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PUNCHING SHEAR BEHAVIOR OF THREE DIMENSION TEXTILES REINFORCED CEMENTITIOUS COMPOSITE PLATES

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ABSTRACT

Self compacting mortars (SCMs) plate specimens with dimension of (500×500×40) mm were cast with three-dimension (3D) textile glass fiber having three diverse thicknesses 6, 10, and 15mm to measure their punching strength. Plates with one and two layers of chicken wires, as well as micro steel fiber of 0.75 % volume fraction were tested under punching for comparison. Punching shear tests have been carried out by applying concentrated load with steel cylinder of 50mm diameter and 10 mm height. The mechanical behavior of SCMs plate was discussed in terms of observed behavior, ultimate load, load - deflection curves, and crack pattern. The results indicated an enhancement in the ultimate load at (28 and 90) day ages by about (7.82% and 24%), respectively. The maximum ultimate load was increased by about (58.4 and 54.1) % for plates reinforced by micro steel fiber at 28 and 90 days, respectively as compared with reference. The maximum deflection at the center of the Self-compact mortars plates for all tested plates was improved.

KEYWORD: 3D textile fiber, 3Dglass fiber, Micro steel fiber, Punching shear, SCMs.

1. INTRODUCTION

Concrete reinforced with traditionally steel is one of the most generally utilized building materials, yet it has historically showed disadvantages in expression of durability and sensibility to corrosion raid. Different renovated manners have been used to conquer the deficiency of this building material, like increasing the concrete cover, but this led to rising the self-weight of the construction. Over the past decade, Textile Reinforced Concrete (TRC) involved an incorporation of Fine Grained Concrete (FGC) and non-corrosive multi-axial textile fibrous, stand out as a suitable version alternate offer corrosion resistance, in addition to light-weight and thinner constructions like façade elements and foot bridges (Natalie et al., 2014).

Different choices to produce reinforced concrete elements, structures reinforce by the 3D textile fiber must be discovered and investigate the possible use of 3D TRC for future structures. Self compacting mortars (SCMs) required to a greater amount of cement and fines content is desired in SCMs due to their stability and followability. Different types of fillers and supplementary cementitious materials are generally additional. Utilize of sands rich in fines may be a cost influence substitute source of filler (Benchaa et al., 2012).

The major properties of SCMs in the fresh situation are that, with no equipment for vibration, SCMs can wholly fill out the formwork structure and surrounding the reinforcement sufficiently (especially in closely reinforced regions), dismissal no segregation with no voids through molding or thereafter, for this reason it was called “viscous liquid” (Schutter and Audenaert, 2007). Those properties are attained by enhancing the mix’s attributions and combining mineral additive and chemical admixtures that, apart from affecting the viscosity and work to prevent segregation and/or bleeding (Gesoğlu et al., 2009 and Gesoğlu et al., 2012).

Structures with flat slabs are utilized usually in practice, in such the plates carry immediately by columns without beams. However, this will introduce an important trouble, punching shear failure of the plates due to high concentration of stress in locality of plate column connections. This failure kind is very risky and can be attributed to its brittle manner. Once the punching shear failure happens resistance of the structure is considerably decrease, which reasons parting of the column and plate and then caused failure of the complete structure. No study found on punching shear behavior of 3D textile fiber reinforce cementitious composite.

Experimental investigation on concrete slab column connections reinforced with hooked end steel fibers failing in punching was studied by (Labib, 2008), it was found that the inclusion of steel fibers significantly increases the load carrying capacity of tested specimens and is strongly dependent on the fiber dosage. Moreover, the crack opening restraint provided by the reinforcement mechanisms of steel fibers bridging the crack surfaces lead to significant increase in terms of load carrying capacity and energy absorption capability of concrete structures. The role of fibers in bridging the crack opening and improving the load capacity and post peak behavior leads to well concrete durability and structural integrity was studied by (Safeer et al., 2004, Banthia, 2010, Granju and Balouch, 2005, and Kunieda, 2014). Also, was confirmed by the experimental results of (Stephen, 2001) which showed that the introduction of steel fibers into the concrete can arrest the early spalling of the concrete cover and increase the load capacity as well as the ductility of the columns over that of comparable non- fibrous reinforced specimens.

An experimental study was carried out by (Mansur et al, 2015) to measure the punching shear capacity on fourteen restrained ferrocement plates under a central patch load. The influences of the degree of end restraint, size of the loaded area, mortar strength, volume fraction of reinforcement, and overall thickness was studied. Test results revealed that the provision of end restraint leads to a substantial enhancement in strength and stiffness of the plates, but the shape and location of the critical punching shear perimeter remained unchanged. Both cracking and punching shear loads increased with an independent increase in any of the test parameters considered in this study, except for the thickness of the edge rib. Based on test results, an equation was proposed to predict the punching shear strength of partially restrained ferrocement plates.

The behavior and strength of self-compacted ferrocement plates under punching shear load was studied and discussed by (Abdulkhaliq and Saad, 2015). Experimental results of thirteen square ferrocement plates of (500×500) mm simply supported on all edges are presented with different thickness of (30 and 45) mm. The specimens comprised of two control ferrocement plates cast with ordinary mortar and the other eleven made with self compacting mortar. The plate specimens were simply supported along the four edges with corners free to lift and free to rotate about the support axes. The support-to-support span for all the plates was 400 mm in each direction. The load has been applied by means of a hydraulic jack. A square rigid steel plate with side (width) of (40 and 80) mm was placed between the jack and another plate was used to apply the load at the center of the plate. The main parameters investigated include the volume fraction of reinforcement, plate thickness and size of load-bearing plate. The load deflection and cracking characteristics of the tested plates were studied and compared. The test results showed that the volume fraction of wire mesh has significant effect on both ultimate load and displacement. The increase of plate thickness leads to decrease in deflection values and increase in stiffness of plates. Both ductility and stiffness increase as the loaded area size was increased.

