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Original Paper

Shear investigation of self compacted concrete at different shapes

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Abstract

Twenty seven self-compacted concrete (SCC) beams at different shaped were designed and tested to determine the effect of using SCC on the shear strength under two concentrated loads. The tested beams were divided into three groups according to the shape of the section rectangular sections, T-sections and I-sections. Each group was divided into three series, according to the clear San to the effective depth ratio (Ln/d). Each series beams have the same longitudinal steel ratio, cross section area and clear span to effective depth ratio, but have different values in compressive strength (f_c').It was found that The ultimate shear strength predicated from ACI 318M-11 is conservative prediction than the experimental values, The ultimate shear strength of SCC rectangular beams increase about 16.5%.35.245%and 25.665% when the compressive strength increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively, The ultimate shear strength of SCC T-beams increase about 28.57%.10.714%and 10.17% when the compressive strength increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively, while The ultimate shear strength of SCC I-beams increase about 14.38%.15.55%and 10.746% when the compressive strength increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively . The clear span to the effective depth ratio (ln/d) has a significant influences on the ultimate shear strength of SCC beams, The ultimate shear strength of SCC rectangular beams increased about 21.58%,32.9% and 32.01% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively, The ultimate shear strength of SCC T-beams increased about 40.47%,34.73%and 20.37% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively, while The ultimate shear strength of SCC I-beams increased about 44.72%,45.19%and 40.13% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively.

Keywords: shear strength, rectangular section, I-section, T-section, self-compacted concrete.

Introduction:

Self-Compacted concrete (SCC), is a new kind of high performance concrete (HPC) with very effective deformability and segregation resistance. The main advantage of SCC is; a flowing concrete without segregation and bleeding, capable of filling spaces in dense reinforcement or inaccessible voids without hindrance or blockage. The composition of SCC should be designed in order not to separate and not to excessively bleed. Concrete strength development is determined not only by the water-to-cement ratio, but also by the content and specification of mix materials. (Bin MUDA, M.F., 2009).

Research significance:

Concrete has been used in the construction industry for centuries. Many modifications and developments have been made to improve the performance of concrete, especially in term of strength and workability. Engineers have found new technology of concrete called self-compacted concrete. The main objective of the work described in this study is to

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investigate and to get more information and more understanding about the shear strength of self-compacted concrete beams at different shapes.

Tested program

Description of specimens:

The tested beams were divided into three groups according to the shape of the section rectangular sections, T-sections and I-sections. The first group consist rectangle has an overall length (952, 903 and 837 mm). The cross section has overall dimension of 100 mm (width of beams) by 170 mm (total depth). The longitudinal steel reinforcement consist of six bar (diameter of the bar 8 mm, with area of 50.265mm^2) laid in two layer at the bottom and two bar (diameter 4 mm, area of 12.566 mm^2) laid in one layer at the top. The internal steel stirrups are 4 mm in diameter (12.566 mm^2) at spacing 73 mm center to center as shown in Fig.(1), the second group consist of T-sections has overall length the overall length(1140, 1080 and 1000) mm long. The T-section has overall dimensions of 220 mm (width of flange) by 200 mm (total depth). The thickness of web is (60) mm and the thickness of flange is (50) mm. The longitudinal deformed steel reinforcement consist of four bars of 8 mm diameter laid in two layer at the bottom and four plane bars of 4 mm diameter laid in one layer at the top. The internal steel stirrups are 4 mm in diameter spaced of 89 mm center to center as shown in Fig.(2),while the third group consist of I-sections has overall the overall length of (1443, 1365 and 1265) mm. The cross section has overall dimension of 250 mm total depth and width of flange 200 mm. The longitudinal steel reinforcement consists of four bars (8 mm diameter of the bar, area of (50.265mm2) lay in one layer at the bottom and four bars (4 mm diameter, area of (12.566 mm2) laid in one layer at the top. The internal steel stirrups are (4 mm) in diameter (12.566 mm^2) at spacing 115 mm center to center as shown in fig.(3).the total description of the beams which used in this study are listed in Tables (1) and the test set-up is shown in fig. (4).

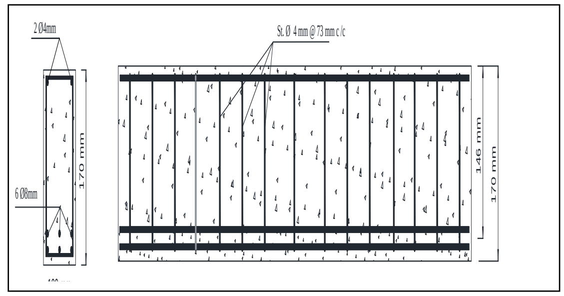

Fig. (1): Details of rectangular section all dimensions in mm.

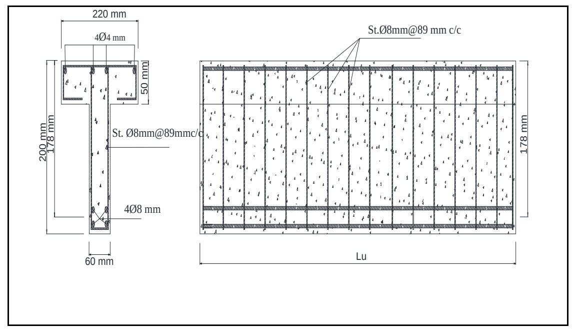

Fig. (2): Details of T-section all dimensions in mm.

