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EXPERIMENTAL COMPARISON OF SHEAR BEHAVIOR BETWEEN NORMAL AND SELF-COMPACTED CONCRETE BEAMS

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Abstract: This study deals with shear behavior between normal and self-compacted concrete beams**.** The experimental work includes design and testing of twelve reinforced concrete rectangular beams to study the effect of using self-compacted concrete (SCC) and normal concrete (NC) on the. shear behavior under two. concentrated load. All beams have same longitudinal and vertical steel ratio and cross sectional area of (17000) mm^2. The tested. beams were divided into two. groups; SCC and NC beams. Each group. was divided into three series according to clear span. to effective depth ratio (ln/d), each. series consist of two compressive. strength of concrete (f_c'). It was found. that the beams which made from SCC was more stiffer as compared with the beam which made from NCC with same of the clear span to effective depth ratio, longitudinal steel ratio, vertical steel ratio and relative compressive strength. This equation is conservative as compared with for NC beams tested while the ACI 318 equation is more conservative as compared with the for SCC beams tested. It was found that the ultimate shear strength of SCC increased about 16.66%, 20.33%,20.88% when the compressive strength (f_c') increased from (29.39) to (42.1) MPa while the shear strength of NC increased about 9.3%,12.9%,14.9% when the compressive strength (f_c') increased from (27.8) to (39.1) MPa at clear span to effective depth ratio (ln/d) (7.534),(6.164),(5.584) respectively. It was found that the shear strength of SCC increased about 12.5%, 18.75% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 29.39 MPa while the shear strength of SCC increased about 16.07%, 25% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 42.1 MPa however, the shear strength of NC increased about 18.02%, 23.84% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 27.8 MPa while the shear strength of NC increased about 21.9%, 30% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.548 at compressive strength (f_c') 39.1 MPa.

Keyword s: *shear strength ,self-compacted concrete beam, normal strength concrete beam.*

مقارنة عملية لتصرف القص للعتبات ذات الخرسانة الاعتيادية والخرسانة ذاتية الرص

الخلاصة: تتناول هذه الدراسة تصميم واختبار اثنا عشر عتبة خرسانية مسلحة ذات مقطع مستطيل لدراسة تأثير الخرسانة ذاتية الرص والخرسانة الاعتيادية على تصرف القص تحت تأثير قوتين مركزتين. علما انه جميع العتبات تحتوي نفس حديد التسليح الطولي والعمودي والمساحة الكلية للمقطع العرضي لجميع العتبات هو 17000 ملم^2 . العتبات المفحوصة قسمت الى مجموعتين: المجموعة الأولى مكونة من ست عتبات ذات خرسانة ذاتية الرص والمجموعة الثانية مكونة من ست عتبات ذات خرسانة اعتيادية كل مجموعة قسمت الى ثلاث متواليات حسب الطول الصافي الى العمق الفعال؛ كل متوالية تحوي قيمتين لمقاومة الانضغاط بعمر 28 يوم. وجد بانه العتبات المصنوعة من الخرسانة ذاتية الرص اكثر قساوة مقارنة بالعتبات المصنوعة من الخرسانة الاعتيادية على الرغم من كون نسبة الفضاء الصافي الى العمق الفعال ونسبة الحديد الطولي والعمودي ومقاومة الانضغاط متساوية. باستخدام المدونة الامريكية (ACI-318) وجد بأنها متحفظة مقارنة مع النتائج المستحصلة من الجانب العملي للعتبات ذات الخرسانة الاعتيادية ومتحفظة اكثر مقارنة مع العتبات ذات الخرسانة ذاتية الرص. ووجد ان سعة التحمل القصوى العتبات ذات خرسانة ذاتية الرص تزداد حوالي 16.66%، 20.33% و 20.88% عندما تزداد مقاومة الانضغاط من 29.39 الى 42.1 (Mpa). اما في حالة العتبات ذات الخرسانة الاعتيادية فان سعة التحمل القصوى تزداد حوالي 9.3%، 12.9% و 14.9% عندما تزداد مقاومة الانضغاط من 27.8 الى 39.1 (Mpa) عندما تكون نسبة طول صافي الى عمق فعال 7.534 ، 6.164 و5.584 على التوالي. وكذلك وجد ان مقاومة القص القصوى للعتبات ذاتية الرص تزداد حوالي 12.5% و 18.75% عندما تقل نسبة الطول صافي الى العمق الفعال من 7.534 الى

