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Finite Element Analysis and Effective Width Method – A Comparative Study on Solid Deck Slab Bridge

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***Abstract:*— Solid deck slab bridges are simplest type of bridges adopted mostly for small span and are constructed with or without footpath. Different methods are developed for the analysis of solid deck slab bridges out of which Finite Element Analysis (FEA) and from conventional analysis side, effective width method (EWM) are popularly used. In this paper, a comparative study between FEA and EWM in the analysis of solid deck slab bridges with and without footpath for different loading conditions as per IRC 6 (2014) was done. The study shows that there is 10-45% variation in design forces. The study also reveals the effect of footpath on solid deck slab bridges for live load cases and brings out the conclusion that inclusion of footpath reduces the design forces by 10-30%.**

***Index Terms* - Solid deck slab bridge, Finite element analysis, Effective width method.**

I. INTRODUCTION

Most of the times, analysis of solid deck slab bridges is carried out using EWM since it is simple and less time consuming compared to FEA, which is also mentioned in the informative annexure of [3]. But FEA gives more accurate results compared to all other conventional analysis methods. This point draws out the necessity of a comparative study between FEA and EWM on the analysis solid deck slab bridges. Since dead load bending moment and shear force are exactly same in FEA and EWM [4] and there is considerable variation in results for class A loading in these two methods [1], live load cases as per [2] is considered for the study in this paper. Since these bridges are constructed with or without footpath and bridges with curb reduces design forces compared to without curb case [5], there is a necessity to study the effect of footpath on design forces.

In FEA of solid deck slab bridge, it is modelled in SAP 2000 using thick shell elements and vehicle loads are applied as surface pressure. Design moment along X direction (Mx) is taken as M11 + M12 and along Y direction (My) is taken as M22 + M12. Design shear force (V) is taken as V13. Excel programme was developed for EWM of analysis for simply supported case. Design moment in Y direction is taken as 0.3 times design moment in X direction.

A numerical study was done by considering a simply supported solid deck slab of span 10m, carriage way width of 7.5m, footpath width of 1.5m on left side and right side and thickness of slab is taken as 500mm. With and without footpath cases were studied. Loading considered are Class B (Single train), Class A (Single train), Class B (Two train), Class A (Two train), Class AA Wheeled, Class AA Tracked, Class 70 R Tracked, Class 70 R bogie load.

II. COMPARISON OF FEA AND EFFECTIVE WIDTH METHOD

From the above mentioned numerical study, results were plotted and comparison was done for design moments M_x, M_y and design shear force V for solid deck slab bridge with footpath and without footpath separately. Fig. 1 (a), (b) and (c) shows the variation of M_x, M_y and V in FEA and EWM with footpath.

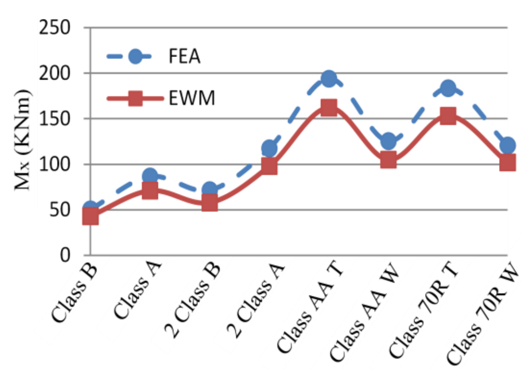

Fig. 1 (a) Comparative plot for M_x – FEA and EWM (With footpath)

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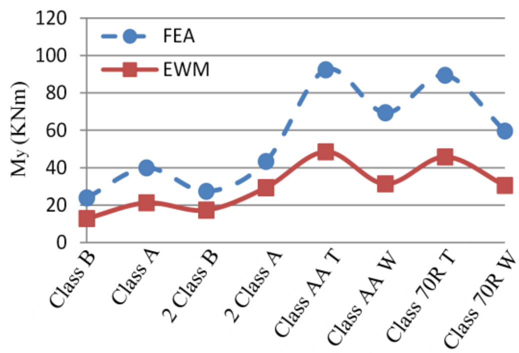

Fig. 1 (b) Comparative plot for M_y – FEA and EWM (With footpath)

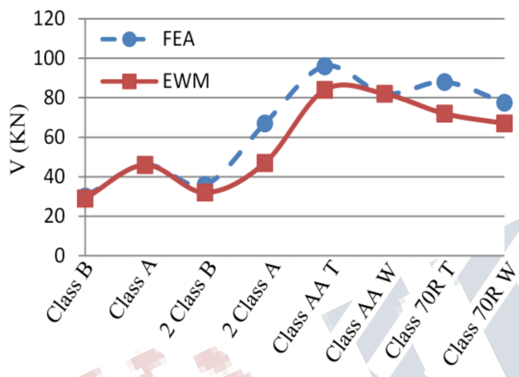

Fig. 1 (c) Comparative plot for V – FEA and EWM (With footpath)

Fig. 1 (a) indicates a variation of 15-20% in M_x for the mentioned case, M_y shows a variation of 30-50% in Fig. 1 (b) and in Fig. 1(c) V shows a variation of 0-25% for V between FEA and EWM.

