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FLEXURAL BEHAVIOUR OF CONCRETE-FILLED STEEL HOLLOW SECTIONS BEAMS

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Abstract. This paper presents an experimental study of normal mix, fly ash, quarry waste and low strength concrete (brick-bat lime concrete) contribution to the ultimate moment capacity of square steel hollow sections. Fifteen simply supported beam specimens of 1200-mm long steel hollow sections filled with normal mix, fly ash, quarry waste and low-strength concrete and identical dimensions of hollow sections were experimented. Extensive measurements of such material properties, strain and deflection were carried out. Theoretical studies of ultimate moment capacity of a beam specimen were also calculated in this study for comparison's sake. These experimental investigation results showed that normal mix, fly ash, quarry waste and low-strength concrete enhance the moment carrying capacity of steel hollow sections. Furthermore, in these studies it can be found that normal mix, fly ash and quarry waste concrete can be used in composite construction to increase the flexural capacity of steel hollow sections.

Keywords: in-filled beams, two-point load, analytical model, ultimate moment capacity.

1. Introduction

Steel–concrete composite section is a new idea, for beams comprising hollow steel elements with an infill of concrete that are suitable as replacement for hot-rolled steel (or) reinforced concrete in small-to medium sized building. The structural advantages of a composite versus a non-composite construction may be thus summarized as follows:

Depth of steel beam is reduced to support a given load.

An increase in the capacity (on a static ultimate load basis) is obtained over that of a non-composite beam.

For a given load, a reduction in dead loads and construction depth, in turn, reduces the storey heights, foundation costs, panelling of exteriors, heating, ventilating and air-conditioning spaces, thus reducing the overall cost of a building.

The major effect of the composite action is to force the steel and the concrete to act together which shifts the neutral axis of the section upward. This leaves the concrete above the neutral axis in compression and forces almost the whole steel beam below the neutral axis into tension. The composite beam is generally much stiffer than the equivalent non-composite beam, so the deflection of the composite beam would be less.

The inherent advantages of this system are derived from its structural configurations. Concrete filled hollow steel sections for beams will allow easy casting of in-fill concrete. These sections do not require temporary formwork to infill concrete as the steel acts as formwork in the construction stage and as reinforcement in the service stage. They are simple to fabricate and construct compared to conventional reinforced concrete, where skilled workers are needed to cut and bend complex forms of reinforcement.

The infill concrete is less likely to be affected by adverse temperature and winds, as experienced in case of reinforced concrete. The infill concrete is generally cured quickly and, in any case, the load capacity of the steel alone may be required upon the almost construction loads. The steel sections can be designed, primarily, for the construction load of wet concrete, workmen and tools.

Hunaiti (1997) conducted a study on the strength of composite sections with foamed and lightweight aggregate concrete. In this research, test specimens of square steel hollow sections and square sections filled with foamed and lightweight concrete were used to investigate the contribution of these concretes to the strength of cross-sections of composite members.

There are few studies covering steel hollow beams filled with normal concrete and lightweight concretes. Some studies considered only the lightweight concrete (lightweight aggregates were produced from a wide variety of raw materials including clay, shale, slate pumice and pearlite) and foamed concrete filled steel hollows (Assi *et al.* 2003). From this study find moment carrying capacity of the filled section.

Tests conducted by Ghannam *et al.* (2004) on steel tubular columns of square, rectangular and circular sections filled with normal and lightweight aggregate concrete were conducted to investigate the failure modes of

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such composite columns. The interest of this research is due to a low specific gravity and thermal conductivity of the lightweight concrete for replacing the normal concrete and lightweight aggregate concrete. The columns filled with lightweight concrete exhibit local buckling when the column reached failure load and an overall buckling took place. Such negative effect (local buckling) does not significantly reduce the load-carrying capacity of the column. Also, a low specific gravity and thermal conductivity of lightweight aggregate concrete is a good possibility to replace normal concrete and lightweight aggregate concrete.

Ramana Gopal and Devadas Manoharan (2004) study the behaviour of fibre reinforced concrete filled steel tubular columns. In this study 16 specimens were tested to investigate the bending moment capacity of fibre reinforced concrete-filled tubular columns of both short and slender sections. A comparison was also performed for similar empty and filled sections. Concrete-filled steel tubular columns showed a large enhancement of load-carrying capacity as compared to hollow steel tubular columns which also sustain large strains and deformations.