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5.584 عندما تكون مقاومة الانضغاط 29.39 (Mpa) بينما مقاومة القص القصوى للعتبات ذاتية الرص تزداد حوالي 16.07% و 25% عندما تقل نسبة الطول صافي الى العمق الفعال من 7.534 الى 5.584 عندما تكون مقاومة الانضغاط 42.1 (Mpa). بينما على الجهة الأخرى وجد ان مقاومة القص القصوى للعتبات ذات الخرسانة الاعتيادية تزداد حوالي 18.02% و 23.84% عندما تقل نسبة الطول صافي الى العمق الفعال من 7.534 الى 5.584 عندما تكون مقاومة الانضغاط 27.8 (Mpa) بينما مقاومة القص القصوى للعتبات ذات الخرسانة الاعتيادية تزداد حوالي 21.9% و 30% عندما تقل نسبة الطول صافي الى العمق الفعال من 7.534 الى 5.584 عندما تكون مقاومة الانضغاط 39.1 (Mpa).

1. Introduction

Concrete is .a heterogeneous material and the. ingredients having various specific gravity values and hence it is difficult to keep them in. cohesive .SCC is defined as a concrete which is capable of self-consolidating without any external efforts like vibration, floating, poking etc., and it is a new kind of high performance concrete (HPC) .with excellent deformability and. segregation resistance. It 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 must 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 is influenced by the content of other concrete ingredients like cement replacement material and admixtures[1].

2. Research significance

Concrete has been used in the construction industry for centuries. Many modification 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-compacting concrete. The principle objective of the work described in this study to investigate and to get more information and better understanding the different between the behavior of shear strength of SCC and NC beams.

3. Tested program

3.1. *Description of specimens*

The experimental program consists of testing twelve beams. The beams are divided into three group according to the overall length 1200, 1000 and 900 mm long. The cross section had 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, area of (50.265mm^2) lay in two layer at the bottom and two bar (diameter 4 mm, area of (12.566 mm^2) lay in one layer at the top. The internal steel stirrups were 4 mm in diameter (12.566 mm^2) at spacing 73 mm center to center as shown in fig.(1). The specimens are divided into four groups (A , B , C , and D). These groups are classified according to shear span to effective depth ratio (ln/d) and concrete compressive strength (f'c) values. All Group relates to larger value of shear span to effective depth ratio (ln/d = 7.534) and small value, (ln/d = 5.48). Group (A) have Self-compacting concrete compressive strength (f'c =29.36 MPa).and Group (B) relates to value of normal compressive strength (f'c=27.8 MPa). Group (C) relates to Self-compacting concrete compressive strength (f'c= 42.1MPa). While group (D) relates normal concrete compressive strength (f'c= 39.3MPa). Table (1) shows details of all twelve beams with their related parameters.

Table (1): Total description of the tested beam

Group	Beam	Comp. strength (f'_c) MPa	Clear span (ln)mm	Effective depth (d)mm	Clear span to effective depth ratio (ln/d)
			Group1		
S.C.C	A_{11}	29.36	1100	146	7.534
S.C.C	A_{12}	29.36	900	146	6.164
S.C.C	A_{13}	29.36	800	146	5.48
S.C.C	C_{11}	42.1	1100	146	7.534
S.C.C	C_{12}	42.1	900	146	6.164
S.C.C	C_{13}	42.1	800	146	5.48
			Group2		
N.S.C.	B_{11}	27.8	1100	146	7.534
N.S.C.	B_{12}	27.8	900	146	6.164
N.S.C.	B_{13}	27.8	800	146	5.48
N.S.C.	D_{11}	39.3	1100	146	7.534
N.S.C.	D_{12}	39.3	900	146	6.164
N.S.C.	D_{13}	39.3	800	146	5.48

