Behaviour of Composite Beam with Trapezoid Web Profiled Steel Section in Sub-Assemblage Frame

Journal	Advanced Materials Research (Volumes 250 - 253)
Volume	Advanced Building Materials
Edited by	Guangfan Li, Yong Huang and Chaohe Chen
Pages	1271-1274
DOI	10.4028/www.scientific.net/AMR.250-253.1271
Citation	Saggaff Anis et al., 2011, Advanced Materials Research, 250-253, 1271
Online since	May, 2011
Authors	Saggaff Anis, Mahmood Md Tahir, Sulaiman Arizu, Poi Ngian Shek, Cher Siang Tan, Ahmad Beng Hong Kueh
Keywords	Composite Beam, Composite Connections, Trapezoid Web Profiled Steel Section

Abstract The objective of this paper is to present the behaviour of composite beam using Trapezoid Web Profiled (TWP) steel section by determining the moment resistance and the deflection of the beam with composite and non-composite connections. The TWP steel section is a built up section where the flange is of S355 steel section and the corrugated web of S275 steel section. Three full scales testing setting-up as sub-assemblage frame have been carried out. It was concluded that the use of composite connection and extended end-plate has reduced significantly the deflection and has significantly increased the loading capacity of composite beam.

First page example

Advanced Materials Research Vols. 250-253 (2011) pp 1271-1274
Online available since 2011/May/17 at www.scientific.net
© (2011) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMR.250-253.1271

Behaviour of Composite Beam with Trapezoid Web Profiled Steel Section in Sub-Assemblage Frame

S. Anis[1,a], M. M. Tahir[2,a], S. Arizu[2,b], P. N. Shek[2,c], C.S. Tan[2,d], A.B.H. Kueh [2,e]

Civil Engineering Department, Faculty of Engineering, Sriwijaya University, Indonesia[1]

Steel Technology Centre, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor[2]

anissaggaf@yahoo.com, mahmoodtahir@utm.my [2,a], arizu@utm.my[2,b], shekpoingian@utm.my[2,c], tcsiang@utm.my[2,d], kbhamad@utm.my[2,e]

Key words: composite beam, composite connections, trapezoid web profiled steel section

Abstract: The objective of this paper is to present the behaviour of composite beam using Trapezoid Web Profiled (TWP) steel section by determining the moment resistance and the deflection of the beam with composite and non-composite connections. The TWP steel section is a built up section where the flange is of S355 steel section and the corrugated web of S275 steel section. Three full scales testing setting-up as sub-assemblage frame have been carried out. It was concluded that the use of composite connection and extended end-plate has reduced significantly the deflection and has significantly increased the loading capacity of composite beam.

Introduction

The use of the composite and non-composite connections in the design of composite beam with TWP section influenced the maximum moment and the deflection of the beam. However, the extent of the difference is yet to be established. This paper will proposed a method to predict the moment resistance of the composite beam in sub-assemblage frame as a result of connections' restrained. Studies on partial strength or semi-rigid connections have been carried out by many researchers. Shi *et al.* [1] tested composite joints with flush end plate connection as partial strength connection under cyclic loading. The composite joints with flush end plate connection showed large strength resistance and good ductility, and the slippage between the concrete slab and steel beam was very small, which showed that between the concrete slab and steel beam, full interaction could be obtained by proper design of shear connectors. Studies on the partial strength connection were also carried out by Saggaff [2] and Sulaiman [3]. A series of non-composite connections comprising of flush and extended end-plate connections was tested and compared with composite connection. The beam sections were a built-up section known as trapezoid web profiled steel sections whereas British Sections were used as columns. It was concluded that the moment resistance and the initial stiffness for composite connection were higher than the non-composite connection. Further study on the partial strength connection with TWP steel section was carried out by Tahir *et al.* [4]. Two full scales testing with beam set-up as sub-assemblage and beam-to-column connections set-up as flush and extended end-plate connections were carried out. It was concluded that the use of extended end-plate connection had contributed to significant reduction in the deflection and significant increase in the moment resistance of the beam than flush end-plate connection.

