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# Finite Element Modelling of RCC Girder Bridge for Distribution Factor

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***Abstract:*** **-- Finite element analysis is the most common and more reliable method of analysis for bridges. Different modelling techniques are available for the analysis of girder bridges. This paper provides a comparison between three finite element modelling techniques for evaluating wheel load distribution factors for RCC girder bridge. A single span, simply supported bridge is used for the study. The bridge is loaded with IRC 70R wheel load and Class A so as to produce maximum bending moments. The results obtained are compared with that obtained from Courbon's method. A parametric study is also done for distribution factor by varying the span length and girder spacing.**

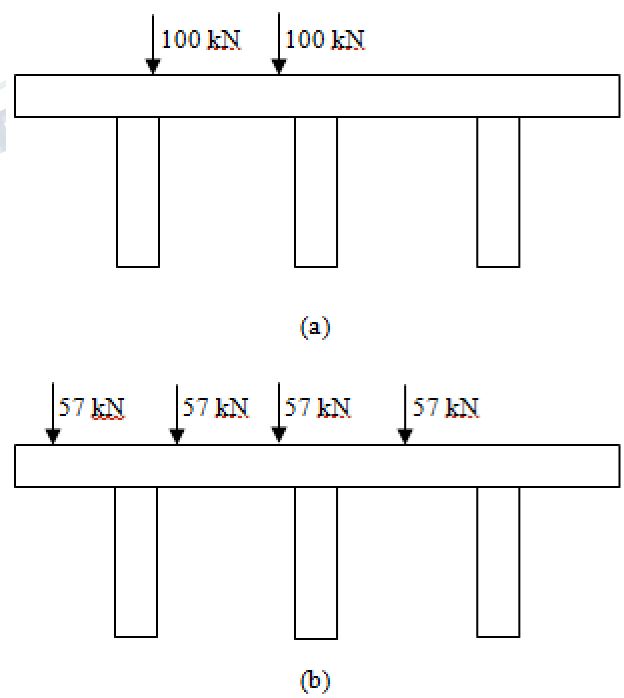
***Index term*** **: - Distribution Factor, Finite element analysis, RCC Girder bridge.**

## I. INTRODUCTION

Live-load distribution is an important step in the analysis of bridge superstructures. With the advancement in analyzing techniques, finite element method has become much popular as it is more accurate and convenient than the conventional methods, especially for complex structures. Proper selection of elements, material properties and loading positions for maximum responses are some factors which determine the accuracy of this method. This paper introduces different FEM modelling techniques [3] to compute live-load distribution for bridge girders and compares the results with conventional method – Courbon's method.

## II. FINITE ELEMENT ANALYSIS

A one-span (20 m), two-lane, simply supported bridge is used for the comparative study of the three different finite element modelling techniques. The bridge is 8m wide with three main girders at 2.5m spacing and 1.5m cantilever projection. Two end diaphragms with a cross girder at the centre is considered. Two load cases, Class 70R and 2xClass A maximum single axle load were considered and positioned so as to obtain maximum bending moment, as per IRC: 6-2016 as shown in Fig. 1. The finite element program SAP 2000 is used for the modeling.




As girders are the main elements of consideration, in the first model (Model 1), main girders along with cross girder and end diaphragm are considered without considering the contribution

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of the deck slab i.e., grid model. Girders along with end diaphragms are modelled using frame element in SAP 2000 as shown in Fig. 2. Supports are provided at the bottom of the girder by using a rigid link.

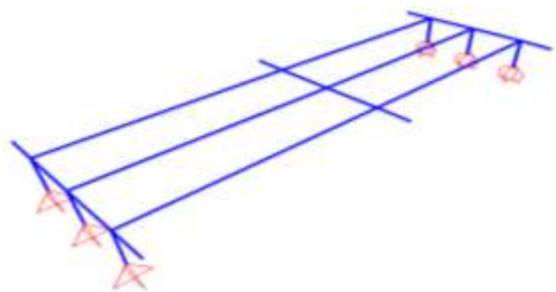

***Fig. 2 Model 1- Grid Model***

The second model is in accordance with the research by Hays et al. (1986)[2]. In Model 2, as compared to the model 1, effect of the deck slab is considered by modelling it using shell element. Girders and cross girder along with end diaphragms are modelled using frame element in SAP 2000 as given in Fig. 3. Rigid links are used for providing supports at the bottom of the girders.