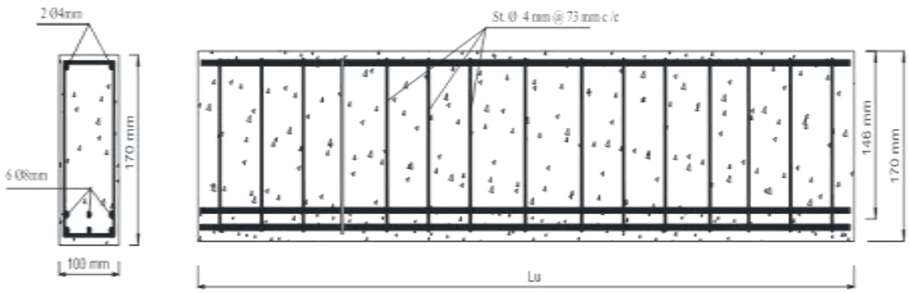


Fig. (1) Details of specimens all dimensions in mm

3.2. *Materials*

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

- Cement: Ordinary Portland cement type I produced at northern cement factory (Tasluja-Bazian) was used throughout this investigation which conforms to the Iraqi specification No. 5/1984[2], Tables (2) and (3) show the chemical and physical properties of the used cement.
- Fine Aggregate: Al-Ukhaider natural sand was used. This complies with the Iraqi Standard Specification No.45/1984,[3] zone(2).The specific gravity, sulfate contents(SO3) and absorption of the used sand were 2.66,0.4%,1.7%, respectively.
- Coarse Aggregate: Crushed gravels maximum size 14 mm from Al-Nibaee area were used in this study. This complies with the Iraqi Standard Specification No.45/ [3] the specific gravity, sulfate contents (SO3) and absorption of the used gravel were 2.65, 0.07%, 0.57% respectively.
- Water: Ordinary potable water was 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 were tested to determine the yield stress of 8mm and 4mm they were 397.88 MPa and 596.83MPa, receptively
- Limestone Powder: A fine limestone powder (locally named as Al-Gubra) of northern origin with fineness (3100 cm^2/ gm) it had been used as a filler for concrete production for many years. It had been found to increase workability and early strength, as well as to reduce the required compaction energy. The increased strength was found particularly when the powder was finer than the Portland cement [4]. The cement in SCC mixes was generally partially replaced by fillers like limestone powder in order to improve certain properties such as;

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

- Super plasticizer[7]: To produce SCC, a super plasticizer known as (High Water Reducing Agent) based on polycarboxylic ether was used; it has the trade mark Glenium 51. Glenium 51 was 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.

Table (2): Chemical Composition of Cement

Compound Composition	Chemical Composition	Percent	Limit of Iraqi specification No.5/1984[2]
Lime	CaO	61.67	-
Silica	SiO2	20.69	-
Alumina	Al2 O3	5.20	-
Iron Oxide	Fe2 O3	4.61	-
Magnesia	MgO	2.43	< 5
Sulfate	SO3	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	C3S		38.55
Dicalcium Silicate	C2S		33.15
Tricalcium Aluminate	C3A		7.12
Tetracalcium Alumina Ferrite	C4AF		10.73

Table (3): Physical Properties of the Cement Used in this Work.

Physical properties	Test Results	Limit of Iraqi specification No. 5/1984[4]
Specific Surface area (Blaine Method , cm^2/gm)	3043	≥ 2300.0
Setting time (Vicats Method)		
Initial Setting time, hrs. : min	174	45 min>
Final Setting time, hrs. : min	3:54	≤ 10:00 hr
Compressive strength of mortar		
2 days (MPa)	21.61	≥ 15
7 days (MPa)	30.75	≥ 23

Table (4): Typical properties of Glenium 51 [7]

No.	*Main action*	Concrete superplasticizer
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

3.3. *Mix Design for Self-Compacted Concrete*

Mix proportioning is more critical for SCC than for NC and HPC. Many trials are carried out on mixes incorporating super plasticizer by increasing the dosage of the admixture gradually, adjusting the w/c ratio to ensure the self-compact ability [7]. Table (5) indicates the mix proportion of SCC and NSC mixes. For each concrete mix, three standard cube specimens (150×150×150) mm were taken, they were tested at 28 days of age, the test result of fresh concrete properties were shown in Table (6) these results were within the acceptable criteria for SCC given by ACI committee-363 [5] and indicate excellent deformability without blocking .

Table (5): mix design of SCC and NC mixes by weight

Group	comp. strength of cylinder (f_c') MPa	W/C Ratio	Mix proportions kg/m^3					lit /m^3	
			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	27.8	0.427	375	----	375	728	1092	160	---
C	42.1	0.38	407	64	599	814	833	155	18
D	39.3	0.4	450	----	450	720	1136	180	---

Table (6): Results of testing fresh SCC property in experimental work

Mix symbol	*Slump flow (mm)*	*T50 Sec.*	*L-box (H2/H1)*	*T20 Sec.*	*T40 Sec.*
A	738	5	0.89	1.65	3.35
C	745	4.5	0.9	1.18	3.01

Acceptance criteria for Self-compacted concrete (SCC) [10]

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

4. 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(2). 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.(3).

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 at 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 (5 kN).At each load stage the deflection readings at the mid span was recorded. The loading increments were applied until failure.

