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Comparison of Different Steel Sections for Design of Industrial Boiler Supporting Steel Structure

Suraj Gaikwad[1], Sandip Hake[2], Uday Tadkalkar[3]

[1]*Student, Dr. VithalraoVikhe Patil College of Engineering, Ahmednagar, Maharashtra, India.*
[2]*Proffessor, Dr. VithalraoVikhe Patil College of Engineering, Ahmednagar, Maharashtra, India.*
[3]*Structural Engineer, S. P. Engg. Corp. Pvt. Ltd., Pune,Maharashtra, India.*

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ABSTRACT: The purpose of this paper is to compare the structural behaviour and weight of Industrial boiler supporting steel structure using different steel sections for beam, columns & bracings and to suggest optimum sections or combination of sections for Industrial boiler supporting steel structure. In this work three models of Industrial boiler supporting steel structures have been created using finite element software STAAD.Pro CONNECT Edition. In first model, Indian standard sections are used i.e., ISMB sections for Beam, ISMB/ISWB sections for column and ISA sections for bracing. In second model Jindal & TATA Structural sections are used i.e., UB sections for Beam, UC/NPB/WPB sections for column and SHS Sections for Bracings. In third model combination of sections are used i.e., ISMB sections for Beams, fabricated PG sections for column and SHS for Bracings. These three models of Industrial boiler supporting steel structure have been analysed and designed for the same geometry, loading, analysis and design parameters and are optimised to make weight of structure economical. After comparing all three models it is observed that third model i.e., ISMB sections for beam, fabricated PG sections for column and SHS sections for bracings has optimum results in terms of weight as compared to first two models.

KEYWORDS: Boiler Supporting structure, Weight comparison, Jindal steel sections, Tata structural tube sections, Indian standard steel sections, STAAD.Pro.

I. INTRODUCTION

In various industries boiler and it's other inter connecting equipment's require supporting structure to carry the load of boiler and its equipment's and also to provide access platforms for supervision and maintenance of equipment's. Structural stability of boiler supporting structure is very important and also at the same time weight of the structure shall be optimum so as to reduce overall cost of project.

In the present study, the boiler supporting structure is analysed and designed and compared for three different models in STAAD.Pro CONNECT Edition software. Different steel sections for beam, column and bracings are used in the design boiler supporting structure of same geometry, loading & design criteria. Indian standard sections, Jindal Steel sections and TATA structural sections are used for comparison.

Table I – Steel sections used in various models

	Section for Beams	Section for Columns	Section for Bracings
Model I	ISMB	ISMB/ISWB	ISA
Model II	UB	UC/WPB	SHS
Model III	ISMB	Fabricated PG	SHS

Boiler supporting steel structure has been modelled, analysed and designed using finite element software STAAD.Pro CONNECT Edition. Limit state method of design as per Indian standard

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code (IS 800:2007) is adopted for structural design. Loading is applied as per mechanical general arrangement drawing of boiler. Loading includes dead load, live load, equipment operating load, equipment empty load, wind load and seismic load. Design parameters are assigned as per Indian steel design code IS 800: 2007 in STAAD.Pro CONNECT Edition software. Design is done in such a way that all members shall be safe for strength and serviceability criteria. Weight optimisation of structure is done wherever possible for all members. All three models are designed for comparative study which includes base shear, nodal displacement, column deflection, beam deflection and weight of structure. These results have been compared to study the behaviour of structure for different steel sections for beam, column &bracings. From the results it is found that Case III structure is economical in terms of cost.

II. METHODOLOGY

Geometry of boiler supporting steel structure

Boiler supporting structure consists 26 columns. Pedestal Elevation of columns is at EL+0.3m LVL. Dimensions of structure are 32.1 m length x 24 m width x 37.561 m height.There are 11 main platform levels for operating and maintenance. Staircases and ladders are provided for access to different levels. Supporting of boiler Equipment is at EL+4.5m LVL. Supporting of Economizer is at EL+28.2m LVL. Boiler pressure part is at EL+35.238m LVL. Desecrator equipment is resting at EL+11.500 LVL. Canopy is provided above top deck level. Beam to beam shear connections are provided. Beam to column web shear connections are provided along with vertical bracings. Beam to column flange moment connections are provided. Vertical bracings are provided in such a way that it should not obstruct the walkway. Tie beams are provided for lateral restraint to beams. Plan bracings are provided to take care of moments in the beam about minor axis. Orientation of column is taken such that column flange will be along width of structure because greater stiffness is required along width of structure.

Codes / standards used for structural design.

•IS 800: 2007 – For steel structure design.
•IS 875: 1987 Part I to III – For Loading.
•IS 875 (Part-3):2015 Wind load calculation.
•IS 1893: 2016 – For seismic load calculation.