Considering to the prior investigation and studies, can concluded that, there is no studies on the punching shear behavior of 3D textile fiber reinforce cementitious composite and the present work focused on punching shear behavior of SCMs plates with fiber having three different thicknesses.

2. EXPERIMENTAL WORKS AND MATERIALS USED

Plate specimens with (500×500×40) mm dimensions were divided into six groups cast with self-compacting mortar and tested under impact loads for two ages 28 and 90 days as indicated in Table 1.

Table 1: Details of SCMs plate specimens.

Group No.	Mix Symbol	Description of plate specimen
1	Ref.	without any fiber
2	F6-1	Plate with 3D glass fiber 6mm thickness (one layer).
	F6-2	Plate with 3D glass fiber 6mm thickness (two layers).
	F6-1-S	Plate with 3D glass fiber 6mm thickness (slice one layer).
	F6-2-S	Plate with 3D glass fiber 6mm thickness (slice two layer).
	F6-2-S-T	Plate with 3D glass fiber 6mm thickness (slice two way reinforcement).
3	F10-1	Plate with 3D glass fiber 10 mm thickness (one layer).
	F10-2	Plate with 3D glass fiber 10 mm thickness (two layers).
4	F15	Plate with 3D glass fiber 15 mm thickness (one layer).
5	FS-1	Mesh chicken wire (one layer).
	FS-2	Mesh chicken wire (two layers).
6	M S F	Micro steel fiber with 0.75 volume fraction.

2.1. Materials Properties

Ordinary Portland cement (type I) of KRASTA Factory was used in the present study. Table 2 shows the chemical composition and physical properties of the used cement. Cement properties comply with the requirements of the (Iraqi standard specifications No. (5-1984). Natural sand from Najaf sea region was used with 0.6mm maximum size. The results of physical and chemical properties of the sand are listed in Table 3, which comply with the requirements of the (Iraqi standard specifications No. (5-1984). Ordinary tap water was used in this work for both casting and curing all the plate specimens. High Range Water Reducing Agent (HRWRA) based on polycarboxylic technology, which is known commercially as Glenium 54. It is produced by BASF Company and conforms to (ASTM C494 Type F), is used in this study. The dosage of HRWRA was one liter per 100 kg of material (cement and binder), Table 4 shows the properties of Glenium 54.

Table 2: Chemical analysis and physical properties of the cement test.

Oxide	**%**	**I.O.S. 5: 1984 Limits**
CaO	61.11	_
SiO_2	20.23	_
Al_2O_3	4.68	_
Fe_2O_3	3.10	_
MgO	2.0	≤ 5.0
K_2O	0.75	
Na_2O	0.35	
SO_3	2.25	≤ 2.8
Loss on Ignition (L.O.I)	2.39	< 4.0
Lime Saturation Factor	0.93	0.66 - 1.02
(L.S.F) Insoluble residu	1.29	≤ 1.5 %
Free lime (F.L)	0.67	-
Compound Composition	**%**	**I.O.S. 5: 1984 Limits**
C_3S	58.16	_
C_2S	19	_
C_3A	7.95	_
C_4AF	9.43	_
Physical Properties	**Test Results**	**I.O.S.5:1984 Limits**
Fineness, Blaine, cm^2/gm	3300	>2300
Setting Time:		
Initial hrs.; min	1;08	≥45 min
Final hrs.; min	4;00	≤10hrs
Compressive Strength, (MPa)		
3-days	20,0	≥15
7-days	25,0	≥23

Table 3. Properties of fine aggregate.

Physical properties*	Test results	Iraqi specification. 45/1984
Specific gravity	2.65	-
Sulfate content	0.3 %	Not more than 0.5%
Absorption	1 %	-
Bulk density(kg/m^3)	1560	-

*Physical testing laboratory in the Najaf Technical Institute of University the Furat Al-Awsat Technical University

Table 4. Typical properties of SP (Glenium54)*.

Form	Viscous Liquid
Commercial name	Glenium 54
Chemical composition	Sulphonated melamine and Naphthaline Formaldehy de condensate
Appearance	Whitish to straw colored liquid
Relative density	1.07 gm/cm^{3}at 20 ^{o}C
Chloride content	Nil.
pH	5-8
Storage	Should be stored in original Containers and at above 5°C
Transport	Not classified as dangerous
Labeling	Not hazard label required
Alkali content (as NaO_2)	0.26%

*According to manufacturer.

2.1.1. Additives or Mineral Admixture

1. **Fly Ash:**

Class F fly ash (FA) produced from Thermal Power plant in Turkey was used as an additive according to (ASTM C618-03), cement was replaced by 20 % of fly ash by weight of cement. The physical and chemical properties of fly ash are presented in Table 5.

2. **Silica Fume:**

Silica fume (SF) produced by BASF Company was used as pozzolanic admixture. Cement was replaced by 5% of silica fume by weight. The silica fume used in this work conforms to the requirements of (ASTM C1240-05) and (ASTM C311-05). The technical specifications of silica fume are presented in Table 6.

Table 5. Physical and chemical properties of class (F) fly ash.

Particular	**Fly ash (Class F)**	**ASTM C 618 Class F fly ash**
Chemical composition		
Silica (SiO_2%)	65.65	
% Alumina (Al_2O_3)	17.69	($SiO_2 + Al_2O_3 + Fe_2O_3$) $\geq$ 70
Iron Oxide (Fe_2O_3)%	5.98	
Lime (CaO)%	0.98	
Magnesia (MgO)%	0.72	
% Sulphur Trioxide (SO_3)	0.19	Max. 5.0
Loss on Ignition	3.1	Max. 6.0
Na_2O	1.35	
K_2O	2.98	
Physical properties		
Specific gravity	2.12	
Fineness (cm^2/gm)	3600	Min. 2250cm^2/gm

Table 6: The technical specifications of silica fume*.

