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Performance evaluation of hybrid double T-box beam girder in steel structure

Sitha Saji[1], Kiran Jacob[2]

[1] *Student, Dept. of Civil Engineering, ICET Mulavoor, Kerala, India*
[2] *Asst. Professor, Dept. of Civil Engineering, ICET Mulavoor, Kerala, India*

Abstract

In this project the finite element of HDTGB was evaluated with the help of ANSYS software and its result compared with experimental study results to ensure validity. After the validation HDTGB is evaluated by conventional, beams ISMB 200 and ISMB150 finding the better performance.as this is hybrid section web and flange are made with different grade steel. To find out the better combination the grade of web and flange analysis with different grade configuration. Local buckling of the section is depending on stiffness, to improve the stiffness providing stiffeners in the flange and web section, and try to evaluate the failure mode. To find out whether it can be provided in a building within ANSYS limitation, it is transferred to the form as a frame, then the lateral loading capacity is checked with the help of PUSH OVER TEST.

***Key Words*: Hybrid double T-box beam girder (HDTBG), double t box girder (DTBG), low tensile (LT), medium tensile (MT), high tensile (HT).**

1.Introduction

The building industry makes widespread use of cold-formed steel structures, either as entire buildings in low- to mid-rise construction or in conjunction with hot-rolled or manufactured steel framing. The phrase "cold-formed steel" (CFS) refers to steel products that have been produced using cold-working techniques that are performed at temperatures close to room temperature, such as rolling, pressing, stamping, bending, etc. Cold-rolled steel (CRS) stock bars and sheets are often utilized in all production sectors. Hot-formed steel and hot-rolled steel are contrasted by the terminology. In the building sector, cold-formed steel, particularly in the form of thin gauge sheets, is frequently used for structural and non-structural elements such columns, beams, joists, studs, floor decking, built-up sections, and other parts. Since they were standardized in the US in 1946, such usage has grown in popularity. Bridges, grain bins, vehicle bodywork, railway coaches, highway items, gearbox towers and gearbox lines have all utilized cold-formed steel members.

The evolution of composite goods in manufacturing, as well as advances in technologies and techniques, have facilitated the process of preparing, , mass producing, fabricating, and implementing Cold-Formed Steel (CFS) built-up sections to perform diverse structural duties. Given the growing popularity of CFS in the construction sector, novel built-up CFS homogeneous and hybrid double-T-box girders (DTBGs and HDTBGs) are proposed in this study. These sections are anticipated to function as a structural girder to handle heavier flexural loads over longer spans and to provide greater resistance to multiple buckling events. The increase in the span of flexural members is connected with phase-wise buckling modes of failure as follows; short members are more susceptible to local plate buckling, which can cause cross-sectional deformation.

Steel forms often have an arrangement of thin plate cross sections. If the thin plates that make up the cross section of a steel shape are excessively thin, the cross section may buckle when the steel shape is subjected to high compressive pressures before the full strength of the member is reached. The member capacity is reached when buckling of a cross sectional element occurs. As a result, local buckling is established as the limit state for the strength of compressively stressed steel forms.

By experimental and numerical examinations, the flexural strength and behavior of cold-formed steel oval hollow section beams were examined. Extensive resources and labor are needed for experimental research on calculating the moment-resisting capacities and structural behavior of various new CFS cross-sections involving many factors. Numerical study using nonlinear Finite Element Analysis (FEA) and commercially accessible software tools is one of the thorough research methods that takes into account many parameters.

In this project the finite element of HDTGB was evaluated with the help of NANSYS software and its result compared with experimental study results to ensure validity. After the validation HDTGB is evaluated by conventional, beams ISMB 200 and ISMB150 finding the better performance.as this is hybrid section web and flange are made with different grade steel. To find out the better combination the grade of web and flange analysis with different grade configuration. Local buckling of the section is depending on stiffness, to improve the stiffness providing stiffeners in the flange and web section, and try to evaluate the failure mode. To find out whether it can be provided in a building within ANSYS limitation, it is transferred to the form as a frame, then the lateral loading capacity is checked with the help of PUSH OVER TEST.

1.1 Description and advantages of DTBGs and HDTBGs

The current research refers to built-up cold-formed steel mono-symmetric sections as Double-T-Box Girder sections (DTBG), which have a special geometry that resembles the shape of a Double "T" plus a Box component and are made up of 4 parts that are assembled into a single closed-form unit. According to Fig. 1, the girder is primarily formed of two webs with uneven lipped channels, and the top and bottom flanges are stiffened plain open channels. In comparison to the width of the bottom flange, the top flange is wider. At the lips, connectors that are uniformly spaced longitudinally hold the pieces together. The webs and flanges of the homogenous DTBG sections are manufactured of the same grade Low steel.

