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T-Beam Behavior In Flexure With Different Layers Of Concrete In Web And Flange

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Abstract:

This study presents an experimental investigation performed to investigate the behavior of reinforced concrete T-beams with different types of concrete in web and/or flange.

More rational way has been used by strengthening the web and the flange by steel fiber reinforced concrete (SFRC) and strengthening the flange by high strength concrete (HSC). Tests were carried out on six beams, simply supported under a single point loading at mid-span. Two of which were made fully with normal strength concrete (NSC) as reference beams, and the others were made fully or partially with (SFRC) and (HSC) in web and/or flange.

Experimental results show that all specimens behaved linearly up to a loading of (40-48 kN) depending on types of concrete used. The maximum deflection increased by (153%) for a beam with SFRC in both web and flange and by (60.8%) for a beam with SFRC in web and normal concrete in flange while it decreased by (50.22%) for a beam with normal concrete in web and high strength concrete in flange in comparison with the reference beams. No interest change in maximum deflection occurred for a beam with SFRC in web and high strength concrete in flange.

. The first cracking load increased by (161%) for a beam with SFRC in web and high strength concrete in flange and no interest changes occurred for the other beams.

This pattern of combination of concrete types may be useful in T-beams used in bridges or wide spans structures and to reduce the cracking of concrete up to failure.

Key Words: T-beam, High strength concrete, Steel fiber reinforced concrete, First cracking load

الخلاصة

تقدم هذه الدراسة بحثا تجريبيا لدراسة سلوك الأعتاب الخرسانية نوع(تي) باستخدام أنواع مختلفة من الخرسانة في الشفة العليا و/او النصل.

لقد تمت تقوية الخرسانة في النصل باضافة الياف الحديد وتقوية الشفة العليا باستخدام الخرسانة عالية المقاومة وتم اجراء الاختبار على ستة نماذج لاعتاب بسيطة الاسناد سلط عليها حمل مفرد في الوسط.اثنان من هذه النماذج صنعت باكملها من الخرسانة الاعتيادية(بدون اضافات)كنماذج مرجعية بينما تم تصنيع النماذج الاخرى بصورة جزئية او كاملة من الخرسانة المسلحة بالياف الحديد او الخرسانة عالية المقاومة في النصل و/او الشفة .

لقد اظهرت النتائج العملية للاختباران جميع النماذج سلكت سلوكا مرنا الى حد الحمل من ٤٠ كيلونيوتن الى٤٨ كيلونيوتن اعتمادا على نوع الخرسانة المستخدمة.لقد ازداد مقدار الانحراف الأقصى بنسبة (١٥٣ %) للنموذج المصنع كليا من الخرسانة المسلحة بالياف الحديد وبنسبة (٦٠.٨ %) للنموذج الذي يحتوي على الياف الحديد في النصل وخرسانة اعتيادية في الشفة العليا بينما انخفض الحيد الاقصى بنسبة (٥٠.٢٢ %) في النموذج المصنع من خرسانة اعتيادية في النصل وخرسانة عالية المقاومة في الشفة العليا بالمقارنة مع النماذج المرجعية.

لم يحصل تغير ملحوظ في قيمة الانحراف الأقصى بالنسبة للنموذج المصنع من الخرسانة المسلحة بألياف الحديد في النصل والخرسانة عالية المقاومة في الشفة العليا.

لقد ازدادت قيمة الحمل المقابل لاول تشقق في الخرسانة في النموذج المصنع من الخرسانة المسلحة بألياف الحديد في النصل والخرسانة عالية المقاومة في الشفة العليا بينما لم تحصل تغييرات مهمة في النماذج الأخرى.

ان هذا النوع من التعشيق بين الأنواع المختلفة من الخرسانة يمكن الاستفادة منه في المقاطع المستخدمة في الجسور او تلك المستخدمة في تسقيف الفضاءات الواسعة كما انه قد يكون مفيدا في التقليل من التشققات التي تظهر في هذه الجسور.

Notations

f́c : Cylinder compressive strength of concrete.
fy : Yield strength of steel.
HSC : High strength concrete.
NSC : Normal strength concrete.
SFRC : Steel fiber reinforced concrete.