Structure of material	**Silica fume**	**Limits of ASTM C 1240-05**
Color	Dark gray	
Density	2.2gm/cm^3	
Chlorine amount	< 0.1 %	
Specific surface area (cm^2/gm)	> 150000 cm^2/gm	$\geq$ 150000 cm^2/gm
SiO_2	> 85 %	$\geq$ 85 %
CaO	< 1 %	
Activity index*	156 %	$\geq$ 105 %
Specific gravity	2.2	

* Done in the Building Materials Laboratory in the University of Technology.

2.1.2. Fiber

1. 3D textile glass fiber

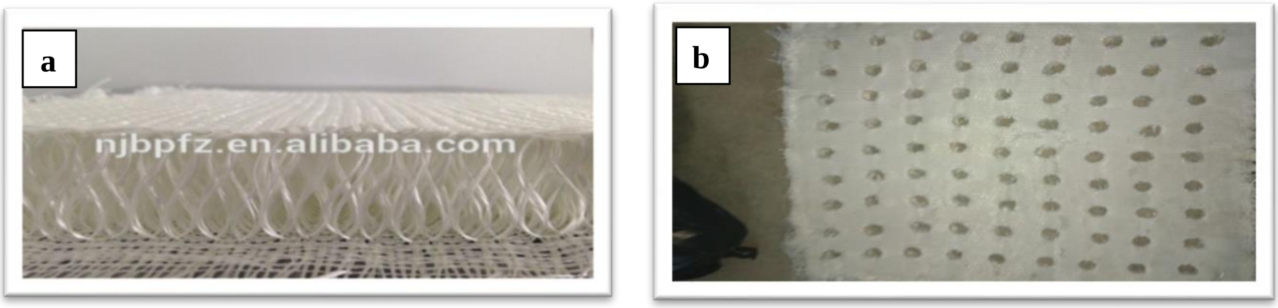
3D textile glass fiber woven fabric consists of two bidirectional woven fabric surfaces, which are mechanically connected with vertical woven piles. And two S-shaped piles combine to form pillar, 8- shaped in the warp direction and I- shaped in the weft direction. For the use of a textile as reinforcement in concrete, an open mesh allowing the mortar or concrete to penetrate the textile for good bond between the materials, for this reason, 19 mm holes at distance 50mm center to center for vertical and horizontal direction were drilled (by tool cutters). Plats 1 show the surface, thickness and fibers holes. Tables 7 and 8 shows typical properties from Fabrics Specifications.

2. Mesh Chicken Wire:

The Rhombic shape meshes of reinforcement, fabricated from 0.54mm nominal diameter steel bars, the opining in the long and short direction are (10.6 & 7.92mm) respectively.

3. Micro Steel Fiber:

Steel fibers are used in self-compacting mortars (SCMs) to enhance some properties and improve the ductility; it was manufactured by Ganzhou Daye Metallic Fiber Co., Ltd, China. It conforms to ISO 9001-2008; the properties are summarized in Table 9.



Plates 1: 3D textile glass fiber made in china; a) Zoom view. b) Holes made in 3D glass fiber.

Table 7. 3D textile glass fiber woven fabrics specifications*

Area Weight (g/m^2)	Core (mm)	Density of Warp (ends/cm)	Density of Weft (ends/cm)	Tensile Strength (MPa) Warp (n/50mm)	Tensile Strength (MPa) Weft (n/50mm)
900	6	15	10	5500	9400
1480	10	15	8	6800	12000
1650	15	12	6	7200	13000

*According to manufacturer

Table 8. Typical properties 3D textile glass Fiber wove fabric specifications.

Property	Result
Weight/ area	From 820 to 2580g/m^2
Surface Treatment	Silicon Coated
Width	1.3m or Made to order
Weave Type	Plain Woven
Yarn Type	E-Glass
Alkali Content	Alkali Free
Standing Temperature	260℃
Color	White
Specific stiffness	Extremely High
Woven	parabeam
Acoustic insulation	Excellent
Wave transmittable	Well
Construction	Two layers and one hollow spacer

Table 9. Specification of micro steel fiber.

Property	Specification
Type	WSF 0213
Surface	Brass coated
Tensile Strength	2850 MPa
Length	15mm
Diameter	0.2 mm
Aspect ratio	65

