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Behaviour of Plate Girder With Flat Web And Corrugated Web

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Abstract: **The structural action of a beam is predominantly bending, with other effects such as shear, bearing and buckling also being presented. Due to the more application of corrugated section in steel design, this paper develops a three-dimensional finite element model using SAP2000 to investigate the effects of web corrugation on bending behavior of corrugated web profile (CWEB) steel sections. A corrugated web profile (CWEB) steel section is a built-up steel section made up of two flanges connected to a web plate of triangular profile. Thin shell element was chosen to represent the element type of the model. Three models were used for analysis one of flat web (FW) and two sizes of CWEB of different corrugation angle. Design is done based on IS: 800-2007(LSM). Loads considered in modeling are Dead load, Live load Wind load and Earthquake load along with the combination as specified in IS. Response spectrum analysis and time history analysis are carried out for zone 5, structural parameters like self weight, vertical deflection, lateral deflection and design forces results are compared for all the models.**

Keywords: **Finite Element Model; Bending; corrugated Web Profile.**

I. INTRODUCTION

A plate girder is basically an I- beam built up from plates using riveting or welding. Plate girders are also known as deep flexural members used to carry loads that cannot be carried economically. Plate girder provides maximum flexibility and economy. Plate girders offer a unique flexibility in fabrication and the cross section can be uniform or non-uniform along the length. It is possible for putting the exact amount of steel required at each section along the length of the girder by changing the flange areas and keeping the same depth of the girder. In other words, it can be shaped to match the bending moment curve itself. Thus, plate girder offers limitless possibilities to the creativity of the engineer.

In construction application, the web usually bears most of the compressive stress and transmits shear in the beam while the flanges support the major external loads. Thus, by using greater part of the material for the flanges and thinner web, materials saving could be achieved without weakening the load-carrying capability of the beam. Nevertheless, as the compressive stress in the web has exceeded the critical point prior to the occurrence of yielding, the flat web loses its stability and deforms transversely. This could be improved by using corrugated web, an alternative to the plane web. The main benefits of this type of beams are that the corrugated webs increase the beam's stability against buckling, which may result in an economical design via the reduction of web stiffeners. Furthermore, the use of thinner webs results in lower material cost, with an estimated cost savings of 10-30% in comparison with conventional fabricated sections and more than 30% compared with standard hot rolled universal beams.

II. PRESENT STUDY

In the present study, Behaviour of plate girder with flat and corrugated web is investigated. Here plate girder with flat web and corrugated web is designed as per Indian standards. Response spectrum analysis and time history analysis are carried out by considering zone 5 earthquake and results are compared. Response of plate girder with flat web and plate girder with corrugated web structures for various parameters like vertical displacement, lateral displacement, maximum shear force, maximum bending moment and base reactions are obtained and compared.

2.1 Structural Details

For present work, a single storied pre engineered building of 18.292m x 45.73m and the bay spacing of 7.65m respectively having springing height of 15.24m and 16.85m from ground level to knee (ridge point), Rafters with a pitch of 10^0 and a rise of 1.61m is considered.