Lapko *et al.* (2005) conducted experiments on reinforced concrete composite beam; the tests were prepared in full scale with the cross-section of 120×200 mm and the effective span of 2950 mm. The basic samples were composed in two layers consisting of high-performance concrete as the top layer and normal strength concrete. The results confirm a significante improvement of structural properties of composite beams in comparison with the beams prepared by normal concrete and the same case in comparison with the HPC.

Mahasneh and Gharaibeh (2005) present an experimental study of the plain concrete and fibre-reinforced concrete filled steel pipe column; the column strength is governed by the composite action of both steel and concrete. The study result is significant for understanding the behaviour of filled steel pipes, i.e. the increase in ductility of confined concrete is related to the stiffness of the confining device. Concrete expands under uniaxial compression device; the steel cylinder is affected by hoop tension, which will provide a continuous confining load around the circumference of the enclosed concrete. The use of fibre reinforcement does increase the maximum carried load for all samples. The aspect ratio also affects the strength. An increase in aspect ratio will decrease the strength of confined samples.

Han, Yao and Zhao (2004) found a mechanics model in this research paper also conducted an experimental on concrete-filled steel CHS beam-columns. The parametric and experimental studies provide information for developing formulas when calculating the ultimate strength of the composite beam-columns. Also, a comparison was made with existing codes, such as LRFD-AISC-1999, AIJ-1997, BS5400-1979 and EC4-1994.

Based on the tests conducted by Hunaiti (2003) on battened composite sections at the age of 5 years, the bond between the steel section and concrete shows considerable strengthening, when compared with results at the age of one year. The results show that the bond strength at the age of 5 years is about two and one-half times of that of one year. This is mainly due to steel rusting at the surface of contact with concrete, which increases mechanical keying due to micro-irregularities, thus enhancing the bond of two materials.

There were 4 main types of concrete filling used in this study, such as normal mix concrete (designated NMC), fly ash concrete, quarry waste concrete (designated FAC, QWC) and low-strength concrete (brickbat lime concrete) (LSC) for comparison purpose.

The British Standards Code of practice for design of composite bridges – BS5400 (Steel 1979) does not permit to use the concrete other than normal weight concrete of a density less than 2300 kg/m^3. Other codes such as Eurocode 4 (Common 1985) and the European recommendations (Composite Structures 1981) permit using lightweight concrete of strength not less than 20 MPa.

Tests of steel hollow of square sections infill with normal mix, fly ash, quarry waste and low strength concrete were conducted to investigate the contribution of these concretes to the strength of the cross-section of composite members.

Unfilled steel sections of similar specimens were also tested and results were compared to those of filled specimens. Also, the ultimate moment capacity values obtained from CIDECT standard included in this study and compared to the experimental values.

The current study led to the development of a novel form of concrete in-filled steel hollow composite beams with recommendations on the use of locally available economical material as infill. In this research an analytical model is also developed for comparison purpose.

2. Analytical consideration by stress-strain block approach

In calculating the capacity of a composite member, the strength of cross-section, which is usually expressed in terms of the ultimate moment of resistance, is a basic requirement. The computation is based on these properties in a full plastic stress distribution. The analysis is based on the following assumptions:

- Initially plane sections remain plain after bending and normal to neutral plane.
- All steel is at yield stress equal to $f_{sk} = f_y / \gamma_{ms}$ (for steel) (γ_{ms} = 1.0).