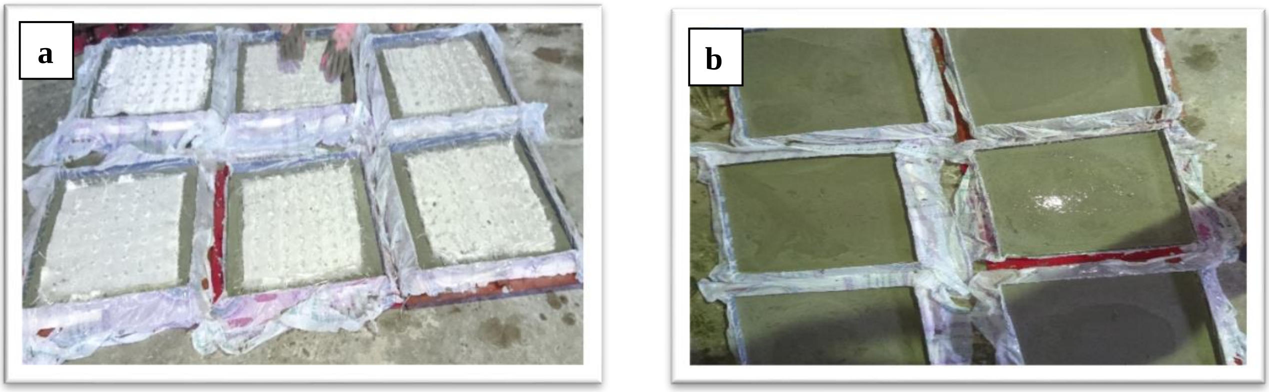
* Adopted by manufacturer

2.2. MIXES

The proportion of the constituents for the prepared mix was 1:1 (by weight) of ordinary Portland cement and cementitious materials: fine aggregate with 0.6mm maximum size, w/p of 0.36 was selected for this investigation. The mixing procedure used to produce self-compacting mortars was as described; Firstly, add cement, fly ash and silica fume while mixer operating at low speed for 30 second till a uniform distribution is reached, Secondly, add sand and mixing for 1 min. at medium speed, thirdly, first part (2/3) of water was added and mixed thoroughly for 30 sec. at low speed, stop 2 min to clean blades, now, adding SP and remainder water and mixing for 2 min. at normal velocity, Stop the mixer and wait for 1 min., and then finalize the process by mixing at normal velocity for 3 min, Finally, Do the discharge to be cast.

2.3. CASTING AND CURING OF SCMS PLATES

Steel molds with (500×500×40) mm are fabricated for casting the plats specimens. The molds are made of (4mm) thickness steel and their side pieces are connected by bolts which can simply be removed and fastened. After mixing process completing, molds were treated with oil before casting the mortar. When used multi layers the first layer of mortar is poured into the mold, followed by placement a layer of (400×400) mm plate or (400×100) mm slice reinforcement (3D textile glass fiber, chicken wire), this procedure is repeat for two-layer reinforcement. Micro steel fiber was distribution by hand after first layer of mortar poured, then the mold fills with mortar, the mortar easily was permeating between reinforcing without any segregation. The specimens were covered with a nylon sheet to prevent evaporation of water. After (24hr), the specimens were demolded, all specimens were marked and soaked in water for 28 days in the laboratory. Then specimens extracted from water and left in laboratory condition until the testing age. Before the testing day, all specimens were cleaned and painted with white paint on both surface to achieve clear visibility of cracks during testing and easily noticed. Plate 2 show 3D textile glass fiber casting.



Plates 2*:* a) During casting 3d textile fiber. b) Complete casting.

2.4. PROPERTIES OF SELF-COMPACTING MORTAR

2.4.1 Determination of Slump-Flow and V- Funnel

The test apparatus for measuring the flow and viscosity of mortar comprises a mini frustum (slump) cone and a graduated glass plate. Mini slump cone has top and bottom diameters of (70) mm and (100) mm respectively with a cone height of (59) mm. The subsequent diameter of the mortar is measured in two perpendicular directions and the average of the diameters is reported as the spread of the mortar. Fresh properties of mortars were evaluated by the mean value two perpendicular flow diameters in the spread test. The procedure for slump test v-funnel test was followed as described in (EFNARC 2002).

2.4.2 Compressive Strength:

This test was done on cubes according to the Standard Specification (I.Q.S. No.5-1984). A3000kN capacity testing machine was used for compressive test. The average compressive strength of three cubes (70×70×70) mm was recorded for each testing age (7, 28 and 90 days).

2.4.3 Flexural Strength:

The flexural strength testing was carried out on a (40×40×160) mm self-compacting mortar prism. The prism was loaded at its center point until failure. Using three mortar prisms for each age (28 and 90) days, the average of three results was adopted. A20kN capacity Beijing United testing machine was used for this test. The modulus of rupture was calculated, as follows:

$$f_r = \frac{2PL}{3bd^2} \quad 1$$

where: fr is the modulus of the rupture [which is measured in (MPa), P is the maximum load, measured in (N). L is the clear span length, measured in (mm). b is the width of specimen, measured in (mm), Finally, d is the average depth of specimen, measured in (mm). The mortar prisms were prepared according to (ASTM C348-14).

2.4.4 Tensile Strength:

Tensile strength of mortar test was test according to (B.S 6319-7:1985). Briquette molds was used for this test. The average of three samples was used.

2.5. PROPERTIES OF SELF-COMPACTING PLATE:

For this test three molds with dimension (500×500×40) mm was molded and tested for each age (28 and 90) days under punching loading. The punching tests were carried out using a universal testing machine, some changes were made to the testing machine so that it could be used for punch tests, this changes including manufacturing a steel supporting rigid frame, the dimension of base frame (510×510×310) mm, while the upper cover (520×520) mm, all the rigid frame made from (50×50×32) mm steel angle section, after insert the specimen between the base frame and upper cover, fixed from four edges by heavy duty coil strut spring compressor before tested, the load applied through a rigid stainless steel cylindrical indenter with diameter of 50 mm, which was connected to an compressive strength machine with a capacity of 1000 kN universal testing machine with rate 0.2 kN/s. After the specimen insert in rigid frame, a concentrated load was applied at the center of the plate until failure. The central deflection, was measured by using a linear variable differential transformer (LVDT) was supported below the center of the specimen, fixed to frame by another angle steel section from the same type which welded at the mid span of the frame part; the test continued till failure, with failure mode and crack patterns were noticed and recorded, digital camera was used to record the result data during test, the Specimen test is shown in plate 3. Fig. 1 shows the experimental setup.