Table 1: Dimensions of the plate girder

b_f(mm)	t_f(mm)	h_w(mm)	t_w(mm)
300	12	300-900	12

2.2 Details of Zone 5 Earthquake

Zone factor = 0.36

Importance factor = 1

Response reduction factor = 5

Type of soil considered = soft soil

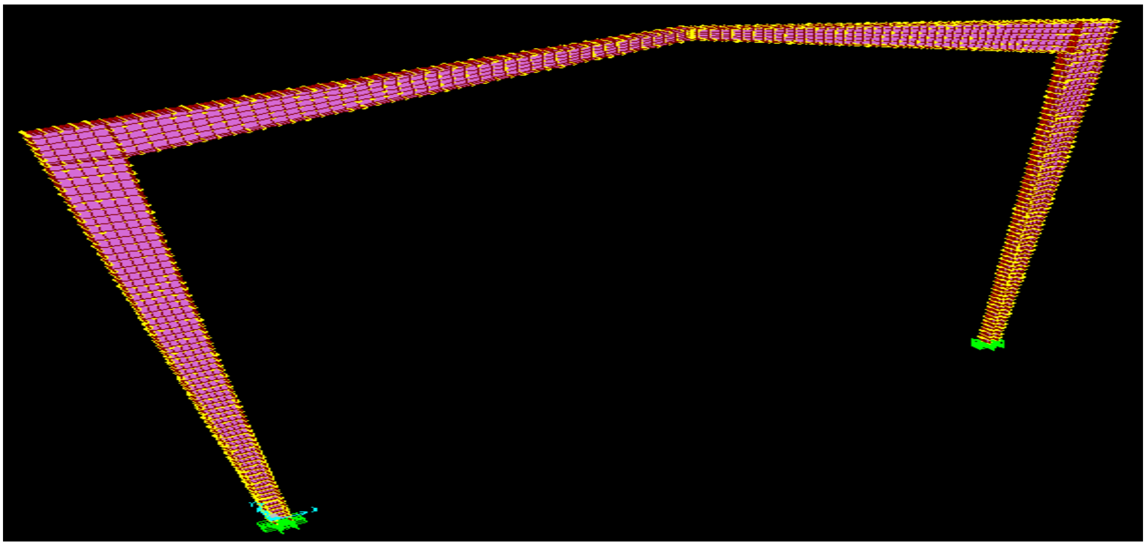

Fig 1: 3D MODEL OF FLAT WEB

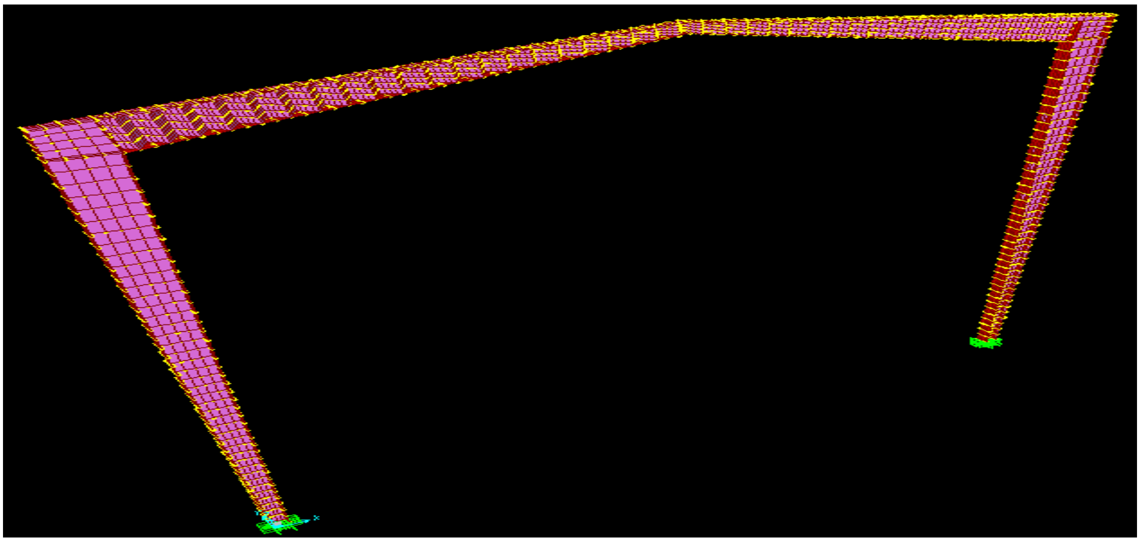

Fig 2: 3D MODEL OF CORRUGATED WEB200

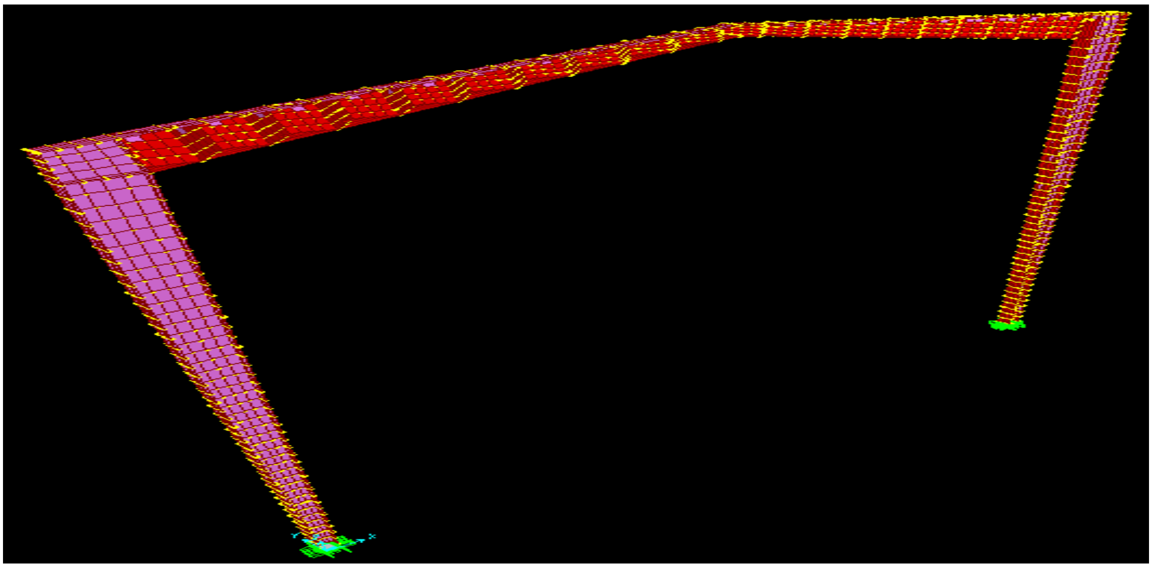

Fig 3: 3D MODEL OF CORRUGATED WEB400

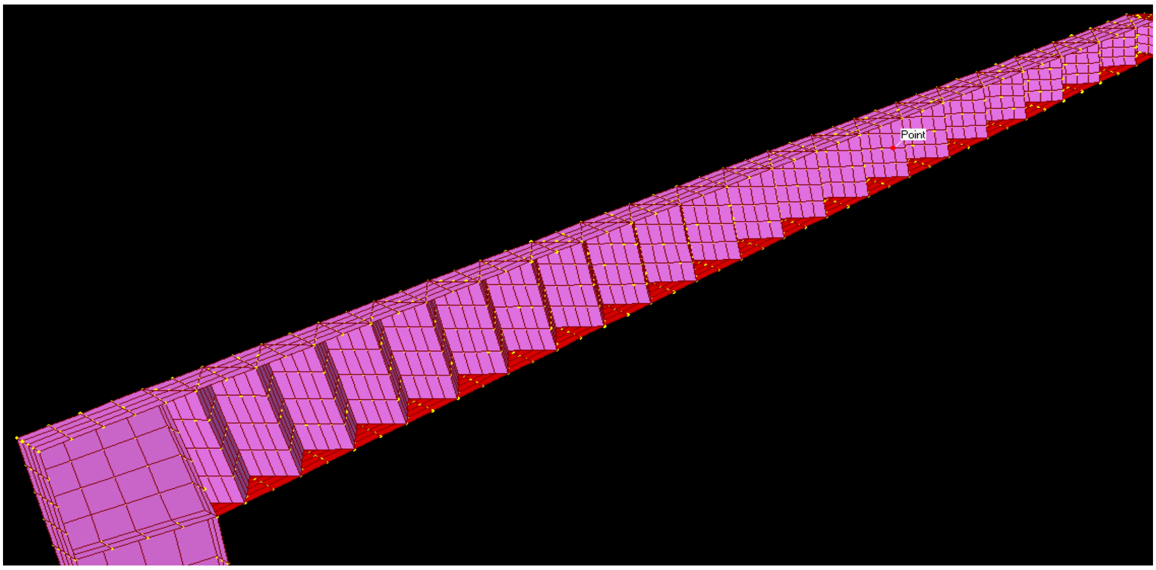

Fig 4: 3D ENLARGED VIEW OF CORRUGATED WEB200

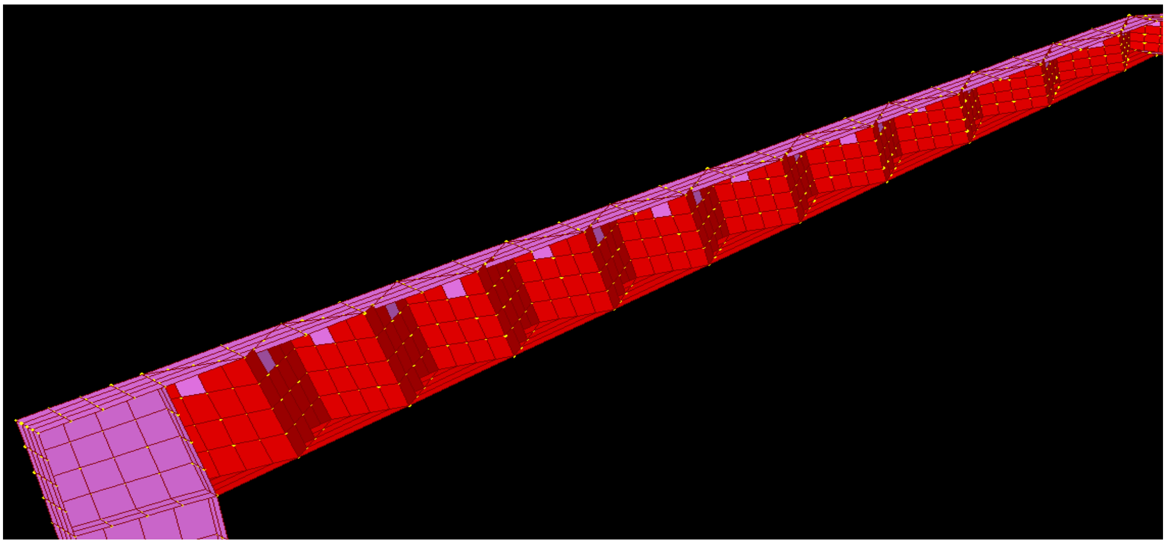

Fig 5: 3D ENLARGED VIEW OF CORRUGATED WEB400

III. RESULTS AND DISCUSSIONS