Fig. (2) Tested Machine

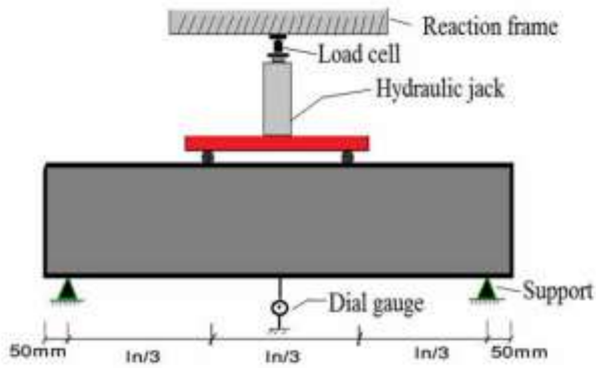


Fig. (3) Schematic diagram of test set-up

5. Shear Strength of Beam in CODE Provision:

ACI 318-08 calculate the nominal shear capacity (V_n) of a beam as follows [(5)]:-

$$Vn = Vc + Vs \quad (1)$$

$$V_c = \frac{\sqrt{f_c'}}{6} bw\ d \quad (2)$$

$$Vc = (\sqrt{f_c'} + 120\ \rho_w\ V_{ud}/M_u) b_w d/7 \quad (3)$$

$$Vs = Avfyd / S \qquad (4)$$

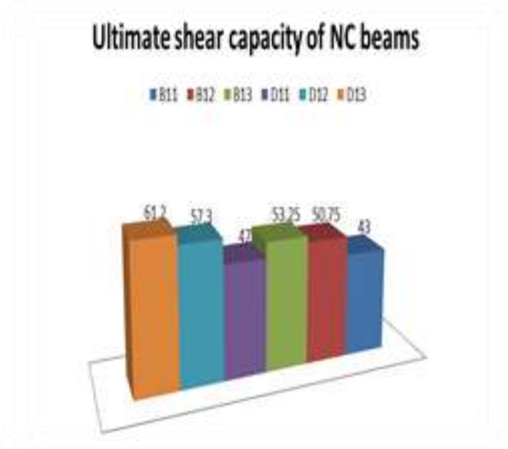
According to clear span to effective depth ratio (ln/d) the main variable in this research , we used Eq.(2)since the shear stress at cracking will depending on the bending moment and shear force at critical section ratio (V_{ud}/M_u)and the longitudinal steel ratio (ρ_w) that lead to reduce the shear crack and improved the ultimate strength.

Where Vc and Vs are shear transfer capacity of concrete and shear reinforcement respectively; Mu and Vud are factored moment and shear force; $\rho_w = As/b_wd$ 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; Av 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.

Table (7) compared the ultimate shear strength obtained from tested of SCC and NC beams with that obtained by using the ACI cod provision, by the inspection of Table (7) and Figs(4)and(5) shown below it can be noted that the ultimate shear strength of SCC is greater than NC when we compared with the predicated from ACI 318-08 values because of the SCC will improved durability, and increased bond strength [7].

Table (7) comparisons of tested results

Beam	*Ultimate shear strength (Vu kN)tested*	*Nominal shear strength (Vn kN) ACI*	*Vu tested/Vn ratio*	*Percentage increace in Vu(test)as compared with Vn(ACI)*
A_{11}	48	35.426	1.355	35.5
A_{12}	54	35.426	1.524	52.4
A_{13}	57	35.426	1.608	60.9
B_{11}	43	35.277	1.219	53.5
B_{12}	50.75	35.277	1.438	78.1
B_{13}	53.25	35.277	1.509	91.8
C_{11}	56	36.493	1.534	21.9
C_{12}	65	36.493	1.781	43.9
C_{13}	70	36.493	1.918	50.9
D_{11}	47	36.273	1.295	29.6
D_{12}	57.3	36.273	1.580	57.9
D_{13}	61.2	36.273	1.687	68.7