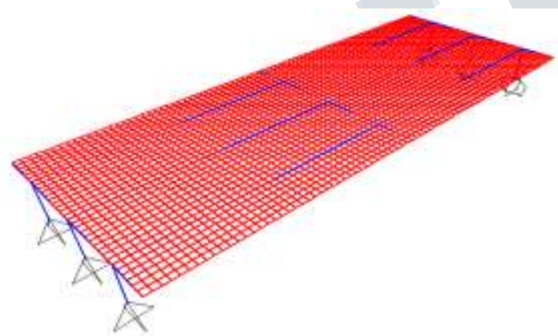

***Fig 3. Model 2 - Beam-Shell element Model***

In the third model (Model 3), which is based on research by Brockenbrough (1986)[1], a complete 3D model of the structure is developed using shell elements for modelling deck slab along with girders and end diaphragms which is shown in Fig. 4.

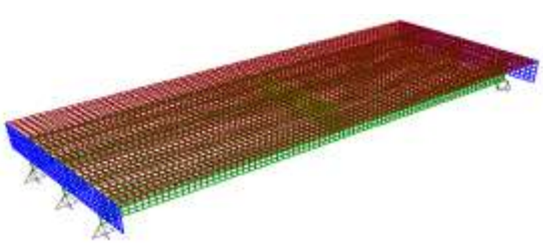

***Fig. 4 Model 3 - Shell Element Model***

Distribution factor for each girder is calculated by dividing the total reaction at both supports of the girder divided by the total load applied. The distribution factor obtained from all the three models are compared with that obtained from Courbon's method and is presented in Table 1 and 2.

***Table 1 Distribution factor for Class 70R***

| Girder | Distribution Factor for Class 70R | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Courbon's Method |
| External | 0.60 | 0.60 | 0.62 | 0.61 |
| Internal | 0.34 | 0.34 | 0.32 | 0.33 |

***Table 2 Distribution factor for 2xClass A***

| Girder | Distribution Factor for 2xClass A | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Courbon's Method |
| External | 0.52 | 0.52 | 0.58 | 0.57 |
| Internal | 0.34 | 0.34 | 0.34 | 0.33 |

From the results, it can be observed that all the FEA models yielded similar results, but Model 3 gives results which are more agreeing with the conventional method.

## III. PARAMETRIC STUDY

Courbon's method does not take into account the effect of span length for calculating distribution factor[4]. For accounting span length, parametric study is done for live load distribution factor using Model 3 for different spans (10m, 20m) and girder spacing (2m, 2.5m and 3m) and the results are compared with Courbon's method. The results obtained are presented in Table 3 and 4.

***Table 3 Comparison of wheel load distribution factor for Class 70R loading***

| Span(m) | Spacing of girder(m) | FEA – Model 3 | Courbon's Method |
|---|---|---|---|
| 10 | 2 | 0.60 | 0.56 |
| | 2.5 | 0.65 | 0.61 |
| | 3 | 0.68 | 0.65 |
| 20 | 2 | 0.61 | 0.56 |
| | 2.5 | 0.62 | 0.61 |
| | 3 | 0.68 | 0.65 |

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*Table 4 Comparison of wheel load distribution factor for 2xClass A loading*

| Span(m) | Spacing of girder(m) | FEA – Model 3 | Courbon's Method |
|---|---|---|---|
| 10 | 2 | 0.53 | 0.48 |
| | 2.5 | 0.59 | 0.57 |
| | 3 | 0.62 | 0.58 |
| 20 | 2 | 0.54 | 0.48 |
| | 2.5 | 0.58 | 0.57 |
| | 3 | 0.62 | 0.58 |

From the results, it can be seen that all the factors obtained through FEA are more than that from Courbon's method, irrespective of span or girder spacing. Also, it can be seen that span length affects the distribution of wheel load between girders.

## IV. CONCLUSIONS

The following conclusions can be drawn from the study:

i. The best suited model for finding out the live load distribution factor is Model 3.
ii. Span length and girder spacing affect the wheel load distribution between girders. As the girder space increases, distribution factor for external girder also increases.

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