Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 7, Issue, 10, pp.21153-21157, October, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

STUDIES ON THE EFFECT OF SHEAR LAG ON BUCKLING BEHAVIOR OF LAMINATED COMPOSITE BOX BEAMS

***Kripa, K. M. and Nithin Mohan**

Department of Civil Engineering, Calicut University, Thrissur, India

ARTICLE INFO

Article History:
Received 17th July, 2015
Received in revised form
25th August, 2015
Accepted 25th September, 2015
Published online 20th October, 2015

Key words:

Box girders,
Buckling, Laminated Composites,
Shear lag, Rotational restraint,
ANSYS15.

ABSTRACT

Shear lag effect on the buckling behaviour of laminated composite box beams is investigated. The investigation involved modelling the box beams for buckling load factor and a method for analyzing the shear lag effects on symmetrically laminated thin walled composite box beams. Studies were done on various parameters affecting both shear lag and buckling as the strength is affected by these conditions. The orthotropic nature of laminated composite box beams has to be taken into consideration in all these analyses. The modelling has been analyzed by ANSYS15.

Citation: Kripa, K.M. and Nithin Mohan, 2015. "Studies on the effect of shear lag on buckling behavior of laminated composite box beams", *International Journal of Current Research*, 7, (10), 21153-21157.

INTRODUCTION

The stress distribution in a transverse loaded I section beam is different from what is calculated by classical beam theory due to shear lag. The phenomenon of non-uniform normal stress distribution in the flange of a thin-walled member is called the shear lag. As top flange experience compression in the longitudinal direction, the flange becomes shorter, due to poisons ratio it becomes wider, opposite for bottom flange. Neglect of shear lag would lead to an unsafe design. The longitudinal stresses at the web-flange junction are larger than those at the midpoint of the flange are positive shear lag and the stresses near the web are smaller than those near the center of the flange are negative shear lag. As far as the lateral buckling of the thin-walled member is concerned, the buckling usually occurs by twisting or by a combination of bending and twisting, and the buckling failure will be sensitive to the magnitude of the deflections. (Lou *et al.,* 2002) It was found that, the finite element method can predict the shear lag phenomenon reasonably well, however, in some cases the difference in the stress predicted by the finite element method and the experimental results can be as high as 25%. (Upadhyay and Kalyanaraman, 2003)

****Corresponding author: Kripa, K. M.***
Department of Civil Engineering, Calicut University, Thrissur, India

The stress concentration may cause the weakening of the structure and thus affect the stability of the structure (Chartree Lertsima and Taweep Chaimsophob, 2005) The effects of shear lag and shear deformation cause ply normal stress distributing non-uniformly along the width of the flange and vertical displacement increases respectively, which can influence the design of strength and stiffness for composite box beam. To reduce the effects of shear lag and shear deformation we can set off-axis ply angle within 40° and 60°. (Wu Yaping *et al.,* 2004) A numerical analysis for the lateral buckling of doubly symmetrical simply supported thin-walled open member by using optimization technique is adopted.

The accuracy of the approach is compared with the solutions of experiment and finite element method. A study on the effect of shear lag of composite laminated plates with buckling form an applied analysis model for thin-walled composite box beams under bending loads. In this model, shear lag effect; shear deformation effect, and ply stresses; strains of the flanges in thin-walled composite box beams can be investigated and expressed explicitly (Quanfeng Wang, 1999) To validate the theory of paper, a comprehensive investigation on the effects of shear lag and shear deformation, displacement, ply normal stresses is given for a simply supported symmetric carbon—epoxy box beam subjected a concentrated load P at the mid-span (Quanfeng Wang and Li, 1997). The numerical results of this paper are correlated with the predictions of the finite element method (FEM) or previously published experimental results. The results obtained from the analyses of this paper can provide reference for the design of related engineering structures.

MATERIALS AND METHODS

Composite beam specimen was analyzed by using ANSYS which is an engineering simulation commercially used software offering a comprehensive suite that spans the entire range of physics, providing access virtually to any field of engineering simulation that a design process requires. The software use its tools to put a virtual product through a rigorous testing procedure such as testing a beam under different loading scenarios before it becomes a physical object.

