Indian J.Sci.Res. 17(2): 279 - 283, 2018

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

STATE OF THE ART ON COMPOSITE BEAM WITH SHEAR CONNECTOR UNDER PURE BENDING

[1] Gnana Rajalakshmi, [2]Vallabhy.S
[1]Department of Structural Engg, Prathyusha Engg College, Thiruvallur
[2]Department of Civil Engg, Prathyusha Engg College,Thiruvallur

Abstract - A simple computation procedure is developed to predict the general behavior of composite beam with shear connector under bending. Different spacing of shear connector should be change cold form sheet considered. The experiments include four series of composite beams tested. The tests reported were used to ascertain the flexural strength of the beams and to validate the theoretical predictions. Companion specimens of concrete cylinders and cubes were tested for compressive strength and elastic modulus properties. Then accuracy of the results was checked with some available experimental data. The section was then exposed to bending, and the change in the behavior was noticed. The effect of a wide range of important parameters was studied on composite beams when they were exposed to two different loading combinations; Shear, torsion accompanied by bending.

Keywords**:** Shear connectors, Composite beam, Flexural strength, pure bending, Shear and torsion

I. Introduction

Modern civilization relies upon the continuing performance of civil engineering infrastructure ranging from industrial building to power station and bridges. For the satisfactory performance of the existing structural system, the need for strengthening is inevitable. Commonly encountered engineering challenges such as increase in service loads, changes in use of the structure, design and/or construction errors, degradation problems, changes in design code regulation and seismic retrofits are some of the causes that lead to the need for new techniques to upgrade the performance of the structures. Though Concrete a versatile construction material has several advantages due to its compressive strength and moldable shape, it has its own tensional limitation and poor ductility. Ductility is an important characteristic of a structure to resist earthquake, impact and blast loading. Steel has excellent ductile property. Hence a judicious combination of structural steel and concrete utilizing the strength possessed by them and suppressing their weakness resulted in the composite construction. The present day demands in construction on parameters such as strength, safety, serviceability, satisfactory and reliable performance expected of a structure apart from economical solutions has also made it imperative to use steel concrete composite construction techniques.

Composite Construction- A structural member composed of two or more dissimilar materials joined together to act as a unit is referred as composite structure. Joining two dissimilar materials to form a composite member does not only combine the collective strengths of the two materials, forming a union between relevant materials actually enhances their physical characteristics and makes the composite stronger than the sum of their strengths. An example in civil structures is the steel-concrete composite beam in which a steel wide-flange shape (I or W shape) is attached to a concrete floor slab.

In order to design the structural member with maximum efficiency and minimum cost, steel-concrete composite construction is adopted. It is a powerful construction concept in which compressive strength of concrete and the tensile strength of steel are almost effectively used. Steel and concrete have almost the same thermal expansion apart from an ideal combination of strength. Hence, these essential different materials are completely compatible and complementary to each other. Steel-concrete composite beams are today widely used for bridges and industrial buildings. In large scale construction, steel and concrete are most frequently used combinations for composite beams. The concrete lends the composite mass, stiffness and compressive strength and reduces deflection and vibration in the slab. The steel members give the beam its tensile strength with excellent strength to weight ratios and rapid construction times. Steel-concrete composite beams have long been recognized as one the most economical structural systems for both multistory steel buildings and steel bridges. Buildings and bridges require a floor slab to provide a surface for occupants and vehicles respectively. Concrete is the material of choice for the slab because its mass and stiffness can be used to reduce deflections and vibrations of the floor system and to provide the required fire protection. The supporting system underneath the slab, however, is often steel because it offers superior strength-weight and stiffness-weight ratio, ease of handling and rapid construction cycles. Since both the steel and concrete are already present in the structures, it is logical to connect them together to better utilize their strength and stiffness.

[1]**Corresponding Author**

A modern composite construction concept was initially developed in North America and is now used extensively in the UK where it has been further developed and redefined. Early application involved concrete encased steel beams for which the concrete served primarily as fire protection. However it was recognized that both the strength and the stiffness of the encased member were increased compared to the bare steel. Many improvements to composite systems have occurred during the past 40 years. Among these is the introduction and wide spread use of composite steel decks that serve initially as work platform and concrete formwork and as slab reinforcement in resisting loads after the concrete hardens. The main reason for this preference is the suitability of the sections and members to resist repeated earthquake loadings, which require a high amount of resistance and ductility. This is the new idea to the composite structure world. And this can be a replacement for hot rolled steel beams or RCC beams in small to medium sized building.