In the present study the behavior of plate girder with flat web and corrugated web are studied. Seismic analysis is carried out as per IS 1893(part 1)-2002. Response spectrum analysis and linear time history analysis are adopted and analysis is carried out for zone 5 using SAP 2000 software and results are compared. Structural response for various parameters like vertical displacement, lateral displacement, design forces and base reactions are presented.

3.1 Comparision of Response Spectrum Analysis and Time History Analysis

Structural response parameters like base shear and maximum lateral deflection variations are obtained and results are compared between response spectrum analysis and time history analysis for flat web. Values of base shear and maximum lateral deflection are shown in table 2

Table 2: Comparision of Base Shear and maximum lateral deflection

COMPARISION OF BASE SHEAR AND MAX LATERAL DEFLECTION		
ANALYSIS	BASE SHEAR (KN)	MAX LATERAL DEFLECTION (MM)
RSA	42.788	52.548
THA	55.20	63.670

Permissible lateral deflection under earthquake load is =h/250

Where h is height of the structure

Maximum permissible deflection=16000/250=64mm> 63.670 mm, hence safe.

From the results obtained for response spectrum analysis and time history case it can be concluded that for the models considered, the time history analysis results has higher base shear and lateral deflections compared to response spectrum analysis. There is an increase of 29% of base shear and 21.16% of maximum lateral deflection when compared with response spectrum analysis.

