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SHEAR BEHAVIOR OF HIGH STRENGTH SELF COMPACTING CONCRETE BEAMS

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ABSTRACT

This research presents an experimental study to investigate the shear behavior of high strength self-compacting concrete slender beams. The experimental program includes testing seven beams with constant size of (150mm height ×125mm width×1000mm length) to study the effect of shear span to effective depth ratio (a/d), longitudinal reinforcement ratio (ρ_w) and shear reinforcement ratio (ρ_v) on shear behavior for these beams. The experimental results showed that, increase shear span to effective depth ratio (a/d) has pronounced effect on decreasing diagonal cracking load and ultimate shear strength and increasing the ductility ratio, as (a/d) increase from 2.5 to 3.0, the decreases in diagonal cracking load and ultimate shear strength are with percentages of 17.8% , 21.6% respectively, while the ductility ratio increase with percentage of 16.7%. Also the results showed that the longitudinal reinforcement ratio (ρ_w) has significant effect on the gain in shear bearing capacity and ductility ratio, as increasing of longitudinal reinforcement ratio from 3.191% to 6.383% the increases in diagonal cracking load, ultimate shear strength and ductility ratio are with percentages of 43.8%, 46.6% and 37.0% respectively. Furthermore the results revealed that the vertical shear reinforcement has the major effect in improvement the shear behavior of these beams, however, using shear reinforcement (ρ_v) with percentage of 0.502% results in increase diagonal cracking load, ultimate shear strength and ductility ratio with percentages 50.7%, 63.6% and 48.1% respectively as compared with beam without shear reinforcement. Also presence of vertical shear reinforcement changed the mode of failure from the brittle to ductile.

Keywords: *Shear Behavior, Self-Compacting Concrete, Reinforced Concrete , Beams.*

INTRODCTUION

In concrete beam without properly designed shear reinforcement, shear failure is likely to occur suddenly with no advance warning of distress. This is in contrast with the nature of flexural failure [1]. Accordingly, there is necessity for provision the required shear reinforcement.

In two past decades self compacting concrete (SCC) has been emerged as high performance concrete and became an excellent alternative to conventional concrete in many fields due to its special properties. In the same time, As compared with conventional concrete, SCC consists of lesser amount and smaller maximum size of coarse aggregate, therefore, one can expect that the shear strength of beam made by SCC is lesser than that carried out by beams made using conventional vibrated concrete, where the interlock mechanism of coarse aggregate is weaker which represents an important part of the total shear strength for these members, therefore there is a necessity to investigate the behavior and capacity of structural members constructed using this type of concrete, especially in high strength levels, as the concrete become more brittle and the failure become more dangerous.

Although a large number of experimental works have been carried out on the shear behavior of conventional vibrated concrete beams and these works contributed in understanding the shear transfer mechanism and developed important recommendations for the shear design, only small portion of these works deals with high strength concrete [2 to 9], and very limited number deals with high strength self compacting concrete, in which; Griffin and Myers[10] presented a comparison in shear behavior between girders with and without shear reinforcement. Al Rawashdeh[11] studied the effect of steel fiber on shear behavior of high strength SCC slender and deep beams. Sultan et al [12 and 13] studied effect of steel fiber on normal and high strength SCC deep beams. Harkouss and Hamad [14] investigate the effect of enhanced fluidity of high strength SCC on the structural behavior of reinforced concrete beams in flexure, shear and bond. All the presented researches didn't deal with the most important parameters such as; shear span to effective depth ratio (a/d), longitudinal reinforcement ratio (ρ_w) and shear reinforcement ratio(ρ_v) on shear transfer mechanism, shear capacity and ductility of high strength SCC slender beams. Therefore there is necessity to studying these parameters on this type of beams to get a better understanding and to provide more information to prevent sudden failure and to enhance the ductility.

THE AIM OF THE RESEARCH

This research presents experimental study to investigate shear behavior of high strength self compacting concrete slender rectangular beams and study the effect of shear span to effective depth ratio (a/d), longitudinal reinforcement ratio (ρ_w) and vertical shear reinforcement ratio (ρ_v) on shear behavior of these beams.

EXPERIMENTAL PROGRAM

The experimental program includes testing seven simply supported beams consists of high strength self compacting concrete. All the beams have the same dimensions of 1000 mm length, 125 mm width and 150mm height. The tested beams is divided into three groups; the first group involves identical beams without shear reinforcement and with varying shear span to effective depth ratios (a/d) of 2.5, 2.75 and 3.0, the second group involves identical beams also without shear reinforcement and with varying longitudinal reinforcement ratios (ρ_w) of 3.191%, 4.787% and 6.383%, and the third group involves identical beams with varying vertical shear reinforcement ratios of 0.251%, 0.502% in addition to beam without shear reinforcement. For each group, when a parameter is changing, all other parameters are held constant. The details of experimental program are listed in Table (1) and Figure (1) shows the layout and cross sections of the beams.

CONSTITUENT MATERIALS

SELF COMPACTING CONCRETE (SCC) INGREDIENTS

The ingredients of SCC used in this research include: Ordinary Portland cement Type I conform to the requirements of the Iraqi specification No.5/1984 [15], Coarse aggregate of maximum size 10 mm conform to the requirements of the Iraqi specification No.45/1984 [16], Natural sand with fineness modulus of 2.6 conform to the requirements of the Iraqi specification No.45/1984 [16], Lime stone powder with particle size of less than 0.125 mm (Sieve No.200) satisfies EFNARC 2002 recommendations [17], high range water reducers (S.P.) complies with ASTM C494 type A[18] and tap water. The components of SCC used in this research and it proportions per cubic meter are listed in Table (2).