When steel sections are bent, the compression zone is typically more susceptible to various types of buckling than the bending effects in the tension zone; this phenomenon happens in the majority of loading scenarios. Therefore, the areas above the neutral axis require additional rigidity and strength. The suggested DTBGs and HDTBGs have a special cross- section shape that combines the benefits of a closed box section and a "T" section.

1.2 Objectives and scopes

The main objectives are Comparing the performance of HDTGB with conventional beam, Performance of Flexural bending tests on HDTBG under hybrid material configuration, Performance of Flexural bending tests on HDTBG under stiffening case to improve the buckling and moment capacity under following parameter, Flange stiffening inner /middle / outer ,Web stiffening ,inner /middle / outer ,Combined stiffening .Stiner numbers (1s 2s) and to study the performance of lateral loading capacity of HDTBG UNDER PUSH OVER ANALYSIS. To develop the hybrid T box beam girder for steel building to improvise the moment capacity of girder using high strength cold firm steel Performance is against flexural capacity, lateral load capacity, and seismic is studies using Ansys non-linear structural analysis.

2. Comparing the performance of HDTBGB with conventional beam

This chapter deals with the analysis on the performance of HDTBG beams and conventional beam. For the analysis selecting ISMB 150 and ISMB 200 beam. Conventional beams and HDTBG for beam with depth of 150,200 and 180 mm are modelled in ANSYS software. conventional beams are designed based on the IS code both web and flanges. after modelling the meshing is done as hexahedral mesh which is 20nodded mesh and the element size is 20mm.the load is applied as 1/3m displacement convergence criteria.

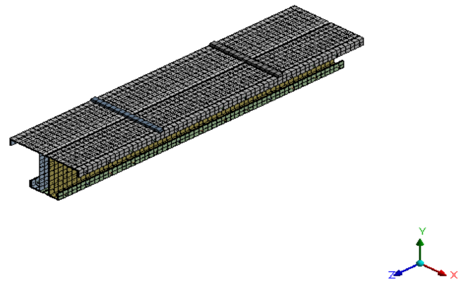

Fig 1- Meshing of HDTBG BEAM

2.1 Analysis

Analysis is carried out to study the flexural performance of HDTBG. Nonlinear static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied. The deformation diagrams are shown in Fig.2,3, and 4.

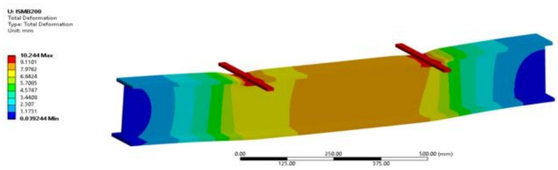

Fig 2- Deformation of HDTGB

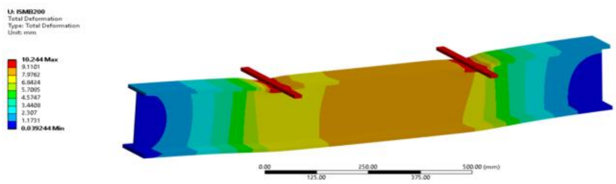

Fig 3- deformation of ISMB200

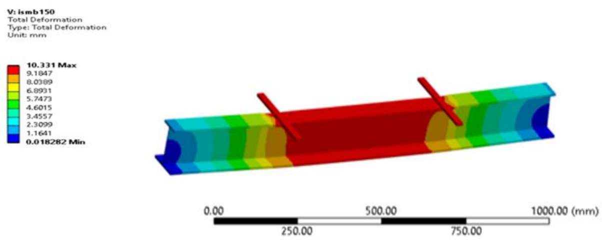

Fig 4- Deformation ISMB150

2.2 Result and discussion

The result obtained from the Nonlinear static structural analysis HDTGB are compared with conventional ISMB200, ISMB150. For that load deformation curve is taken for each model. The table indicate HDTGB beam moment always similar to ISMB150.ISMB200 showing higher moment value. The graphical prestation of moment and deformation of three beams are showing chart 1

Chart -1: moment and deformation

Table 1: deformation and moment

section	Deformation(mm)	Moment (KNm)
HDBT MT-LT	4.942	26.085
ISMB 200	20.462	48.073
ISMB 150	20.726	24.738

Comparing the equivalent to performance of conventional I beam with hybrid double t-box girder beam. From this study it's found that HDTBG showing equal performance to ISMB150 Comparing the equivalent to performance of conventional I beam with hybrid double t-box girder beam. From this study it's found that HDTBG showing equal performance to ISMB150 section. When economical condition weight is constant HDTBG showing better performance than ISMB 150.so the ISMB150 can be replaced by HDTBG.