ANSYS can carry out advanced engineering analyses quickly, safely and practically by variety of contact algorithms. In this study it is used to carry out discrete modelling of box to analyze it under static loading conditions. For modelling of composite beam the ANSYS used an element named as 8 noded 281 shell element which is linear model of brittle material similar to concrete. It was an eight noded iso-parametric element with three degrees of freedom at each node.

Numerical investigations and observations

Modal analysis

The effect of various parameters such as orthotropic parameter, cross section and various fibre orientations are investigated.

Evaluation by orthotropic parameter

Beam was modelled and analysed using ANSYS software. The beam was of size 605 x 250 x 3000. Linear orthotropic properties are EX – 145000, EY – 16500,EZ – 16500,PRXY – 0.314, PRYZ – 0.037, PRXZ – 0.314,GXY – 4480, GYZ – 4480, GXZ – 4480.Element used is shell 281 which is an 8 noded linear shell element with six degrees of freedom at each node. By keeping B/D, L/B, B/t_f, t_f, fibre orientations and hence ω1 as constant values and by changing t_w, shearlag and buckling load factor is calculated. Many models are analyzed using ANSYS15 each with 6 symmetric layers.

Table 1. shear lag and buckling load factor with constant ω1

t_f/t_w	k_1	Shear lag Be/B	Buckling load factor
`4	0.4444	0.229812	0.10474
2	0.4	0.310836	0.76371
1.333333	0.3636	0.369415	1.1887
1	0.33334	0.416218	1.4357
0.8	0.30769	0.455324	1.6459
0.666667	0.28572	0.48855	1.8166
0.5	0.25	0.543939	2.0821
0.4	0.2222	0.587698	2.2989
0.307692	0.19048	0.639102	2.5857
0.25	0.1667	0.015625	2.8545

Fig.1 and Fig.2 was plotted between buckling load factor and cross sectional parameter with ω1 as 21.8222 and fibre orientation for flanges as [0/0/0] and web as [0/0/0]