1-Introduction

T-beams have wide importance in bridges decks and an interest in floor or roof simply supported slabs on load bearing walls or girders. This technique of construction is widely used and suitable for residential, commercial, prefabrication and industrial buildings especially for large spans. The importance of using T-beam is that it gives a big compressive area and then increasing the provided reinforcement area which increase the capacity of section.

2- Experimental Study

2-1 Experimental Program

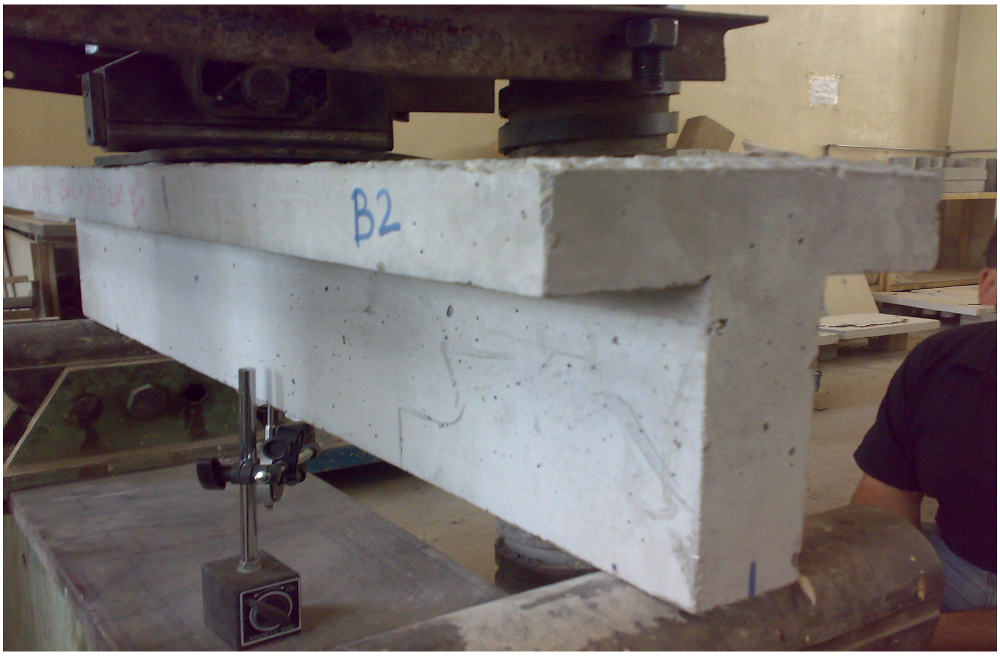
Tests were carried out on six beams, simply supported under a single point load at mid-span to investigate their behavior in bending(4). All beams were under reinforced to insure them to fail in flexure. Maximum shear reinforcement was provided.

The parameters were the concrete types of web and flange. The span, section and reinforcement were kept constant for all tested beams

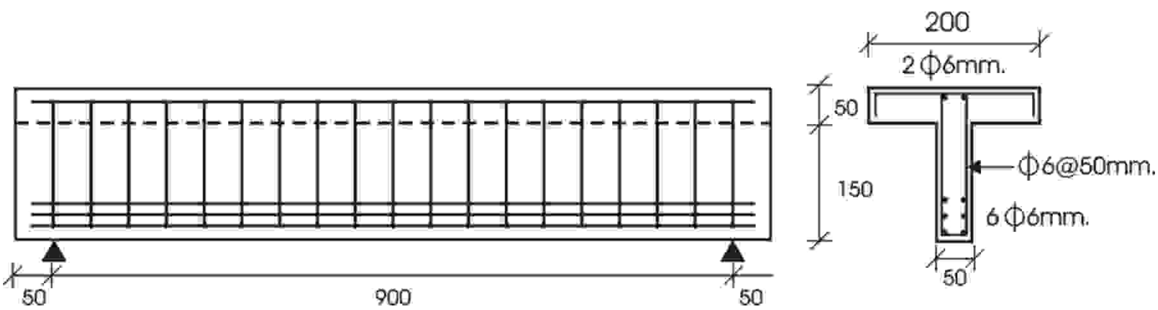
2-2 Specimen Details

Figure(1) (a&b) presents the detailed testing program and nominal dimensions of the tested beams. The main reinforcement consisted of (6ϕ6mm) mild, hot-rolled, smooth steel bars employed as flexural reinforcement and (ϕ6mm @ 50mm) stirrups.