The cold formed steel sheet is bonded to surface of concrete by means of shear connectors. Stud shear connectors are used to take up the bond between sheet and concrete. The passive confinement by the cold formed sheet in the sides and bottom influences the strength and ductility of the system. These beams are simple to fabricate and provides very good confinement of concrete. One of the most important parts of a composite beam is the fixing points of shear connectors between the two materials. The correct connection of the two parts of the composite allows the materials to act as a unit and gives the composite beam its inherent strength. A composite beam is constructed generally by casting a reinforced concrete slab on the top of the steel beam. Composite action between the steel and the concrete is achieved by means of mechanical connectors by the effective transfer of shear at the interface between concrete and sheet elements. These connectors are generally dubbed as shear connectors. They are typically connected by welding to the top of the flange of a steel beam and cast within the concrete slab. The transfer of longitudinal shear forces at the interface between both components is mostly realized by headed shear studs. Without these connectors, the slab acts independently and analysis is relatively simple. Shear connection significantly increases the strength and stiffness performance of composite beams. A composite beam can made to be considered to have full shear connection or partial shear connection, proportional to the amount of shear connections. Shear connectors can take the form of either headed studs, channels or high strength structural bolts. These shear connectors are typically studs welded to the steel beams and set into the concrete slab. The number and size of these shear connectors are carefully calculated as they represent a critical part of the composites mechanical performance. Design of the shear connection is important because it affects:

- Choice of a suitable ultimate strength design method for the composite beam
- Vertical deflection of the composite beam.
- Economics and speed of construction.
- Stability of the steel beam and safety against collapse.

II. Previous Studies

Muhammad Faisal Javed (2017) CFS members are more vulnerable to fire due to high section factor (fire-exposed area to the heated volume) Hence, an extensive review of experimental and numerical studies performed on CFS beams and columns at elevated temperatures is presented. Various types of buckling under different loading conditions and influence of different factors affecting the ultimate capacity and critical temperature of members are discussed. A comparison between different test methods and fire curves used around the world is presented. The research gaps as well as recommendations are also proposed. Conclusively, this review will provide basic data for the development of design codes. CFS members are more vulnerable to fire due to high section factor (fire-exposed area to the heated volume). Hence, an extensive review of experimental and numerical studies performed on CFS beams and columns at elevated temperatures is presented. Various types of buckling under different loading conditions and influence of different factors affecting the ultimate capacity and critical temperature of members are discussed. A comparison between different test methods and fire curves used around the world is presented. The research gaps as well as recommendations are also proposed. Conclusively, this review will provide basic data for the development of design codes.

Karthika G N (2017) In steel construction, cold–formed structural members are becoming more popular and have a growing importance. Its growing popularity in building construction is due to its advantages over other construction materials such as lightness and consequent ease of erection and installation, economy in transportation and handling. Even though the static behavior of cold-formed steel elements is well established, fatigue behavior of these elements under fluctuating loads is still uncertain. Most of the codes of practice for usage of cold-formed steel sections in structural applications, deal only with static conditions of loading. Fatigue strength is important for cold-formed steel structural members and the probability of failure by fatigue is comparable with that of other Ultimate Limit State modes of failure. Hence the prospect of using cold-formed steel sections under dynamic conditions becomes attractive. Objective of this study is to examine the performance of cold formed steel beam column joint subjected to fatigue loading. Using ANSYS software, fatigue analysis of double channel beam column - joint with a bolted and a welded connection with varying thickness (2mm and 4mm) are planned to be studied. Within bolted connection, bolts only and cleat angle connections are studied. From this study, the best connection is flange and web cleat bolted connection.

Cameron B. Ritchie (2017) This paper presents a literature review focused on the material performance of cold-formed, carbon steel, hollow structural sections under impulsive (highly dynamic) loading. Impulsive loading, represented by impact and blast, is characterized by a very rapid, time-dependent loading regime in the affected members and materials. Thus, the effect of high-strain-rate loading is initially reviewed. Next the material toughness, an important energy-absorption property and one measure of a material's ability to arrest fracture, is considered by means of studying the Charpy V-notch behavior. The response of hollow sections under axial and lateral impact loading is then reviewed. Studies of blast on hollow sections, most of which fall under the categories of contact/near-field loading or far-field loading are presented. Under large-scale field blast experiments, cold-formed hollow sections have shown excellent behavior. Software for modeling blast loading and structural response, the latter including single degree of freedom analysis and explicit finite element analysis, is described and discussed.

