp/Analytical | Experimental Torsional stress (MPa) | Analytical torsional stress (MPa) | Exp/Analytical |
|-----------------|-------------------------------|-------------------------------|----------------|-----------------------------------|---------------------------------|----------------|-----------------------------------|---------------------------------|----------------|
| 1 Normal        | 4.1                           | 3.73                          | 0.91           | 4.5                               | 4.05                            | 0.90           | 10.10                             | 9.26                            | 0.92           |
| 2 High strength | 6.6                           | 6.11                          | 0.93           | 7.5                               | 6.75                            | 0.90           | 14.42                             | 13.4                            | 0.93           |
| 4 1/4 High      | 4.3                           | 3.9                           | 0.91           | 4.68                              | 4.21                            | 0.90           | 10.58                             | 9.83                            | 0.93           |
| 5 1/2 High      | 4.5                           | 4.24                          | 0.94           | 4.8                               | 4.38                            | 0.91           | 11.06                             | 10.1                            | 0.91           |
| 7 1/4 Ultra-High| 5.1                           | 4.89                          | 0.96           | 4.8                               | 4.57                            | 0.95           | 11.54                             | 10.42                           | 0.90           |
| 8 1/2 Ultra-High| 5.6                           | 5.23                          | 0.93           | 5.7                               | 5.34                            | 0.94           | 12.98                             | 11.89                           | 0.92           |
| 9 3/4 Ultra-High| 6.2                           | 5.95                          | 0.96           | 6.9                               | 6.28                            | 0.91           | 14.42                             | 13.56                           | 0.94           |
| 10 Ultra-high strength with fiber | 7.8                           | 7.21                          | 0.92           | 10.5                              | 9.42                            | 0.90           | 18.27                             | 17.2                            | 0.94           |
| 11 1/4 Ultra-High with fiber | 5.6                           | 5.27                          | 0.94           | 6                                | 5.4                             | 0.90           | 13.46                             | 12.57                           | 0.93           |
| 12 1/2 Ultra-High with fiber | 6.2                           | 6.01                          | 0.97           | 7.5                               | 7.21                            | 0.96           | 15.38                             | 14.27                           | 0.93           |
| 13 3/4 Ultra-High with fiber | 7                            | 6.62                          | 0.95           | 9.3                               | 8.78                            | 0.94           | 17.79                             | 16.25                           | 0.91           |
Figure 30. 3-D view and dimensions of the shear molds.

Figure 31. Shear stress for normal concrete mold.

Figure 32. Shear stress for high strength concrete mold.

Figure 33. Shear stress for Ultra-high strength concrete mold.

Figure 34. 3-D view and dimensions of the Flexural molds.

Figure 35. Flexural stress for normal concrete mold.

Figure 36. Flexural stress for high strength concrete mold.

Figure 37. Flexural stress for Ultra-high strength concrete mold.

Figure 38. 3-D view and dimensions of the torsional molds.

Figure 39. Torsional stress for normal concrete mold.

Figure 40. Torsional stress for high strength concrete mold.

Figure 41. Torsional stress for Ultra-high strength concrete mold.
6. Conclusions
1. Four types of concrete were studied here these are (normal, high and ultra-high-strength concrete with or without steel fiber). This research represented an experimental study of a hybrid layer effect on the prism with different concrete types under different tests including (flexure, shear, and torsion) to find the best hybrid concrete layer that increases the load-carrying capacity for the member with minimum cost.

2. Two-hybrid layers with different depths were used here were always normal concrete at the top and high strength and ultra-high-strength concrete at the bottom of the prism.

3. When using all ultra-high strength with fiber the flexural stress increase of about (133.33, 94.11 and 40%) compared to all normal, high and ultra-high-strength concrete mold.

4. When using all ultra-high strength with fiber the shear stress increase of about (90.24, 52.94 and 18.2%) compared to all normal, high and ultra-high-strength concrete mold.

5. When using all ultra-high strength with fiber the torsional stress increase of about (80.95, 40.75 and 26.7%) compared to all normal, high and ultra-high-strength concrete mold.

6. Results proved that the effect of steel fiber is more effective in flexural stress than shear and torsion.

7. For flexural stress, comparison of the results to (all normal concrete mold) it can be seen that all model can overcome the flexural stress, for (all high strength concrete mold) just seven models can overcome the flexural stress which include the ultra-high-strength concrete and while for (all ultra-high-strength concrete mold) just three models can overcome the flexural stress which includes the ultra-high-strength concrete with fiber.

8. For shear stress, comparison of the results to (all normal concrete mold) it can be seen that all model can overcome the shear stress, for (all high strength concrete mold) just eight models can overcome the shear stress which include the ultra-high-strength concrete and while for (all ultra-high-strength concrete mold) just two models can overcome the shear stress which includes the ultra-high-strength concrete with fiber.

9. For torsional stress, comparison of the results to (all normal concrete mold) it can be seen that all model can overcome the torsional stress, for (all high strength concrete mold) just seven models can overcome the torsional stress which include the ultra-high-strength concrete and while for (all ultra-high-strength concrete mold) just four models can overcome the torsional stress which includes the ultra-high-strength concrete with fiber.

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