Longitudinal tension reinforcement was bent with (90^{O}) angle at the ends to prevent slip.



(a)



(b)

Fig.(1) Details of tested beams and testing program

Table(1) shows the designation of tested beams and the concrete types used in each beam.

Table (1) Properties of Test Beams

Beam Designation	Type of Concrete	
	Web	Flange
B2&B6 *	NSC **	NSC
B1	SFRC***	HSC****
B3	SFRC	SFRC
B4	SFRC	NSC
B5	NSC	HSC

* Reference beams
** Normal strength concrete(f́c =35 MPa)
*** Steel fiber reinforced concrete
**** High strength concrete(f́c = 50 Mpa)

2-3 Materials

In the experimental program, (ϕ6mm) smooth steel bars having (276 MPa) yield strength were used as flexural reinforcement.

In manufacturing the test specimens, the following materials were used: ordinary Portland cement (Type I); crushed gravel with maximum size of (10mm); natural sand from Al-Ukhaidir region with maximum size of (4.75mm); cramped mild carbon steel fibers with average length of (30mm), nominal cross section of (0.5mm*0.5mm), aspect ratio of (60) and yield strength of (1130MPa) (manufacturer).

The mixes proportions for the NSC, SFRC and HSC are reported and presented in Table (2).

Table (2) Proportions of Concrete Mixes

Parameter	Concrete Type		
	NSC	SFRC	HSC
Water/cement ratio	0.4	0.4	0.30
Water (kg/m^3)	155.2	155.2	116.4
Cement (kg/m^3)	388	388	388
Fine Aggregate (kg/m^3)	582	582	582
Coarse Aggregate (kg/m^3)	1164	1164	1164
Steel Fiber volume (%)	-	1.0	-
Superplastisizer (letter/ m^3)	-	-	3

2-4 Test Measurements and Instrumentation

Hydraulic universal testing machine (MFL system) was used to test the beam specimens. Mid-span deflection has been measured by means of (0.01mm) accuracy dial gauge (ELE type). The dial gauges were placed underneath the bottom face of each span at the middle (Fig.1).

2-5 Test Procedure

All beam specimens were tested using universal testing machine (MFL system) with monotonic loading to ultimate states. The tested beams were simply supported over an effective span of (900mm) and loaded with a single-point load at mid-span.

The beams have been tested at ages of (28) days and they were placed on the testing machine and adjusted so that the centerline, supports, point load and dial gauge were in their locations.

Loading was applied slowly in successive increments. At the end of each load increment, observations and measurements were recorded for the mid-span deflection and crack development and propagation on the beam surface.

When the beams reached advanced stage of loading, smaller increments were applied until failure, at which the load indicator stopped recording any more and the deflections increased very fast without any increase in applied load (2).

The development of cracks (crack pattern) was marked at each load increment. The compressive zone (flange) crashed in all beams at failure except for beam B5 in which the flange manufactured of HSC and the web of NSC. Figures (2 to 7) show the cracks pattern of each beam.