Ling Zhu Chen (2016) This paper describes an extensive experimental and numerical study conducted to evaluate the thermo-structural response of shear connectors embedded in composite slabs with steel sheeting parallel to the steel beam, with particular focus on open trapezoidal profiles. For this purpose, eight push-out tests were carried out at different levels of temperature. A three dimensional finite element model was developed in Abaqus and its accuracy was validated against the experimental measurements collected as part of this study. The model was then used to perform a parametric study to gain insight into the structural response at different temperatures. The experimental and numerical results were then used to evaluate the accuracy of available European guidelines for predicting the capacity of shear connectors at elevated temperatures (when embedded in composite slabs with the profiled sheeting parallel to the steel beam). Finally, a new design equation was proposed to calculate the degradation factor defining the resistance of shear connectors for different levels of temperature.

Yushun Lia (2015) In order to extend the utilization of bamboo as a green building material, a new type of lightweight I-section bamboo–steel composite beam consisted of two pieces of cold-formed thin-walled steel channel and three pieces of bamboo plywood laths with adhesive bonding was developed and its mechanical properties was investigated. The results showed that the bamboo plywood and cold-formed thin-walled steel channel could form a good integrated composite cross-section. The failure modes, bearing capacities and deformation characteristics of the composite beams are associated with the flange thickness of the bamboo plywood, thickness of the cold-formed steel channel and the whole sectional dimension. Furthermore a simplified mechanical model and a calculation method were proposed based on the superposition principle and the predicted deformation and bearing capacity matched well with the experimental results, which indicate that the bamboo plywood can be used as a modern structural material.

Raja Prasanth (2015) In order to extend the utilization of bambooas a green building material, a new type of lightweight I-section bamboo–steel composite beam consisted of two pieces of cold-formed thin-walled steel channel and three pieces of bamboo plywood laths with adhesive bonding was developed and its mechanical properties was investigated. The results showed that the bamboo plywood and cold-formed thin-walled steel channel could form a good integrated composite cross-section. The failure modes, bearing capacities and deformation characteristics of the composite beams are associated with the flange thickness of the bamboo plywood, thickness of the cold-formed steel channel and the whole sectional dimension. Furthermore a simplified mechanical model and a calculation method were proposed based on the superposition principle and the predicted deformation and bearing capacity matched well with the experimental results, which indicate that the bamboo plywood can be used as a modern structural material.

Yazdanmajdi (2014) In this research, the structural behavior of anew type of composite floor system is explored through finite element modeling. The new composite floor incorporates cold-formed (light-gauge) steel profiles as the joist on bottom, a corrugated steel deck as the formwork for concrete, a continuous hat channel (furring channel) as the shear connector and finally a concrete slab on top. All steel parts in the system are cold-formed and connected together by self-drilling fasteners. In the present study, a comprehensive three-dimensional finite element modeling is performed for this composite floor system. A local bond-slip model is applied to simulate the slip of the shear connector inside the concrete slab. A nonlinear analysis is performed on the composite floor considering all different types of structural nonlinearities and the behavior of the system is monitored from beginning of loading all the way to a defined point of failure. Results of finite element analyses are compared with experimental data. Further, parametric studies are conducted to determine the effect of shear connector's slip on reducing ultimate strength and initial stiffness of such a floor system.

Cheng Tzu Thomas Hsu (2014) A new composite beam and floor system has been developed to achieve a higher strength and ductility, as well as to yield a more economical design purpose. This new composite beam system consists of three elements: reinforced concrete slab on corrugated cold-formed metal deck, back to back cold-formed steel joists, and continuous cold-formed furring shear connector. The continuous shear connector is screwed through the metal deck and the top flange of the support joists in order to provide vertical interlocking and horizontal shear resistance between the concrete slab and the cold-formed steel joists. The self-drill fasteners are used for fastening the furring shear connector through the metal deck into the supporting joists.

To understand the behavior of the new composite beam, a total of six 12 feet long composite beam tests were conducted to obtain the positive moment capacity, vertical deflection, and end slip of proposed composite beam system. Comparing with the non-composite section, the proposed composite section presents a better performance for both strength and ductility. Based on present beam tests the ultimate load and mid-span deflection of the proposed composite section can be increased by 14–38% and 56–80%, respectively. According to the experimental bending test results, the composite section can reach the ultimate strength without local shear or compression buckling failure when the proposed shear connector is presented in the composite section. Analysis and design of composite beams with cold-formed steel joists and concrete slab are also studied to validate the present test results.