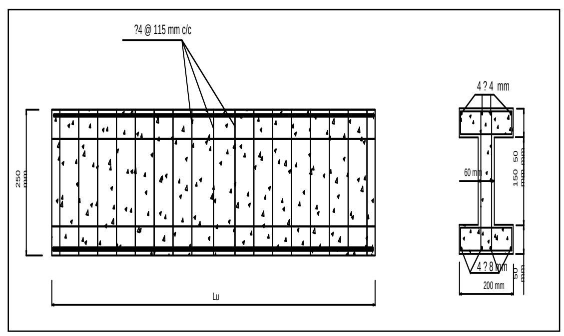

Fig. (3): Details of I-section all dimensions in mm.

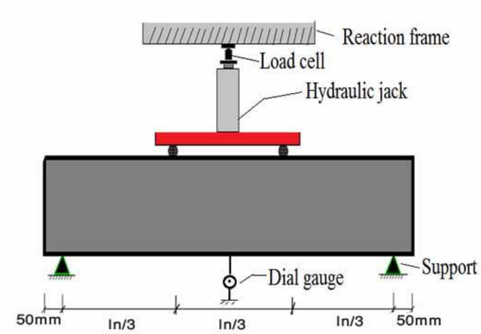

Fig. (4): Schematic diagram of test set-up.

Shapes	Beam	Comp. strength (f_c') MPa	Clear span (ln) mm	Effective depth (d) mm	Clear span to effective depth ratio (ln/d)
Rectangular Section	A 1	29.39	852	146	5.84
	A 2	29.39	803	146	5.50
	A 3	29.39	737	146	5.05
	B 1	41.4	852	146	5.84
	B 2	41.4	803	146	5.50
	B 3	41.4	737	146	5.05
	C 1	49.2	852	146	5.84
	C 2	49.2	803	146	5.50
	C 3	49.2	737	146	5.05
T-Section	A 10	29.39	1040	178	5.84
	A 20	29.39	980	178	5.50
	A 30	29.39	900	178	5.05
	B 10	41.4	1040	178	5.84
	B 20	41.4	980	178	5.50
	B 30	41.4	900	178	5.05
	C 10	49.2	1040	178	5.84
	C 20	49.2	980	178	5.50
	C 30	49.2	900	178	5.05
I-Section	A 100	29.39	1343	230	5.84
	A 200	29.39	1265	230	5.50
	A 300	29.39	1162	230	5.05
	B 100	41.4	1343	230	5.84
	B 200	41.4	1265	230	5.50
	B 300	41.4	1162	230	5.05
	C 100	49.2	1343	230	5.84
	C 200	49.2	1265	230	5.50
	C 300	49.2	1162	230	5.05

Table (1): Total description of the tested beams.

Materials:

General description and specification of materials used in the tested beams are listed below; tests are made in the National Center for Constriction Laboratories and Research

- Cement: Ordinary Portland cement type I produced at the northern cement factory (Tasluja-Bazian) is used throughout this investigation which conforms to the Iraqi specification No. 5/1984 (المواصفة العراقية رقم (٥) ١٩٨٤)), Tables (2) and (3) show the chemical and physical properties of the cement used
- Fine Aggregate: Al-Ukhaider natural sand is used. This complies with the Iraqi Standard Specification No.45/1984, (المواصفة العراقية رقم (٤٥) ١٩٨٤) zone (2). The specific gravity, sulfate contents (SO_3) and absorption of the used sand was 2.66, 0.4%, 1.7% respectively.
- Coarse Aggregate: Crushed gravels maximum sizes 10 mm from the Al - Nibaee area are used in this study. This complies with the Iraqi Standard Specification No.45/1984, (المواصفة العراقية رقم (٤٥) ١٩٨٤). The specific gravity, sulfate contents(SO_3) and absorption of the used gravel were 2.65,0.07%,0.57% respectively
- Water: Ordinary potable water is used throughout this work for both mixing and curing of concrete.
- Steel Reinforcement: Deformed longitudinal steel bars with nominal diameter of 8mm and 4mm were used in this study. Reinforcement was tested to determine the yield stress of 8mm and 4mm they were 400 and 350 MPa receptively
- Limestone Powder: A fine limestone powder (locally named as Al-Gubra) of northern origin with fineness (3100 cm^2/ gm) it has been used as a filler

for concrete production for many years. It has been found to increase workability and early strength, as well as to reduce the required compaction energy. The increased strength is found particularly when the powder is finer than the Portland cement (ECOSERVE Network 2004). The cement in SCC mixes is generally partially replaced by fillers like lime stone powder in order to improve certain properties such as

- Avoiding excessive heat generation.
- Enhancing fluidity and cohesiveness.
- Enhancing segregation resistance.
- Increasing the amount of powder (cement +filler), so it becomes more economical than using cement alone.

Superplasticizer (Degussa construction chemicals 2002) To produce SCC, a superplasticizer known as (High Water Reducing Agent) based on polycarboxylic ether is used; it has the trademark Glenium 51. Glenium 51 is free from chlorides and complies with ASTM C494, types A and F. It is compatible with all Portland cements that meet recognized international standards. Table (4) shows the typical properties of Glenium 51.