STEEL REINFORCEMENT

Deformed steel bars of nominal diameter (ϕ16mm) of 525 MPa yield stress were used as tension reinforcement in all beams, while (ϕ4mm) deformed steel bars of 345 MPa yield stress were used as stirrups and (ϕ4mm) smooth steel bars were used to fix the stirrups. The test results of bars (ϕ16mm) and (ϕ4mm) satisfy ASTM A615 requirements [19].

All the beams are longitudinally reinforced by two bars of 16 mm diameter except beams B4 and B5 which reinforced with three and four bars respectively. Also all the beams are without shear reinforcement except beams B6 and B7 which have shear reinforcement of ϕ4mm@100 and ϕ4mm@50 respectively in non zero shear zones as listed in Table (1).

MIXING , CASTING AND CURING

Many mix proportions were tried to get high strength SCC. The procedure of mixing was as follows: firstly, the fine aggregate, cement and limestone powder were mixed for one minute before adding half of the mixing water. Then, the mixture is mixed for two minutes. The coarse aggregate is added with the remaining quantity of water and superplasticizer. Mixing was continued for two minutes to achieve uniform distribution through the concrete mix. The concrete mixing was achieved using a titling a horizontal rotary mixer machine available in the material construction laboratory, College of Engineering, Diyala University. After mixing, the fresh SCC placed in timber molds and after 24 hours from casting, the beam specimens were de-moulded, and immersions in a tank of water for 28 days according to ASTM C 192/C 192M [20].

FRESH SCC TESTS

In this study, the beams were casted in the three batches. All the batches had the same ingredients and mix proportions. In order to verify from being the concrete used in this research is SCC, the four standard tests (Slump flow test, T50 cm slump flow test, V-funnel test and L-box fresh test) of SCC were carried out on each batch and the results were compared with the standard limitations mentioned in EFNARC [17]. Figure (2) shows the tests of fresh SCC carried out in this study. All the results of these tests satisfy the requirements of EFNARC[17] as shown in the Table(3).

MECHANICAL PROPERTIES OF HARDENED SCC

For each batch the control specimens (cylinders and prisms) were casted with the beams to determine the mechanical properties of SCC. The compressive strength (**f_c'**) tests were carried out on cylinders (100×200mm) in accordance with ASTM C39 [21]. Flexural strength (**f_r**) (modulus of rupture) tests were carried out on prisms (100×100×500mm) in accordance with ASTM C78 [22], while the indirect tensile strength (**f_t**) (splitting tensile strength) tests were carried out on cylinders (150×300mm) in accordance with ASTM C496 [23]. The results of these tests are listed in Table (4). According to ACI Committee 363 [24], the high strength concrete is the concrete has compressive strength greater than 41MPa, therefore all the SCC used in this research is high strength.

TESTING POCEDURE OF THE BEAMS

The beams were lifted from the curing water tank at the age of 28 days after casting, left to dry, and then painted with white color so that cracks can be easily detected. The beams were tested under two point loading using a universal hydraulic machine of (2000kN) capacity available in the Structural Engineering Laboratory, College of Engineering, Diyala University. The beam specimens were simply supported using rigid supports with 900mm clear span. The loads were applied in successive increments up to failure. A dial gauge of 0.001 mm accuracy was attached firmly to the bottom face of midspan to record midspan deflection. Figure (3) shows one of the beams under test. The load that produced the first crack, the diagonal crack and the ultimate shear crack were recorded. Crack patterns were marked on the beams.

RESULTS AND DISCUSSION

FAILURE MODES

The experimental work reveals that most of the beams without shear reinforcement (beams B2 , B3, B4, and B5) failed in diagonal tension mode and these beams had general behavior can be described as follows: at low load levels, short flexural cracks were formed in the zone of pure bending, between the two point loads. With increasing loads the initiated flexural cracks slightly extended vertically upward, and additional flexural cracks were formed in the same region and other cracks were formed in the shear spans between the point loads and supports. With further increasing in load, diagonal inclined cracks were formed suddenly in the shear span between the point load and support in one side or in the two sides of the beams in the same time or in successive. Finally, failure occurred as the diagonal crack expanded and extended deeply in the compressive zone towards the point load. Failure of these beams was always sudden with loud sound. Another failure mode for the beam without shear reinforcement is shear-compression failure which was occurred in the beam (B1), in this mode, after formation of the inclined crack, the concrete portion between the two point loads suffers high compression stress and it then finally fails. This mode of failure is also brittle. On the other hand, the beams with vertical shear reinforcement (beams B6 and B7), failed in shear-flexure mode, however, at early levels of loading, these beams exhibit the same behavior of beams failing in diagonal tension mode, but later, the flexural cracks in pure bending zone grew and extended together with cracks in shear zone and the failure occurred due to enlarge these cracks in shear and flexure zones. This type of failure is ductile in which the beam deflects at the center and no loud sound was heard at the time of failure.

