I-251 ARRANGEMENT OF SHEAR CONNECTORS IN COMPOSITE INVERTED ARCH BRIDGE

Tohoku University Graduate student M.A.C. MOHAMED ANZAR
Univ. of Utsunomiya Member Hidehiko ABE
Univ. of Utsunomiya Member Akinori NAKAJIMA

1.INTRODUCTION

Composite inverted arch bridges are considered as one of the possible alternatives to widely adopted composite girder bridges, when the span increases. However, the shear force distribution among the shear connectors of a composite girder bridge and that of a composite inverted arch bridge are not identical because the composite upper chord member of the latter is subjected to the horizontal reaction due to the force transferred by the arch members and to the negative moment depending on the type of loading. In order to clarify the longitudinal shear force distribution along the concrete-steel interface and the behavior, of this new type of composite structure, parametric studies were carried out. The influence of different longitudinal arrangements of shear connectors on the behavior of this type of structure, is discussed.

2.METHOD OF ANALYSIS

In order to incorporate the slip between the concrete slab and the steel beam, the shear connector should be well represented in the analysis. It is modeled as axial and shear springs connecting the bottom surface of the concrete slab and the top surface of the steel beam. The other structural members are considered as FEM beam elements but for the concrete slab, three different FEM elements are considered and their influence on the calculated results is also compared. They are FEM beam element, FEM in-plane plate element and combination of FEM in-plane plate element and FEM plate bending element.

3.COMPARISON OF CALCULATED RESULTS

The results of the present analytical method were compared with those of model tests. The longitudinal concrete strain distribution along the longitudinal center line is shown in Fig.1. The analytical and experimental results are in good agreement.

The composite structures having incomplete interaction are analyzed in the three steps described in Reference 1. This method and the present one are compared. The former one yields slightly higher slippage between the concrete slab and steel beam in the vicinity of loading point as shown in Fig.2.

4.PARAMETRIC STUDIES

An eight-panel composite inverted arch bridge of 60m length and 8.5m arch rise, was selected to perform parametric studies and is shown in Fig.3 and the shear stiffness, the loading condition, the arrangement of shear connectors and the strengths of

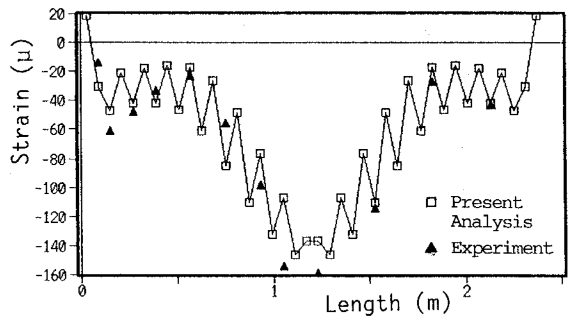

Fig.1 Longitudinal Strain Distribution of Concrete Slab

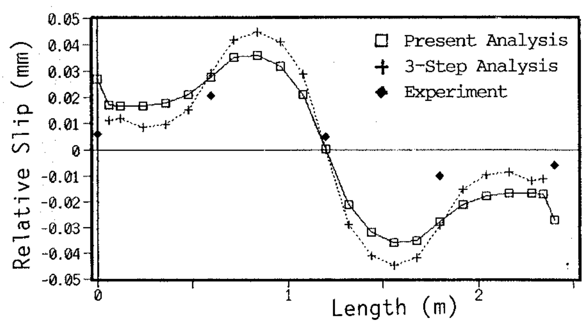

Fig.2 Relative Slip between Concrete Slab and Steel Beam

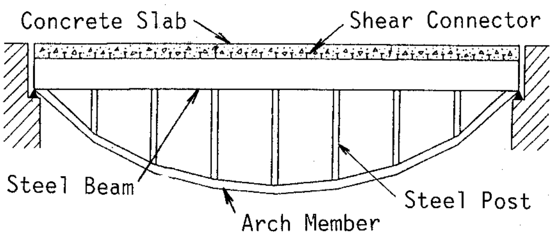

Fig.3 Prototype of Composite Inverted Arch Bridge

concrete and steel, are considered as parameters. It is understood that increasing the shear stiffness up to a certain value or beyond a certain value does not seem to have much influence. But between these two values, changing the stiffness has remarkable influence on the behavior of the structure. This tendency is observed even if the physical arrangement of shear connectors is altered.