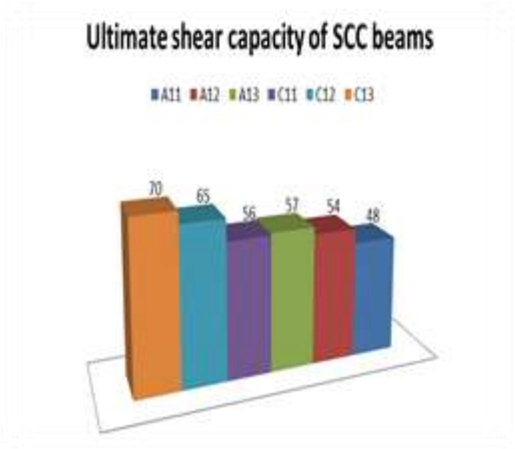


Fig.(4) Ultimate shear capacity for NC and SCC beams

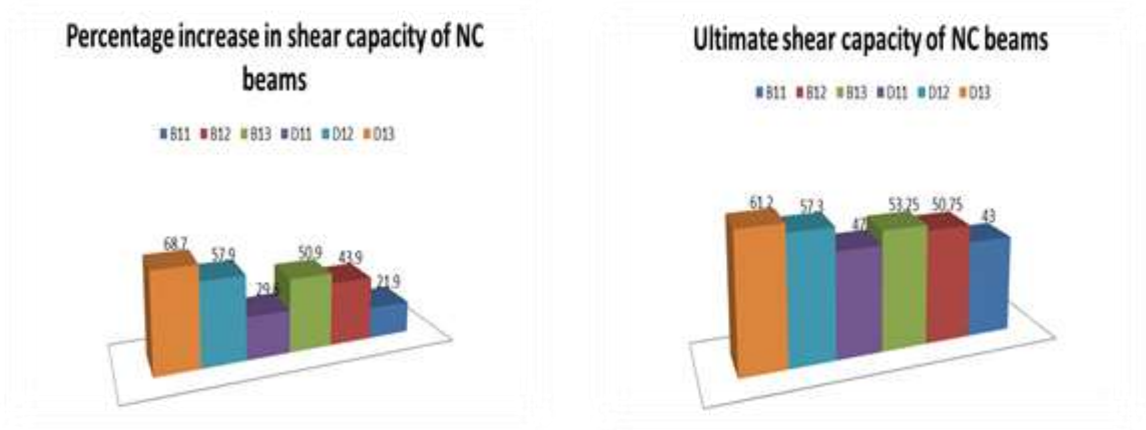


Fig.(5)Percentage increase in shear capacity for NC and SCC beams

6. Results and discussion

All the result show that the SCC beams was gave higher performance than NSC, this can be assumed that shear strength of SCC beam may be caused good bond between the reinforcement and concrete this occurrence may possible be explained by SCC having grater fill capacity, which enables them to cover the reinforcement entirely without need of vibrato while control process depends on the vibration to be compacted perfectly. The greater filling capacity of SCC and its smaller amount of bleeding also reduced the occurrence of voids between the reinforcement and the concrete [7]. As shown below

6.1. *General observation*

All beams showed typical structural behavior in shear, inclined cracks were observed near the support to the concentric load and final failure occurs due to crashing of the concrete. Figs (6-9) showed that the beams which made from SCC was more stiffer as compared with the beam which made from NCC with same of the longitudinal steel ratio, vertical steel ratio and relative compressive strength.

6.2. *Compressive strength*

The compressive strength (f_c') has minor influence on the shear strength for both SCC beams and NSC beams. Table (8) and Figs. (10)and(11) showed the influence of compressive strength (f_c') on the shear strength. It was found that the ultimate shear strength of SCC increased about 16.66%, 20.33%,20.88% when the compressive strength (f_c') increased from (29.39) to (42.1) MPa while the shear strength of NC increased about 9.3%,12.9%,14.9% when the compressive strength (f_c') increased from (27.8) to (39.1) MPa at clear span to effective depth ratio (ln/d) (7.534),(6.164),(5.584), respectively.

6.3. *Clear span to effective depth ratio*

The clear span to effective depth ratio (ln/d) has influence on the shear strength for both SCC beams and NSC beams. Table (9)and Figs.(12)and(13) showed the influence of clear span to effective depth ratio (ln/d) on the shear strength. It was found that the shear strength of SCC increased about 12.5%, 18.75% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 29.39 MPa while the shear strength of SCC increased about 16.07%, 25% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 42.1 MPa however, the shear strength of NC increased about 18.02%, 23.84% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 27.8 MPa while the shear strength of NC increased about 21.9%, 30% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 39.1 MPa.

6.4. *Failure mode*

As was expected, all the tested beams failed in shear mode as shown in Fig.(14),the diagonal crack form independently. The beams remain stable after such cracking. Further increase in shear force will cause the diagonal crack to penetrate into the compression zone at the loading point, until eventually crushing failure of concrete occurs there [7].

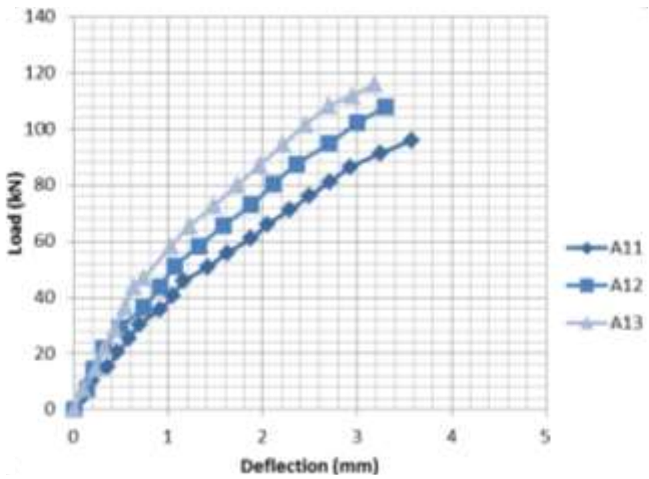


Fig.(6) load –deflection curve for SCC at comp. strength (f_c'=29.36 Mpa) at different clear span to effective depth ratio (ln/d)

