Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 13 (1988)

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DOI: https://doi.org/10.5169/seals-13128

Steel Multispan Rigid Frame Structures with Fastened Knees

Cadres métalliques rigides avec des attaches particulières

Mehrfeldrige Stahlrahmenbrücke mit spezieller Lagerung

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In the guideway beams for high speed transportation systems and the beams of highway viaducts, of which the beam depth is severely limited, at times there are the cases that the severe restriction of deflection is demanded within the range of the given beam depth.

One of the methods of solving the problems in such cases is to make beam systems into so called rigid frames (Rahmen) by rigidly connecting main beams with substructures, in particular with columns.

These beam systems are advantageous when the beams comprise a number of continuous spans. However, the thermal stress due to temperature change becomes high. Therefore, usually every three or four spans are made independent and discontinuous, and this method is good for reducing thermal stress, but its economical efficiency is to be somewhat impared.

The structural system which is newly proposed now is to prevent these rigid frames being connected in a large number from causing large thermal stress.

As shown in Figure 1, in a multispan rigid frame, beams and columns are separated, and like an ordinary continuous beams, only one support of the beams is fixed, and the rigid connection with one column is made there. At the other supports, the beams are made so as to be able to slide over columns. Then, by fastening a beam and a column with a pair of long tie-bolts (tendons), the bending moment of the beam is to be transmitted to the column.

That is, as shown in Figure 2, this proposed rigid frames are supported vertically with two supports A and B on the top of each column, at the same time, in the vicinity of respective supports, they are fastened with the tie-bolts used in vertical direction (prestress), so as to be able to resist tensile force. Accordingly when a beam deflects due to a vertical load applied to it, by the couple composed of the tensile force of the bolts and the compressive force on the supports arising due to the deflection, a moment occurs and reduces the deflection. This is to show the behavior close to that of the knee of a so-called fixed Rahmen just like rigidly connected beam and column.

However, unlike a theoretically perfectly rigid knee, the structures of various elastic fixing are to be obtained according to the tightening force of the tie-bolts (amount of prestress), the length and diameter of the bolts and so on.

Thereupon, it was decided to give a new concept "knee rigidity factor" to this rigidity of knees, and the characteristics of a multispan rigid frame having these knees is discussed.

Of course, respective supports are made easy to slide using lubricant (for example, Teflon), and the tie-bolts are made so as to be able to incline due to the movement of beams, at the same time, the sliding of their heads is made easy, beforehand.

In order to experimentally confirm this mechanism, the model experiment was carried out, and the experimental setup is shown in Figure 3.

The points of this experiment are the state of sliding of beams at knees and the tightening force of tie-bolts. Concerning the tightening force, it was attempted to obtain the functionally optimum values to use those as the design data by changing the tightening force, the length and cross-sectional area of the bolts, and the position of tie-bolts as the parameters.

The typical examples of the experimental results are shown in Figures 4 and 5. Figure 4 shows the comparison of the bending moment and deflection curve of a beam with the theoretical values in the case of the length of bolts $750m^{-3}$, small tightening force, load 2 kN, and the spring constant of PTFE plates $k = 0.245m^{-3}/kN$. In the figure, also the cases of the length of bolts being $450m^{-3}$ and $320m^{-3}$ are shown. Besides, Figure 5 shows the deflection curve of a beam when the spring constant of PTFE plates was changed in the same case.

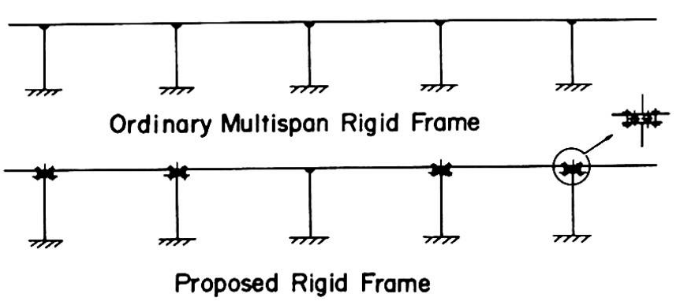

Fig. 1 Multispan Rigid Frame

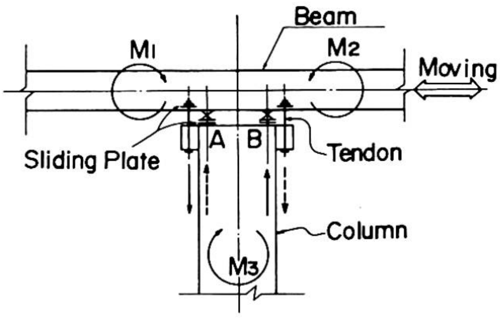

Fig. 2 Mechanism of Fastened Knee

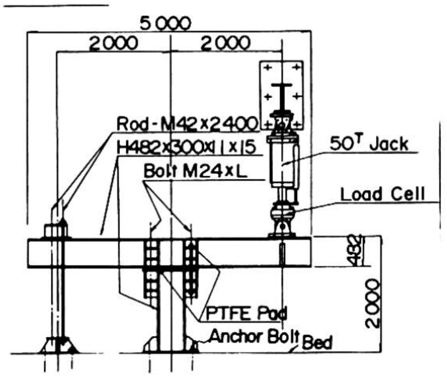

Fig. 3 Model Test Device

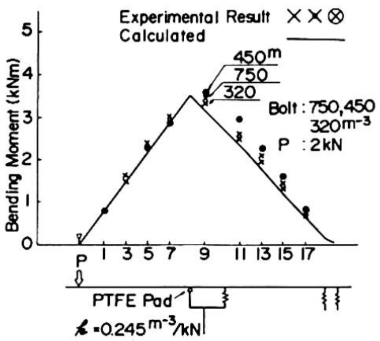

Fig. 4 Comparison of Theoretical and Experimental Results of Bending Moment Curves

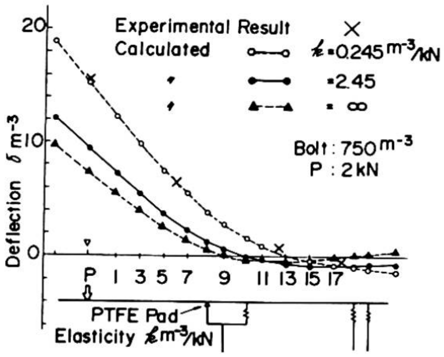

Fig. 5 Comparison of Theoretical and Experimental Results of Deflection Curves