IJBPAS, November, 2015, 4(11), Special Issue: 510-515

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

FINITE ELEMENT ANALYSIS OF CASTELLATED NON-PRISMATIC CASTELLATED BEAMS USING 2D BEAM-COLUMN ELEMENT

[1]REZA GHASSEMI, 2*MAHMOUD-REZA HOSSEINI-TABATABAEI

1: Department of Civil Engineering, College of Engineering, Zahedan Branch, Islamic Azad University, Zahedan, Iran

2: Department of Civil Engineering, University of Zabol, Zabol, Iran

***Corresponding Author's E Mail: MR.HTabatabaei@uoz.ac.ir**

ABSTRACT

In order to save materials, castellated beams are designed and produced in such a way decreasing their height when reducing amount of flexural anchor. With development of welding and cutting technology in producing steel beams, now castellated steel beams (CSB) are feasible for structural engineers. In this research, we consider modelling and analysis of castellated beams with variable height using finite elements method. In this regard, SAP and ABAQUS software are used. Samples of castellated beams have different geometric features. In modelling, just half of beam is analyzed due to its symmetry. The comparison between results of two mentioned software shows that shifts obtained by SAP software is lower than that of ABAQUS, indicating that modelled structure with SAP beam-pillar component is more severe than ABAQUS structure. Also increase in height of profiles would enhance behavioural difference.

Keywords: Castellated beams with variable height, shift, tension, flexion, limited element method

INTRODUCTION

Castellated steel beams known firstly as 'Boyd beams' were initially used in 1910; afterwards they were designed and produced in 1930s as ceiling beams in Czech Republic. The first elasticity and plasticity computation methods of these beams were introduced in 1942 and early of 1970s, respectively. Beam castellation is a crinkle process in which one half is rotated, and then welded to the other half. This process increases depth of main beam in some parts.

Altfillisch et al (1959) showed that increase in containment difficulty would increase flexural resistance due to its prevention of lateral torsional buckling.

Dougherty B.K (1993) compared buckling distortion of castellated beams with real scale beams under load. The result s of his theoretical and laboratory analysis is reported close to each other.

Khaled M. El –Sawy (2009) studied impact of axial shear deformation on flexion of castellated pillars using limited element method. Finally, he presented his results in order of a dimensionless parameter to calculate flexion length of castellated pillar.

Ellobody (2011) studied flexion mood of castellated beams, and analyzed their lateral - torsional and distortion buckling; then he calculated final load that causes buckling.

G. Baylor et al (2013) present limited component model for I-shaped wooden beams; they concluded that there is a good correlation between limited components and experimental results for wooden castellated beams of 241 and 305mm.

Esra Mete Guneyisi (2013) studied genetic algorithm method for 'I and H levels' of castellated beams; they concluded that this is a suitable model for final flexural resistance.

Peijun Wang (2013) studied Varindle failure on steel castellated beams with different openings, and finally presented a V-M interaction equation to predict load-bearing capacity of these beams.

Delphine Sonck (2014) compared buckling behavior of castellated members with normal ones using residual tension created in castellation process and its impact on model's buckling resistance. They concluded that residual tension is very significant factor in buckling of castellation components.

Wei-bin Yuan et al (2014) studied critical buckling of castellation pillars with T-shaped levels; finally, they concluded that shear deformation can increase critical buckling up to 25%. They also presented some solutions to prevent this type of buckling.

S.Durif et al investigated about castellated beams to calculate destruction and Varindle coefficients of these beams. In another article then they obtained failure moods for 1/4 of sinus openings using limited element method. Finally, in third article they limited their experiment to 3 defined beams to compare results obtained by beams with that of failure moods.

Soltani et al (2012) presented a numerical method foe behavior of hexagonal and octagonal castellated beams; they (beams) were compared with ENV model. The researchers finally concluded that castellated beams with averaged sheets are talented for more buckling.