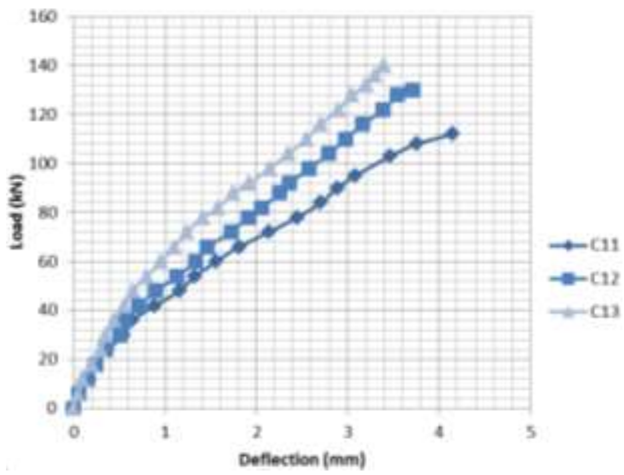


Fig.(7) load –deflection curve for SCC at comp. strength (f_c'=42.1 Mpa) at different clear span to effective depth ratio (ln/d)

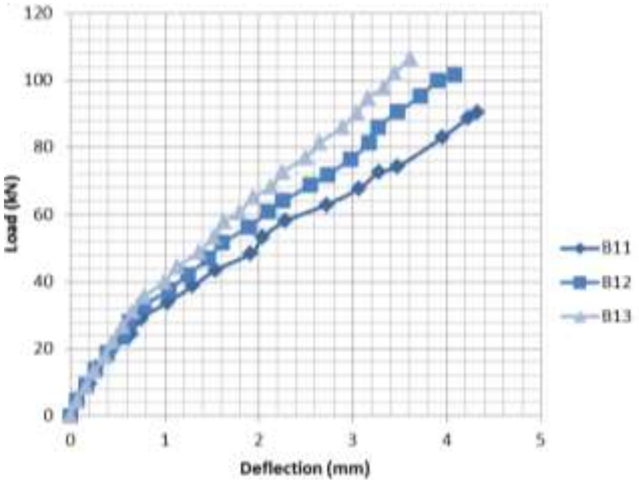


Fig.(8) load –deflection curve for NC at comp. strength (f_c'=27.8 Mpa) at different clear span to effective depth ratio (ln/d)

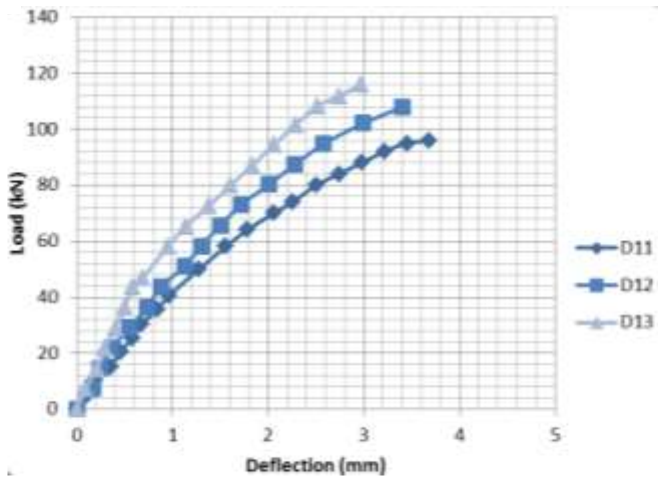


Fig.(9) load –deflection curve for NC at comp. strength (f_c'=39.3 Mpa) at different clear span to effective depth ratio (ln/d)

Table (8) effect of compressive strength (f_c') on the percentage increased in the ultimate shear strength.

Group	Clear span to effective depth ratio (ln/d)	Compressive strength (fc)MPa	Ultimate shear capacity (Vu)kN	Percentage of increased %
S.C.C.	7.534	29.36	48	-------
S.C.C.	7.534	42.1	56	16.666
S.C.C.	6.164	29.36	54	------
S.C.C.	6.164	42.1	65	20.333
S.C.C.	5.48	29.36	57	------
S.C.C.	5.48	42.1	70	20.88
N.S.C.	7.534	27.8	43	-------
N.S.C.	7.534	39.1	47	9.30
N.S.C.	6.164	27.8	50.75	-------
N.S.C.	6.164	39.1	57.3	12.90
N.S.C.	5.48	27.8	53.25	-------
N.S.C.	5.48	39.1	61.2	14.9