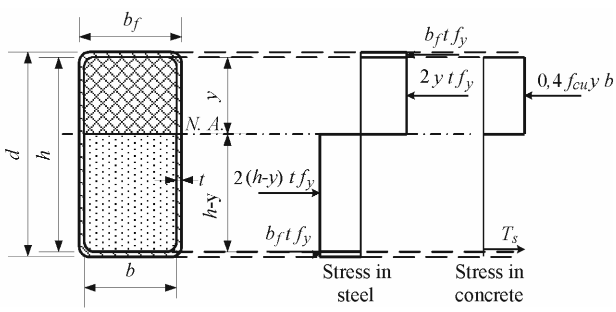


Fig. 1. Stress distribution in concrete-filled hollow sections at M_u

- Concrete in tension is ignored and the concrete above the neutral axis is under a uniform compression stress:
  $f_{ck} = 0.67 \cdot f_{cu} / \gamma_{mc} = 0.67 f_{cu} / 1.5 = 0.4 f_{cu}$.
  (γ_{mc} =1.5)

As defined by the stress distribution in Fig. 1, the depth of the neutral axis can be determined from the static equilibrium by equating the compressive and tensile forces, thus the depth of the neutral axis y is given by

$$y = (As - 2b_f t)/(4t + \rho b),$$

where ρ, the concrete-to-steel strength ratio, is given by

$$\rho = f_{ck} / f_{sk} = 0.4 f_{cu} / f_y.$$

Also, from the Fig. 1, the ultimate moment of resistance can be obtained by taking moments about the line of action of the compressive in concrete, and thus ultimate moment of resistance

$$M_{u(the)} = f_y[b_f t(t+y) + t\,y^2 + t(h-y)^2 + b_f t(t+(h-y))].$$

In calculating the $M_{u(the)}$, a value (0.67 f_{cu}) was used for the characteristic concrete strength. Moreover, based on "code of practice for reinforced cement concrete", IS-456-2000 the material safety factors of concrete and steel, γ_{mc} and γ_{ms} were taken as 1.50 and 1.00, respectively.

3. Experimental programme

3.1. Description of composite beam

Comprehensive series of tests were conducted to study the behaviour of concrete filled SHS beams. Table 1 shows the specimen designation, dimensions of steel sections and the type of concrete filler for each test specimen. Each mix proportion consists of 3 specimens. The specimens were designated as normal mix concrete (NMC), fly ash concrete (FAC), quarry waste concrete (QWC) and low strength concrete (LSC) and hollow steel section (designated HS).

All the steel hollows used in the present investigation were factory-made products. They are produced by TATA STEEL INDUSTRIES, India. The length of a specimen is 1.2 m. The size and thickness of section are 72×72×3.2 mm of square section. Grade of steel is Y_{st} 310 as per IS 4923:1997 "INDIAN STANDARD HOLLOW STEEL SECTIONS FOR STRUCTURAL USE – SPECIFICATIONS".

Ordinary Portland cement (OPC-43 grade) was used for the entire investigations. The required quantity was procured as single batch. The physical properties of the above cement tested as shown in Table 3. The standard procedure confirmed the requirements of I.S.12269-1989. A locally available river sand conforming to zone II of IS 383 (1970) is used. The coarse aggregate of 8–10 mm size, granite stone supplied by the local quarry was used. Ordinary potable water available in the laboratory was used for experimental investigations and for curing purposes.

Pulverized fly ash or fly ash in the form of extremely small particles and whose chemical constituents of the original clay minerals in the coal was obtained by the residue from modern thermal power station. Fly ash procured from Neyveli Thermal power plant was used as replacement of a binder. The cement replacement is 20 %. The quarry wastes are procured from near by quarry mines. Fat limes were used.

3.2. Material test

To find the actual properties of steel specimen, three coupons from three faces of the steel hollow sections were taken and tested to failure under tension according to the IS: 1608-1972 "Indian standard method for tensile testing of steel products". The average yield stress (f_y) and ultimate stress (f_u) of the steel hollow sections is in Table 2.

To prevent the premature buckling failure of steel hollow specimens, the allowable B/t ratio of the steel hollow sections specified in EC4 as shown below was referenced.

$$B/t \le 52\sqrt{235/f_y},$$

where f_y = steel yield stress in N/mm^2, B = depth of the section, t = thickness of the section.

The allowable d/t limits for the square steel hollow section (72×72×3.2 mm) was determined as 20.5, as shown in Table 2.

The steel hollow specimens were filled with concrete in many layers and carefully compacted by a steel rod to avoid any gaps that occur inside the specimen. Three 150 mm cubes were prepared for each type of concrete mix to determine the average compressive strength. These cubes were cured in water tanks with a curing period of 28 days and tested at almost the same time of the corresponding beam specimen. The average cube strength of the four different batches were determined as 32.6 N/mm^2, 32.5 N/mm^2, 21.63 N/mm^2 and 0.88 N/mm^2 respectively, as shown in Table 4.