Elham Shahraki (2014) performed limited element model for castellated beams with assumption of 2- tied elements. She compared it with programming model and concluded that the less is amount of profile beam, the maximum is shift difference percent for 2-tied elements (17.33%).

Modeling of castellated beams with variable height and help of inside sheet and beam-pillar components

a. 2-tied beam-pillar component with three degrees of freedom in each tie

b. 3-tied triangular component (fixed buckling)

c. Function of two above components is based on the formula below:

Ke=0l[Be]TEAx[Be]dx

In this research, SAP and ABAQUS software are used to analyze castellated beam with variable height (limited component method). In software modeling, the beam is divided to components that are linked together just in points called 'tie'.

Modeling and analysis of castellated beams with variable height using SAP and ABAQUS software

To analyze models with SAP and ABAQUS/CAE software, the beam must be analyzed with limited element software such as ABAQUS. Then, the problem is analyzed and results are obtained. The maximum change in location, tension, and strain of each profile are shown in related tables and figures.

Results of model analysis

Shifts and tensions of in-prismatic castellated beams IPE45, IPE80, IPE100, IPE120, and IPE140 with opening of 15mm under focused load -5000N is obtained with solving overall equation with Choleski method.

For analysis, castellated beams with variable height are divided to 28 components in which shifts are calculated for start and end points of each component. Therefore, the maximum shift of in-prismatic element castellated beams is shown in table (1) with results of maximum shift obtained by each software. Figures 1-5 show shift of each profile as the start and end points of elements.

Table (1) maximum shift of profiles

Error percentage	Maximum shift of SAP	Maximum shift of ABAQUS	Profile
36%	0.006571cm	0.0082376 cm	IPE45
32%	0.0267255 cm	0.035277 cm	IPE80
24%	0.01940656 cm	0.2406414cm	IPE100
15%	0.0076200 cm	0.0087631cm	IPE120
12%	0.0045149 cm	0.0050567cm	IPE140

Further, tension is calculated in a panel of in-prismatic castellated beams (element 26):

Table (2) Axial tensions obtained by SAP and ABAQUS

ABAQUS tension (kg/cm^2)	SAP tension (kg/cm^2)	profile
768.976	**724.505**	**IPE45**
43.876	**38.323**	**IPE80**
28.987	**23.944**	**IPE100**
19.879	16.701	IPE120
14.534	12.963	IPE140

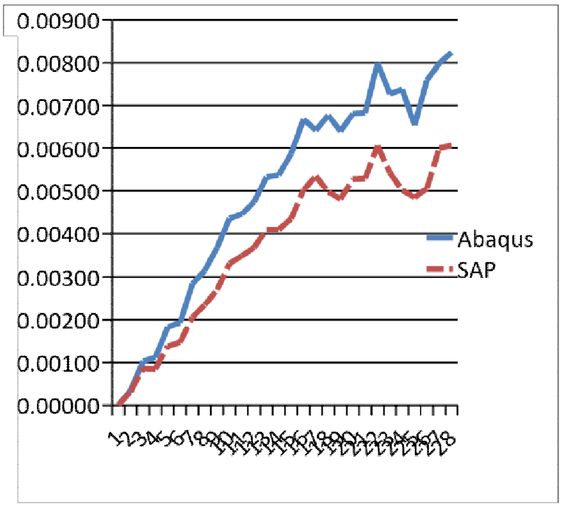

Figure (1) vertical shift of SAP and ABAQUS (IPE45)

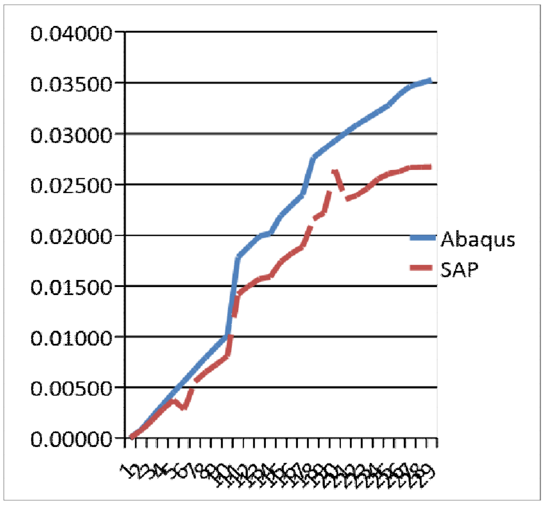

Figure (2) vertical shift of SAP and ABAQUS (IPE80)