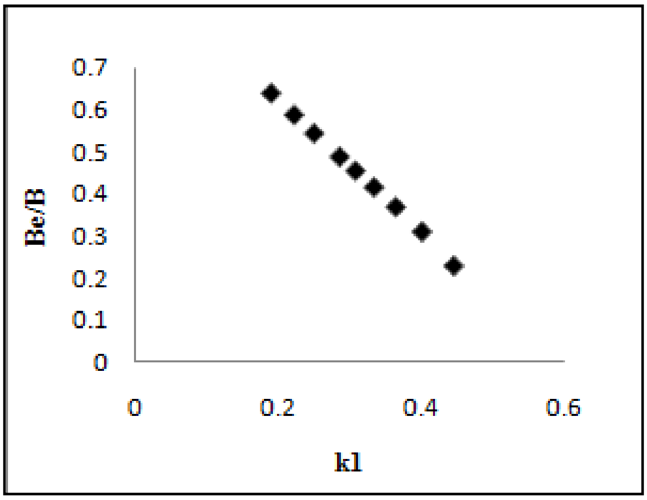

Fig. 1. Shear lag vs. Cross sectional parameter

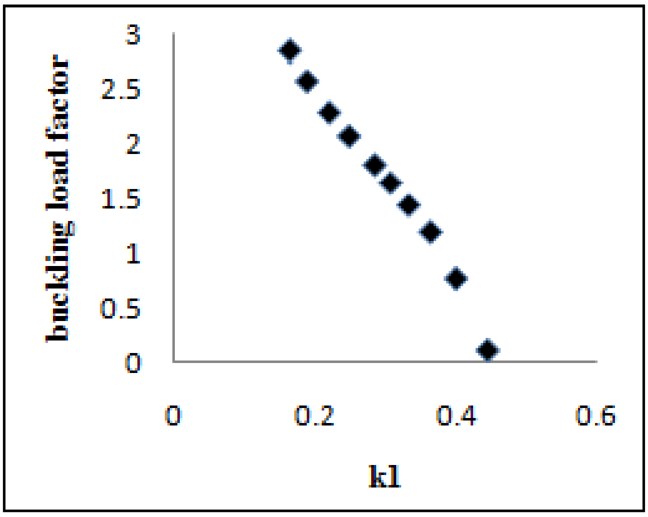

Fig. 2. Buckling load vs. Cross sectional parameter

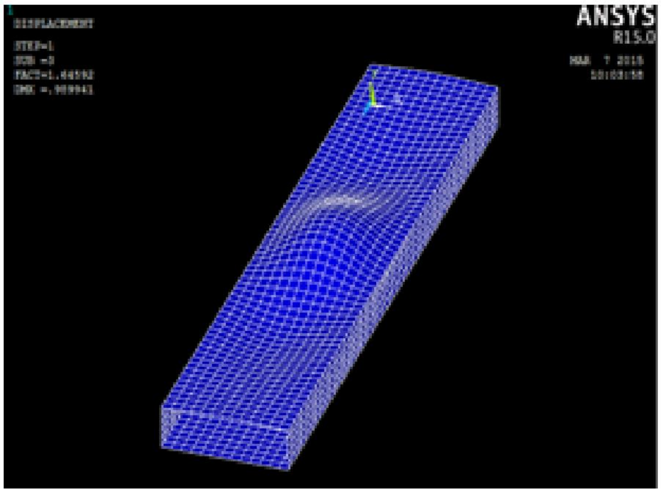

Fig. 3. Buckling model using ANSYS 15

Fig.4 and Fig.5 was plotted between buckling load factor and cross sectional parameter with ω1 as 0.83624 and fibre orientation for flanges as [+/-45] and web as [+/-45]

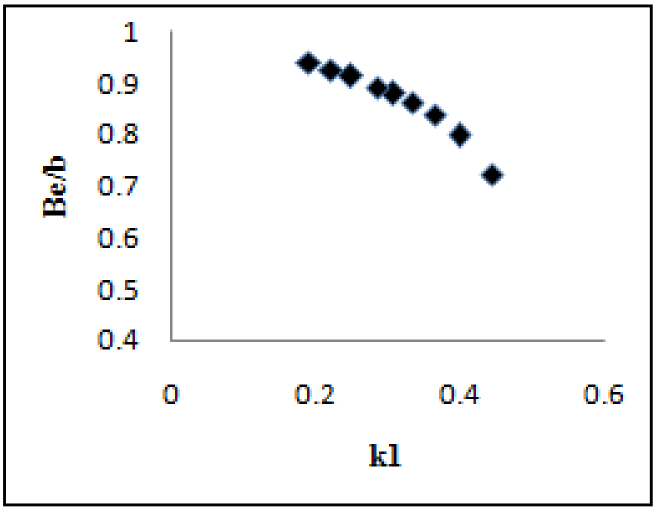

Fig .4. Shear lag vs. Cross sectional parameter

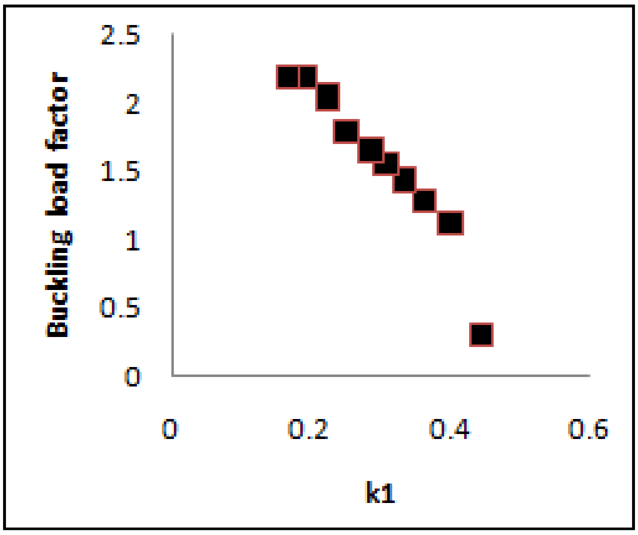

Fig. 5. Buckling load vs. cross sectional parameter

Fig.6 and Fig.7 was plotted between buckling load factor and cross sectional parameter with ω1 as 15.3759 and fiber orientation for flanges as [0/90/0] and web as [0/90/0]