Trapezoidal web profiled steel sections

TWP is a built-up steel section comprised of two flanges connected to a thin corrugated web usually between 3 to 8 mm thick by fillet welding. The web is corrugated at an angle of 45 degree and welded to the two flanges using automated welding machine. The web and the flanges comprised of different steel grade depending on the design requirements. TWP section is also classified as a hybrid steel section with two different types of steel grade welded together to form the section. The steel grade of the flanges is designed for S355 and the steel grade of the web is designed for S275. The flanges are purposely designed for S355 for maximum flexural resistance and the web is designed for S275 so as to reduce the cost of steel material. The shear capacity and bearing capacity are usually not that critical in the design of the beam as the web is corrugated.

Username:

@scientific.ne

Password:

Log In

Advanced Materials Research Vols. 250-253 (2011) pp 1271-1274
Online available since 2011/May/17 at www.scientific.net
© (2011) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMR.250-253.1271

Behaviour of Composite Beam with Trapezoid Web Profiled Steel Section in Sub-Assemblage Frame

S. Anis[1,a], M. M. Tahir[2,a], S. Arizu[2,b], P. N. Shek[2,c], C.S. Tan[2,d], A.B.H. Kueh [2,e]

Civil Engineering Department, Faculty of Engineering, Sriwijaya University, Indonesia[1]

Steel Technology Centre, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor[2]

anissaggaf@yahoo.com, mahmoodtahir@utm.my [2,a], arizu@utm.my[2,b], shekpoingian@utm.my[2,c], tcsiang@utm.my[2,d], kbhamad@utm.my[2,e]

Key words: composite beam, composite connections, trapezoid web profiled steel section

Abstract: The objective of this paper is to present the behaviour of composite beam using Trapezoid Web Profiled (TWP) steel section by determining the moment resistance and the deflection of the beam with composite and non-composite connections. The TWP steel section is a built up section where the flange is of S355 steel section and the corrugated web of S275 steel section. Three full scales testing setting-up as sub-assemblage frame have been carried out. It was concluded that the use of composite connection and extended end-plate has reduced significantly the deflection and has significantly increased the loading capacity of composite beam.

Introduction

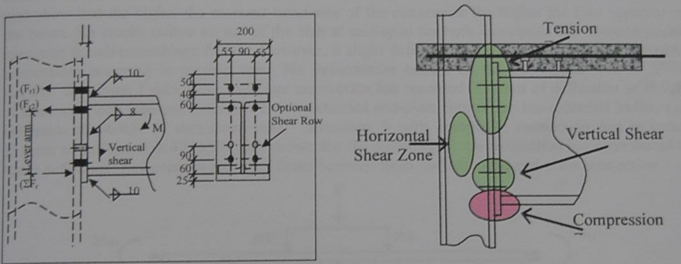
The use of the composite and non-composite connections in the design of composite beam with TWP section influenced the maximum moment and the deflection of the beam. However, the extent of the difference is yet to be established. This paper will proposed a method to predict the moment resistance of the composite beam in sub-assemblage frame as a result of connections' restrained. Studies on partial strength or semi-rigid connections have been carried out by many researchers. Shi *et al.* [1] tested composite joints with flush end plate connection as partial strength connection under cyclic loading. The composite joints with flush end plate connection showed large strength resistance and good ductility, and the slippage between the concrete slab and steel beam was very small, which showed that between the concrete slab and steel beam, full interaction could be obtained by proper design of shear connectors. Studies on the partial strength connection were also carried out by Saggaff [2] and Sulaiman [3]. A series of non-composite connections comprising of flush and extended end-plate connections was tested and compared with composite connection. The beam sections were a built-up section known as trapezoid web profiled steel sections whereas British Sections were used as columns. It was concluded that the moment resistance and the initial stiffness for composite connection were higher than the non-composite connection. Further study on the partial strength connection with TWP steel section was carried out by Tahir *et al.* [4]. Two full scales testing with beam set-up as sub-assemblage and beam-to-column connections set-up as flush and extended end-plate connections were carried out. It was concluded that the use of extended end-plate connection had contributed to significant reduction in the deflection and significant increase in the moment resistance of the beam than flush end-plate connection.