Fig. 2 (a), (b) and (c) shows the variation of design moments M_x, M_y and design shear force V between FEA and EWM of analysis for without footpath case.

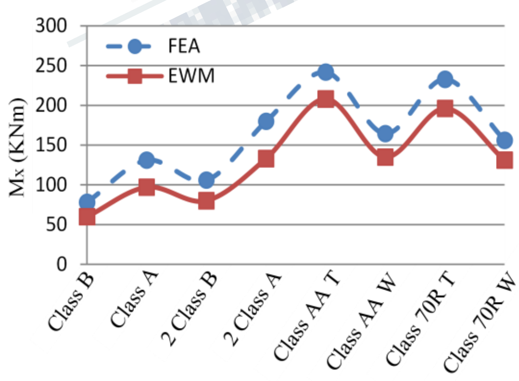

Fig. 2 (a) Comparative plot for M_x – FEA and EWM

(Without footpath)

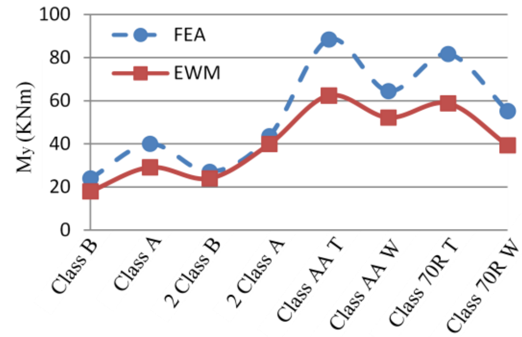

Fig. 2 (b) Comparative plot for M_y – FEA and EWM (Without footpath)

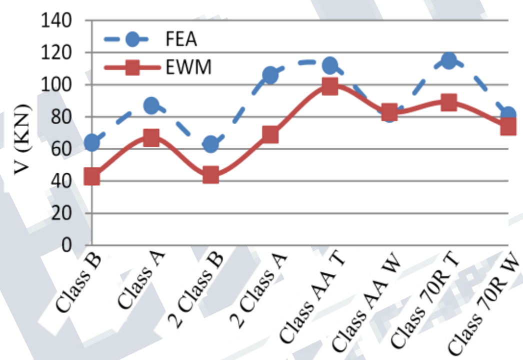

Fig. 2 (c) Comparative plot for V – FEA and EWM (Without footpath)

Fig 2. (a) indicates a variation of 15-25% in M_x for the mentioned case, M_y shows a variation of 10-27% in Fig. 2 (b) and Fig. 2 (c) indicates a variation of 0-30% for V between FEA and EWM.

III. EFFECT OF FOOTPATH

In order to study the effect of footpath in design forces, a comparative study on M_x, M_y and V between with footpath and without footpath condition for FEA and EWM was done separately. Fig. 3 (a), (b) and (c) shows the variation of design moments M_x, M_y and design shear force V with footpath and without footpath cases for FEA.

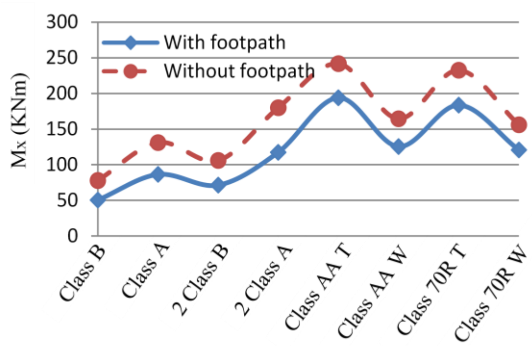

Fig. 3 (a) Variation of M_x - with footpath and without footpath (FEA)

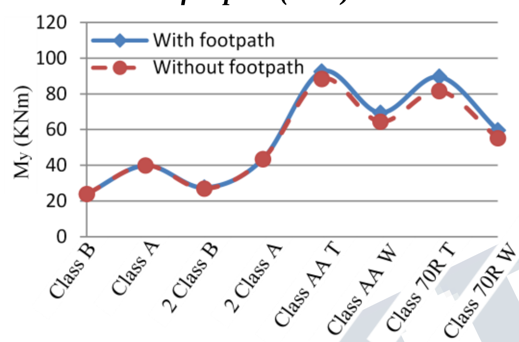

Fig. 3 (b) Variation of M_y - with footpath and without footpath (FEA)