DIAGONAL CRACKING LOAD AND ULTIMATE SHEAR LOAD

According to ACI-ASCE Committee 426 [25] and ACI-ASCE Committee 445[26] , the diagonal cracking load is defined as that load in which the inclined crack is formed in the shear span region extending from the support toward the concentrated load, while ultimate shear load, is defined as the load at which the shear failure occurs. It was observed that the diagonal crack either form suddenly in shear zone as occurred in the beams without shear reinforcement or it initiate from extend one of inclined flexural cracks in shear zone toward the point load as occurred in beams with shear reinforcement. Table (5) lists the results of the tested beams and Figures (4) to (6) show effect of (a/d), ρ_w and ρ_v on the diagonal cracking load and ultimate shear load.

Effect of shear span to effective depth ratio (a/d) :

Generally, it can be observed from Table (5) and Figure (4) that the shear span to effective depth ratio has a pronounced effect on the diagonal cracking load and ultimate shear strength of high strength SCC beams without shear reinforcement. However, as (a/d) ratio increase from 2.5 in beam B1 to 2.75 in beam B2 and 3.0 in beam B3, the diagonal cracking load decreases with percentages of 9.6%, and 17.8% respectively, while the ultimate shear strength decreases with percentages 13.6%, and 21.6% respectively as compared with the beam B1. The decreases in diagonal cracking load and ultimate shear strength can be attributed to that rising (a/d) ratio results in increase bending moment in the shear span, thus flexural stresses also increase which in turn lead to increase the tensile stress component which act with the shear stress in formation principal tensile stresses and consequently diagonal tension stresses causing reduce shear strength.

Effect of longitudinal reinforcement ratio (ρ_w):

Table (5) and Figure (5) shows that the diagonal cracking load and ultimate shear strength of high strength SCC beams significantly affected by increasing ρ_w . However, for the beams with (a/d) equal to 2.5 and without shear reinforcement, it was observed that increasing ρ_w from 3.191% in beam B1 to 4.787% in beam B4 and 6.383% in beam B5, the diagonal cracking load increase with percentages 28.8% and 43.8% respectively, while the ultimate shear strength increase with percentages 27.3% and 46.6% respectively as compared with beam B1. These improvements can be attributed to the dowel action of longitudinal reinforcement on the shear transfer mechanism, since the dowel action increase with increasing reinforcement area. Also, increasing ρ_w results in increase the tensile strength which resists the tensile stresses induced in the surrounding concrete. Furthermore, formation diagonal crack depend on the intensity of shear stresses and subsequently the principal stresses near the crack tip, and these stresses decrease with decreasing the penetration depth of the flexural cracks which in turn decrease with increasing longitudinal reinforcement ratio.

Effect of vertical shear reinforcement ratio (ρ_v):

It can be observed from Table (5) and Figure (6) that the shear reinforcement has the major effect on increasing diagonal cracking load and ultimate shear strength of high strength SCC beams. However using shear reinforcement with ratios of 0.251% in beam B6 and 0.502% in beam B7 results in increase the diagonal cracking load with percentages 32.9% and 50.7% respectively, and increase the ultimate shear strength with percentages 40.9% and 63.6% respectively as compared with the beam without shear reinforcement (B1). This response is attributed to the fact that the shear reinforcement restricts growth the diagonal and shear cracks and obstructs it from extension and also redistributes the principal tensile stresses in the shear zone, resulting in increase the shear strength.

LOAD-DEFLECTION CURVES, ULTIMATE DEFLECTION AND DUCTILITY RATIO

Figures (7) to (9) shows effect of (a/d), ρ_w and ρ_v on the load-midspan deflection curves and Table (5) lists the effect of these parameters on ultimate deflection and ductility ratio. It is well known that the ductility ratio is index to the ductility which is very important property for concrete structural members especially these subjected to shear loads as the ductility makes concrete give warning before failure and prevents sudden collapse. The ductility ratio can be calculated as the ratio of deflection at ultimate load to the deflection at the first crack.

Figures (7) to (9) reveal that all the high strength SCC beams without shear reinforcement have load-deflection curves consists of three parts; the first part is linear with constant slope until formation the first flexural cracks in the tension zone, the second began beyond the first crack with slope less steeper than first part due to increase and enlargement flexural cracks and formation shear cracks, the third part began as crack of diagonal tension in shear zone become large and the deflection increase until the failure occurs. It can be noted also that the beams with vertical shear reinforcement do not have the third part due to the ability of vertical shear reinforcement in arresting the shear cracks and obstructing it's extension, thus, the slope of the second part continue until the failure.

Figure (7) shows that the effect of (a/d) before first crack load is little and become large after first crack and although the beam become less stiffer with increasing (a/d) but the deflection at first crack decreases with increasing (a/d) due to decrease the first crack load corresponding it. Table (5) reveals that increase (a/d) from 2.5 to 2.75 and 3 makes the ultimate deflection increases with percentages 7.0% and 11.6% respectively as compared with the beam of (a/d) equal to 2.5. Also, the ductility ratio, increases with percentages 9.3% and 16.7% respectively.

Figure (8) reveals that increase longitudinal reinforcement ratio from 3.191% to 4.787% and 6.383% makes the beam more stiffer in all steps of loading and Table (5) shows that the ultimate deflection decreases with percentages 16.5% and 36.0%, but the ductility ratio increased with percentages 13.0% and 37.0% respectively, this behavior can be attributed to the large reduction in the deflection corresponding to the first crack with increasing longitudinal reinforcement ratio due to the ability of longitudinal steel in improvement the crack control and arrested the flexural cracks.