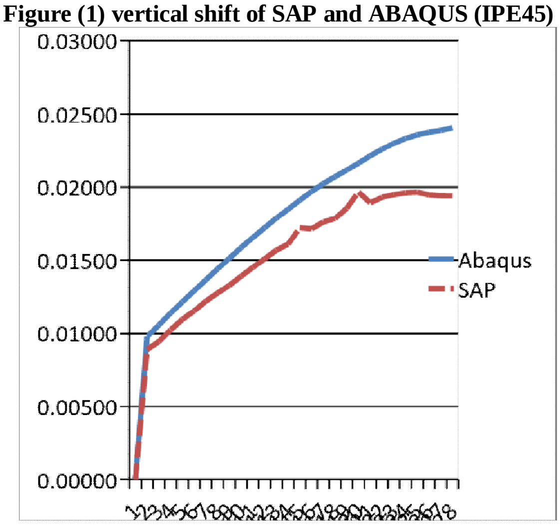

Figure (3) vertical shift of SAP and ABAQUS (IPE100)

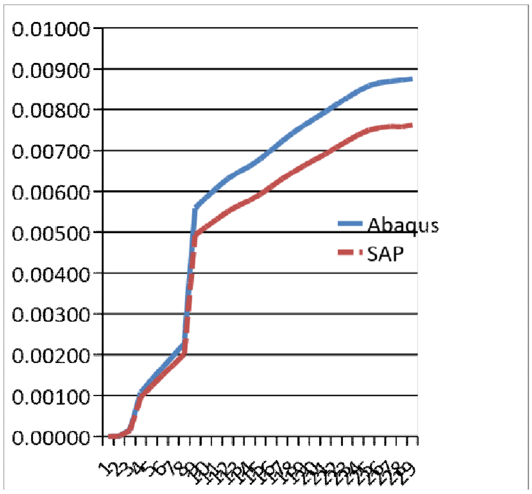

Figure (4) vertical shift of SAP and ABAQUS (IPE120)

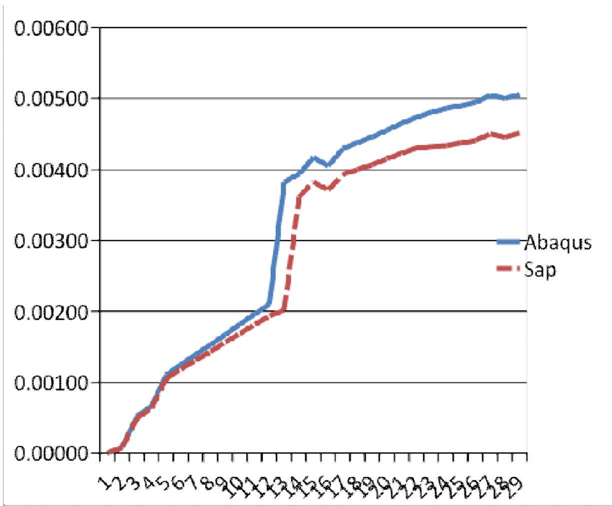

Figure (5) vertical shift of SAP and ABAQUS (IPE140)

CONCLUSIONS

Results obtained for castellated beams load using SAP software was not detailed enough, and it can be used just for low and little shifts.

While linear impact of this modeling was performed with help of 3-tide element, it was observed that maximum shift was taken place at center of opening.

Axial tensions obtained by SAP at center of opening are less than that of ABAQUS software indicating more severe behavior of SAP.

Final wave items are observed on shift diagrams due to shear intensity of holes.

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