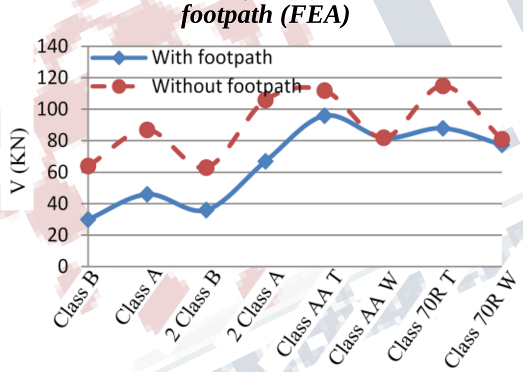

Fig. 3 (c) Variation of V - with footpath and without footpath (FEA)

Fig. 3 (a) indicates considerable reduction in M_x by 20-35% in solid slab bridge with footpath compared to that without footpath. Fig. 3 (c) also shows a similar trend in reduction of V by 10-45%. Compared to these two cases, M_y does not show any considerable variations as shown in Fig. 3(b).

Fig. 4 (a), (b) and (c) shows the variation of design moments M_x, M_y and design shear force V with footpath and without footpath cases for EWM.

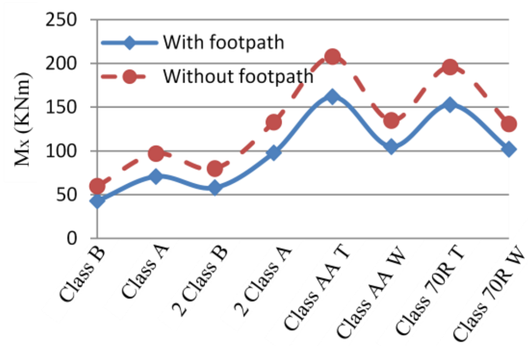

Fig. 4 (a) Variation of M_x - with footpath and without footpath (EWM)

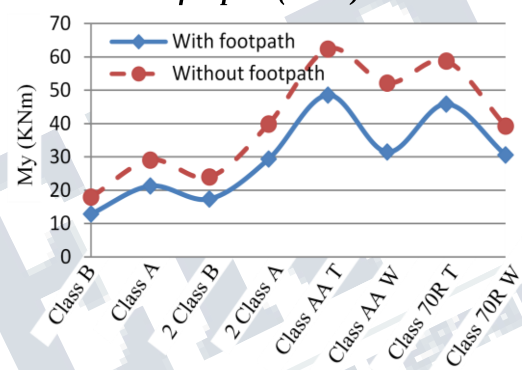

Fig. 4 (b) Variation of M_y - with footpath and without footpath (EWM)

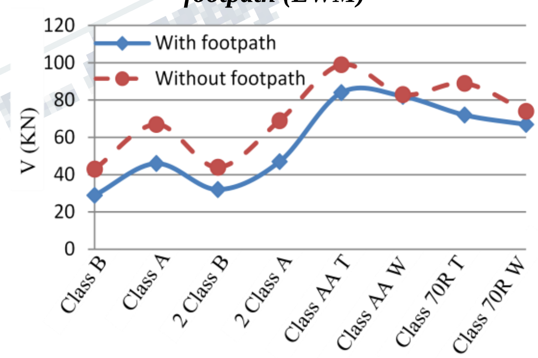

Fig. 4 (c) Variation of V - with footpath and without footpath (EWM)

Fig. 4 (a) indicates a considerable reduction in M_x by 22-28% in solid slab bridge with footpath compared to that without footpath. Fig. 4 (b) also shows a similar trend in reduction of M_y by 25-40% and 0-30% reduction in V as shown in Fig. 4 (c). From Fig. 3 (b) it can be observed that M_y does not show any variation between with footpath and without footpath cases in FEA, but there is considerable variation of M_y in EWM as shown in Fig. 4 (b).This variation of M_y is due to the fact that in EWM M_y is taken as 0.3 times

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M_x, which in turn get reduced due to the inclusion of footpath as shown in Fig. 3 (a) and Fig. 4 (a). This is in contradictory with FEA results and this is reason behind higher variation of M_y between FEA and EWM in with footpath case as shown in Fig. 1 (b).

CONCLUSIONS

Based on above study, following conclusions can be summarised

[1] Design forces are showing a considerable variation between FEA and EWM. EWM results are not conservative.

[2] Apart from M_y, all other design forces get considerably reduced due to the inclusion of footpath.

[3] Method of taking M_y as 0.3 times M_x in EWM is not conservative.

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