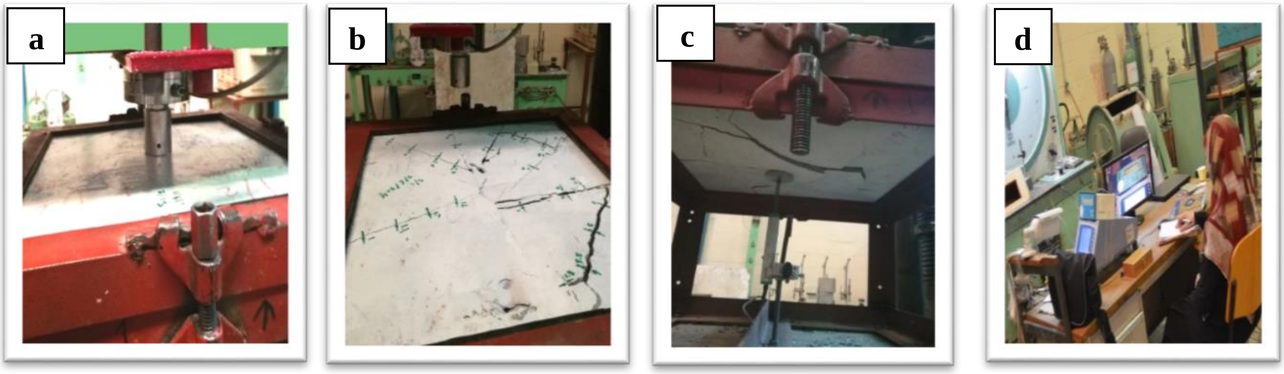


Plate 3: Specimen test. a) Plate during test. b) Shape failure form top side. c) Shape failure form bottom side. d) Camera and output screen data

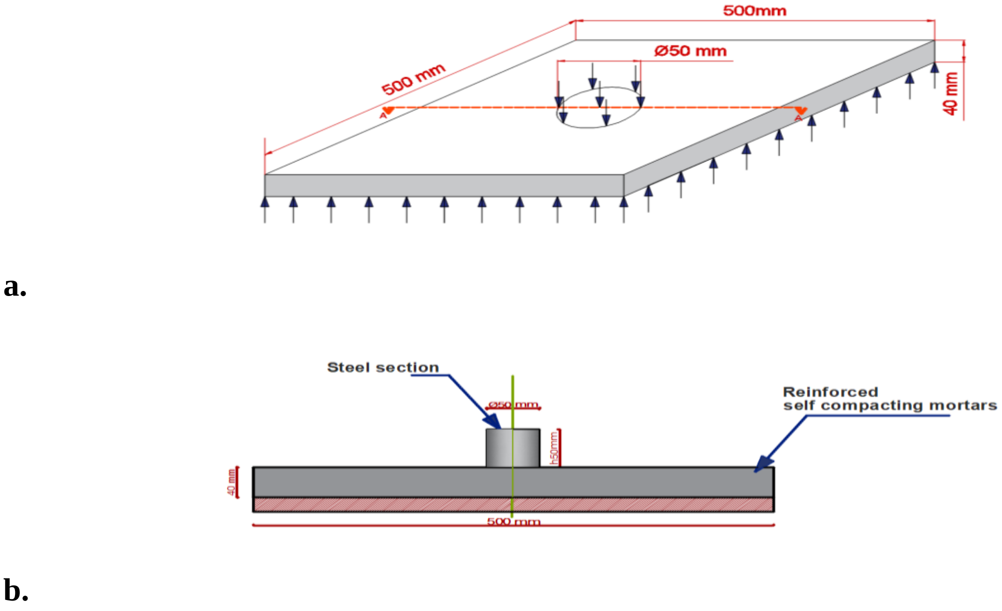


Fig. 1. Experimental setup: (a) Overall view; (b) Section (A-A).

3. RESULT AND DISCUSSION:

3.1. Fresh Mortar Properties:

The test results relevant to the slump flow diameter; V-funnel flow time are presented in Table 10. From result show the mixture had slump flow diameter, V-funnel flow time conforming

(EFNARC, 2002). Where Dm is the mean value of the two perpendicular diameters, measured in (mm); D0 is the initial diameter of the base of the cone, measured in (mm), and finally, the (t) represents the time of flow in the v-funnel, which is measured in second.

3.2. Hardened SCMs Properties:

The hardened properties of the mortars were summarized in Table 11 the strength increased with ages. This development in compressive strength, tensile strength and flexural strength can be attributed to the fact of continuous hydration process (C-S-H), also present of silica fume tends basically to consume the calcium hydroxide crystals released from the hydration process leading to the formation of further calcium -silicate- hydrate (secondary C-S-H).

Table 10. Fresh properties of SCMs.

SCMs test results	Slump Flow Diameter (cm)	V-funnel time (s)	$G_m = \left(\frac{Dm}{D_0}\right)^2 - 1$	$R_m = \frac{10}{t}$
	25.4	9.5	5.45	1.05
Acceptance criteria of SCMs suggested by (EFRANCE, 2002)	24-26	7-11	-	-

Table 11. Mechanical properties of SCMs.

Type of Test	Compressive Strength (MPa)			Tensile Strength (MPa)		Flexural Strength (MPa)	
Test Age (days)	7	28	90	28	90	28	90
	45.7	61.22	77.9	3.3	5.1	5.3	9.12

3.3. PROPERTIES OF HARDENED PLATES SPESIMENS

3.3.1. Punching shear strength

Punching Shear tests have been carried out on SCMs plates specimens and determined by applying concentrated point load with (punching load) have 50mm diameter of a steel cylinder. A total of 72 SCMs plates with (500×500×40) mm dimension has been tested under punching load. The experimental results summarize in Table 1. The mechanical behavior of a SCMs plate specimens is discussed in terms of observed behavior, ultimate load, load – deflection curves and crack pattern as plotted in Fig. 2 to Fig. 5. The ultimate loads and crack width for SCMs plates at 28 and 90 days are listed in Table 12.