Figure (9) shows that although increase vertical shear reinforcement makes the beam more stiffer especially after first crack since presence shear reinforcement restricts expansion of shear cracks and reduce transfer the flexural cracks to inclined and diagonal cracks in shear zone but increase shear reinforcement also makes the beam more ductile due to increase the area under load by increasing both the ultimate strength and ultimate deflection thus the toughness which also considered ductility index increase and by sequence the ductility increase due to the ability of shear reinforcement in redistribution the diagonal tension stresses. Table (5) shows that using shear reinforcement with ratios of 0.251% and 0.502% results in increase the ultimate deflection with percentages 22.3% and 30.2% and increase the ductility ratio with percentages of 25.9% to 48.1% respectively as compared with the beam without shear reinforcement.

CRACK PATTERNS

All the high strength SCC beams tested in this study failed in shear although the mode of failure differed from one to another as mentioned previously. Figures (10) to (12) show photographs of the crack patterns after the failure of the tested beams. The numbers shown beside the crack indicated the load when the crack penetrated to that position. It can be noted from Figure (10) that under the same load increasing (a/d) results in increase the penetration depth of the cracks within the beams. Figure (11) shows that increase longitudinal reinforcement ratio makes the cracks narrow and multiple. While Figure (12) shows that the number of inclined cracks in beams with high amount of shear reinforcement was more than that of lower amount of shear reinforcement, indicating an enhanced redistribution of internal forces in the beam with high shear reinforcement.

CONCLUSION

Based on the results obtained from the experimental work it can be conclude that:

1) All the high strength SCC beams tested in this study failed in shear although the mode of failure differed from one to another such as shear-compression, diagonal tension and shear-flexure depending on shear span to effective depth ratio and shear reinforcement ratio.
2) Increasing shear span to effective depth ratio (a/d) has pronounced effect on shear performance of high strength SCC beams. As (a/d) ratio increase from 2.5 to 3.0, the diagonal cracking load decreases with percentage of 17.8%, while the ultimate shear strength decreases with percentage of 21.6%.
3) Increasing (a/d) improve the ductility and increase the ultimate deflection of high strength SCC beams under shear loads. As (a/d) increase from 2.5 to 3, the ductility ratio increase with percentage of 16.7% and the ultimate deflection increase with percentage of 11.6%.
4) Increasing longitudinal reinforcement ratio (ρ_w) has significant effect on improvement shear behavior of high strength SCC. However increasing (ρ_w) from 3.191% to 4.787% and 6.383% results in increase the diagonal cracking load with percentages of 28.8% and 43.8%, while the ultimate shear strength increase with percentages 27.3 % and 46.6% respectively.
5) Although increase the longitudinal steel ratio (ρ_w) results in significant decrease in the ultimate deflection but the ductility ratio increase. However, increasing (ρ_w) from 3.191% to 4.787% and 6.383% results in decrease the ultimate deflection with percentages of 16.5% and 36.0% respectively, while the ductility ratio increase with percentages of 13.0% and 37.0% respectively.
6) Increase the vertical reinforcement ratio (ρ_v) has the major effect on shear behavior of high strength SCC beams. However using shear reinforcement with ratios of 0.251% and 0.502% results in increase the diagonal cracking load with percentages 32.9% and 50.7% respectively, and increase the ultimate shear strength with percentages 40.9% and 63.6% respectively as compared with the beam without shear reinforcement.
7) Using vertical shear reinforcement with ratios of 0.251% and 0.502% results in increase the ultimate deflection 22.3% and 30.2% and makes the ductility ratio increase with percentages of 25.9% to 48.1% respectively as compared with the beam without shear reinforcement.

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Table(1) : The parameters and beams properties

Group No.	Details of group	Beam designation	a/d	Long. rein. bars	ρ_w (%)	Shear rein. bars	ρ_v (%)
1	Changing shear span to effective depth ratio (a/d)	B1	2.5	2Φ16	3.191	-----	without
		B2	2.75	2Φ16	3.191	-----	without
		B3	3.0	2Φ16	3.191	-----	without
2	Changing longitudinal reinforcement ratio (ρ_W)	B1	2.5	2Φ16	3.191	-----	without
		B4	2.5	3Φ16	4.787	-----	without
		B5	2.5	4Φ16	6.383	-----	without
3	Changing vertical shear reinforcement ratio (ρ_V)	B1	2.5	2Φ16	3.191	-----	without
		B6	2.5	2Φ16	3.191	Φ4@100mm	0.251
		B7	2.5	2Φ16	3.191	Φ4@50mm	0.502

Table (2) Proportions of SCC mixes per cubic meter

Mix type	Cement (kg)	Limestone Powder (kg)	Water (liter)	Sand (kg)	Gravel (kg)	Superplasticizer (liter)
High strength SCC	**552**	**52**	**165**	**860**	**758**	**20**

Table (3) Results of fresh SCC for slump flow, T50,V-funnel and L-box tests

Batch name	Slump flow (mm)	T50 (sec)	V-funnel	L-box (H2/H1)
High strength SCC1	**710**	**3.5**	**7**	**0.96**
High strength SCC2	**715**	**3.0**	**6**	**0.98**
High strength SCC3	**712**	**3.5**	**7**	**0.97**
Limits of EFNARC[17]	**650-800**	**2-5**	**6-12**	**0.8-1**