Material properties of structural steel sections.

•Hot Rolled Sections - IS 2062 GR. E250 BR
•SHS Tubes - IS 4923 YST 310

Analysis and Design Procedure.

In order to perform structural analysis and design, a 3D model of Boiler supporting steel structure and has been created through finite element software 'STAAD Pro CONNECT Edition'. Stability of Structure is taken care considering moment or shear connections and bracings arrangement as per design requirement.Beam to Column flange moment connections are provided. Beam to column web shear connections along with vertical bracings are provided. Horizontal or plan bracings are provided wherever required as per design requirement. Equipment loads are provided as per equipment general arrangement drawing. Other loads are applied as per applicable standards. Load combinations are defined as per IS 800: 2007. Design parameters are assigned as per IS 800: 2007. All members are checked for strength and serviceability criteria as per IS 800: 2007. Optimization of members is done for weight reduction, allowing utility stress ratio less than 1.

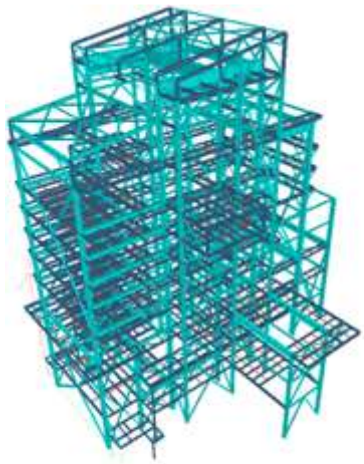


Fig. 3D View of Model I

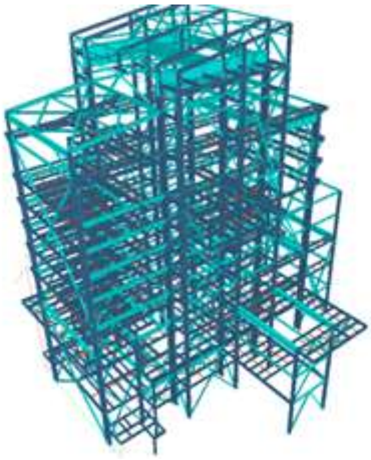


Fig.3D View of Model II

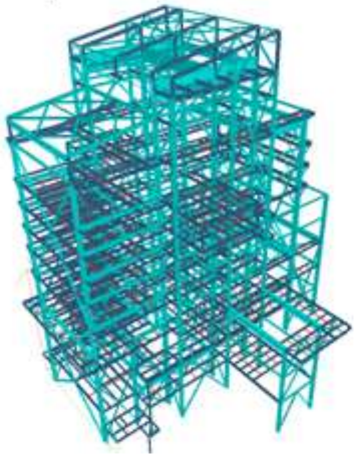
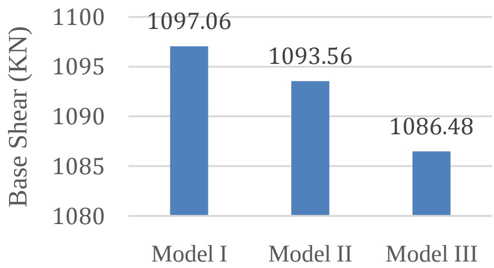


Fig.3D View of Model III

III. RESULTS & DISCUSSION

Base shear for static equivalent analysis.

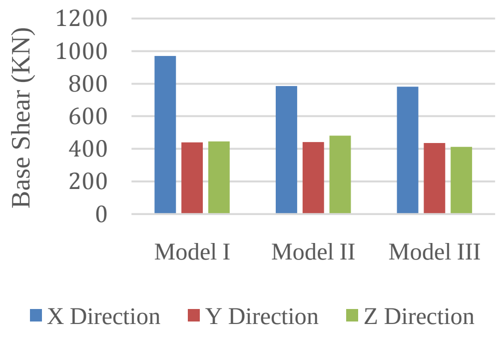
Base shear is generated maximum in model I and minimum in model II. Base shear in model I is greater than around 1 % of base shear in model III. Base shear in model II is less than around 0.4 % of base shear in model I and greater than 0.7 % of base shear in model III.



Graph 1 – Base shear for static equivalent analysis.

Base Shear for response spectrum analysis

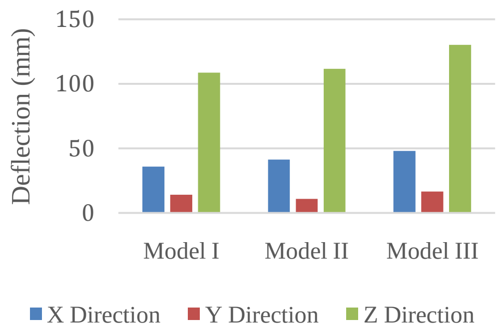
Base shear for response spectrum analysis is generated maximum in model I. For model II and III almost negligible change in base shear is observed in X direction. Base shear in Y direction is generated less than around 55 % of base shear in X direction. Base shear in Z direction is generated less than around 35 % of base shear in X direction. Minimum base shear is generated in Model III as compared to other two models.