Compound Composition	Chemical Formula	Percent of cement weight	Limit of Iraqi specification No.5/1984
Lime	CaO	61.67	-
Silica	SiO_2	20.69	-
Alumina	Al_2O_3	5.20	-
Iron Oxide	Fe2 O3	4.61	-
Magnesia	MgO	2.43	< 5
Sulfate	SO_3	2.21	< 2.8
Loss on Ignition	L.O.I.	3.31	< 4
Insoluble Residue	I.R.	0.5	< 1.5
Lime Saturation Factor	L.S.F	0.90	0.66 – 1.02
Main Compounds (Bogue's Equation) Percentage by Weight of Cement			
Tricalcium Silicate	C_3S	38.55	
Dicalcium Silicate	C_2S	33.15	
Tricalcium Aluminate	C_3A	7.12	
Tetracalcium Alumina Ferrite	C4AF	10.73	

Table (3): Chemical Composition of Cement.

Physical properties	Test Results	Limit of Iraqi specification No. 5/1984
Specific Surface area (Blaine Method , cm^2/gm)	3043	≥ 2300.0
Setting time (Vicats Method) **Initial Setting time, hrs. : min** **Final Setting time, hrs. : min**	 174 3:54	 > 45 min ≤ 10:00 hr
Compressive strength of mortar **2 days (MPa)** **7 days (MPa)**	 21.61 30.75	 ≥ 15 ≥ 23

Table (4): Physical Properties of the Cement Used in this Work.

No.	Main action	Concrete super plasticizer
1	Color	Light brown
2	pH. Value	6.6
3	Form	Viscous liquid
4	Subsidiary effect	Hardening
5	Relative density	1.1 at 20°C
6	Viscosity	128 ± 30 cps at 20°C
7	Transport	Not classified as dangerous
8	Labeling	No hazard label required

Table (5): Typical properties of Glenium 51 (Degussa construction chemicals 2002)

Mix proportioning is more critical for SCC than for NSC and HSC. Many trials are carried out on mixes incorporating superplasticizer by increasing the dosage of the admixture gradually, adjusting the w/c ratio to ensure the self-compact ability (Al-Jadiri, R.S.F., 2008). Table (5) indicates the mix proportion of SCC mixes. For each concrete mix, three standard cube specimens (150×150×150) mm are taken, they were tested at 28 days of age, the test results of fresh concrete properties are shown in Table (6) these results are within the acceptable criteria for SCC given by ACI committee-363 (American concrete institute, Detroit., 1998) and indicate excellent deformability without blocking.

Group	comp. strength of cylinder (f'_c) MPa	W/C Ratio	Mix proportions kg/m3					lit /m3	
			Cement	Limestone powder(lsp)	Total powder	Sand	Gravel	Water	Glenium 51
A	29.36	0.55	346	204	550	743	833	190	6.6
B	41.42	0.55	474	105.3	357.3	758.4	833	180	8.1
C	49.2	0.38	535	64	599	814	833	155	18

Table (6): mix design of SCC mixes by weight.

Mix symbol	Slump flow (mm)	T50 Sec.	L-box (H2/H1)	T20 Sec.	T40 Sec.
A	750	2.6	0.96	1.8	3.5
B	715	3.8	0.90	2.1	3.9
C	685	4.9	0.88	2.3	4.2

Acceptance criteria for Self-compacted concrete (SCC) (The European Guidelines for SCC Specification ,2005)

NO.	Method	Unit	Typical range of values	
			Minimum	Maximum
1	Slump flow	mm	650	800
2	T50	Sec	2	5
3	L-Box	(H2/H1)	0.8	1

Table (7): Results of testing fresh SCC property in experimental work.

Test procedure of Beams

All the beams were white-washed in order to aid the observation of the crack development during the testing. Beams were tested under gradually increasing load up to failure under two point symmetric top loading in universal-Testing machine (MFL systems) at the structural laboratory of the college of the engineering, Al-Mustansiriya University as shown in Fig. (5), the tested beams were simply supported at ends over an effective span of (50 mm) the distance between the two point loads at the third of the clear span length. A dial gauge of (0.01 mm) accuracy with (30 mm) capacity was fixed at the middle of the bottom of the beam to measure the mid span deflection; the test set-up is shown in Fig. (٤). Loading procedure was started by the application of single point load from the testing machine to the upper midpoint of the loading bridge. The single load was then divided equally between the two point loads that were transferred to the concrete beam through two (Φ 30 mm) steel bars loaded at the end of the bridge. Beam specimens were placed in the testing machine and adjusted so that the centerline, supports, point loads and dial gauge was fixed at the correct and proper location. Loading was applied in small increments of (4 KN). At each load stage the deflection readings at the mid span was recorded. The loading increments were applied until failure.

Fig. (5) Tested Machine.

Shear strength of beam in Code provisions:

$$V_n = V_c + V_s \qquad \text{......... (1)}$$

$$V_c = \frac{\sqrt{f'_c}}{6} b_w \, d \qquad \text{........... (2)}$$

$$V_c = (\sqrt{f'_c} + 120 \ell w V_u d/M_u) b_w d/7 \qquad \text{........... (3)}$$

$$V_s = Av \; f_y \; d / S \qquad \text{.......... (4)}$$

Where:-

V_c and V_s are shear transfer capacity of concrete and shear reinforcement respectively; Mu and Vud are factored moment and shear force; ℓ_w = $As/b_w d$ is the longitudinal bottom reinforcement ratio; As is the longitudinal bottom reinforcement area; b_w is the width of the web; d is the effective depth; A_v is the vertical shear reinforcement area, S is the spacing between the vertical stirrups reinforcement; f_c' is the compressive strength of concrete and f_y the yield strength of shear reinforcement According to clear span to effective depth ratio (ln/d) the main variable in this research , Eq.(3) will be used since the shear stress at cracking will depend on the bending moment and shear force at critical section ratio (Vud/Mu)and the longitudinal steel ratio (ℓ_w) that lead to reduce the shear crack and improved the ultimate strength(American concrete institute, Detroit,, 2011).