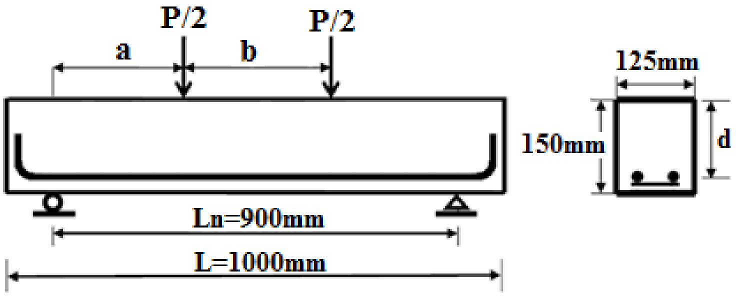
Table (4) Mechanical properties of SCC mixes

Batch name	Beams	f_c'(MPa)	f_r(MPa)	f_t(MPa)
High strength SCC1	B1, B2 and B3	64.8	5.7	5.2
High strength SCC2	B4 and B5	64.4	5.6	5.1
High strength SCC3	B6 and B7	64.5	5.6	5.1

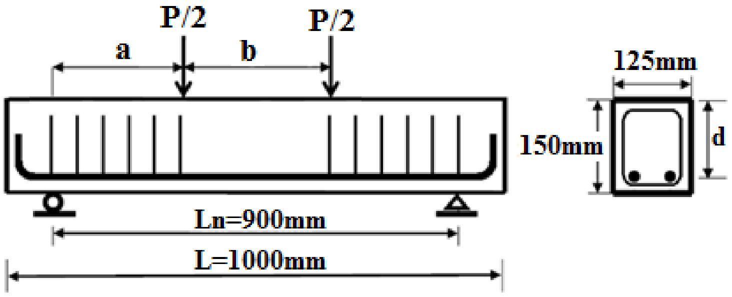
Table (5) Tests results of the beams

Parameter	Beam	a/d	ρ_w(%)	ρ_v(%)	Deflection at first crack Δ_{cr} (mm)	Diagonal cracking load P_{cr} (kN)	Variation in diagonal cracking load (%)	Ultimate deflection Δ_{ult} (mm)	Variation in ultimate deflection (%)	Ultimate shear load P_{ult} (kN)	Variation in ultimate shear load (%)	Ductility ratio(Δ_{ult}/Δ_{cr})	Variation in ductility ratio (%)	Failure mode
Changing shear span to effective depth ratio (a/d)	B1	2.5	3.191	Without	1.24	73	-----	6.72	-----	88	-----	5.4	-----	S.C
	B2	2.75	3.191	Without	1.22	66	-9.6	7.19	+7.0	76	-13.6	5.9	+9.3	D.T
	B3	3.0	3.191	Without	1.19	60	-17.8	7.50	+11.6	69	-21.6	6.3	+16.7	D.T
Changing longitudinal reinforcement ratio(ρ_W)	B1	2.5	3.191	Without	1.24	73	-----	6.72	------	88	-----	5.4	-----	D.T
	B4	2.5	4.787	Without	0.92	94	+28.8	5.61	-16.5	112	+27.3	6.1	+13.0	D.T
	B5	2.5	6.383	Without	0.58	105	+43.8	4.30	-36.0	129	+46.6	7.4	+37.0	D.T
Changing vertical shear reinforcement ratio (ρ_V)	B1	2.5	3.191	Without	1.24	73	-----	6.72	-----	88	-----	5.4	-----	D.T
	B6	2.5	3.191	0.251	1.21	97	+32.9	8.22	+22.3	124	+40.9	6.8	+25.9	S.F
	B7	2.5	3.191	0.502	1.10	110	+50.7	8.75	+30.2	144	+63.6	8.0	+48.1	S.F

D.T: Diagonal tension mode failure, S.F : Shear-flexure failure mode, S.C. shear compression failure mode



Beams(B1,B2,B3,B4 and B5) (without shear reinforcement)



Beams (B6 and B7) (with vertical shear reinforcement)