3.2 Comparision of Design Forces

Comparision of design forces for all the three models has been studied. Values of design forces for all the three models are shown in table 3

Table 3: Comparision of design forces

COMPARISION OF DESIGN FORCES			
MODEL	MAX MOMENT		MAX SF
	MAJOR AXIS MOMENT(M_X)	MINOR AXIS MOMENT(M_Y)	SHEAR FORCE (V_Y)
FLAT WEB	0.927kN-m/m L/C(1.5DL+1.5LL)	0.572kN-m/m L/C 1.2DL+1.2LL-1.2WL(+ICP)	605.64kN/m L/C 1.2DL+1.2LL-1.2EQTH
CWEB 200	15.368kN-m/m L/C(1.5DL+1.5LL)	6.888kN-m/m L/C 1.2DL+1.2LL-1.2WL(+ICP)	833.753kN/m L/C 1.2DL+1.2LL-1.2EQTH
CWEB 400	11.145kN-m/m L/C(1.5DL+1.5LL)	10.027kN-m/m L/C 1.2DL+1.2LL-1.2WL(+ICP)	710.007kN/m L/C 1.2DL+1.2LL-1.2EQTH

From the table it is observed that there is an increase of design forces when compared with flat web model.

Maximum major axis bending moment is observed for the cweb200 case, there is an increase of 37.89% of major axis bending moment when compared with cweb400.

Maximum minor axis bending moment is observed for the cweb400 case, there is an increase of 45.57% of minor axis bending moment when compared with cweb200

Maximum shear force is obtained for the cweb200 case, there is an increase of 37.66% shear force when compared with flat web case and 17.42% of shear force when compared with cweb400 case

3.3 Comparision of Deflection

Comparision of Lateral Displacement due to earthquake motions for all models are studied. Values of deflections are shown in table 4

Table 4: Comparision of deflection

COMPARISION OF DEFLECTION		
MODEL	VERTICAL DEFLECTION(MM)	HORIZONTAL DEFLECTION(MM)
FLAT WEB	16.362	63.893
CWEB 200	20.673	106.398
CWEB 400	20.325	70.390

From the table it can be concluded that there is an increase of deflection when compared with flat web model.

Maximum vertical deflection is observed for cweb200 case, there is an increase of 26.34% of deflection when compared with flat web case and 1.71% of deflection when compared with cweb400 case.

Maximum lateral deflection is observed for cweb200 case, there is an increase of 66.52% of deflection when compared with flat web case and 51.15% of deflection when compared with cweb400 case.

3.4 Variation in Base Reaction (Self Weight*)*

Comparision of base reaction for all models is studied. Values of base reactions are shown in table 5

Table 5: Variation of base reaction

COMPARISION OF BASE REACTION (SELFWEIGHT)	
MODELS	SELF WEIGHT (DL)
FLAT WEB	77.559
CWEB 200	83.938
CWEB 400	81.475

From the table it can concluded that there is an increase of base reaction in all the three model, maximum base reaction is observed in cweb200 model with an increase of 8.22% when compared with flat web model and 3.02% when compared with cweb400 model.

IV. CONCLUSIONS

1. From the results obtained for response spectrum analysis and time history analysis it can be concluded that for the models considered, the time history analysis results higher base shear and lateral deflections compared to response spectrum analysis.
2. When the design force results of corrugated web models are compared with flat web, it is observed, flat web is effective in resisting major axis bending moment which clearly states that corrugated web sections are not effective in resisting major axis bending moment as corrugation drastically decreases the major axis bending stiffness.
3. To make the corrugated web sections effective in resisting major axis bending moment, the corrugation parameters such as corrugation angle should be studied and proportioned accordingly otherwise corrugated web profiles can result in uneconomical solution.
4. Maximum minor axis bending moment is observed for the case cweb400 in corrugated models. it can be observed that, denser the corrugation, higher the bending stiffness in minor axis. in other words increase in corrugation angle increase the minor axis bending stiffness.
5. Maximum shear force is observed for the case cweb200. Though corrugation increases the shear capacity for a particular corrugation parameters, denser corrugation increases the self weight and stiffness of the beam and under lateral load such as earthquake, corrugated beams experience higher design shear forces.
6. Maximum vertical deflection is observed for the case cweb200 due to increase in self weight per unit length of the beam because of dense corrugation.
7. Maximum lateral deflection is observed for the cweb200 due to decrease in inplane stiffness with the increase in corrugation angle and increase in self weight of the beam due to dense corrugation which increases the earthquake force.
8. By comparing the base reaction of the frame for dead load case, it is observed that, girders with corrugation increase the dead weight of the structure which in turn increases the cost of foundation.

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