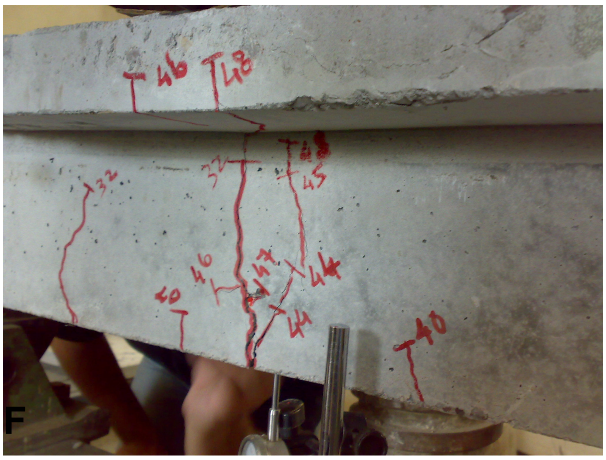


Fig.2 Cracks pattern of beam B1

Fig.3 Cracks pattern of beam B2

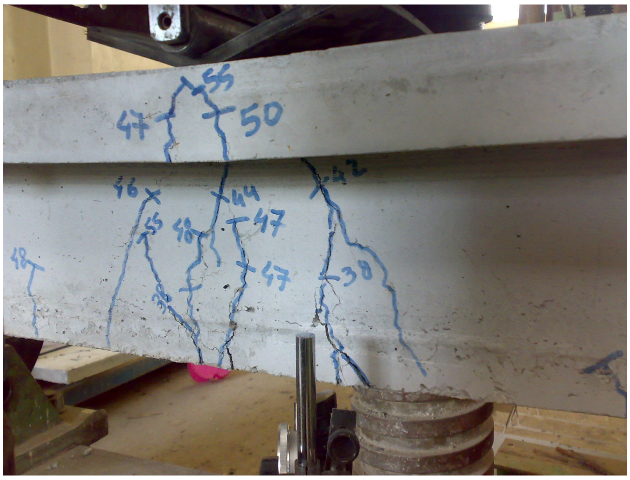


Fig.4 Cracks pattern of beam B3

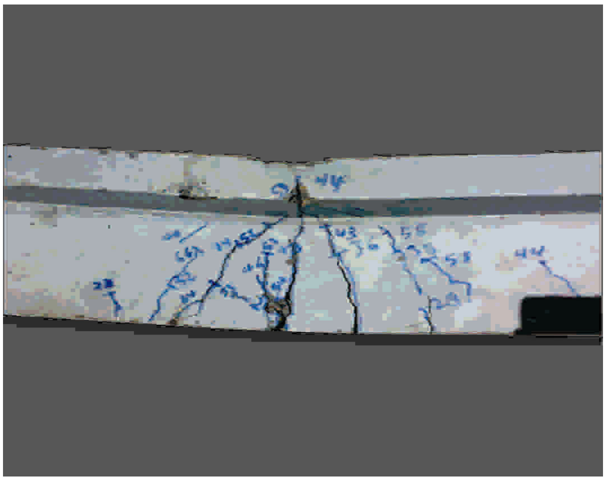


Fig.5 Cracks pattern of beam B4

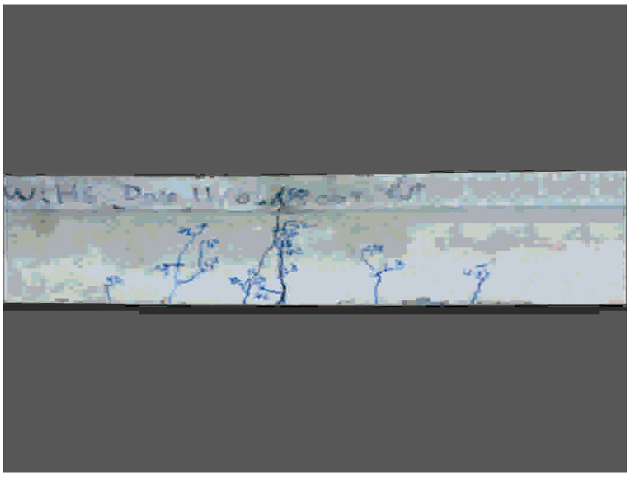


Fig.6 Cracks pattern in beam B5

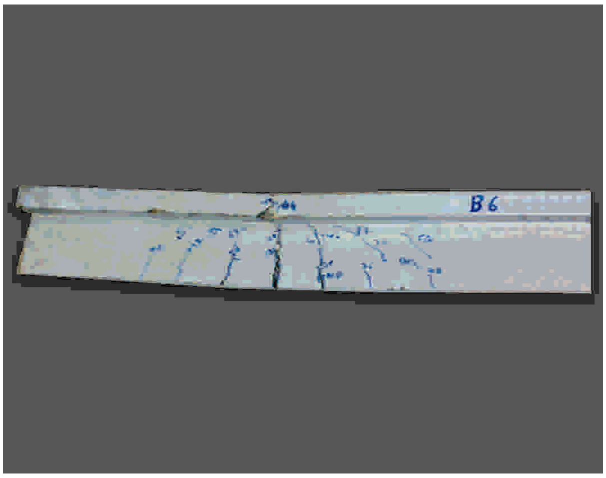


Fig.7 Cracks pattern in beam B6

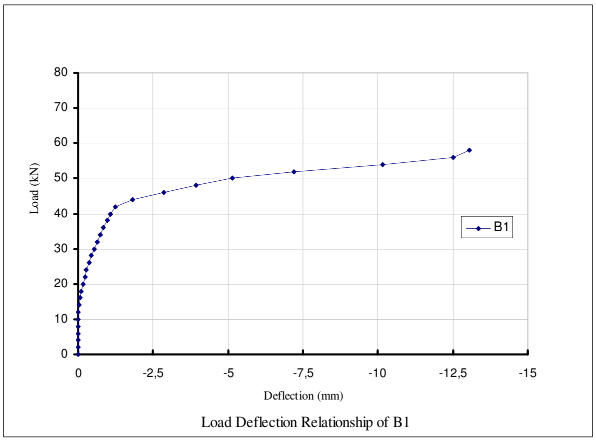


Fig. 8 Load Deflection Relationship For Beam B1

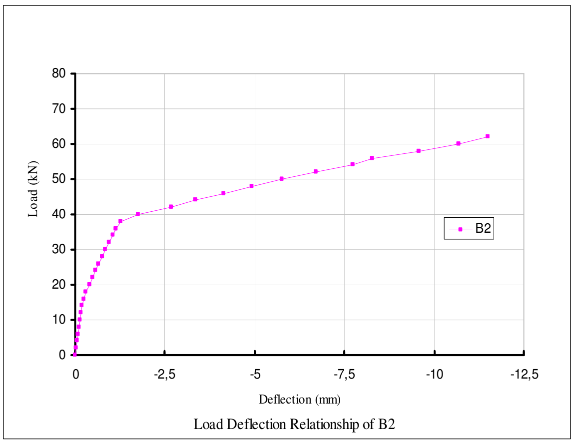


Fig.9 Load Deflection Relationship For Beam B2

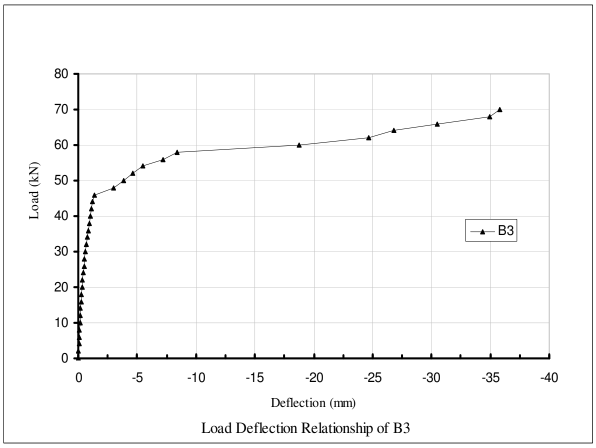


Fig. 10 Load Deflection Relationship For Beam B3

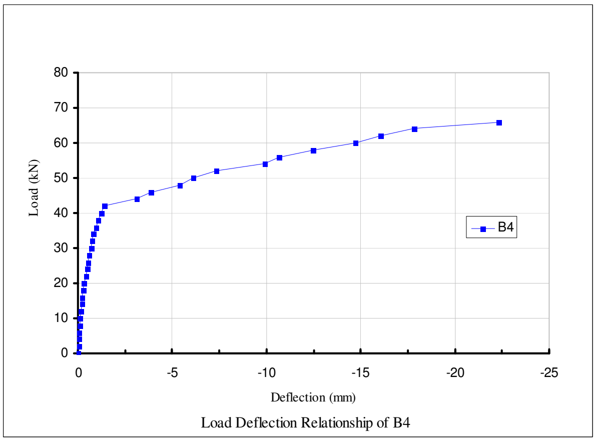


Fig.11 Load Deflection Relationship For Beam B4

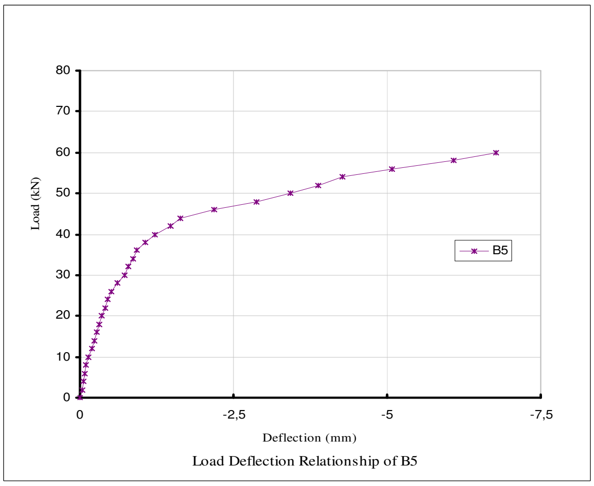