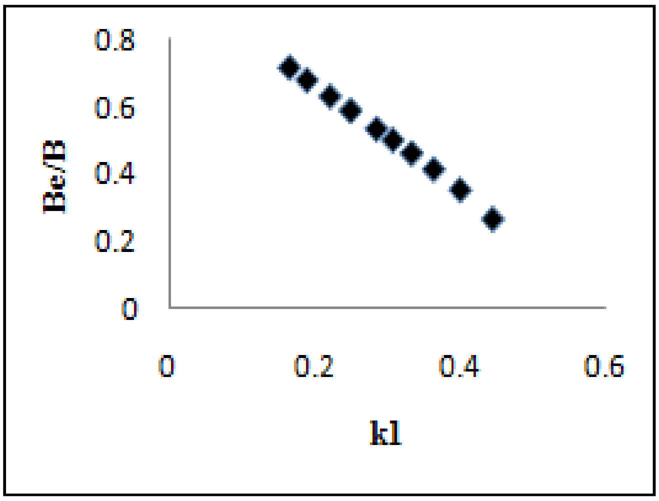

Fig. 6. Shear lag vs. Cross sectional parameter

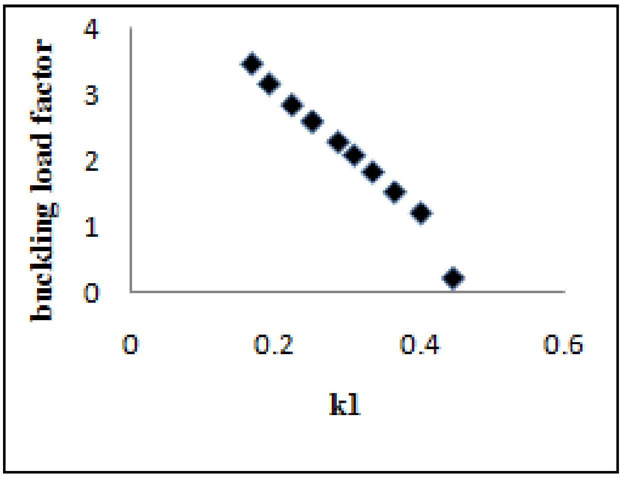

Fig.7. Buckling load vs. Cross sectional parameter

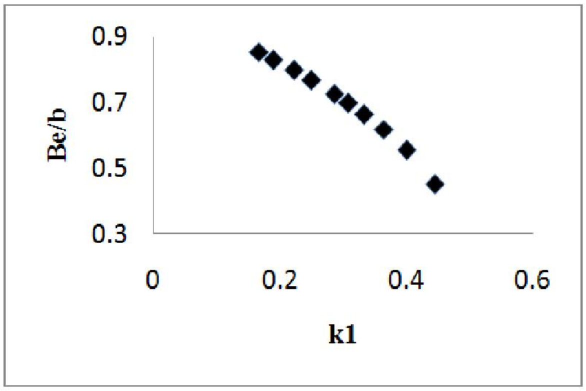

Fig.8. Shear lag vs. cross sectional parameter

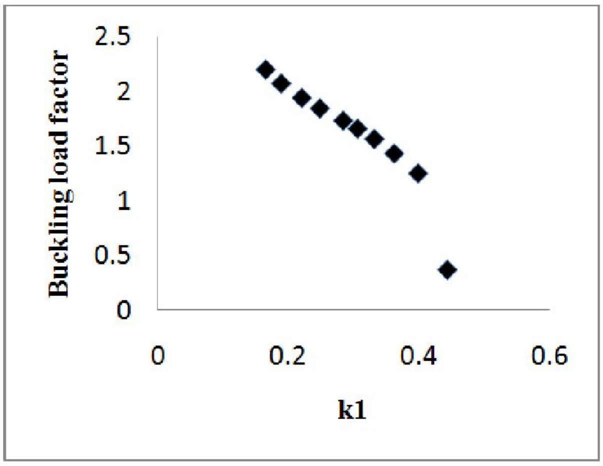

Fig.9. Buckling load factor vs. Cross sectional parameter

Fig.8 and Fig.9 was plotted between buckling load factor and cross sectional parameter with ω1 as 16.9847 and fiber orientation for flanges as [0/0/0] and web as [90/90/90]