Figure (1): Layout, cross-section and details of the beams used in this study

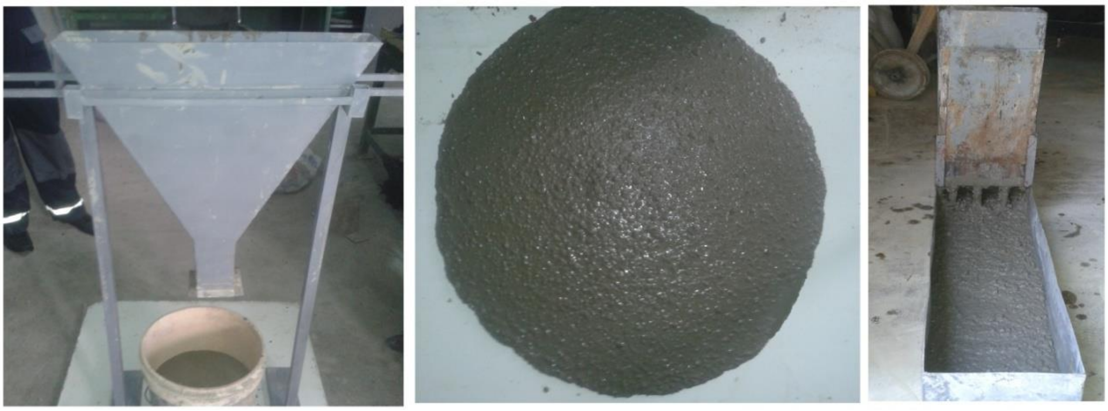


Figure (2) V-funnel, slump flow and L-box tests of fresh SCC

Figure (3) One of the beams under test

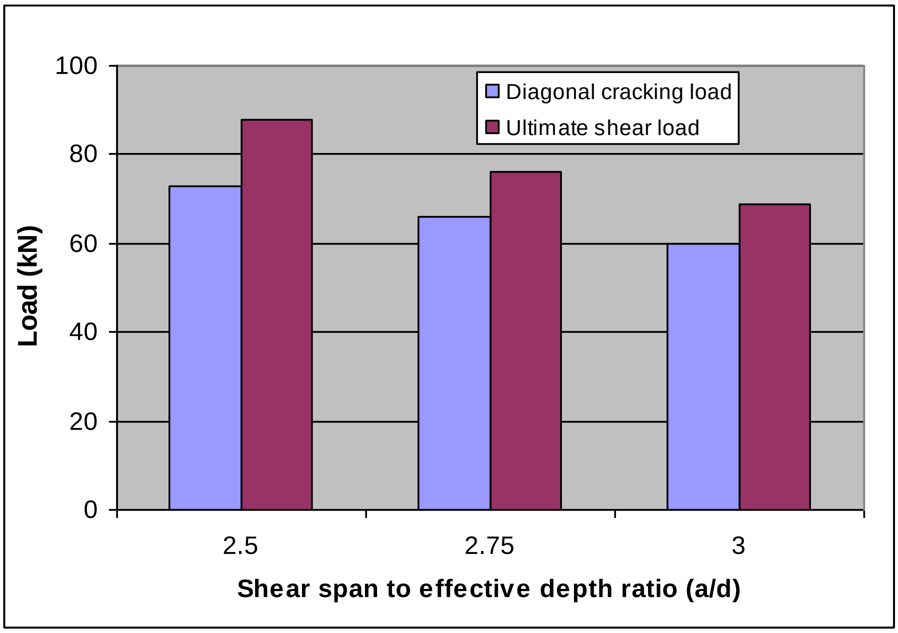


Figure (4) Effect of shear span to effective depth ratio (a/d) on diagonal cracking load and ultimate shear strength

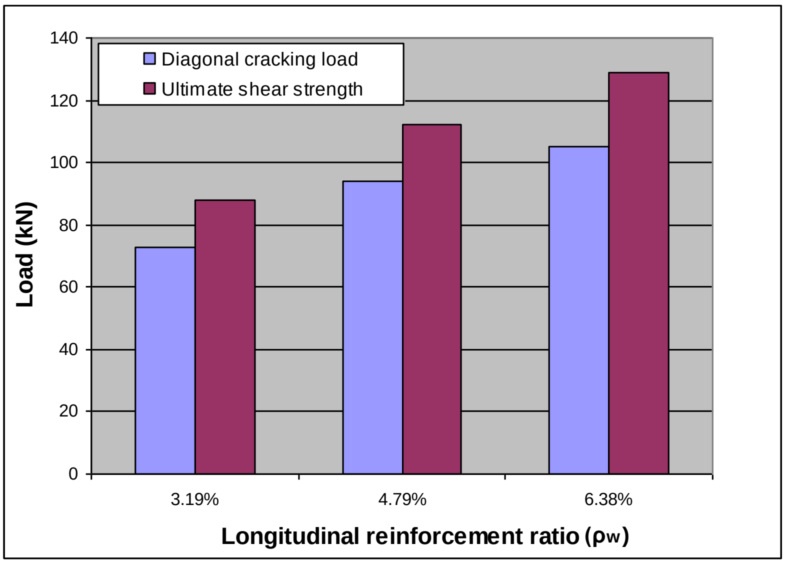


Figure (5) Effect of longitudinal reinforcement ratio (ρ_w) on diagonal cracking load and ultimate shear strength

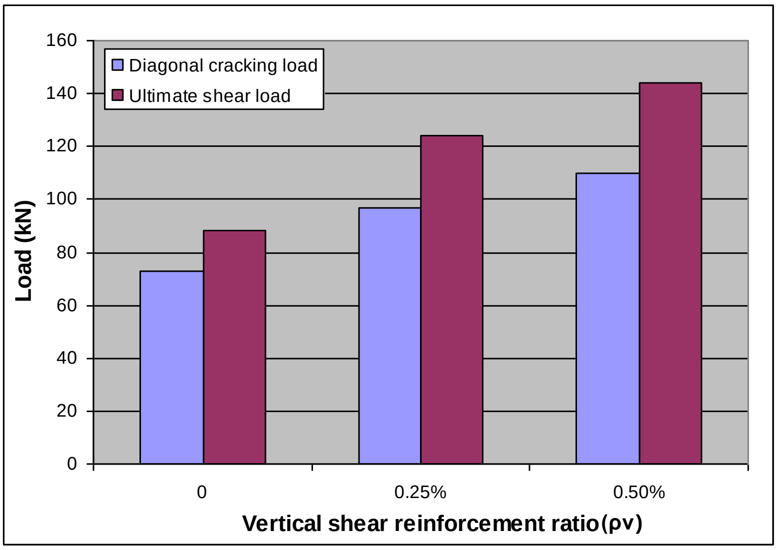


Figure (6) Effect of vertical shear reinforcement ratio (ρ_v) on diagonal cracking load and ultimate shear strength

