Transverse moments in concrete bridge deck slabs - 2

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A discussion on transverse moments in deck slabs of multi-beam bridges was presented in part 1 of the paper published in the January 1991 issue of the Journal. Transverse moments in deck slabs of single and double-cell concrete box girders are compared with those in fixed slabs in the second and last part of the paper presented here. It is shown that the transverse moments in deck slabs in box girders also approximate the values in fixed slabs of the same span for the usual cross sectional profiles.

Box girders are used extensively in bridge structures because of their slender profile and economy compared to other available forms. The deck slab spans mainly between the webs of the box girder, and the slab moments are influenced, among other parameters, by the overall stiffness of the box girder and the load position. These moments are investigated in this paper for dead and live loads in the same way as the moments in multi-beam bridges. The results indicate that the deck slab spanning between the webs can be analysed as a fixed slab of the same span for usual box girder bridge profiles.

Analysis

Prismatic single-cell rectangular concrete box girders of constant top and bottom slab, and web thicknesses are analysed for dead load, including a 75-mm thick wearing coat, and several positions of live loads. The cross section of single-cell box girder considered in these analyses is indicated in Figure 6. The cross section of double-cell box girder is similar to that of a single-cell with the difference of an additional web, of the same thickness as the outer webs, at the axis of symmetry of the section. Figure 7 indicates the placements of IRC class 70 R track loading considered in the analyses. The overall width of the bridge was taken as 8.4m for a carriage-way width of 7.5mThe span of the box girder was generally assumed to be 20.0m, but increasing the span to 60.0m did not affect the transverse moments very significantly. Spread of live load was taken to be 45 degrees through the wearing coat alone. The box section was divided into 30 strips generally, and 25 non-zero terms were considered in the analyses. Several parameters of the cross section were varied within the practical limits and an exhaustive comparative study was carried out[5]. The parameters considered in the analyses and their range of variation are

web spacing depth of cross	:	2.0m to 6.0m
section	:	1.0m to 4.0m
top slab thickness	:	0.15m to 0.25m
bottom slab thickness	:	0.15m to 0.25m
span of the box girder	:	20.0m to 60.0m

Influence of various parameters

Transverse moments in the deck slab are compared with those in slabs with fixed boundaries of the same span as the spacing between webs of the box girder[5, 6]. The influence of various parameters is presented in Figures 8 to 12, and discussed briefly here. In all the analyses presented here, the top slab