3.3. Test set up

All beam specimens were of a span length of 1200 mm and placed in simply supported by 40 mm diameter steel rods shown in Fig. 2. The beams were tested under two point loading applied at the centre of a very rigid plate to ensure the load distribution.

Deflections of the beam specimens were measured by three-dial gauges. One was placed at the mid span of the specimen, the other two were placed at under concentrated loads.

Four strain gauges were bonded in the specimen, two gauges in top and bottom centre of specimen and two in front face of the loading direction as shown in Fig. 2. The strain gauges were used to determine the maximum compressive and tensile strains.

The test specimens were instrumented to measure loads and strains. The beams were tested under two-point load in a 40-tonne capacity universal testing machine. The instruments were controlled and calibrated according to standard specifications (Fig. 3).

Table 1. Details of test specimens

Specimen designation	Dimensions (mm) ($D.\ B_f.\ t$)	Area of steel A_s (mm^2)	Area of concrete (A_c) (filled section) mm^2	Types of filled concrete
NMC	72×72×3.2	881	4303	Normal mix concrete
FAC	72×72×3.2	881	4303	Fly ash concrete
QWC	72×72×3.2	881	4303	Quarry waste concrete
LSC	72×72×3.2	881	4303	Low strength concrete
HOLLOW(HS)	72×72×3.2	881	–	Hollow section

Table 2. Yield and ultimate stress of steel sections

Dimensions of steel section (mm)	d/t ratio	Yield stress f_y (Mpa)	Ultimate stress f_u (Mpa)
72×72×3.2	20.5	345	510

Table 3. Physical properties of cement (opc 43 grade)

Property	Value
Consistency	33 %
Initial setting time	30 min
Final setting time	10 hr
Specific gravity	3.1

Table 4. Details of concrete mixes

Type of concrete (Designation)	28-days cube strength (N/mm^2)	28-days cylinder strength (N/mm^2)
Normal mix concrete	32.6	26.08
Fly ash concrete	32.5	20.70
Quarry dust	21.63	17.30
Low strength concrete	0.88	0.70

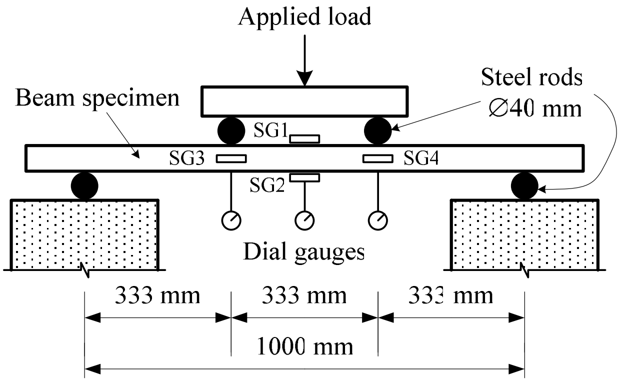


Fig. 2. Details of loading system for beam specimens

Load interval of less than one-tenth of the estimated load capacity was used. Each load interval was maintained for about 2–3 min at each load increment. Allspecimens were loaded to failure. They behaved in a purely flexural manner. Primary tension failure occurred in all beams with no lateral deformation or any other form of instability. All specimens exhibited a ductile failure, which highlighted good performance of this type of composite beams.

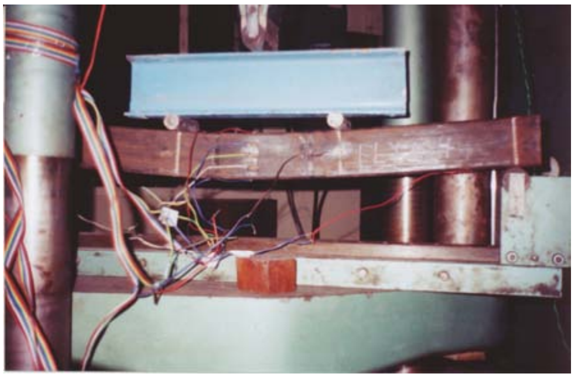


Fig. 3. Testing arrangement of beam specimen

4. Results and discussion

All beams behaviour was predicted during the test. They have reached ultimate moments with no signs of lateral movement of the cross-section or any other instability form. In other words, the beam specimens developed the full flexural strength of the section. The experimental results of this study demonstrated the predominant failure mechanism of the beam specimens to be excessive deflection accompanied with some local distortions near the points of load applications at a stage very close to maximum loading.