Graph 2 – Base shear for response spectrum analysis in X, Y, Z Direction.

Column Deflection

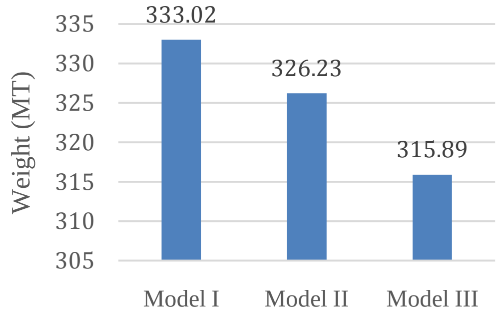
Maximum column deflection is occurred in model III which is around 25 % of maximum column deflection in model I and 17 % in model II. Maximum column deflection is occurred in Z direction in each model as compared to X direction. Deflection in Z direction is more than around 225 % of deflection in X direction.



Graph 3 – Deflection of column in X, Y, Z direction for different models.

Total weight of Structure

Total weight of structure in model III is minimum as compared to model I & III. Total weight of structure in model III is less than around 5.5 % of total weight of structural steel in model I. Total weight of structure in model III is less than around 3.27 % of total weight of structural steel in model I.



Graph 4 – Total weight of structure for different models.

Weight of structural elements

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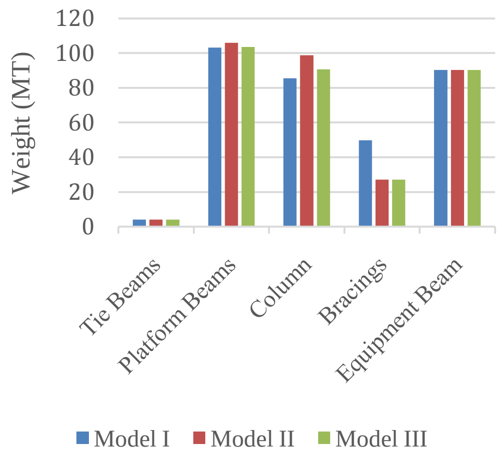
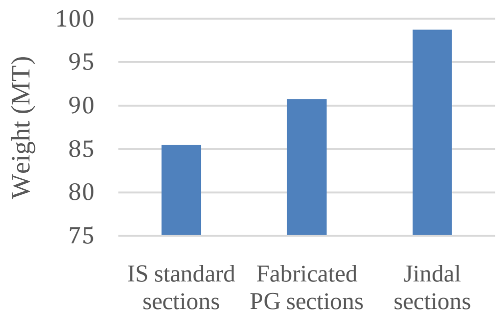
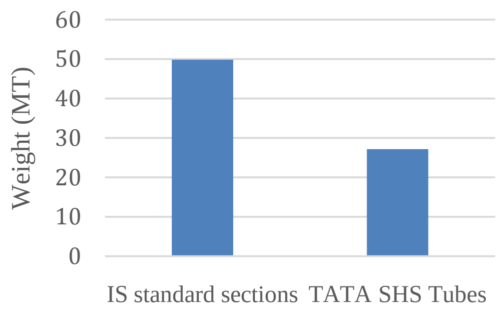


Graph 5 – Weight of different structural elements in different models.



Graph 6 – Weight of columns for different steel sections.



Graph 7 – Weight of bracings for different steel sections.

Weight of beams in model I & III is minimum which is around 2.5 % less than weight of beams in model II. Weight of columns in model I is minimum which is less than around 15 % of weight of columns in model III and 6 % less than weight of columns in model II. Weight of bracings in model II and model III is less than around 85 % of weight of bracings in model I.

IV. CONCLUSION

From above results it is concluded thatTATA structural square hollow sections for design of bracing are economical as compared to Indian standard angle sections in terms of weight and cost. Secondly it is observed that ISWB sections with top and bottom flange plates are weight efficient sections for columns of boiler supporting structure but fabricated plate girder section for columns is better choice in boiler supporting structure due to easy material availability, weight and cost efficiency, easy and time saving fabrication. After observing base shear results, base shear is generated lower in model III, i.e., ISMB sections for beam, fabricated sections for column & TATA square tubes for bracings. Finally in terms of optimum steel sections to be used in typical boiler supporting structure, ISMB or UB sections for beam, fabricated PG sections for column& TATA Square hollow sections for bracings are optimum in terms of weight, stability and easy fabrication.

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