3. Performance of flexural bending test on HBDTG under hybrid material configuration.

This chapter deals with the analysis hybrid double t -box girder with different grade of steel configurations. The ideal finite element models for steel products and their material attributes for fine-grained structural steel products of grades S275 (Low Tensile - LT), S355 (Medium Tensile - MT), and S460 (High Tensile - HT), HDTBGs are wisely chosen as indicated.

The material properties of HDTBG beam are in Table 6.1

Table -2: material properties

Density	7850kgm^-3
Young's modulus	210Gpa
Poisson's ratio	0.3
Shear modulus	7.692E+10
Bulk modulus	1.667E+11

3.1 modelling and Analysis

Conventional beams and HDTBG for beam with depth of 150,200 and 180 mm are modelled in ANSYS software. Hybrid beams are designed based on the IS code webs and flanges are made of different grade steel.

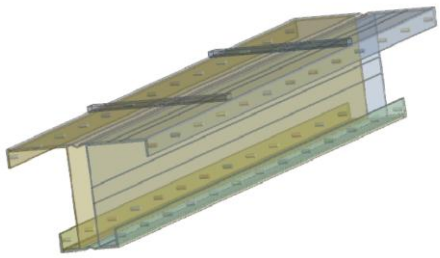

Fig 5- modelling of HDTBG

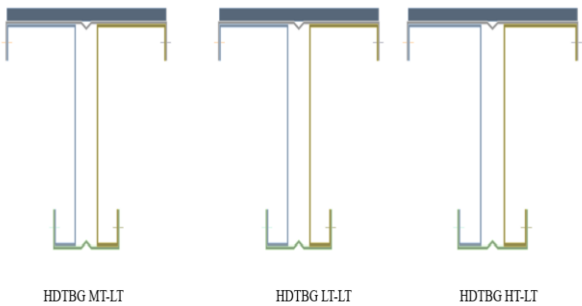

Fig 6- model of HDTBG MT-LT, HDTBG LT-LT&HDTBG HT-LT

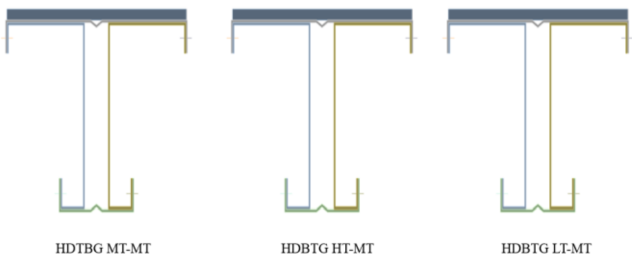

Fig 7- model of HDTBG MT-MT, HDTBG HT-MT&HDTBG LT-MT

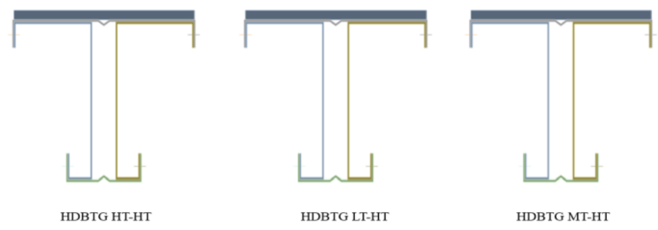

Fig 8- model of HDTBG HT-HT, HDTBG LT-HT&HDTBG MT-HT

Analysis is carried out to study the performance of hybrid double t box girder beam with different grade configuration. Nonlinear static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied. The deformation diagrams are shown in below