Evaluation by fibre orientations

Beam was modelled and analysed using ANSYS software. The beam was of size 605 x 250 x 3000. Linear orthotropic properties are EX – 145000,EY – 16500,EZ – 16500,PRXY –

0.314, PRYZ – 0.037, PRXZ – 0.314,GXY – 4480, GYZ – 4480, GXZ – 4480. Element used is shell 281 which is an 8 noded linear shell element with six degrees of freedom at each node. By keeping B/D, L/B, B/t_f, t_f, t_w, fibre orientations in web and by changing fiber orientation in flanges ,shear lag and buckling load factor is calculated. Many models are analyzed using ANSYS15 each with 6 symmetric layers.

Table 2. Shear lag and buckling load factor with different fibre orientations

fibre orientation		shear lag	$d22_f$/	buckling load
flanges [s]	Web [s]	be/b	$d22_w$	factor
45/-45	0/0/0	0.6944	22.98	0.4948
45/-45	90/0/0	0.7048	3.546	1.5616
45/-45	90/90/0	0.726	2.704	1.6071
45/-45	0/-45/0	0.7045	15.47	0.6324
45/-45	90/45/0	0.7213	3.299	1.7036
45/-45	90/90/90	0.7964	2.615	1.52
45/-45	0/45/-45	0.7839	14.78	0.7797
45/-45	90/90/45	0.8168	2.682	1.5724
45/-45	45/90/45	0.8115	5.215	1.0549
45/-45	45/-45	0.8355	8	1.3992

Table 3. Shear lag and buckling load factor with different fibre orientations

fibre orientation		shear lag be/b	$d22_f$/d2	buckling
flanges [s]	Web [s]		2_w	load factor
0/0/0	45/-45	0.5937436	2.79	1.35
90/0/0	45/-45	0.5963011	18	1.47
90/90/0	45/-45	0.6024083	23.7	0.98
0/-45/0	45/-45	0.7345003	4.14	1.29
90/45/0	45/-45	0.7383106	19.4	1.17
90/90/90	45/-45	0.6342579	24.5	0.84
0/45/-45	45/-45	0.7879225	4.33	1.2
90/90/45	45/-45	0.7541385	23.9	0.85
45/90/45	45/-45	0.7983371	12.3	1.27
45/-45	45/-45	0.8354649	8	1.4

Evaluation by changing cross sections

Beam was modelled and analysed using ANSYS software. Linear orthotropic properties are EX – 145000,EY – 16500,EZ – 16500,PRXY – 0.314, PRYZ – 0.037,PRXZ – 0.314,GXY – 4480, GYZ – 4480,GXZ – 4480.Element used is shell 281 which is an 8 noded linear shell element with six degrees of freedom at each node. By keeping L/B, B/t_f, t_f, t_w, fibre orientations as constants and by changing B/D ratio, shear lag and buckling load factor is calculated. Many models are analyzed using ANSYS15 each with 6 symmetric layers.

Table 4. Shear lag and buckling load factor with various B/D

B/D	Shear lag Be/B	Buckling load factor
2	0.396468	1.4957
2.999995	0.338021	1.1827
3.499962	0.317606	1.0237
4	0.300705	0.90433
4.500015	0.286384	0.81116
5	0.274028	0.73167
5.5	0.26321	0.67442
6.00002	0.253623	0.62259
6.500064	0.245042	0.57847
7.000694	0.237287	0.5403

Fig 10 and Fig 11 was plotted between buckling load factor, shear lag and various B/D with fiber orientation for flanges as [90/45/0] and web as [+/-45]