Results:

Carrying capacity of the tested beams-Load:

The relationship between the applied load and the deflection of the tested beams is shown in Fig. (6) To Fig. (14). at every stage of loading, the deflection at mid-span is obtained by using dial gage at mid span, it can be noticed that:

- During the early stage of loading no interface slip is recorded and this continues until the applied loading is equal to first crack loading approximately, beyond the first crack loading each beam has behaved in a certain manner.
- The ultimate shear strength obtained from tests of SCC beams were compared with that obtained by using the ACI code provisions, see Table (8), by the inspection of this table it can be noted that the ultimate shear strength predicated from ACI 318M-11 is conservative in comparison with experimental values because of the SCC will improve durability, and increased bond strength (Krieg, W 2003).
- The ultimate shear strength of SCC beams increased when the compressive strength (f_c') of the SCC increased as shown Fig. (15), (16) and (17). The ultimate shear strength of SCC rectangular beams increase about 16.5%.35.245%and 25.665% when the compressive strength(f_c') increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively ,The ultimate shear strength of SCC T-beams increase about 28.57%.10.714%and 10.17% when the compressive strength(f_c') increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively, while The ultimate shear strength of SCC I-beams increase about 14.38%.15.55%and 10.746% when the compressive strength(f_c') increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively see Table (9) .
- The clear span to the effective depth ratio (ln/d) has a significant influences on the ultimate shear strength of SCC beams as shown in Fig (18), (19), and (20), the ultimate shear strength of SCC rectangular beams increased about 21.58%,32.9% and 32.01% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively ,the ultimate shear strength of SCC T-beams increased about 40.47%,34.73% and 20.37% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively ,while the ultimate shear strength of SCC I-beams increased about 44.72%,45.19%and 40.13% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively as shown in Table (10)

Failure mode:

As was expected, all the tested beams failed in shear as shown in Fig. (21) and Fig. (22), the diagonal cracks form independently. The beams remain stable after such cracking. Further increase in shear force causes the diagonal crack to penetrate into the compression zone at the loading point, until eventually crushing failure of concrete occurs there (bdel-Razzak, A.A., 2001).

Group	Beam	Ultimate shear strength (Vu kN)tested	Nominal shear strength (Vn kN) ACI	Vu tested/Vn ACI ratio
Rectangular Section	A 1	46.94	34.60	1.356
	A 2	50.78	34.60	1.467
	A 3	57.07	34.60	1.649
	B 1	51.68	36.181	1.428
	B 2	64.35	36.181	1.778
	B 3	68.68	36.181	1.898
	C 1	54.32	37.391	1.452
	C 2	66.36	37.391	1.774
	C 3	71.71	37.391	1.917
T-Section	A 10	42	29.30	1.433
	A 20	56	29.30	1.911
	A 30	59	29.30	2.013
	B 10	47.5	30.90	1.537
	B 20	60	30.90	1.941
	B 30	64	30.90	2.071
	C 10	54	31.70	1.703
	C 20	62	31.70	1.955
	C 30	65	31.70	2.050
I-Section	A 100	56.05	31.719	1.767
	A 200	73.99	31.719	2.332
	A 300	81.13	31.719	2.557
	B 100	60.47	33.725	1.793
	B 200	82.75	33.725	2.453
	B 300	87.8	33.275	2.638
	C 100	64.11	34.866	1.838
	C 200	85.5	34.866	2.452
	C 300	89.85	34.866	2.577

Table (8) comparisons of tested results.

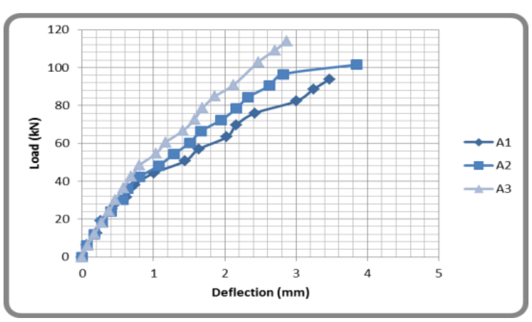

Fig. (6): Load –deflection curve for SCC rectangular beams at compressive strength (f_c') =29.36 Mpa.

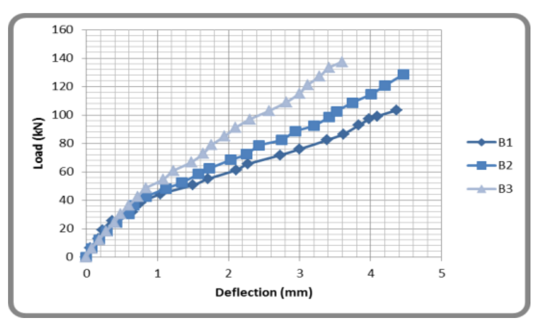

Fig. (7): Load –deflection curve for SCC rectangular beams at compressive strength (f_c') =41.42 Mpa.