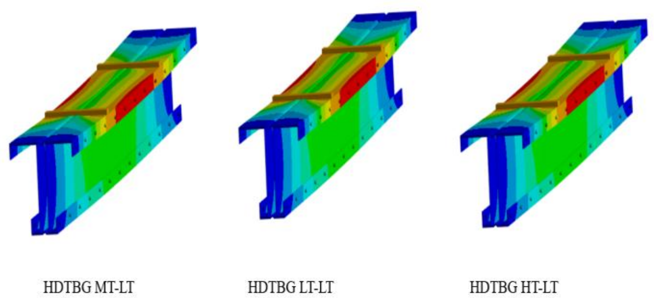

Fig 9- deformation diagram HDTBG MT-LT, HDTBG LT-LT&HDTBG HT-LT

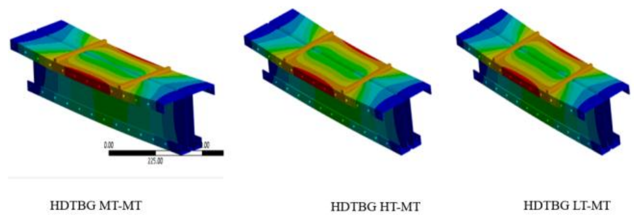

Fig 10- deformation diagram HDTBG MT-MT, HDTBG HT-MT&HDTBG LT-MT

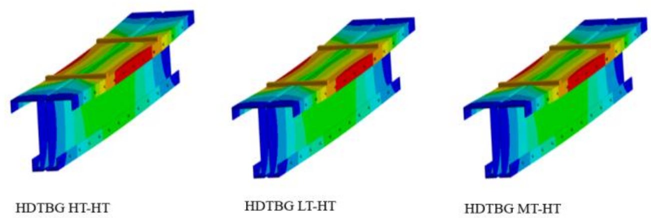

Fig 11- deformation diagram HDTBG HT-HT, HDTBG LT-HT&HDTBG MT-HT

3.2 Result and discussion

The result is obtained from Nonlinear static structural analysis of workbench on ANSYS software. The flexural behaviors of different grade configuration of beam are shown in table

Table -2: flexural behaviors of different grade HDTBG

Section	Deformation (mm)	Moment (KNm)	% increase in moment capacity
HDTBG MT-LT	4.942	26.085	1
HDTBG LT-LT	4.932	25.06	-3.876
HDTBG HT-LT	4.9463	26.067	-0.049
HDTBG MT-MT	4.9141	28.618	9.731
HDTBG HT-MT	4.919	29.351	12.542
HDTBG LT-MT	4.905	27.572	5.720
HDTBG HT-HT	5.921	31.481	20.709
HDTBG LT-HT	4.883	29.681	13.807
HDTBG MT-HT	5.919	30.734	17.845

The graphical presentation of flexural performance of beam are showing in chart

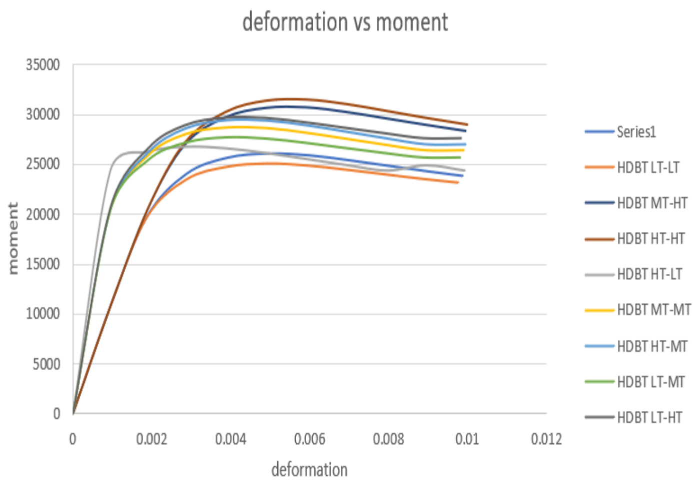

Chart -2: deformation and moment

When web is LT flange is different grade LT, MT, HT negligible result is founded. While web constant with MT flange change with LT, MT, HT minimum 5-12% improved, when web is HT flange is LT, MT, HT minimum 13-20% improved'. Only moment capacity was enhanced in this study. Failure patterns are consistent across all models.

3. CONCLUSIONS

The result obtained from the Nonlinear static structural analysis HDTGB are compared with conventional ISMB200, ISMB150. Comparing the equivalent to performance of conventional I beam with hybrid double t-box girder beam. From this study it's found that HDTGB showing equal performance to ISMB150 section. When economical condition weight is constant HDTGB showing better performance than ISMB 150.so the ISMB150 can be replaced by HDTGB. The flexural behaviors of different grade configuration of beam, when web is LT flange is different grade LT, MT, HT negligible result is founded. While web constant with MT flange change with LT, MT, HT minimum 5-12% improved When web is HT flange is LT, MT, HT minimum 13-20% improved'. Only moment capacity was enhanced in this study. Failure patterns are consistent across all models. In this analysis the stiffener is providing for improving the stiffening of the section. Changing the position of showing different performance.

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