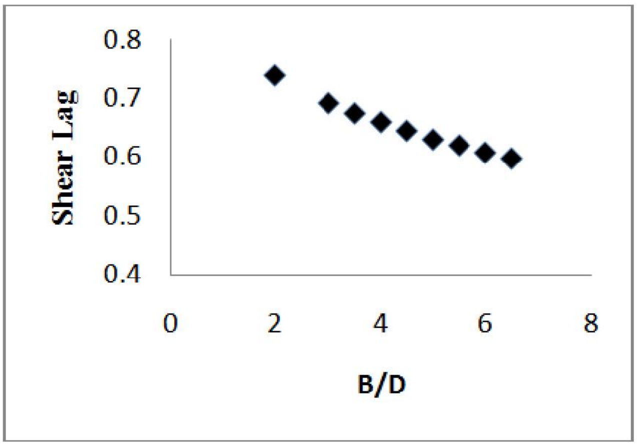

Fig.10. Shear lag vs B/D

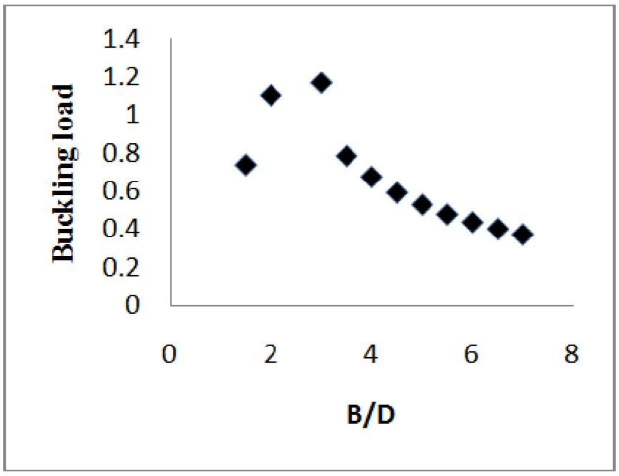

Fig.11. Buckling load vs B/D

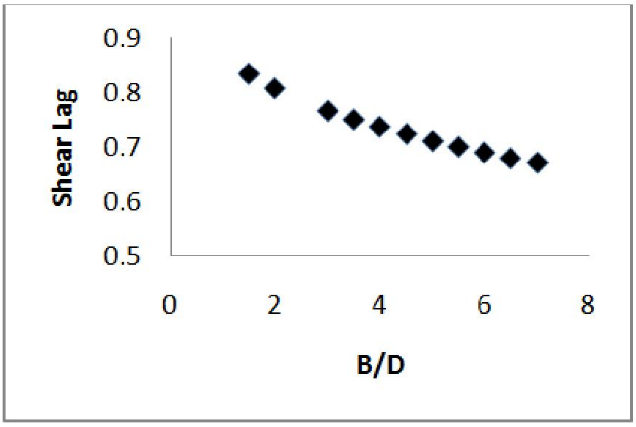

Fig.12. Shear lag vs B/D

Fig 12 and Fig 13 was plotted between buckling load Factor shear lag and various B/D with fibre orientation for flanges and web as [0/45/90]

Fig 14 and Fig 15 was plotted between buckling load Factor shear lag and various B/D with fibre orientation for flanges and web as [0/45/90]