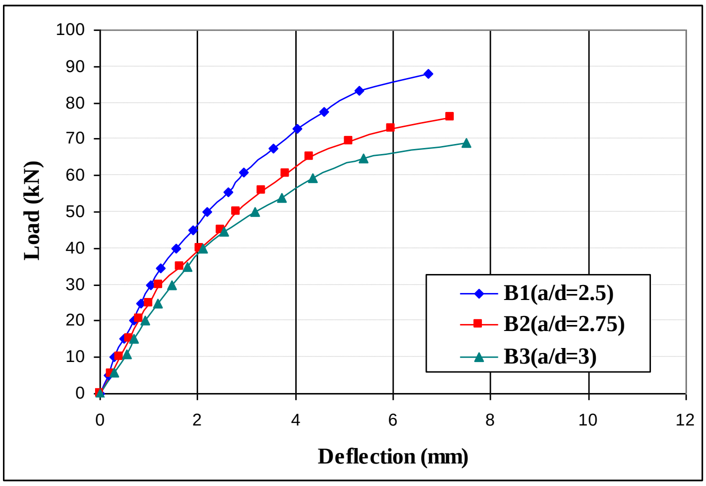


Figure (7) Effect of shear span to effective depth ratio (a/d) on load-midspan deflection curves

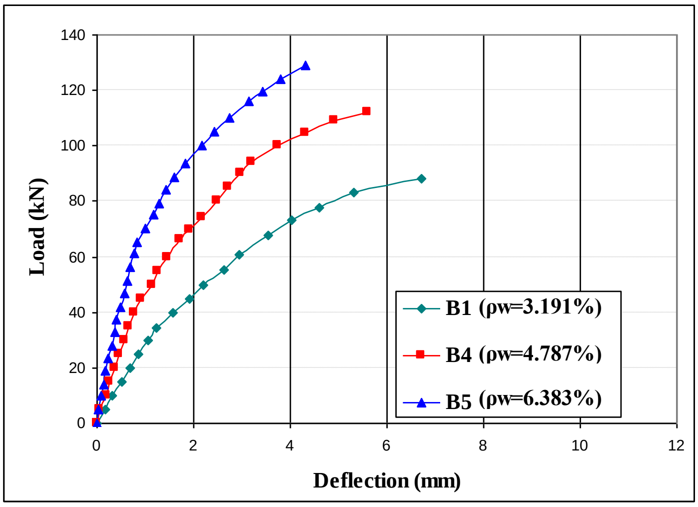


Figure (8) Effect of longitudinal reinforcement ratio (ρ_w) on load-midspan deflection curves

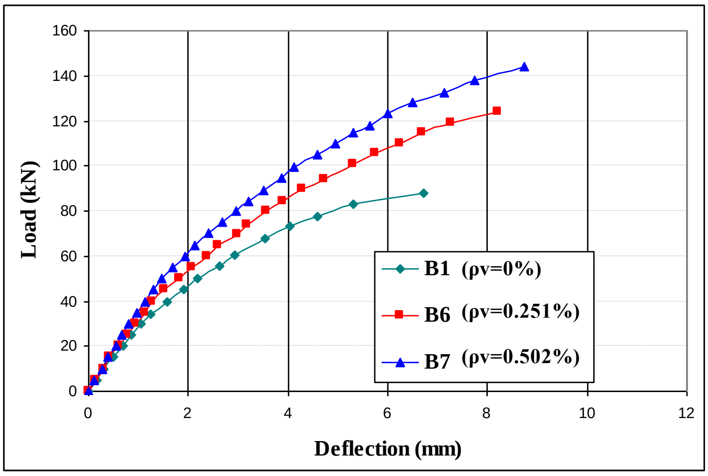


Figure (9) Effect of vertical shear reinforcement ratio (ρ_v) on load-midspan deflection curves

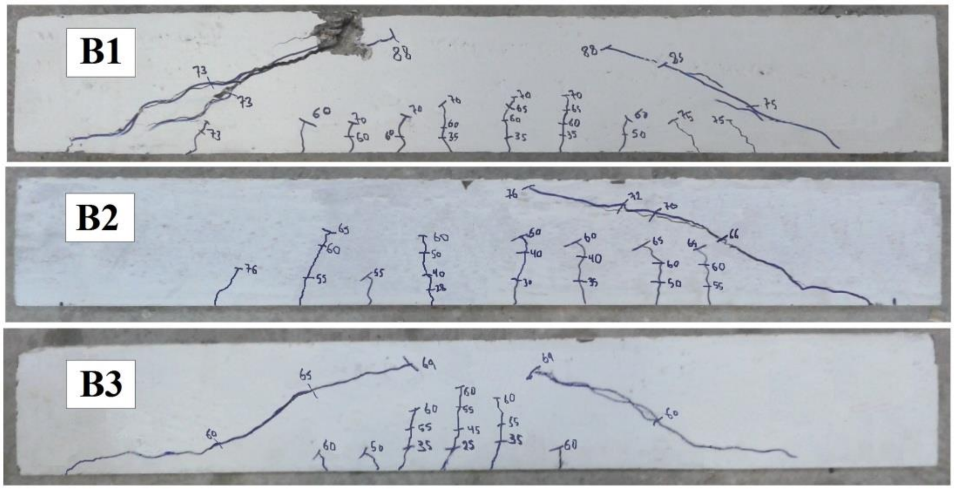


Figure (10) Effect of shear span to effective depth ratio (a/d) on crack pattern at failure

