UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF BENT-UP TRIANGULAR TAB SHEAR TRANSFER (BTTST) ENHANCEMENT IN COLD-FORMED STEEL (CFS)-CONCRETE COMPOSITE BEAMS

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Thesis submitted in fulfillment of the requirements

for the degree of

Doctor of Philosophy

Faculty of Civil Engineering

March 2010

CANDIDATE'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

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Date	March 2010

ABSTRACT

Cold-formed steel (CFS) sections, have been recognised as an important contributor to environmentally responsible and sustainable structures in developed countries, and CFS framing is considered as a sustainable 'green' construction material for low rise residential and commercial buildings. However, there is still lacking of data and information on the behaviour and performance of CFS beam in composite construction. The use of CFS has been limited to structural roof trusses and a host of non-structural applications. One of the limiting features of CFS is the thinness of its section (usually between 1.2 and 3.2 mm thick) that makes it susceptible to torsional, distortional, lateral-torsional, lateral-distortional and local buckling. Hence, a reasonable solution is resorting to a composite construction of structural CFS section and reinforced concrete deck slab, which minimises the distance from the neutral-axis to the top of the deck and reduces the compressive bending stress in the CFS sections. Also, by arranging two CFS channel sections back-to-back restores symmetricity and suppresses lateral-torsional and to a lesser extent, lateral-distortional buckling. The two-fold advantages promised by the system, promote the use of CFS sections in a wider range of structural applications. An efficient and innovative floor system of built-up CFS sections acting compositely with a concrete deck slab was developed to provide an alternative composite system for floors and roofs in buildings. The system, called Precast Cold-Formed Steel-Concrete Composite System, is designed to rely on composite actions between the CFS sections and a reinforced concrete deck where shear forces between them are effectively transmitted via another innovative shear transfer enhancement mechanism called a bent-up triangular tab shear transfer (BTTST). The study mainly comprises two major components, i.e. experimental and theoretical work. Experimental work involved small-scale and large-scale testing of laboratory tests. Sixty eight push-out test specimens and fifteen large-scale CFS-concrete composite beams specimens were tested in this program. In the small-scale test, a push-out test was carried out to determine the strength and behaviour of the shear transfer enhancement between the CFS and concrete. Four major parameters were studied, which include compressive strength of concrete, CFS strength, dimensions (size and angle) of BTTST and CFS thickness. The results from push-out test were used to develop an expression in order to predict the shear capacity of innovative shear transfer enhancement mechanism, BTTST in CFS-concrete composite beams. The value of shear capacity was used to calculate the theoretical moment capacity of CFS-concrete composite beams. The theoretical moment capacities were used to validate the large-scale test results. The large-scale test specimens were tested by using four-point load bending test. The results in push-out tests show that specimens employed with BTTST achieved higher shear capacities compared to those that rely only on a natural bond between cold-formed steel and concrete and specimens with Lakkavalli and Liu bent-up tab (LYLB). Load capacities for push-out test specimens with BTTST are

relatively higher as compared to the equivalent control specimen, i.e. by 91% to 135%. When compared to LYLB specimens the increment is 12% to 16%. In addition, shear capacities of BTTST also increase with the increase in dimensions (size and angle) of BTTST, thickness of CFS and concrete compressive strength. An equation was developed to determine the shear capacity of BTTST and the value is in good agreement with the observed test values. The average absolute difference between the test values and predicted values was found to be 8.07%. The average arithmetic mean of the test/predicted ratio (μ) of this equation is 0.9954. The standard deviation (σ) and the coefficient of variation (CV) for the proposed equation were 0.09682 and 9.7%, respectively. The proposed equation is recommended for the design of BTTST in CFS-concrete composite beams. In large-scale testing, specimens employed with BTTST increased the strength capacities and reduced the deflection of the specimens. The moment capacities, $M_{u,exp}$ for all specimens are above $M_{u,theory}$ and show good agreement with the calculated ratio ($\geq$1.00). It is also found that, strength capacities of CFS-concrete composite beams also increase with the increase in dimensions (size and angle) of BTTST, thickness of CFS and concrete compressive strength and a CFS-concrete composite beam are practically designed with partial shear connection for equal moment capacity by reducing number of BTTST. It is concluded that the proposed BTTST shear transfer enhancement in CFS-concrete composite beams has sufficient strength and is also feasible. Finally, a standard table of characteristic resistance, P_{tab} of BTTST in normal weight concrete, was also developed to simplify the design calculation of CFS-concrete composite beams.

ACKNOWLEDGEMENTS

I am extremely grateful to my supervisor, Associate Prof. Datin Dr. Hanizah Ab Hamid and Associate Prof. Dr. Azmi Ibrahim for their support, encouragement, inspiration and guidance at all stages of my PhD program at UiTM. Special gratitude to Prof Boswell and Dr De Mello for your guidance and support especially during my six months attachment program at City University, London.

I also owe my gratitude University Tun Hussein Onn Malaysia for the financial support and for University Technology Mara for the technical support.

I would like to express my sincere gratitude to my friends Aruan, Azerai, Adib, Cindy, Koh and Izudin for generously helping me with any problem I ran across along my PhD journey. I thank all the technicians Zu, Saiful, Ali, Mizi, Azri and all technicians for their help during laboratory works. I would like to thank all my friends at UTHM and UiTM for their support.

Above all, to my parents for the emotional support and blessing. To my lovely wife Norzila, my sons Irfan and Irsyad who have been an inspiration to me. Without the blessing of them, I would not have made it through.