3.3.2. Load-deflection response

The load-displacement relationships for SCMs fibrous plates and corresponding reference plates (non-fibrous) plates are presented in Fig. 2 to Fig. 5. It can be noticed, that the relationship between applied load and the maximum deflection at the center of the SCMs plates was typical for all tested plates, an approximate linear increase behavior followed by a nonlinear behavior until failure. At the same load, the maximum deflection was decreased fiber was added and decreased with increase thickness and number of fibers layers. The results showed a significant reduction in maximum deflection values when micro steel fiber was used at the same load as compared with non-fibrous SCMs plate.

Table 12: Experimental ultimate punching loads at (28 and 90) days age.

Mix ID	28 days		90 days	
	Ultimate Load (kN)	Crack Width (mm)	Ultimate Load (kN)	Crack Width (mm)
R	15.4	2.91	17.9	2.567
F6/1	17.6	1.963	19.3	1.78
F6/2	17.9	1.89	21	1.66
F6/1/S	18.3	1.99	20	1.04
F6/2/S	18.5	1.82	20.1	1.61
F6/S/T	18.6	0.86	22.2	0.182
F10/1	17.9	1.93	20.2	1.67
F10/2	18.1	1.857	21.2	1.417
F15	17.9	1.87	21.2	1.65
FS/1	17.9	2.8	21.1	1.81
FS/2	18.1	2.41	21.1	1.645
FMS	24.4	0.72	27.6	0.504

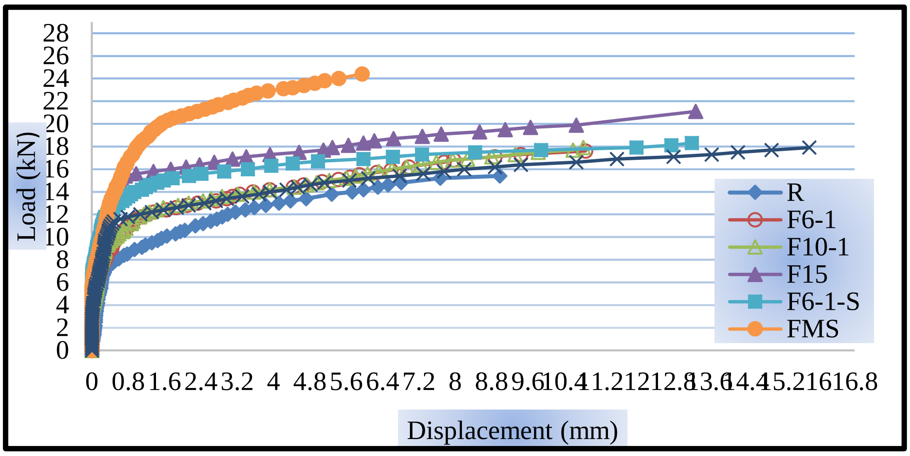


Fig. 2. Load vs displacement for reference and one layer 3D textile fiber plates at 28 days age.

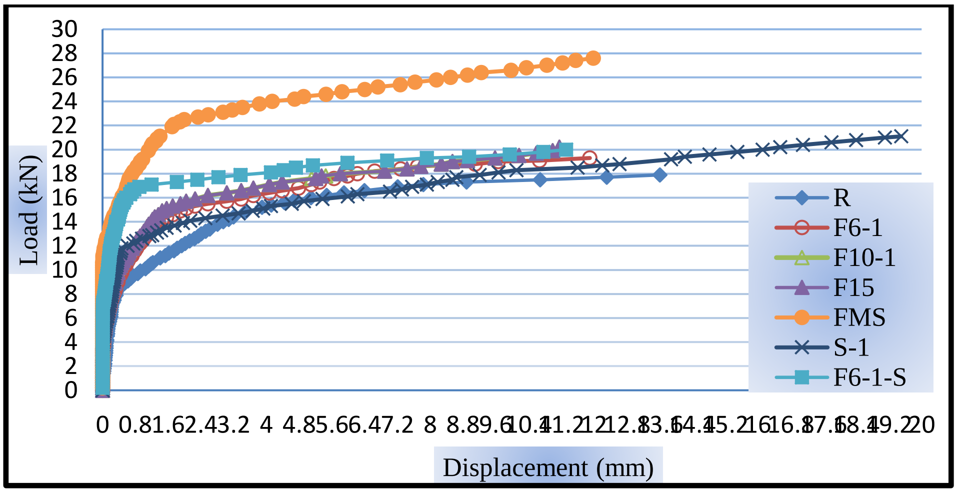


Fig. 3. Load vs displacement for reference and one layer reinforcement plates at 90 days age.

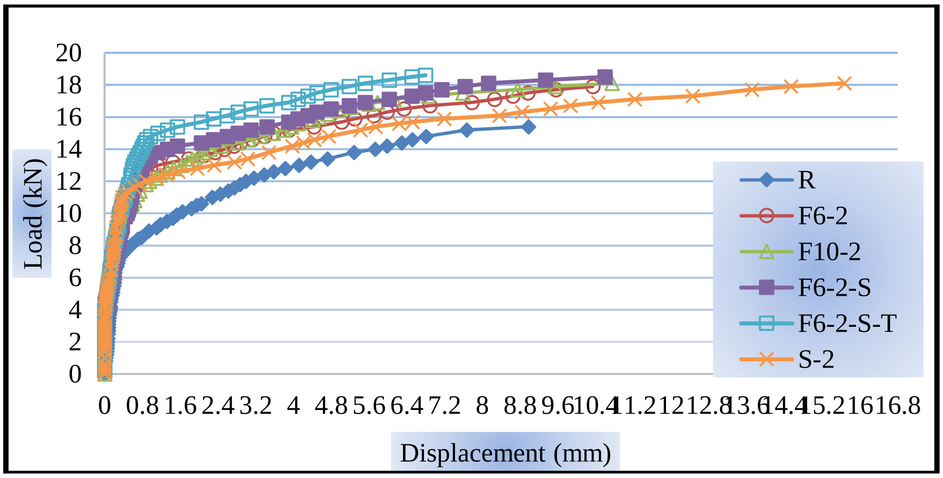


Fig. 4. Load vs displacement for reference and two layer reinforcement at 28 days age.