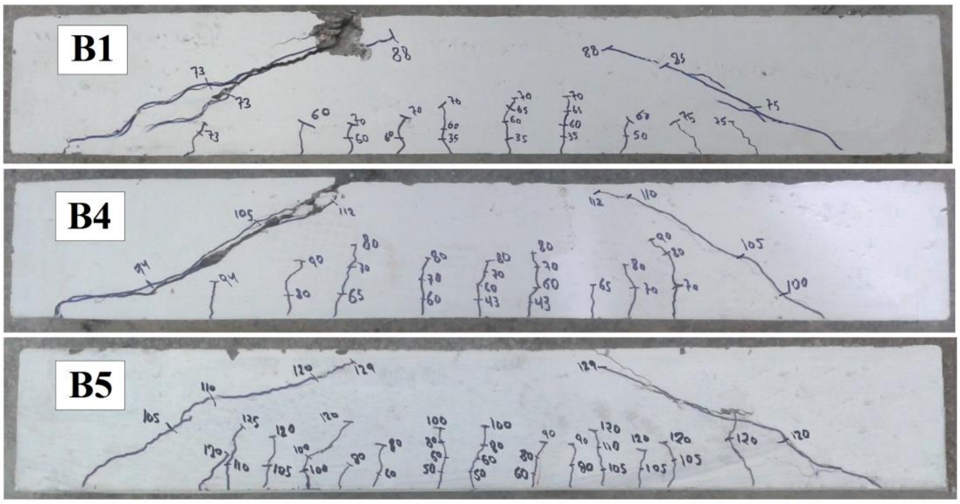


Figure (11) Effect of longitudinal reinforcement ratio on crack pattern at failure

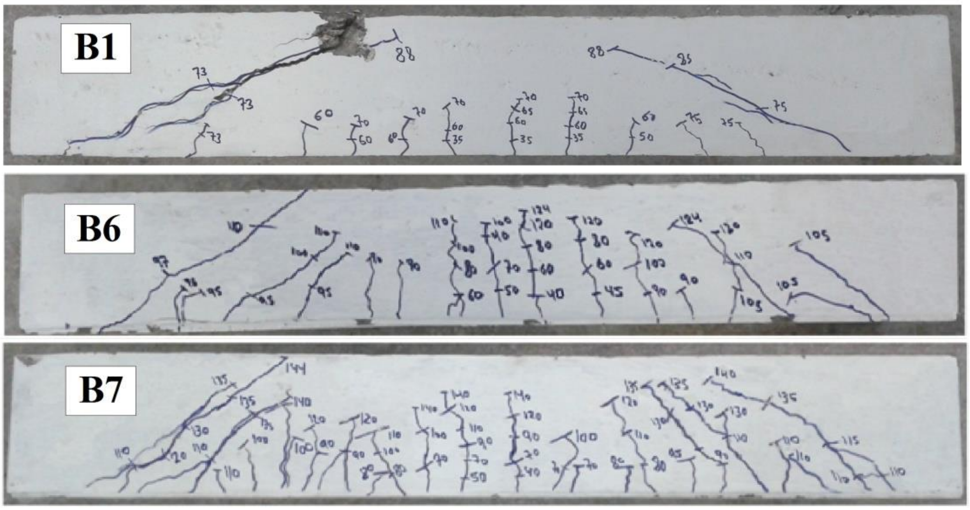


Figure (12) Effect of vertical shear reinforcement ratio on crack pattern at failure

سلوك القص للعتبات ذات الخرسانة ذاتية الرص عالية المقاومة

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الخلاصة

هذا البحث يقدم دراسة عملية لتحري سلوك القص للعتبات النحيفة المكونة من الخرسانة ذاتية الرص ذات المقاومة العالية. البرنامج العملي تضمن اختبار سبعة عتبات بأبعاد ثابتة (١٥٠ملم ارتفاع × ١٢٥ ملم عرض ×١٠٠٠ملم طول) لدراسة تأثير نسبة فضاء القص الى العمق المؤثر ، نسبة حديد التسليح الطولي ونسبة حديد تسليح القص على سلوك القص لهذه العتبات . النتائج العملية بينت ان نسبة فضاء القص الى العمق المؤثر ذات تأثير واضح على نقصان حمل التشقق القطري و مقاومة القص القصوى وزيادة نسبة المطيلية. حيث انه عند زيادة هذه النسبة من ٢,٥ الى ٣ فان النقصان في حمل التشقق القطري و مقاومة القص القصوى كانت بالنسب ١٧,٨٪، ٢١,٦٪ على التوالي ، بينما زادت نسبة المطيلية بنسبة ١٦,٧٪ . كذلك بينت النتائج ان نسبة حديد التسليح الطولي تمتلك تأثيرا مهما على سعة التحمل المكتسبة للقص ونسبة المطيلية، حيث ان زيادة نسبة حديد التسليح الطولي من ٣,١٩١٪ الى ٦,٣٨٣٪ أدى الى زيادة حمل التشقق القطري ، مقاومة القص القصوى ونسبة المطيلية بالنسب ٤٣,٨٪، ٤٦,٦٪ و ٣٧٪ على التوالي. بالاضافة لذلك فقد بينت النتائج ان حديد تسليح القص العمودي يمتلك التأثير الرئيسي في تحسين سلوك القص لهذه العتبات، حيث ان استخدام حديد القص بنسبة ٠,٥٠٢٪ ادى الى زيادة حمل التشقق القطري ، حمل القص الاقصى ونسبة المطيلية بالنسب ٥٠,٧٪، ٦٣,٦٪ و ٤٨,١٪ على التوالي بالمقارنة مع العتبة غير الحاوية على تسليح القص. كذلك وجود حديد تسليح القص أدى الى تغيير نمط الفشل من القصيف الى المطيلي .