Trapezoidal web profiled steel sections

TWP is a built-up steel section comprised of two flanges connected to a thin corrugated web usually between 3 to 8 mm thick by fillet welding. The web is corrugated at an angle of 45 degree and welded to the two flanges using automated welding machine. The web and the flanges comprised of different steel grade depending on the design requirements. TWP section is also classified as a hybrid steel section with two different types of steel grade welded together to form the section. The steel grade of the flanges is designed for S355 and the steel grade of the web is designed for S275. The flanges are purposely designed for S355 for maximum flexural resistance and the web is designed for S275 so as to reduce the cost of steel material. The shear capacity and bearing capacity are usually not that critical in the design of the beam as the web is corrugated.

Test specimen and procedures

The proposed sub-assemblage tests were comprised of three specimens. Each specimen consists of a beam of TWP section connected to the column by the proposed connections as shown in Table 1. The extended and composite connection used are shown in Fig. 1(a and b). No. top bolt row for flush end-plate connection. Details of the geometrical configuration of the sub-assemblage tests are presented in Table 1. The applied load was positioned at the centre of the beam and converted into two point loads by a beam spreader at a distance of 2.1 m as shown in Fig. 2. An increment of about 5 kN was applied to the specimen. The readings of the applied load, displacement, and rotation were recorded after two minutes had elapsed so as to reach an equilibrium state. The incremental load procedure was then repeated until there was a significant increase in deformation. The loading on the specimen was then controlled by deflection increments of 3 mm. The test was continued until failure, when large deformation or the load decreases significantly. A graph of moment versus rotation was plotted to predict the moment resistance of the connection. The rotation of the connection was measured as the difference between the rotation at the centre of the beam and the rotation at the centre of the column that recorded using inclinometer.



a) Extended end-plate

b) Composite connection

Fig. 1 Connections used in the test

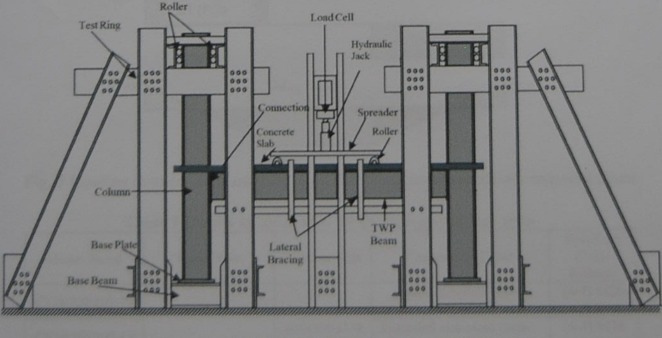


Fig. 2 Test rig for the sub-assemblage tests

Moment resistance of composite beam

The design of composite beam is based on BS 5950: Part 3.1[5]. Full shear connecters are used in the tested composite beam specimen. Based on the design using BS 5959: Part 3.1, the moment resistance of the beam M_D is calculated as 497.0 kNm. To predict the moment resistance of the composite beam, the moment resistance of the connection in sub-assemblage frame needs to be established first. The moment resistance of the connection can be established by superimposing the rotation of the connection as maximum moment occurred in sub-assemblage frame to the moment versus rotation curves plotted from the isolated tests as presented elsewhere [2, 6]. The predicted moment resistance of the connection is used in the bending moment diagram calculation to predict the maximum moment resistance of the beam in the sub-assemblage test as shown in Fig. 3 and the results are tabulated in Table 2. The results show that the design moment of the beam agrees well with the free bending moment developed from the tested specimens as the ratio is very close to 1.0. The results also show that as the moment resistance of the connection increases the maximum moment at mid-span decreases. Specimen with composite connection tends to reduce the mid-span moment of the beam as the connection is stiffer that the non-composite connection. The results also show that the higher the moment resistance of the connection the higher the load capacity of the beam. No cracks failure on top of the slab at mid-span for both composite and non-composite specimen in sub-assemblage frame. However, a slight deformation of end-plate in non-composite connections occurred in tension zone. No deformation occurs on the corrugated web of TWP section. Specimen 1 with flush end-plate connection has recorded 30.0mm of deflection at 395kN of maximum load whereas specimen 2 with extended end-plate connection has recorded 34.0mm of deflection at 464kN of maximum load. Specimen 3 with composite connection has recorded 35.0mm of deflection at 477 kN. This shows that the stiffening of the connection has contributed to lesser deflection; however not that significant between flush and extended end-plate connection.