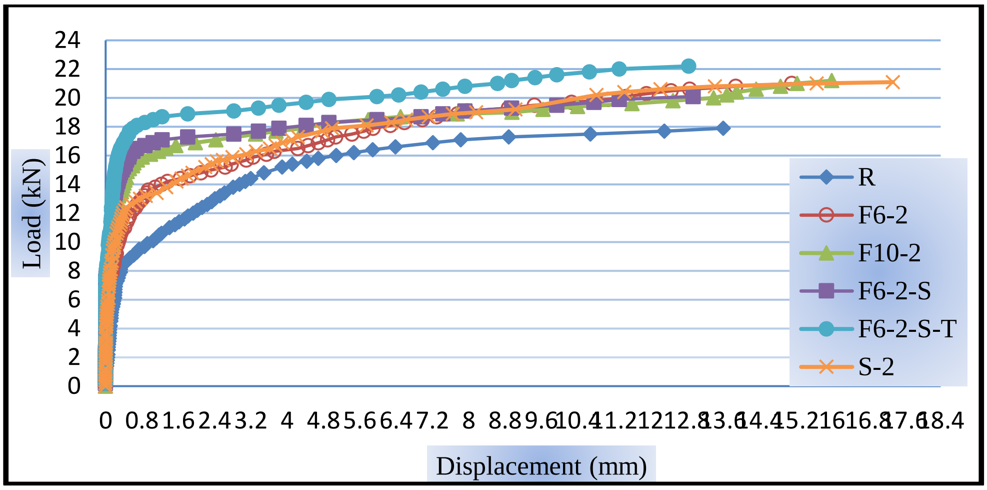


Fig. 5. Load vis displacement for reference and two layer reinforcement at 90 days age.

3.3.3. Cracking and failure patterns:

A high quality Portable Microscope designed for measuring crack widths in concrete members was used to measure initial and final crack width. The general behaviors of SCMs plates subjected to punching load are all nearly identical as shown in Plate 4. While load applying the first visible crack was observed at the tension face of the plates tested.

In all SCMs plats tests, cracking on the tensile face started near by the center of SCMs plates and radiated towards the edges. As the load is increased the cracking propagated to the opposite face. At higher loads, the early formed cracks got widened while new cracks started to form. The new formed cracks are roughly semi-circular or elliptical in shape and happened in the tension zone of the plate. Failure of the SCMs plate occurred when the cone of failure radial outward from the point of load application pushed up through the SCMs plate thickness. At failure, the plate was no longer capable of taking additional load. Plate 4 showed the bottom surface failure of SCMs plates with displacement transducer measure. Diverse cracking patterns of some plates may be observed in Plates 5, 6 and 7 such as spacing (crack width), extent of cracks and perimeter of failure cone. These differences dependent on the thickness and number of fiber layers reinforced the SCMs plate.

The crack width at failure became more closely spaced with increasing the thickness or number of layer of 3D textile SCMs, while non-fibrous plates shows brittle failure. The results indicate that, the average crack width has decreased by introduced different type of fibers (3D textile glass, chicken wire mesh, micro steel).

The average crack width has decreased by increasing the thickness and layer numbers of 3D textile glass fiber reinforce SCMs plate, also increase number of chicken wire mesh from one to two layers and introduction micro steel fiber in reinforced SCMs plate led to decrease the average crack width.

Regarding to the results, the average crack width and crack propagation for micro steel fiber reinforced SCMs plates was much less as compared to cracks in plates with non-fiber plates. The cause of that results may be because of mixing action of the fiber are uniformly distrusted fibers disallow the micro crack from developing into macro-cracks and potential troubles, in addition these fibers bridge and therefore hold together the existing macro crack thus reinforcing the concrete against disintegration.

Plate 4: Bottom failure of SCMs fibre reinforced plate.

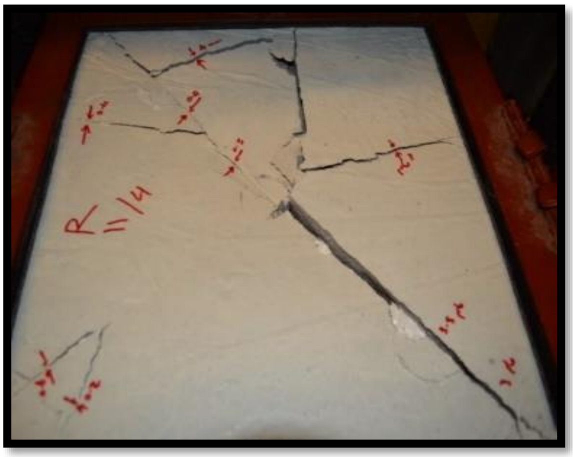


Plate 5: Crack pattern of non-fibrous reference plate.