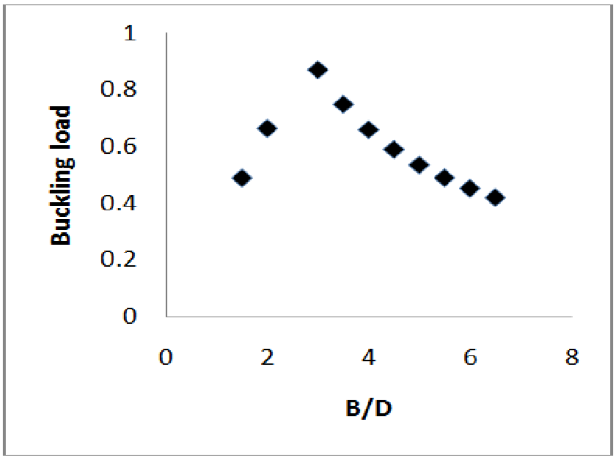

Fig.13. Buckling load vs B/D

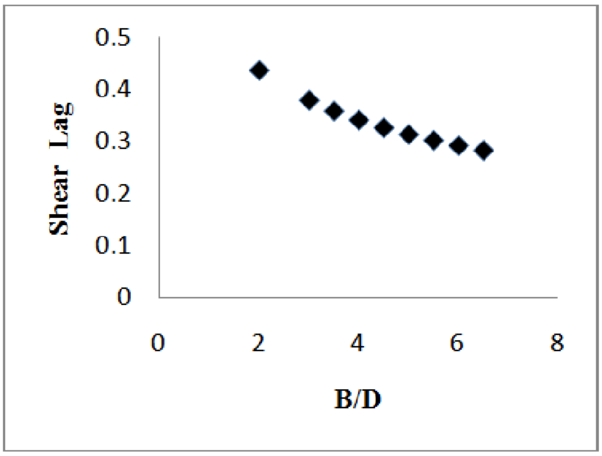

Fig.14. Shear lag vs B/D

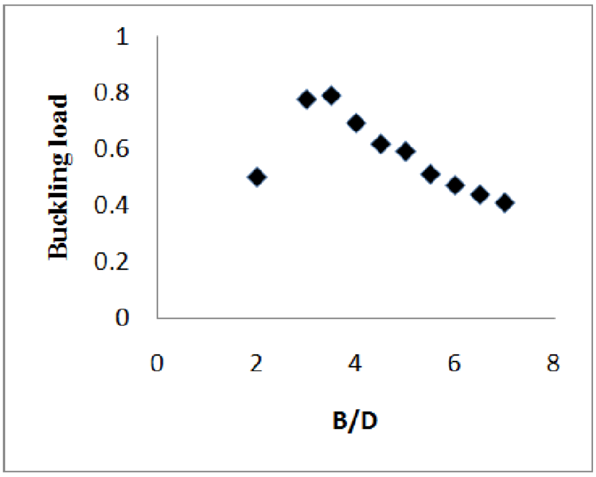

Fig.15. Buckling load vs B/D

DISCUSSION

The above results plots the variations of shear lag parameter along with the buckling load factor. The results show that when shear lag parameter increases buckling load factor decreases. Various fibre orientations are adopted and rotational restraint factor (D_{22f}/D_{22w})is considered. This shows the influence of rotational restrained on the beams.

Conclusion

Finite element models of composite beams, constructed in ANSYS15 using the solid shell 281 elements up to buckling. Behaviour of laminated box beams is affected by shear-lag, fibre orientation, stacking sequences of laminas and cross sectional parameters. Consequently they exhibit many different failure modes. Simple beam theory cannot account for all these factors. Although finite element method can be used to analyze such box section, the time required to carry out the analysis makes its use impractical in the preliminary design and optimum design stages. An approximate analysis method, considering various factors that affect the laminated composite beam behaviour, was developed subsequently when the shear lag factor decreases buckling load factor increases. Finally it was concluded that when shear lag increases buckling load decreases.

REFERENCES

Chartree Lertsima and Taweep Chaimsophob, 2005. “Deflection of simply supported box girder including effect of shear lag”, *Elsevier*, *Journal of Computers and Structures,* 84, 11-18

Lou, Q.Z., Wu, Y.M., Tang, J. and Li, Q.S. 2002. “Experimental studies on shear lag of box girders”, *Elsevier*, *Journal of Engineering Structures,*

Quanfeng Wang and Li, W.Y. 1999. “Buckling of thin-walled members with shear lag using spline finite member element method”, *Elsevier*, *Journal of Engineering structures,*

Quanfeng Wang, 1997. “Lateral buckling of thin-walled open members with shear lag using optimization techniques”, *Elsevier, Journal of Engineering structures,*

Upadhyay, A. and Kalyanaraman, V. 2003. “Simplified analysis of FRP box girders”, *Elsevier*, *Journal of Composite structures*, 59,217-225

Wu Yaping , Zhu Yuanlin, Lai Yuanming and Pan Weideng, 2004. “Analysis of shear lag and shear deformation effects in laminated composite box beams under bending loads”, *Elsevier*, *Journal of Engineering Structures,*

****