The tested beams failed in a very ductile manner. No tension fracture was observed on the tension flange. Typical failure modes of the concrete filled steel specimens are in Fig. 4.

Each void-filled specimen was bent to a maximum angle of (θ) of 29°. The rotation angles, when the ultimate moment is reached for void-filled SHS beams, are shown in Table 5, for the section filled with normal mix concrete, fly ash concrete, quarry waster concrete and low-strength concrete respectively. They are compared in hollow SHS beams at yield strength. From the rotation of θ_{filled}/θ_y increase in rotation angles at ultimate moment is about 300 %. Fig. 5 shows the increase in rotation angle at the ultimate moment. It can be concluded that void filling significantly increases the ductility of SHS beams.

Fig. 4. Failure mode shape

The measured strains were used to determine the bending curvature. Typical moment V_s curvature graphs are shown in Fig. 6. The moment V_s curvature graph shows that there is an initial elastic response, then inelastic behaviour with gradually decreasing stiffness, until the ultimate moment is reached.

The measured bending moment V_s extreme fibre compressive and tensile strains are shown in Fig. 7a to Fig. 7e. It was found that yield strain values obtained during the test were in the permissible limits of 0.003.

The measured load V_s mid-span deflections are in Fig. 7f. From the curve showed that all filled beam specimen established similar behaviour to that the hollow steel sections but with an increasing ductility.

The experimental ultimate moment of resistance are compared with the theoretical ultimate moment of resistance $M_{u(exp)}/M_{u(the)}$ results as in Table 6. In addition, the experimental ultimate moment capacity of filled beams is compared to the hollow steel sections by considering the ratio of $M_{u(exp)}/M_{u(pla)}$ as shown in Table 6.

The test results of this study showed that the enhancement of the ultimate moment capacity of filled beam using normal mix concrete reached maximum value up to 125 %, fly ash concrete reached maximum value up to 125 %, quarry waste concrete reached maximum value up to 125 % and the low-strength concrete reached maximum value of 116 %. The test results of a square hollow section showed that the beam specimens filled with normal mix concrete failed at moment in the range of 15–25 %. Fly ash concrete failed in the range of 19–25 %. The beam specimens filled with quarry waste concrete failed at moment was in the range of 19–25 %. Furthermore, the test results of square hollow sections specimens filled with low-strength concrete (brick bat lime concrete) failed at moment in the range of 11–16 %.

The prediction moment (M_{CIDECT}) based on CIDECT standard was compared with experimental ultimate moment ($M_{u(exp)}$), as shown in Table 7. It can be seen that it underestimates the ultimate moment capacity. This is mainly because of the ultimate tensile yield stress (f_u) rather than of the tensile strength. If the tensile strength (f_y) is used to replace ultimate yield stress (f_u), a better prediction is obtained.

Table 5. Rotation angles at ultimate moment

Size of hollow specimen	θ_y	θ_{NMC}	θ_{FAC}	θ_{QWC}	θ_{LSC}	θ_{Pla}	$\frac{\theta_{NMC}}{\theta_y}$	$\frac{\theta_{FAC}}{\theta_y}$	$\frac{\theta_{QWC}}{\theta_y}$	$\frac{\theta_{LSC}}{\theta_y}$
72×72×3.2	8°	29°	25°	26°	26°	21°	3.625	3.125	3.25	3.25