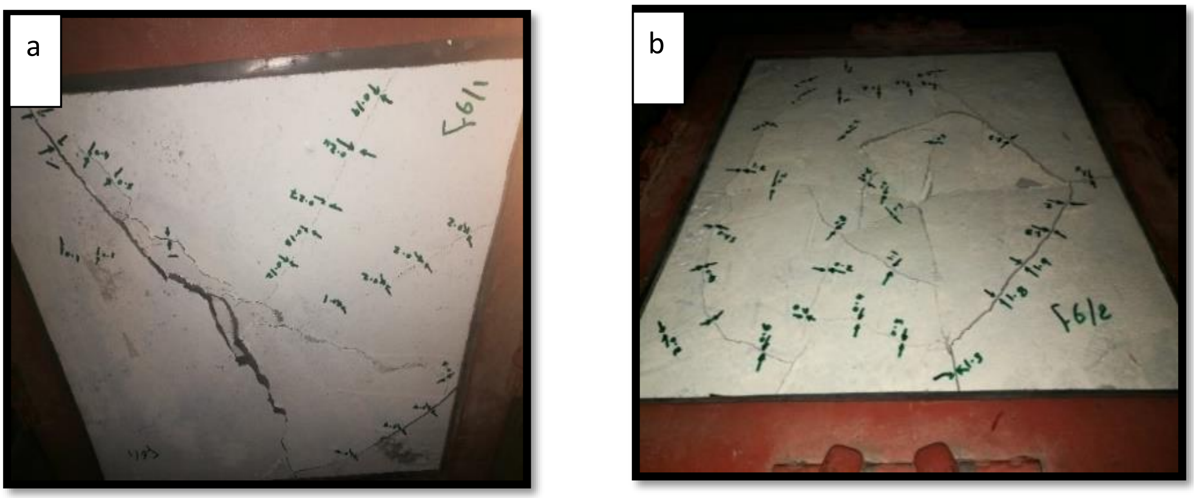


Plate 6: Crack pattern of 3Dtextile fibres 6mm, a) One layer. b) Two layers.

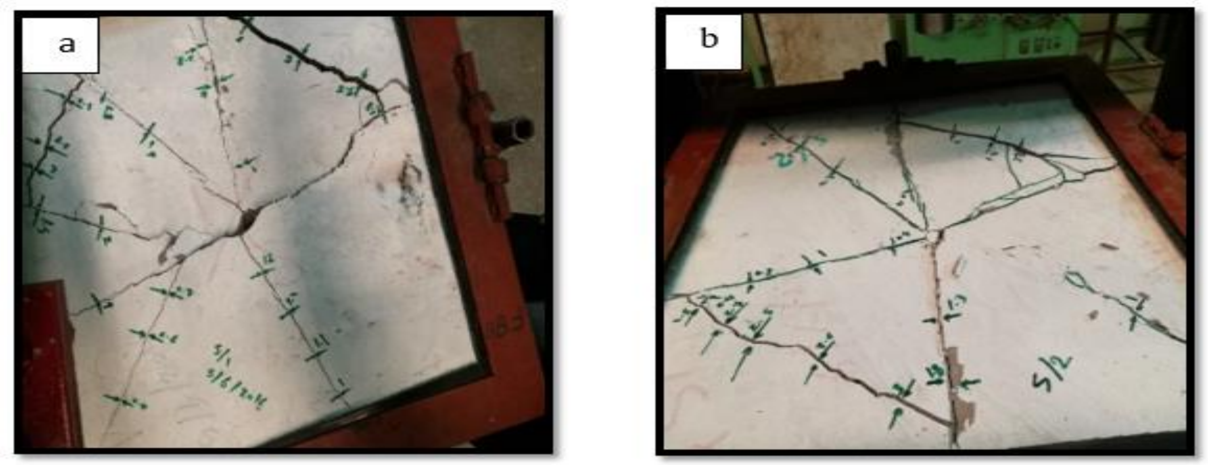


Plate 7: Crack pattern of ferrocement. a) One layer b) Two layers.

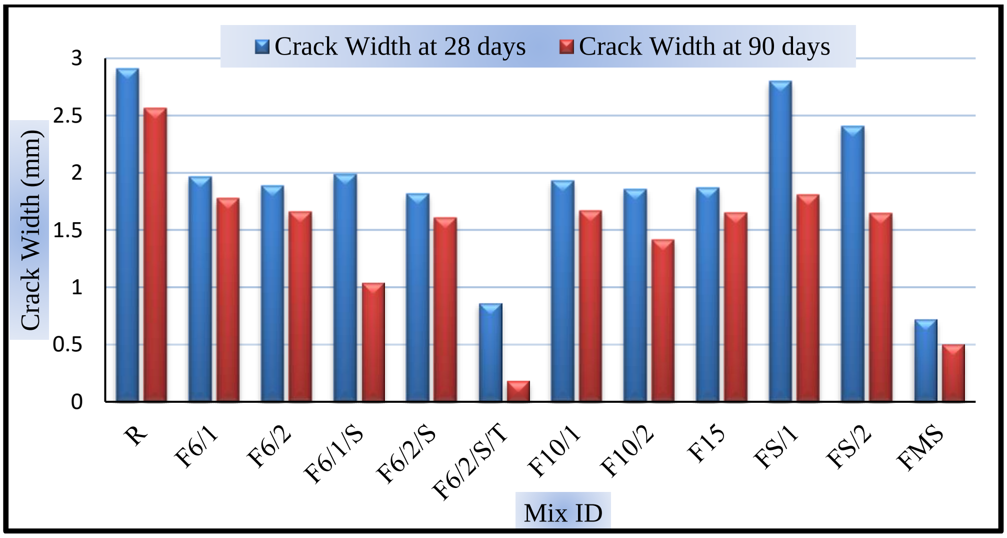


Fig. 6: Crack width of punching load SCMs plates at 28 and 90 days age.

4. CONCULOSION

The following conclusions can be drawn based on the results of the present study for the flowing ability of self-compacting mortars reinforced with diverse types of fibers:

- From the above results, the compressive strength improves with age by about (33.96 and 70.45) %, the tensile strength was (54.5) % whiles the flexural strength was 72 % for age (28 and 90) respectively.
- Under punching load and at the same load, the maximum deflection was decreased when adding fibers and decreased with increase thickness and number of fibers layers at 28 and 90 days.

- The crack width at failure became more closely spaced with increasing the thickness or number of layer of 3D textile SCMs with non-fibrous reinforcement show brittle failure.
- The failure mode of SCMs non-fibrous reference plate was exhibited brittle failure mechanism while the fibrous SCMs plates were quite ductile.

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