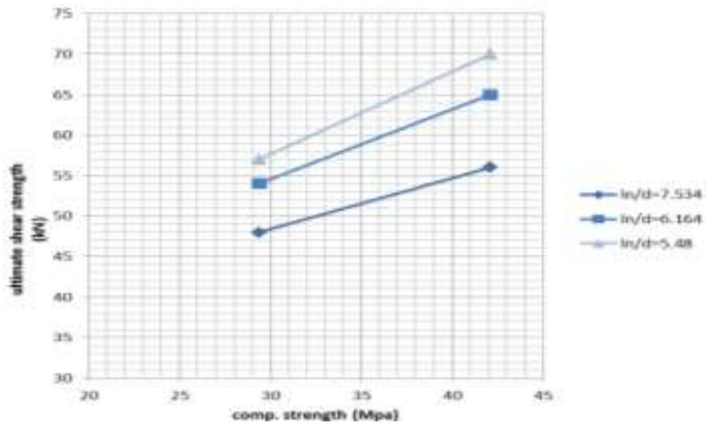


Fig.(10) effect of compressive strength ($f_c^{'}$) for SCC beams on the ultimate shear strength.

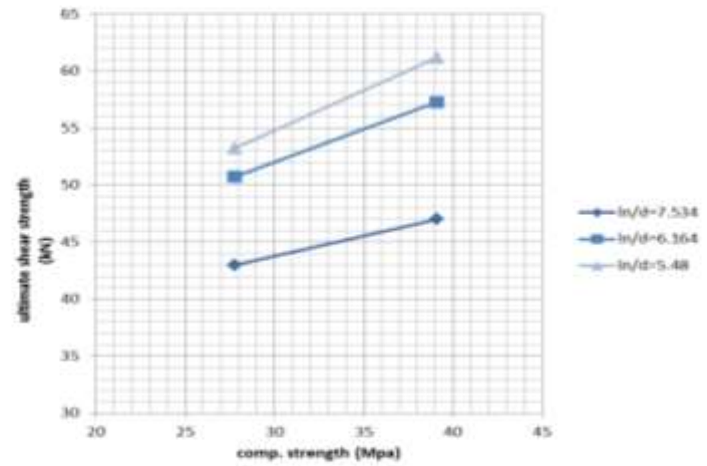


Fig.(11) effect of compressive strength ($f_c^{'}$) for NC beams on the ultimate shear strength

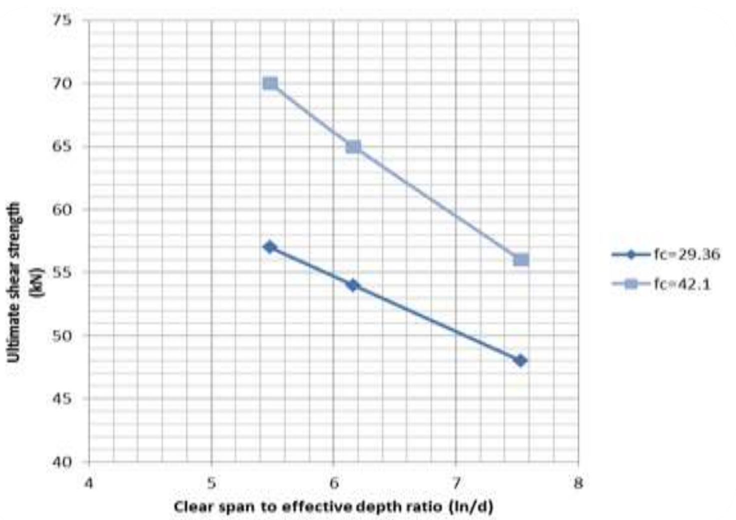


Fig.(12) effect of clear span to the effective depth ratio(ln/d) on the ultimate shear strength for SCC beams.

Table (9) effect of clear span to effective depth ratio (ln/d) on the percentage increased in the ultimate shear strength.