Table 6. Results of beam specimens

Beam specimen	P_e KN	$M_{u(exp)}$ kN-M	$M_{u(the)}$ kN-M	$M_{u(Pla)}$ kN-M	$M_{u(exp)}$/ $M_{u(the)}$	M_u(exp)/ $M_{u(Pla)}$
NMC-1	61	10.06	8.30	8.20	1.21	1.23
NMC-2	58	9.57	8.30	8.20	1.15	1.17
NMC-3	63	10.40	8.30	8.20	1.25	1.27
FAC-1	60	9.90	8.30	8.20	1.19	1.21
FAC-2	61	10.07	8.30	8.20	1.21	1.23
FAC-3	63	10.40	8.30	8.20	1.25	1.27
QWC-1	59	9.74	8.21	8.20	1.19	1.19
QWC-2	60	10.00	8.21	8.20	1.22	1.22
QWC-3	62	10.23	8.21	8.20	1.25	1.25
LSC-1	55	9.10	8.22	8.20	1.11	1.11
LSC-2	56	9.24	8.22	8.20	1.12	1.13
LSC-3	58	9.57	8.22	8.20	1.16	1.17
HS1	54	8.91	---	8.20	---	1.09
HS2	55	9.08	---	8.20	---	1.11
HS3	57	9.41	---	8.20	---	1.15

Table 7. Comparison of experimental and CIDECT standard values

Sl. No.	Specimen	$M_{u(exp)}$ kN-m	CIDECT (based on f_y)		CIDECT (based on f_u)	
			M_{CIDECT}	$\frac{M_{u(exp)}}{M_{CIDECT}}$	M_{CIDECT}	$\frac{M_{u(exp)}}{M_{CIDECT}}$
1	NMC-1	10.06	9.84	1.02	13.84	0.73
2	NMC-2	9.57	9.36	1.02	13.16	0.73
3	NMC-3	10.40	10.16	1.023	14.29	0.73
4	FAC-1	9.90	9.68	1.023	13.61	0.73
5	FAC-2	10.07	9.84	1.023	13.84	0.73
6	FAC-3	10.40	10.16	1.023	14.29	0.73
7	QWC-1	9.41	9.52	0.99	13.39	0.70
8	QWC-2	9.08	9.76	0.93	13.73	0.66
9	QWC-3	9.90	9.98	0.99	14.06	0.70
10	LSC-1	8.10	8.88	0.91	12.49	0.65
11	LSC-2	7.76	9.04	0.86	12.71	0.61
12	LSC-3	8.42	9.36	0.90	13.13	0.64

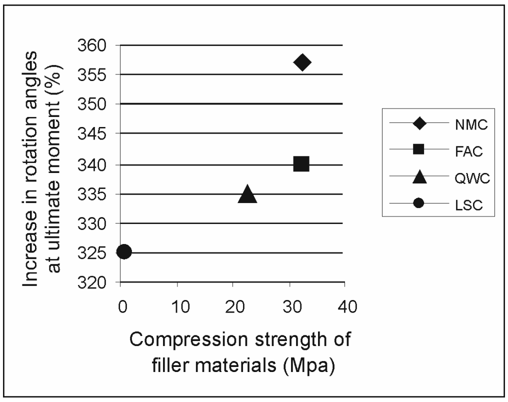


Fig. 5. Increase in rotation angles at ultimate moment

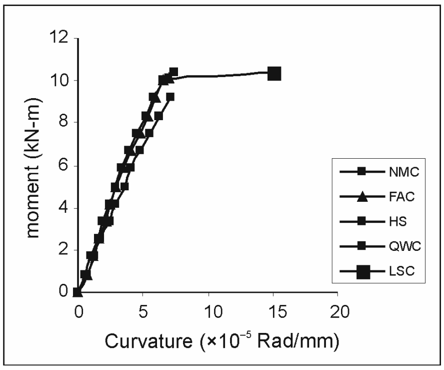


Fig. 6. Moment V_s curvature

It was observed that low-strength concrete (LSC) has a lower bond strength than normal mix concrete, fly ash concrete and quarry waste concrete. It seems to be important factor for reducting the strength in low-strength concrete beams. Also, it was observed that beam specimens filled with low-strength concrete (brick bat lime concrete) have less ultimate loads at failure than those filled with normal mix, fly ash, quarry waste concrete. It is because the filler material and binding material (brick bat and lime) is of a very low strength. Generally, mechanical shear connectors are normally unnecessary to develop the complete interaction in concrete-filled steel sections (Assi *et al.* 2003).