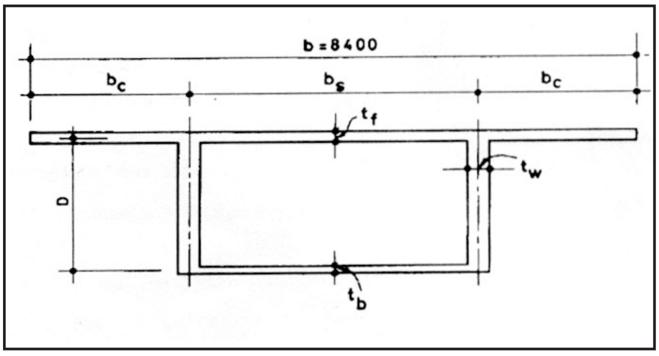

Figure 6. Cross section of box girder bridges

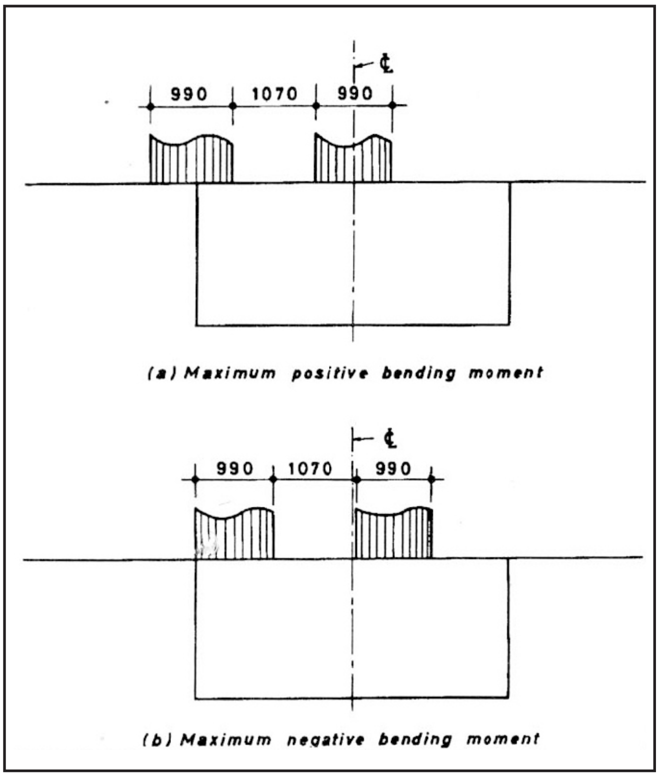

Figure 7. Position of 70R track load considered in the analysis

thickness was assumed to be 0.15m, bottom slab thickness to be 0.10m, and the web thickness to be 0.30m, unless specified, Figure 6.

Web spacing

The difference between the moments in deck slab and the corresponding fixed slab is very small for dead loads as indicated in Figure 8 (a); web spacings of less than 4.0m indicating double-cell box girders. The largest difference was found to be about 6 percent for dead load span moments for a web spacing of 6.0m, the deck slab moments being slightly greater than those in fixed slabs. The difference in the support moments was found to be negligible for dead loads, but was

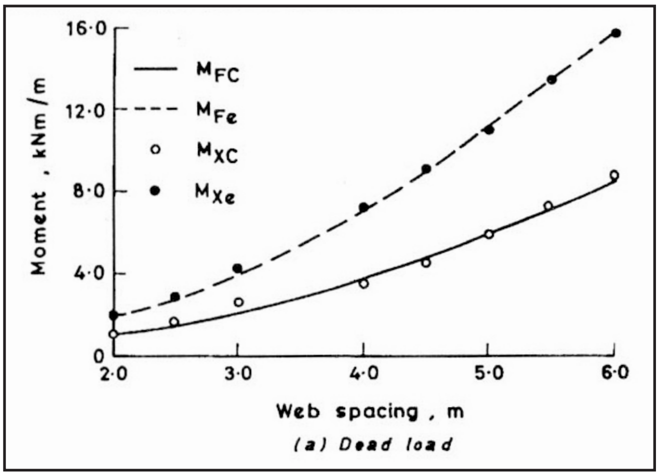

Figure 8. (a) Bending moments in deck and fixed slabs for dead load

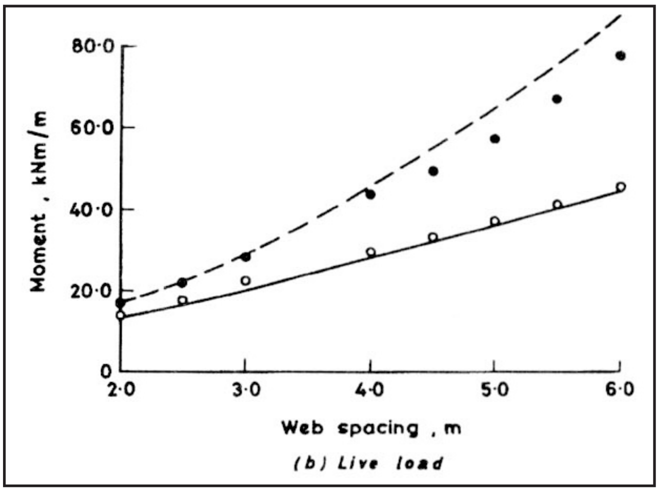

Figure 8. (b) Bending moments in deck and fixed slabs for live load

found to be upto about 15 percent for live load. The deck slab moments were found to be smaller than those in fixed slab, Figure 8 (b). The deflected profile of the cross section of box girder for live load is indicated in Figure 9 for a web spacing of 5.0m. The distortion of cross section reduces the moments at the webslab junction; thus the moments computed for fixed boundary conditions will be on the conservative side for support moments.