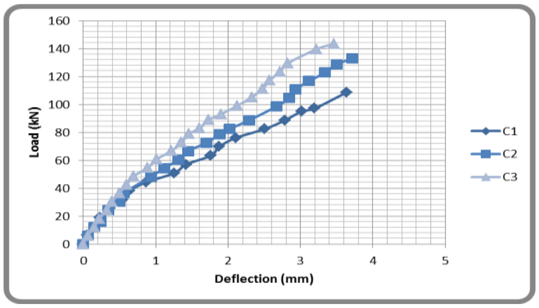

Fig. (8): Load –deflection curve for SCC rectangular beams at compressive strength (f_c') =49.2 Mpa.

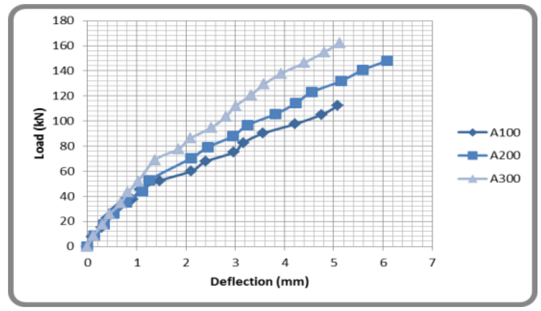

Fig. (12): Load –deflection curve for SCC I-section beams at compressive strength (f_c') =29.36 Mpa.

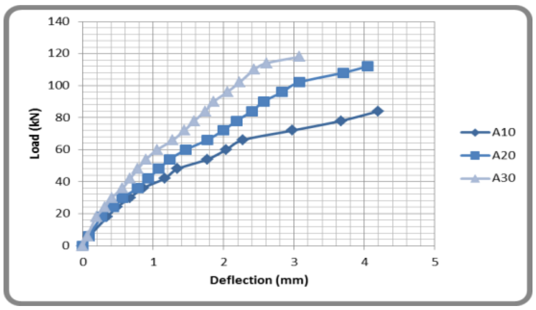

Fig. (9) Load –deflection curve for SCC T-section beams at compressive strength (f_c') =29.36 Mpa.

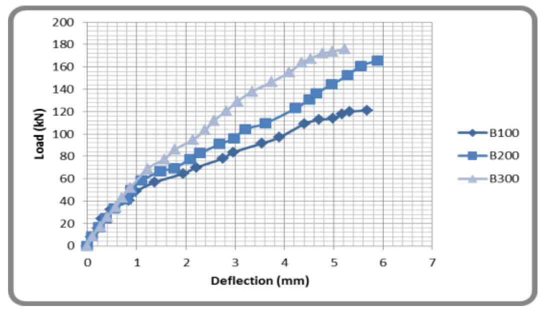

Fig. (13): Load –deflection curve for SCC I-section beams at compressive strength (f_c') =41.42 Mpa.

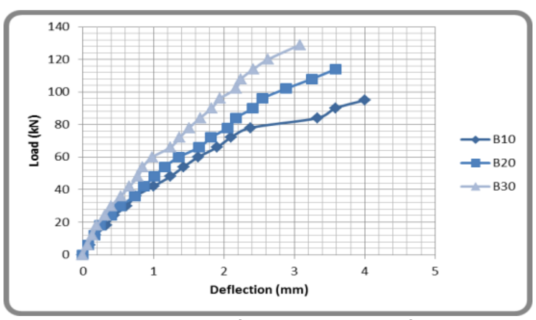

Fig. (10): Load –deflection curve for SCC T-section beams at compressive strength (f_c') =41.42 Mpa.

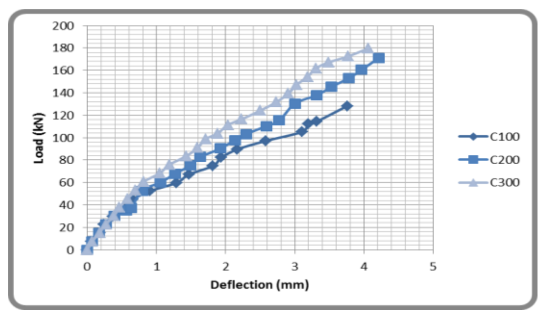

Fig. (14): Load –deflection curve for SCC I-section beams at compressive strength (f_c') =49.2 Mpa.

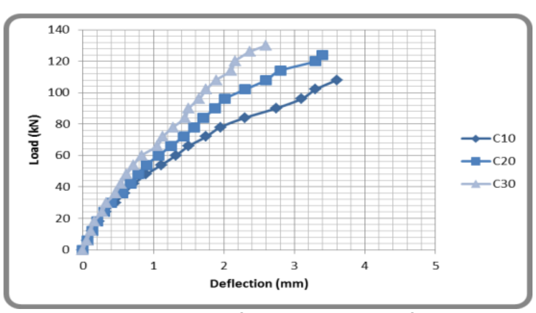

Fig. (11): Load –deflection curve for SCC T-section beams at compressive strength (f_c') =49.2 Mpa.

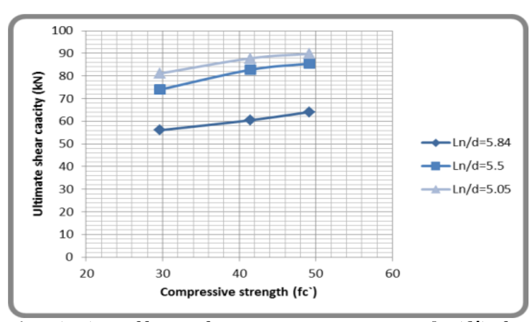

Fig. (15): Effect of compressive strength (f_c') for SCC rectangular beams on the ultimate strength.