The longitudinal concrete strain distribution along the center line is shown in Fig.4, as an example, for four different physical arrangements of shear connectors, namely, uniformly distributed shear connectors, shear connectors at panel points only, shear connectors at panel and panel mid points, and as in the previous one with varying shear stiffness referred to as mixed arrangement, when the structure is subjected to concentrated load at quarter point. In the last arrangement, the shear connectors of three different stiffnesses are assumed that the stiffnesses of edge connectors and other panel point connectors are ten and five times of the stiffness of shear connectors at panel mid points respectively. Fig.4 shows how the longitudinal concrete strain would change if the shear connectors are arranged with different spacings.

The shear force distributions obtained for the above mentioned shear connector arrangements are shown in Figs.5 and 6 for low and high interactions respectively, when the structure is subjected to point load at quarter point. By comparing the shear force distributions for panel and panel mid point arrangement and mixed arrangement, it can be said that changing the shear stiffness does not seem to have any appreciable influence on the shear force distribution when high interaction exists.

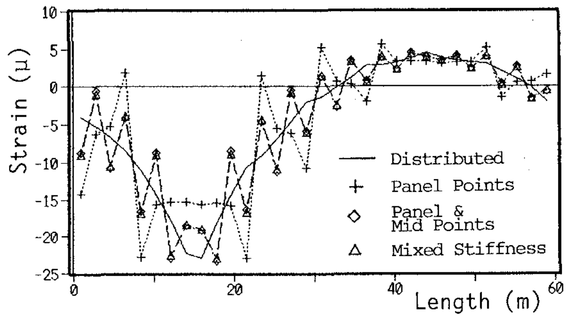

Fig.4 Longitudinal Strain Distribution of Concrete Slab(C=1.0x10^{6}tf/m/m)

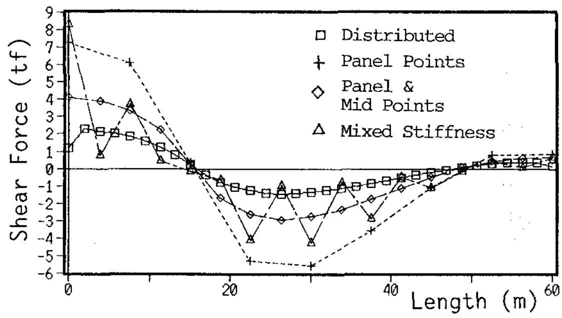

Fig.5 Shear Force Distribution (Low Interaction C=1.0x10^{3}tf/m/m)

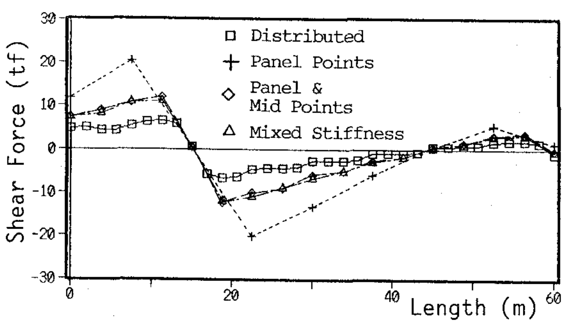

Fig.6 Shear Force Distribution (High Interaction C=1.0x10^{6}tf/m/m)

5.CONCLUSIONS

(1) The results of the present analytical method showed good accord with those of model tests and other theoretical solutions.

(2) The three-step method adopted in Reference 1 generally yields higher shear force than the present one in the vicinity of the loading point.

(3) The discrete arrangement of shear connectors causes uneven concrete strain distribution along the center line, but the strain distribution away from the center line is relatively smooth.

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