Fig. 12 Load Deflection Relationship For Beam B5

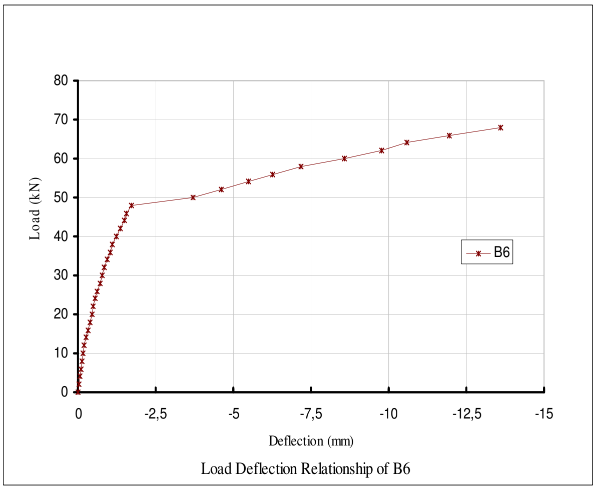


Fig.13 Load Deflection Relationship For Beam B6

Figures (8 to 13) show the load deflection relationships for all specimens.

3- Test Results

All beam specimens behave elastically from zero loading up to loading of about 40-48 kN and then began to give large deflections for relatively small loads except for specimen beam B1 which gave a very small deflection up to a loading of (12 kN).

Fig.8 shows the relationships between the applied load and deflection at mid-span for the six tested specimens. The reference specimen beams B2&B6 with NSC in both web and flange gave a maximum deflection of (14.15 mm) and (13.6 mm) and a first cracking of (10 kN) and (10.5 kN) respectively .The failure loads were (63 kN) for B2 and (68 kN) for B6 and the failure modes were yielding of steel reinforcement first and then crashing of flange.

The specimen beam B1 with SFRC in web and HSC in flange gave (14 mm) maximum deflection. First cracking load was (32 kN) (increasing of 161% in comparison with reference beams) when the failure load was (58.5 kN) .The specimen beam B3 with SFRC in both web and flange gave (35.8 mm) maximum deflection (increasing of 153 %).The failure load was 68.5 kN. For the specimen beam B4 with SFRC in web and NSC in flange the maximum deflection was (22.32 mm) (increasing of 60.8) and the failure load was (65 kN). The specimen beam B5 with NSC in web and HSC in flange gave a maximum deflection of (6.77 mm) (decreasing of 50.22%).The first cracking load was (11 kN) and the failure load was 65 kN).