A. Jayaraman and Balaji (2014) Cold formed steel members are extensively used in the building construction industry, especially in residential, commercial and industrial buildings. This paper presents a study on behavior and economical. In of cold formed steel (CFS) built up channel section and channel section by same cross sectional area. This study involves in examination of theoretical and numerical investigations of specimens in series. Overall two specimens were designed and comparison of all the internal force, and hence, to evaluate the co-existing moments and shear forces at the critical cross-section with same configuration area by keeping all other parameters constant. The theoretical data are calculated using Indian Standard code IS 801-1975 and the section properties of the specimens are obtained using IS 811-1975. The specimens are designed under uniformly distributed loading with simply supported condition. The theoretical results are verified using ANSYS V11 software. The research project aims to provide which section is economical, high bending strength, more load carrying capacity and high flexural strength. The studies reveal that the theoretical investigations channel section have high bending strength, high load caring capacity, minimum deflection and minimum local buckling& distortional buckling compare to the built up channel section by same cross sectional area.

Ashraf Mohamed Mahmoud (2012) The Author investigated involves for unstrengthen and strengthened RC beams with openings in enhancing the output results at failure such as deflections and strains for concrete and steel than other models. The use of Solid46 element for representing CFRP laminates is much better than Link10 element in enhancing output results due to its orthotropic properties. The CFRP strengthening system enhanced the crack distribution at the opening zone. The ACI 440 technique is valid for evaluating the short-term deflection for concrete beam models reinforced with CFRP and having openings in shear zone, especially for small opening heights, and is not suitable for the large one.

III. Conclusion

This study was analyzing the effect of using Cold Formed Sheet behavior of Composite beam with Shear Connector under bending. The experiments include four series of composite beams tested. The tests reported were used to ascertain the flexural strength of the beams. Several tests were conducted on the materials of the concrete composites and the reports are noted. With the results obtained, the study is further being carried out in the Second Phase of the project. In the Second Phase, the cubes will be casted, cured and tested according to the curing periods. The Shear Connector, Pure Bending, Composite Beam, Shear, Torsion, Compressive and Flexural strength of the Concrete cubes will be found out and moreover, Durability test will be conducted and the results will be published in the second phase of the project.

References

[1] Ansourian.P. (1981), “Experiments on Continuous Composite Beams,”Proc. Inst. Civ. Engg. Part 2, 71, 25-51.

[2] Antonio.F. Barbosa, Riberia Gabriel O., (1998) “Analysis of reinforced concrete structures using ANSYS nonlinear concrete model,”Computational Mechanics New trends and Applications, Barcelona, Spain, 1998.

[3] Arivalagan Soundararajan, Kandasamy Shanmugasundaram. (2008), “Flexural Behavior of Steel Hollow Beams,” J. Civil EnggandManagement, pp.107-114.

[4] Baskar.K, Shanmugam N.E. (2003), “Steel Concrete Composite PlateGirder Subjected to Combined Shear and Bending,” J. Constr. SteelRes., 59, pp.531-557.

[5] Brian Uy and Mark Bradford (1995), “Ductility of ProfiledComposite Beams Part.1 Experimental

Study," Journal of StructuralEngg, Vol.121, No.5, May 1995, pp. 876-882.

[6] Carmel Navin (2008),"Studies on composite beam subjected tocombined bending and torsion" Proc. of SEC-2008.

[7] Chapman J.C., Balakrishnan S. (1964), "Experiments on CompositeBeams," Struct. Eng., 42(11), 369-383.

[8] Chapman J.C, Yam.L.C.P. (1968), "The inelastic behaviour of simplysupported composite beams of steel and concrete" Proc.Inst.Civ.41 (1),651-683.

[9] Damien Kachlakev.,Thomas Miller (2001), "Finite ElementModelling of concrete structures strengthened with FRP laminates" A report of Oregan Dept. of Transportation and Federal Administration,Washington.May2001,pp.4-11.

[10] Dennis Lam and EhabLobody (2005), "Strength analysis of steelconcrete composite beams in combined bending and shear" 2005,Vol.131, No.10, pp.1593-1600.

[11] Derric John Oehlers (1993), "Composite Profiled Beams," Journal ofStructural Engg., Vol.119, No.4, April 1993, pp.1085-1100.

[12] E.L. Tan, B. Uyb, (2011), "Nonlinear analysis of composite beamssubjected to combined flexure and torsion", Journal of ConstructionalSteel Research 67 (2011) 790–799.

[13] Fanning P., (2001), "Nonlinear model for Reinforced and Posttensioned Concrete Beams," JSE, 2, September 2001.