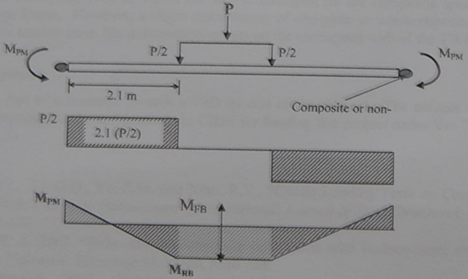


Fig. 3 Bending moment diagram used to predict moment resistance of composite beam

Table 1 Details of specimens for the sub-assemblage tests

Model Name	Beam Size	Column Size	Connection Types	Bolt Row (Top-Bottom)
CF2R20P200-12			Flush end-plate (non-composite)	(4-4) M20 8.8
CE3R20P200-12	450x160x50.2/12/4	305x305x118 (UC-S275)	Extended end-plate (non-composite)	(6-4) M20 8.8
CFR2R20P200-12			(composite connection)	(4-4) M20 8.8

Table 2 Test results from the Composite Full-Scale Sub-Assemblage tests

Specimen Name	Maximum Load, (kN)	Free Bending Moment M_{FB} (kNm)	Ratio of M_{FB}/M_D	Moment At Connection M_{PM} (kNm)	Moment At Mid-Span, M_{RB} (kNm)	Deflection At Max. Load (mm)
Specimen 1 (non-comp. connection)	395	415	1.12	135	280	30
Specimen 2(non-comp. connection)	464	487	1.02	205	282	34
Specimen 3 (composite connection)	477	501	0.99	320	181	35

Conclusions

The concluding remarks from the experimental results of the proposed connections are as follows:-

1) The use of composite connection and extended end-plate connection has significantly reduced the deflection of the beam and increase the loading capacity of the beam. The significant increment in the stiffness of composite connection and extended end-plate connection however has not developed any failure on the column section which concludes that no stiffener is needed.
2) The results show that the higher the moment resistance of the connection the higher the load capacity of the beam.
3) The results show that the design moment of the beam agrees well with the free bending moment developed from the tested specimens as the ratio is very close to 1.0.
4) No cracks failure observed on top of the slab at mid-span for the composite specimen in sub-assemblage frame. However, a slight deformation of end-plate in non-composite connections occurred in tension zone. No deformation occurs on the corrugated web of the TWP section.

Acknowledgements

This study is part of a research towards a PhD by one of the authors. The authors would like to acknowledge special thanks and gratitude to CIDB for funding this project under Vot 73049.

References

[1] Shi, W.L., Li, G.Q., Ye, Z.M. and Xiao, R.Y., "Cyclic Loading Tests on Composite Joints with Flush End Plate Connections", *International Journal of Steel Structures*, Vol. 7, 2007, pp 119-128.

[2] Saggaff, A. 2007. "Behaviour of composite connection with built-up steel sections". *PhD Thesis*. Universiti Teknologi Malaysia, Malaysia.

[3] Sulaiman, A. 2007. "Behaviour of partial-strength connection in semi-continuous construction for multi-storey braced steel frame using TWP sections". *PhD Thesis*. Universiti Teknologi Malaysia, Malaysia.

[4] Tahir, Sulaiman, and Saggaff, " Structural Behaviour of Trapezoidal Web Profiled Steel Beam Section Using Partial Strength Connection", *Electronic Journal of Structural Engineering*, Vol. 8 pp 55-66.

[5] British Standard Institute, Structural use of steelwork in building, Part 3: Design in composite construction, Section 3.1 Code of practice for design of simple and continuous composite beams, 1990.

[6] Tahir, M.Md., Sulaiman A, Anis S, 2008 (March) "Experimental Tests on Composite and Non-Composite Connections Using Trapezoid Web Profiled Steel Sections". *International Journal of Steel Structures*, Vol. 8, No. 1, pp 43-58.