Thus we have observed that the flexural capacity of beam is increased when filling is carried out. From the above study, we can understand that there was no significance difference observed compared to normal mix concrete, fly ash concrete and quarry waste concrete. There is a slight difference in low strength concrete, as we have observed.

Because of the infill of concrete, the SHS beams behaved in a relatively ductile manner, the test proceeded in a smooth and controlled way. The enhanced structural behaviour of the beams can be explained by establishing a "composite action" between steel hollows and the concrete core.

CIDECT Standard

The ultimate moment capacity for concrete-filled SHS sections can be expressed as

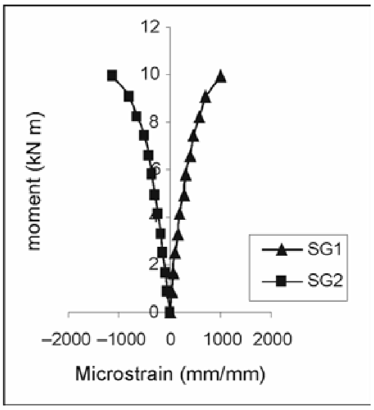
$$M_{uCIDECT} = M_{ratio.} \frac{D^2 \cdot B - (D - 2 \cdot t)^2 \cdot (B - 2 \cdot t) \cdot f_y}{4},$$

where M_{ratio} = ratio of the bending capacity of composite hollow section to that of the hollow section, D = depth of the section, B = breadth of the section, T = thickness of the section, f_y = yield stress.

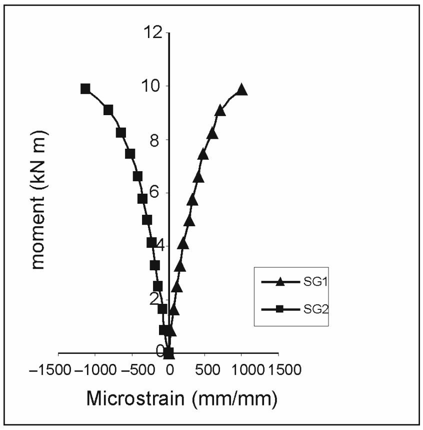
5. Conclusions

The test conducted in this study on normal mix concrete, fly ash concrete, quarry waste concrete and low strength concrete filled steel SHS sections may be finished with the following conclusions.

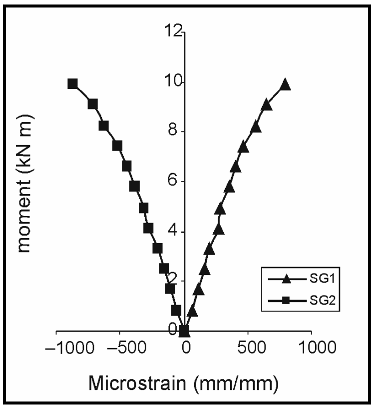
When filling is carried out, the ultimate moment capacity of filled beams is increased by 25 % for normal mix concrete, fly ash concrete and quarry waste concrete, and 16 % for low strength concrete.



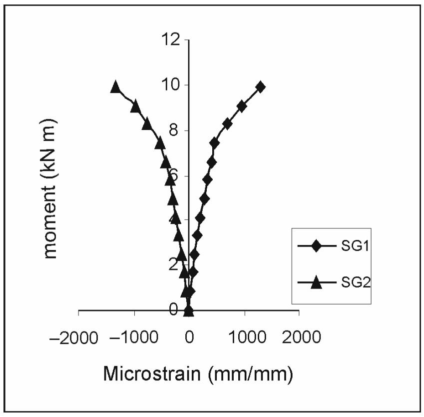
a – Hollow section (HS)



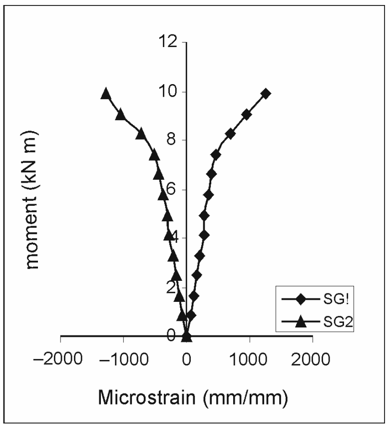
b – Normal mix concrete (NMC)