Box girder depth

The ratio of moments in deck slabs to those in corresponding fixed slabs (M_x /M_F) are indicated in Figure 10 for various depths of the box girder, and for a web spacing of 6.0m, the most severe case. Only the live load moment ratios are plotted, since the difference in dead load moments in deck slabs and fixed slabs was found to be insignificant (less than 5 percent). It can be seen in Figure 10 that the span moments are about the same in deck and fixed slabs, but the support moments, M_{xe} in deck slabs can be smaller by up to about 20 percent in deck slabs. The difference in support moments between deck and fixed slabs was found to be about 20 percent for a girder depth of 1.0m, reducing to about 8 percent as the depth was increased to 3.0m and beyond.

Web thickness

Figure 11 indicates the variation of the ratio M_x / M_F with web thickness for live load Depth of the girder was taken as 2.0m

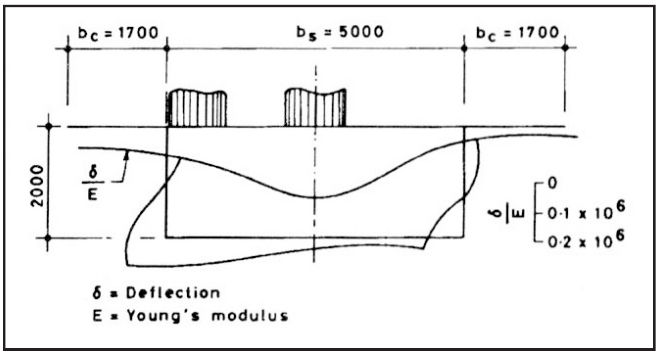

Figure 9. Deflected shape of box section under 70R loading

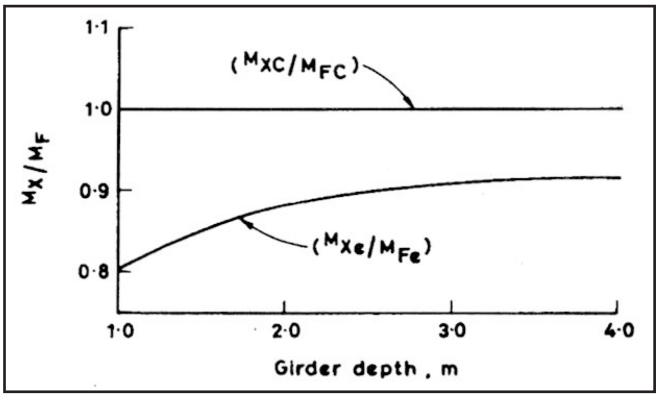

Figure 10. **Comparison of live load moments in deck and fixed slabs for various girder depths**

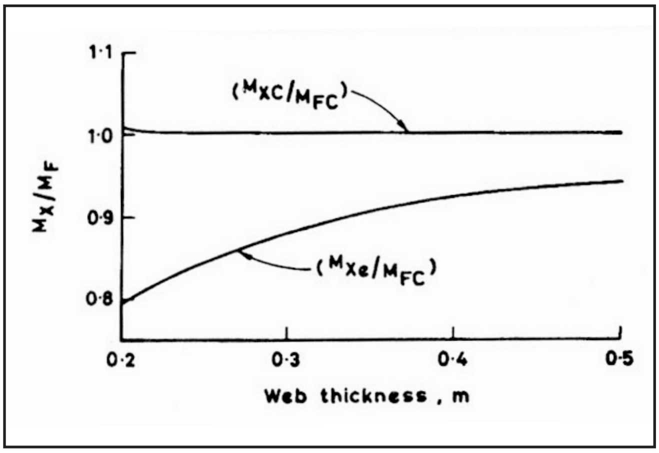

Figure 11. Comparison of live load moments in deck and fixed slabs for various web thicknesses

