Journal of Constructional Steel Research 75 (2012) 160–168

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Experimental studies on composite haunch beams

Y.H. Ng [a], N.E. Shanmugam [b,*], J.Y. Richard Liew [c]

[a] TTJ Design and Engineering Pte Ltd., 57 Pioneer Road, Singapore 628508, Singapore
[b] Department of Civil and Structural Engineering, National University of Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[c] Department of Civil Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore

ARTICLE INFO

Article history:
Received 29 September 2011
Accepted 22 March 2012
Available online 20 April 2012

Keywords:
Experimental
Composite beams
Haunch connection
Moment capacity
Rotation capacity
Failure modes
Construction

ABSTRACT

The paper is concerned with the behavior of steel–concrete composite haunch beams. Experiments were carried out to investigate the ultimate load behavior of haunch composite beams. Three continuous composite haunch beams were tested to failure. Two different proportions of slab reinforcements and two different haunch lengths were studied in order to examine the effects of these parameters on the ultimate load carrying capacity. Results obtained are presented in the form of load–deflection plots and different failure modes. It is found that through proper design and detailing optimum design of composite haunch beam can be achieved when plastic hinge occurs at haunch toes followed by a hinge at the mid-span to form a plastic collapse mechanism. Experimental results show that composite haunch beam exhibits a ductile moment–rotation behavior and is able to redistribute moment to the mid-span by loss of stiffness due to cracking of concrete slab and yielding of either steel reinforcement or cross section.

1. Introduction

Composite structures comprising steel frames and concrete floors are commonly used in modern construction because of structural economy and speed of construction. Interaction between steel beam and concrete slab is achieved by means of shear connectors. Metal decking may be used as permanent formwork to support any load during construction and later to act compositely with the hardened concrete slab to form a composite slab. Strong demand for large column-free spaces in buildings in recent times has necessitated further research into the behavior of haunched beams since they are considered to be an efficient and economical form for long span construction. This system is able to offer more variety to the designer in planning the usage of the column-free space [1,2].

Haunch beam in this paper is defined as a beam stiffened at two ends with a taper T-section as shown in Fig. 1. The taper section is usually cut from a section similar to the main beam as shown in Fig. 2 in which two typical taper sections are cut from a universal beam. These taper sections are then welded to the beam-ends through end plates at both ends of the beam as shown in the figure. Haunch beams are designed by assuming a rigid moment connection between the beams and columns. Length and depth of a haunch are so chosen that they result in an economical moment transfer to the column and in a reduced beam depth, to a practical minimum. Haunch composite beams in which steel beams are designed to act in conjunction with a concrete slab of definite width could result in shallow beams, provide sufficient rotation capacity of the connection that will permit a redistribution of the moment and thus mobilize a full sagging capacity of the beam resulting in an economical design. Furthermore, haunch beam system could also provide a long unobstructed space for services and increased speed of construction.

Haunch composite beam may provide continuity at the beam–column support and thus increase the structural performance of the system as a continuous beam. A continuous beam could offer about 33% more strength compared to the corresponding simply supporting beam system. The continuity in composite beam provides benefits at both the ultimate and serviceability limit states for long span structures. For instance, the deflection of a continuous beam could be easily 50% less compared to a simply supported beam system. However, one of the shortcomings in continuous composite beam is that the composite sagging section capacity is always larger than the hogging moment. For a continuous composite beam such as parallel beam grillage system, the negative bending at internal supports is generally significantly less than the resistance in positive bending in the midspan region. Therefore, introduction of haunch may be an option to overcome the shortcoming because it will increase the hogging section capacity. And if necessary, tension reinforcement could be added thus increasing the hogging capacity. Test results show that the hogging capacity is as high as the sagging section capacity when sufficient tension reinforcement is placed at the concrete slab at the hogging region. The ultimate strength of composite beams under sagging moment has been well established and Eurocode 4 has offered a detailed design guideline.

* Corresponding author. Tel.: +60 3 8921 6217; fax: +60 3 8921 6147.
E-mail addresses: shan@vlsi.eng.ukm.my, neshanmugam@yahoo.com (N.E. Shanmugam).

0143-974X/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcsr.2012.03.016