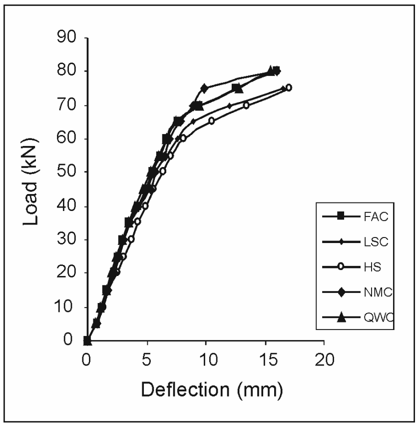
c – Fly ash concrete (FAC)



d – Quarry waste concrete (QWC)



e – Low strength concrete (LSC)



f – Mid-Span deflection

Fig. 7. Square section: moment V_s strain & load V_s mid-span deflection

It can be seen that void filling increases the ultimate moment capacity of SHS beams.

Beams filled with normal mix concrete, fly ash concrete, quarry waste concrete and low strength concrete of flexural behaviour were capable of developing the full flexural strength of their sections. Moreover, normal mix concrete, fly ash concrete, quarry waste and low strength concrete enhance the ultimate moment capacity of the steel hollow sections.

All specimens demonstrated favourable post-yield behaviour with a good ductility performance.

From the experimental results of the current investigation, it can be concluded that the failure mechanism of the beam sections result in an excessive deflection with no lateral disturbances or any other form of instability.

The difference in percentage of increase is due to the different compressive strengths of the filler material.

Fly ash concrete (with 20 % of cement replacement), quarry waste concrete give a very close value of normal mix concrete. So, FAC and QWC, when used as composite construction, give an economy.

Finally, the tests conducted in this investigation confirm, that normal mix concrete, fly ash concrete and quarry waste concrete can be used as infill material in composite construction to increase the flexural capacity of steel sections.

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Notations

A_c	Cross-sectional area of concrete,
A_s	Cross-sectional area of steel,
b	Internal breadth of the section,
b_f	External breadth of the section,
D	External depth of the section,
h	Internal depth of the section,
f_{ck}	Characteristic strength of concrete,
f_{cu}	Characteristic 28-day cube strength of concrete,
f_y	Yield strength of structural steel,
$M_{u(the)}$	Ultimate theoretical moment of resistance,
$M_{u(exp)}$	Ultimate experimental moment resistance,
$M_u(_{pla})$	Ultimate plastic moment of hollow steel section,
t	Thickness of steel section,
y	Depth of neutral axis,
z_p	Plastic section modulus of the steel beam.

BETONŠERDŽIŲ PLIENINIŲ STAČIAKAMPIO SKERSPJŪVIO VAMZDINIŲ SIJŲ ELGSENA

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S a n t r a u k a

Pateikiamas normalaus, lakiųjų pelenų, akmenų skaldymo atliekų ir mažo stiprumo (skaldytųjų plytų kalkinio) betonų įtakos kvadratinio skerspjūvio plieninių vamzdžių ribinei lenkiamajai galiai eksperimentinis tyrimas. Išbandyta penkiolika dviatramių sijų bandinių iš 1 200 mm ilgio plieninių tuščiavidurių profiliuočių, pripildytų normalaus, lakiųjų pelenų, akmenų skaldymo atliekų ir mažo stiprumo betonų ir identiškų matmenų tuščiavidurių profiliuočių. Atlikti didelės apimties medžiagų savybių, santykinių deformacijų ir įlinkių matavimai. Lyginant teoriškai apskaičiuota sijų laikomoji galia. Eksperimentinio tyrimo rezultatai parodė, kad normalus, lakiųjų pelenų, akmenų skaldymo atliekų ir mažo stiprumo betonai didina plieninių tuščiavidurių profiliuočių lenkiamąją galią. Be to, iš šio tyrimo galima matyti, kad normalus, lakiųjų pelenų ir akmenų skaldymo atliekų betonus galima naudoti kompozitinių konstrukcijų plieninių tuščiavidurių profiliuočių lenkiamajai galiai didinti.

Reikšminiai žodžiai: betonšerdės sijos, dvitaškė apkrova, analitinis modelis, ribinė lenkiamoji galia.

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