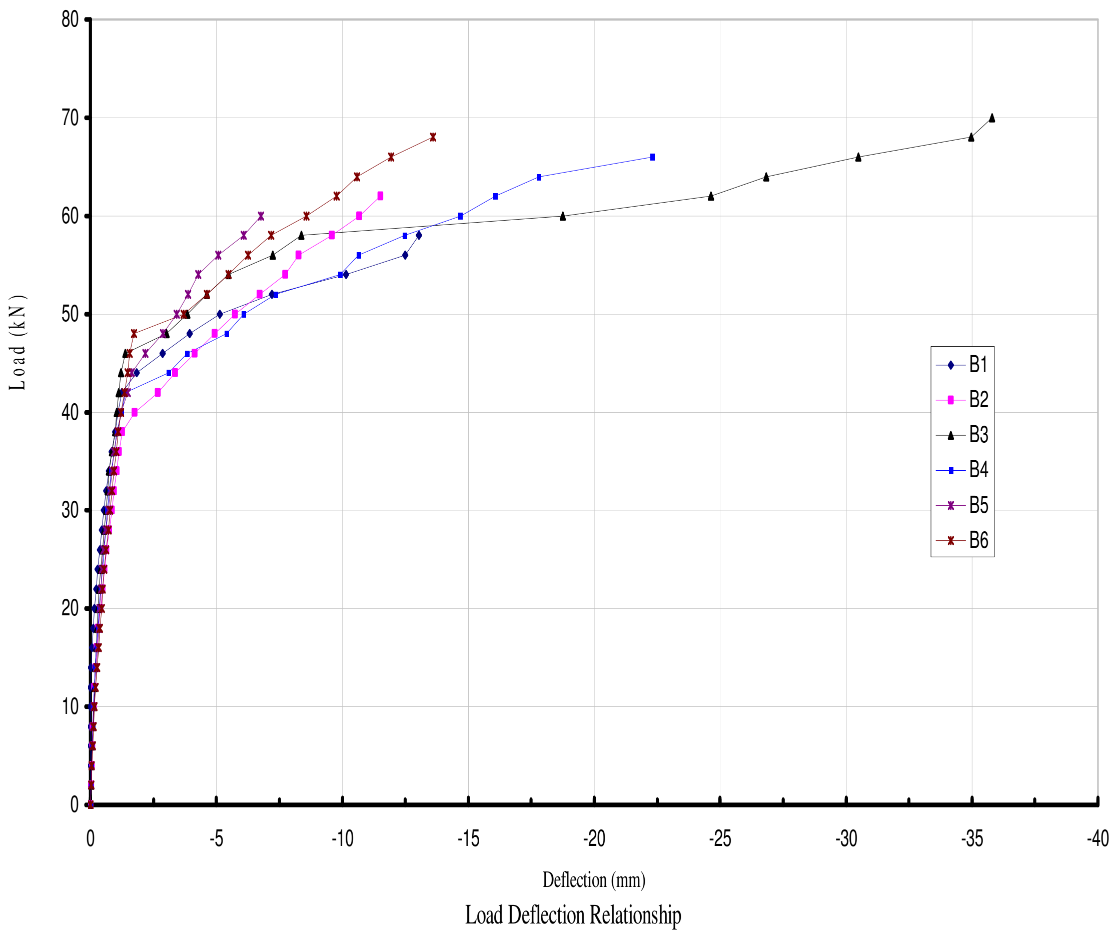


Fig.14 Comparison Of Load Deflection Relationships For All Specimens

4-Conclusions

1-The use of HSC with SFRC in beam B1 gave a very stiff section up to a loading of (18 kN) but approximately with the same ductility for the reference beams.

2-The specimen beam B3 introduce a more ductile behavior and increasing in the maximum deflection of (153 %) because of using SFRC in both web and flange in addition it behave elastically in the beginning and then started yielding at a relatively high load.

3- The use of SFRC with NSC in beam B4 gave a more ductile section with increasing in the maximum deflection of (60.8 %) but less ductility in comparison with B3.

4-A combination of HSC and NSC in beam B5 gave less ductile section for approximately the same section capacity of reference beams but with decreasing in maximum deflection about (46.1 %) .

5-References

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