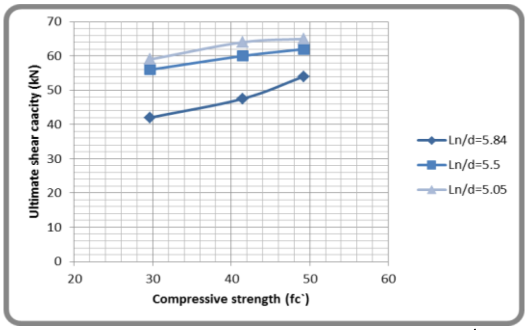

Fig. (16): Effect of compressive strength (f_c') for SCC T-section beams on the ultimate shear strength.

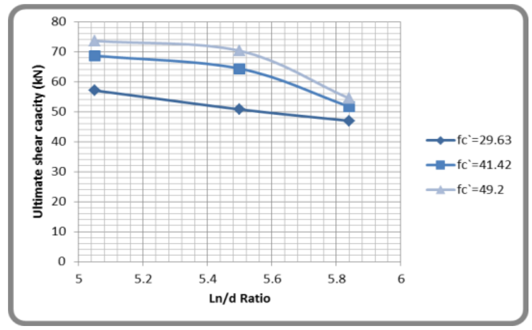

Fig. (18): Effect of clear span to the effective depth ratio (ln/d) on the ultimate shear strength for rectangular section.

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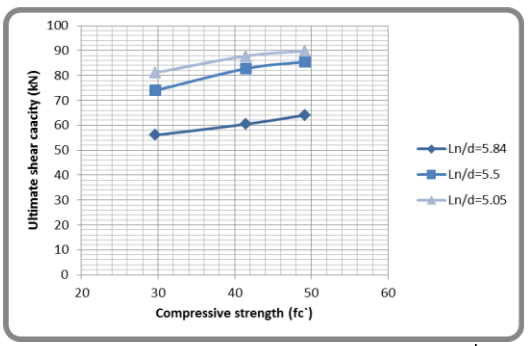

Fig. (17): Effect of compressive strength (f_c') for SCC I-section beams on the ultimate strength.

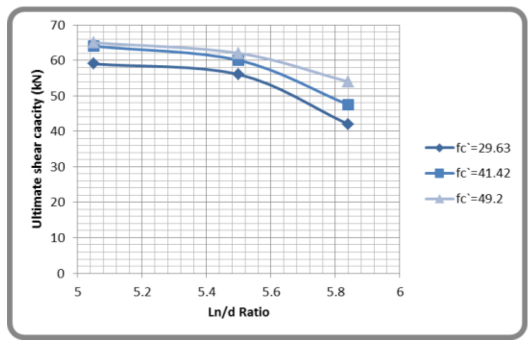

Fig. (19): Effect of clear span to the effective depth ratio (ln/d) on the ultimate shear strength for T- section.

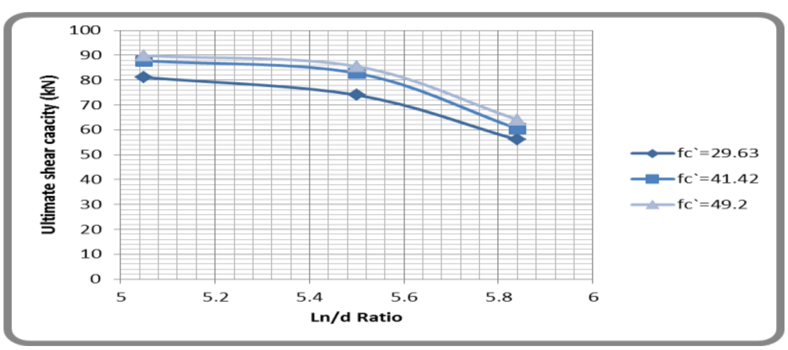

Fig. (20) Effect of clear span to the effective depth ratio (ln/d) on the ultimate shear strength for I- section.

Shapes	Clear span to effective depth ratio (ln/d)	Beam	Comp. strength (f'_c) MPa	Ultimate shear capacity (Vu)kN	Percentage of increased %
Rectangular Sections	5.84	A1	29.39	46.94	-----
	5.84	B1	41.4	51.687	10.123
	5.84	C1	49.2	54.32	16.50
	5.50	A2	29.39	50.779	-----
	5.50	B2	41.4	64.35	26.725
	5.50	C2	49.2	68.686	35.245
	5.05	A3	29.39	57.070	----
	5.05	B3	41.4	68.686	20.354
	5.05	C3	49.2	71.717	25.665
T- Sections	5.84	A10	29.39	42.0	-----
	5.84	B10	41.4	47.5	13.09
	5.84	C10	49.2	54.0	28.571
	5.50	A20	29.39	56.0	-----
	5.50	B20	41.4	60.0	6.666
	5.50	C20	49.2	62.0	10.7142
	5.05	A30	29.39	59.0	-------
	5.05	B30	41.4	64.0	8.475
	5.05	C30	49.2	65.0	10.170
I- Sections	5.84	A100	29.39	56.05	----
	5.84	B100	41.4	60.47	7.885
	5.84	C100	49.2	64.11	14.380
	5.50	A200	29.39	73.99	----
	5.50	B200	41.4	82.75	11.8394
	5.50	C200	49.2	85.50	15.556
	5.05	A300	29.39	81.131	----
	5.05	B300	41.4	87.80	8.220
	5.05	C300	49.2	89.85	10.746

Table (9) effect of compressive strength (f'_c)) on the percentage increased in the ultimate shear strength of tested beams.