Group	Compressive strength (f'_c)MPa	Clear span to effective depth ratio (ln/d)	Ultimate shear capacity (Vu)kN	Percentage of increased %
S.C.C	29.36	7.534	48	-------
S.C.C	29.36	6.164	54	12.50
S.C.C	29.36	5.48	57	18.75
S.C.C	42.1	7.534	56	-------
S.C.C	42.1	6.164	65	16.07
S.C.C	42.1	5.48	70	25
N.S.C.	27.8	7.534	43	------
N.S.C.	27.8	6.164	50.75	18.02
N.S.C.	27.8	5.48	53.25	23.84
N.S.C.	39.1	7.534	47	-------
N.S.C.	39.1	6.164	57.3	21.91
N.S.C.	39.1	5.48	61.2	30.21

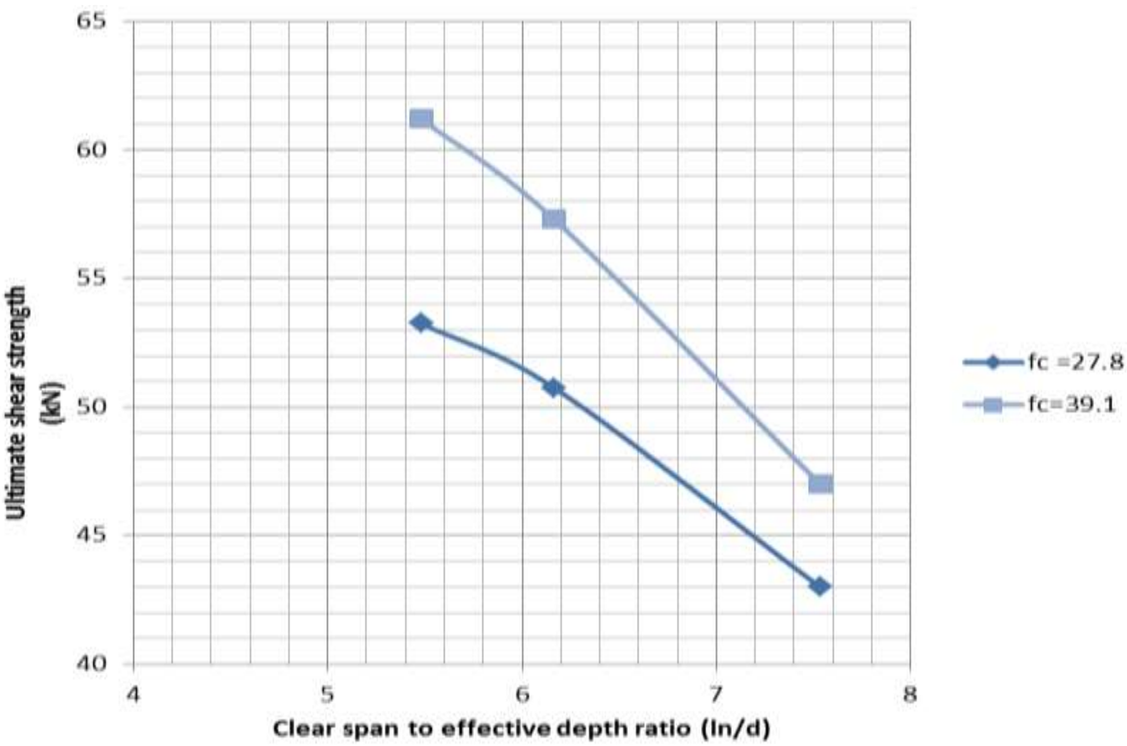


Fig.(13) effect of clear span to the effective depth ratio(ln/d) on the ultimate shear strength for NC beams.

Fig. (14) Crack pattern for tested beams (group A)

Fig. (15) Crack pattern for tested beams (group B)

Fig. (16) Crack pattern for tested beams (group C)

Fig. (17) Crack pattern for tested beams (group D)

7. Conclusions

Based on the tested results of this experimental investigation for evaluation of maximum crack width, number of crack, cracking load and cracking moment of SCC and NC beams the following conclusions are drawn:

1. The beams which made from SCC was more stiffer as compared with the beam which made from NCC with same of the clear span to effective depth ratio, longitudinal steel ratio, vertical steel ratio and relative compressive strength.
2. The ACI 318 equation is concrete as compared with the experimental study for NC beams
3. The ACI 318 equation is more concrete as compared with the experimental study for SCC beams.
4. The ultimate shear strength of SCC increased about 16.66%, 20.33%,20.88% when the compressive strength (f_c') increased from (29.39) to (42.1) MPa at clear span to effective depth ratio (ln/d) (7.534),(6.164),(5.584) respectively.
5. The shear strength of SCC increased about 12.5%, 18.75% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 29.39 MPa
6. The shear strength of SCC increased about 16.07%, 25% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 42.1 MPa
7. The shear strength of NC increased about 18.02%, 23.84% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 27.8 MPa
8. the shear strength of NC increased about 21.9%, 30% when the clear span to the effective depth ratio (ln/d) decreed from 7.534 to 5.48 at compressive strength (f_c') 39.1 MPa.
9. Reinforced concrete is better than unreinforced concrete for one major reason. concrete is an extremely strong material when it is put under pressure. however, when tension forces are introduced it will tend to fail without reinforcement

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