and web spacing as 6.0m. It can be noticed that the support moments in deck slab are about 20 percent smaller than those in fixed slabs for a web thickness of 0.2m; the difference decreases to about 6 percent as the web thickness is increased to 0.5m. The difference in span moments of deck slabs and fixed slabs is negligible, Figure 11. The difference between deck slab and fixed slab moments for dead load was found to be negligible (less than 5 percent), and not plotted here.

Top slab thickness

An increase in top slab thickness reduces the stiffness of the webs relative to slabs, and thus reduces the support restraint at the web and deck slab junction. This tendency is discernible in Figure 12. The ratio (M_x / M_F) is little affected by the variation in top slab thickness for span moments. However, the ratio of support moments increases as the top slab thickness is reduced. The support moment M_{xe} was found to be about 0 percent smaller in deck slab fora top slab thickness of 0.10m and about 32 percent smaller for a top slab thickness of 0.25m than the corresponding fixed slab, when the web thickness was 0.3m and web spacing was 6.0m. The difference was found to be much less significant in all other cases investigated.

Bottom slab thickness

The influence of bottom slab thickness was found to be

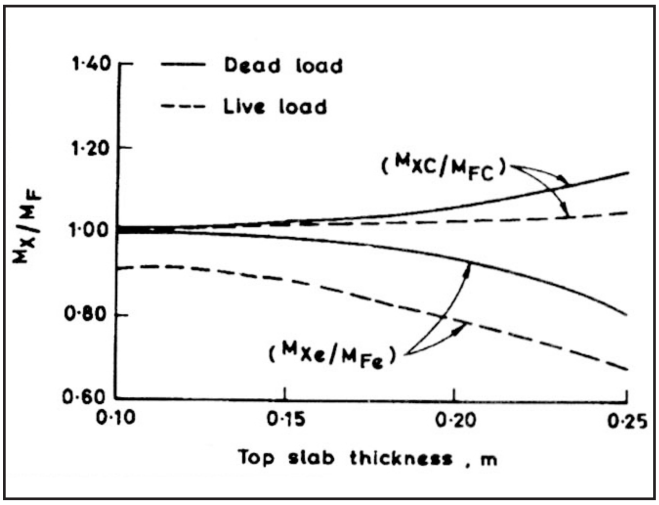

Figure 12. Comparison of deck and fixed slab moments for various top slab thicknesses

insignificant (less than about 3 percent) for the range of parameters investigated. These results are thus not included here.

Span of the girder

The transverse moments in box girders were found to vary little (by less than 5 percent) as the span was increased from 20.0m to 60.0m for girder depths of 2.0m and 3.0m. The deck slab support moments decrease as expected, because of the reduced longitudinal stiffness of the section, as the span increases. These values were computed for various web spacings, but were not plotted.

It can be said, in general, that stiffer the box girder the closer will be the agreement between deck slab and fixed slab moments. Similarly, stiffer webs (greater thickness) ensure better fixity at the junction of top slab and web.

Conclusion

The deck slab spanning between the webs can be analysed as a fixed slab of the same span for usual box girder profiles. Such an assumption is likely to be realistic in most of the cases, but slightly conservative for support moments.

Based on the results presented for multi-beam bridges(in Part 1 of the paper) and for box girder bridges(in Part 2 of the paper) it can be concluded that the deck slabs can be analysed as slabs with fixed boundaries. However, caution should be exericsed in the case of dead load moments when large side cantilevers are provided, and also in the case of live load moments in multi-span bridges when the webs are closely spaced (less than about 2.0m).

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