Shapes	Clear span to effective depth ratio (ln/d)	Beam	Comp. strength (f'_c) MPa	Ultimate shear capacity (Vu)kN	Percentage of increased %
Rectangular Sections	5.84	A1	29.39	46.94	-----
	5.50	A2	29.39	50.78	8.18
	5.05	A3	29.39	57.07	21.58
	5.84	B1	41.4	51.68	------
	5.50	B2	41.4	64.35	24.51
	5.05	B3	41.4	68.68	32.90
	5.84	C1	49.2	54.32	------
	5.50	C2	49.2	66.36	22.165
	5.05	C3	49.2	71.71	32.01
T- Sections	5.84	A10	29.39	42.0	-----
	5.50	A20	29.39	56.0	33.33
	5.05	A30	29.39	59.0	40.47
	5.84	B10	41.4	47.5	-----
	5.50	B20	41.4	60.0	26.31
	5.05	B30	41.4	64.0	34.73
	5.84	C10	49.2	54.0	-----
	5.50	C20	49.2	62.0	14.81
	5.05	C30	49.2	65.0	20.37
I- Sections	5.84	A100	29.39	56.05	------
	5.50	A200	29.39	73.99	32.0
	5.05	A300	29.39	81.12	44.72
	5.84	B100	41.4	60.47	-----
	5.50	B200	41.4	82.75	36.38
	5.05	B300	41.4	87.80	45.19
	5.84	C100	49.2	64.11	------
	5.50	C200	49.2	85.5	33.36
	5.05	C300	49.2	89.85	40.15

Table (10) effect of clear span to effective depth ratio (Ln/d)) on the percentage increased in the ultimate shear strength of tested beams.

Conclusions

Based on the tested results of this experimental investigation for evaluation of shear strength of SCC beams, the following conclusions are drawn:

- The ultimate shear strength predicated from ACI 318M-11 is a conservative prediction than the experimental values for the SCC beams. The ultimate shear strength obtained from tested of SCC beams were compared with that obtained by using the ACI code provisions.
- The ultimate shear strength of SCC rectangular beams increase about 16.5%35.245%and 25.665% when the compressive strength(f_c') increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively
- The ultimate shear strength of SCC T-beams increase about 28.57%, 10.714%, and 10.17% when the compressive strength(f_c') increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively,
- The ultimate shear strength of SCC I-beams increase about 14.38%.15.55%and 10.746% when the compressive strength (f_c') increased from (29.36 to 49.2 MPa) at clear span to effective ratio (ln/d) 5.84, 5.5 and 5.05 respectively.
- The ultimate shear strength of SCC rectangular beams increased about 21.58%,32.9%and 32.01% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively.
- The ultimate shear strength of SCC T-beams increased about 40.47%, 34.73%, and 20.37% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively.
- The ultimate shear strength of SCC I-beams increased about 44.72% ,45.19% and 40.13% when the clear span to the effective depth (ln/d) decreased from (5.84 to 5.05) at compressive strength (f_c') 29.36, 41.42 and 49.2 MPa respectively .

Fig (21): Crack pattern of SCC Rectangular beams.

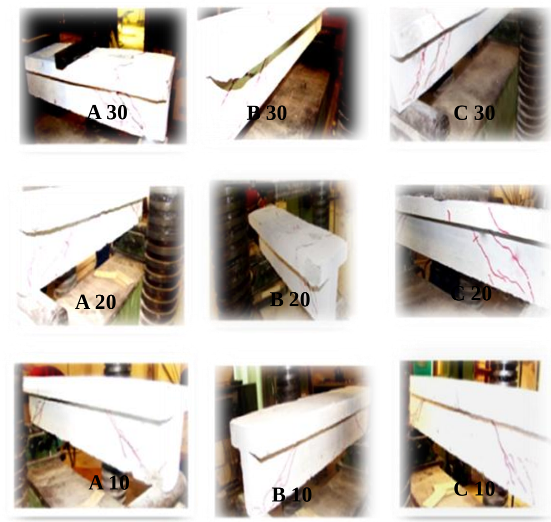

Fig (21): Crack pattern of SCCT-section beams.

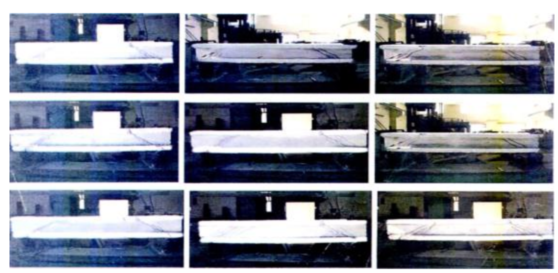

Fig (22): Crack pattern of SCC I-section beams.

References

ACI Committee 363 "Guide to Quality Control and Testing of High Strength Concrete (ACI- 363, 2R-98)", American Concrete Institute, Detroit, (1998).

Al-Jadiri, R.S.F., "A Method for Proportioning Self-Compacting Concrete Based. M.Sc.

Thesis, University of Al- Mustansiriya. Baghdada (2008).

bdel-Razzak A.A., “The Effect of Low Shear Span Ratio on the Shear Strength of RC Beams”, M.Sc. Thesis, University of Technology, Baghdad, (2001).

"Baseline Report for the Aggregate and Concrete Industries in Europe", ECO-SERVE Network, Cluster 3: Aggregate and Concrete Production, June (2004), 68 PP.

Bin MUDA, M.F., "The Properties and Flexural Behavior OF self-Compacting Concrete Using Rice Husk Ash and Admixture", M.Sc. Thesis, University of Technology. Malaysia, (2009).

"ACI Committee 318" Building Code Requirements for Structural Concrete and Commentary (ACI 318M-11)", American Concrete Institute, Detroit, (2011).

"Glenium 51", Degussa construction chemicals. 06\MBT-Me Revised 06 \(2002).

Krieg, W. " Self Compacting Concrete : Definition, Development, and Applications", A technical Paper Presented in the Meeting of the ACI, Saudi Arbia Chapter, Eastern Province, October, (2003).

The European Guidelines for Self-Compacting Concrete Specification", production and use, May (2005), www.efca.info or www.efnarc.org, pp.68.

المواصفة العراقية رقم ٥ "الاسمنت البورتلاندي، الجهاز المركزي للتقييس والسيطرة النوعية" بغداد (١٩٨٤)، ص٨

المواصفة العراقية رقم ٤٥ لسنة (١٩٨٤) (ركام المصادر الطبيعية المستعملة في الخرسانة والبناء، ص (٥-٢)

الملخص العربى

سبع وعشرون عتبة خرسانية ذاتية الرص ذات اشكال مختلفة صممت وفحصت لدراسة مقاومة القص للعتبات الخرسانية ذاتية الرص تحت حملين مركزين. قسمت العتبات المفحوصة إلى ثلاثة مجاميع حسب شكل المقطع الى مقاطع مستطيلة ومقاطع شكل حرف (T) ومقاطع شكل حرف (I) ، كل مجموعة قسمت إلى ثلاثة متواليات، حسب نسبة الطول الصافي الى العمق الفعال(ln/d) تحوي كل متوالية على نفس نسبة حديد تسليح الطولي وحديد تسليح القص (الأطواق) ومساحة المقطع العرضي ونسبة الطول الصافي إلى العمق الفعال ولكن بمقاومة انضغاط مختلفة. وجد من خلال نتائج الفحص إن مقاومة القص القصوى المستحصلة باستخدام معادلة المدونة الأمريكية (318M-11) متحفظة مقارنة مع النتائج المستحصلة من الجانب العملي، وان مقاومة القص للعتبات الخرسانية ذاتية الرص المستطيلة الشكل تزداد بمقدار 16.5%و35.245%و 25.665% عند زيادة مقاومة الانضغاط من ٢٩,٣٦ نت/ملم^{٢} الى ٤٩,٢ نت/ملم^{٢} وبنسب طول الصافي الى العمق الفعال(ln/d) (٥,٨٤ و ٥,٥ و٥,٠٥)على التوالي، وان مقاومة القص للعتبات الخراسانية ذاتية الرص ذات شكل حرف(T) تزداد بمقدار ١٠,١٧%و١٠,٧١٤و 28.57% عند زيادة مقاومة الانضغاط من ٢٩,٣٦ نت/ملم^{٢} الى ٤٩,٢ نت/ملم^{٢} وبنسب طول الصافي الى العمق الفعال(ln/d) (٥,٨٤ و ٥,٥ و٥,٠٥)على التوالي، وان مقاومة القص للعتبات الخراسانية ذاتية الرص ذات شكل حرف(I) تزداد بمقدار ١٠,٧٤%و١٥,٥٥% و 14.38% عند زيادة مقاومة الانضغاط من ٢٩,٣٦ نت/ملم^{٢} الى ٤٩,٢ نت/ملم^{٢} وبنسب طول الصافي الى العمق الفعال(ln/d) (٥,٨٤ و ٥,٥ و٥,٠٥)على التوالي. العملي وان نسبة الطول الصافي إلى العمق الفعال ذات تأثير مهم على مقاومة القص القصوى، حيث ان مقاومة القص القصوى للعتبات الخرسانية المستطيلة ذاتية الرص تزداد بمقدار ٢١,٥٨% و ٣٢,٩ % و ٣٢,٠١% عند نقصان نسبة طول الصافي الى العمق الفعال(ln/d) من (٥,٨٤ الى ٥,٠٥) بمقاومة الانضغاط للخرسانة من ٢٩,٣٦ و٤١,٤٢و ٤٩,٢ نت/ملم^{٢} على التوالي، بينما مقاومة القص القصوى للعتبات الخرسانية ذاتية الرص ذات شكل حرف(T) تزداد بمقدار ٢٠,٣٧% و ٣٤,٧٣ % و ٤٠,٤٧% عند نقصان نسبة طول الصافي الى العمق الفعال(ln/d) من (٥,٨٤ الى ٥,٠٥) بمقاومة الانضغاط للخرسانة من ٢٩,٣٦ و٤١,٤٢و ٤٩,٢ نت/ملم^{٢} على التوالي. ، وان مقاومة القص القصوى للعتبات الخرسانية ذاتية الرص ذات شكل حرف(I) تزداد بمقدار 40.13% و 45.1 % و 44.72% عند نقصان نسبة طول الصافي الى العمق الفعال(ln/d) من (٥,٨٤ الى ٥,٠٥) بمقاومة الانضغاط للخرسانة من ٢٩,٣٦ و٤١,٤٢و ٤٩,٢ نت/ملم^{٢} على التوالي.