VIBRATION TEST ON THE LONGEST PRESTRESSED CONCRETE BRIDGE

by
Mitsuharu Mikoshiba,[I] Fumio Nemoto,[II]
Yoichi Nojiri[III] and Yoshiyuki Kasai[IV]

SYNOPSIS

Precise forced vibration tests were conducted on the Urado Ohashi Bridge with respect to the transverse and longitudinal directions, and several lower resonant modes were satisfactorily excited. As the results, it can be seen that these lower resonant modes and frequencies of such a long spanned prestressed concrete bridge with tall piers could be estimated through the eigen-value analysis in which the effect of ununiform damping characteristics of super-structure and pier foundations were not taken into consideration, and a response analysis using a conventional lumped mass model would be useful.

INTRODUCTION

In July 1972, the construction of Urado Ohashi Bridge which crosses the mouth of Urado Bay, Shikoku Island, Japan, was completed as shown in Photo. 1. It is a five spanned prestessed concrete frame bridge, the main span of which is the longest in the world. As shown in Figure 2, the main span is 230 meters and provides a hinge which can slide to the longitudinal direction. The maximum height of the bridge is 50 meters from water surface.

Just before the completion of the bridge, precise forced vibration tests were conducted and the vibration characteristics of long spanned bridge were confirmed.

VIBRATION TEST

1) Vibrator; A rotating unbalanced mass type vibrator was installed at the center of the main span, or the top of the P3 pier. In the test, the bridge was excited by adjusting the exciting unbalanced moment 200 kg-m(0.2 Hz$\sim$2.0 Hz) and 50 kg-m (2.0 Hz$\sim$4.0 Hz).

2) Measuring system; Twelve sets of pick-ups(moving-coil type) were installed on the various points of the super-structure and foundations. The signals from the pick-ups were sent to the measuring van named MIK System, which was equipped with the data acquisition system based on a correlation technique. By the system, the real response amplitude and phase angle are clearly determined by separating noisy signals caused by wind or ground tremor. Detailed description for the MIK System is given in the other presentation for this conference.

(I) Deputy Chief, No.4 Section of No.2 Construction Dept., Japan Highway Public Corporation
(II) Chief, No.2 Section of Civil Engineering Dept., Kajima Corporation
(III) Senior Research Engineer, Kajima Institute of Construction Technology
(IV) Research Engineer, Muto Institute of Structural Mechanics

3) The response displacements for various exciting frequencies were obtained at 35 measuring points on the bridge. Typical examples are shown in Figure 1. From these results, the virtual damping factors obtained by familiar half-power method are 0.01~0.03.

4) The resonant modes were obtained by plotting 90 degrees out-of-phase component of response displacements to the exciting force. The typical examples are shown in Figure 3.

COMPUTER USED ANALYSIS OF VIBRATION CHARACTERISTICS

1) During construction of the bridge, the forced vibration tests were conducted for the P2 pier erected on the clay-slate stratum and for the P3 pier constructed on the diluvium through the alluvium. And coefficients of subgrade reaction and damping factors were obtained. In the analysis, requirements for each pier foundation were determined referring to the test results.

2) Natural modes and frequencies were calculated using the conventional lumped mass model. In the preparation of the model, not only variation of girder section but also rize of girder was taken into consideration. Results of the analysis, which are also shown in Figure 3, showed relatively good agreement with the measured resonant modes.

DISCUSSION AND CONCLUSIONS

1) The vibration component of the transverse direction is predominant when the bridge is excited transversely. But when the bridge is excited longitudinally, predominant vibration component is the vertical. And it is noted that a fundamental frequency with respect to the transverse component is lower than that to the vertical component.

2) In the test, lower resonant modes were satisfactorily excited, of which phase angles were generally in-phase or 180 degrees out-of-phase between each point, except some cases where slight coupling of vibration modes arose at side spans. Therefore it can be seen there are few cases that difference of damping characteristics between super-structure and pier foundations interferes these lower vibration modes which will have major affection to earthquake response.

3) These modes were considered to be arisen almost by the ones of super-structure itself, and so an earthquake response analysis using a conventional lumped mass model will be useful even in case of such a long spanned prestressed concrete frame bridge with tall piers.

ACKNOWLEDGMENT

The authors wish to express their sincerest gratitude to Dr. K. Muto of Muto Institute of Structural Mechanics, Inc., Prof. K. Kubo of Tokyo University and to the engineers of Kajima Corporation engaged in the test.

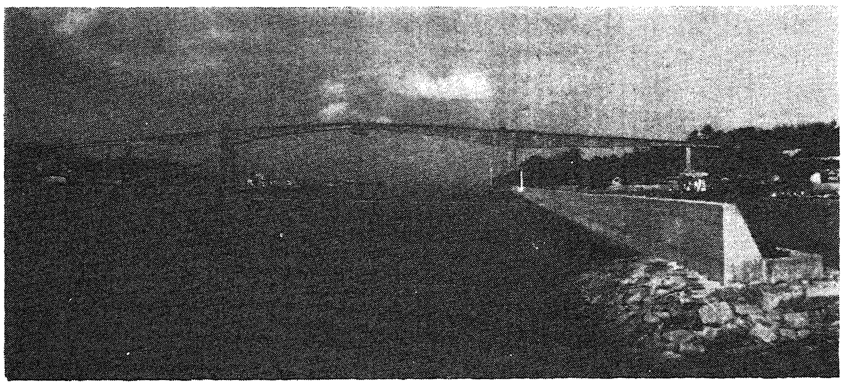


Photo-1 The Urado Ohashi Bridge

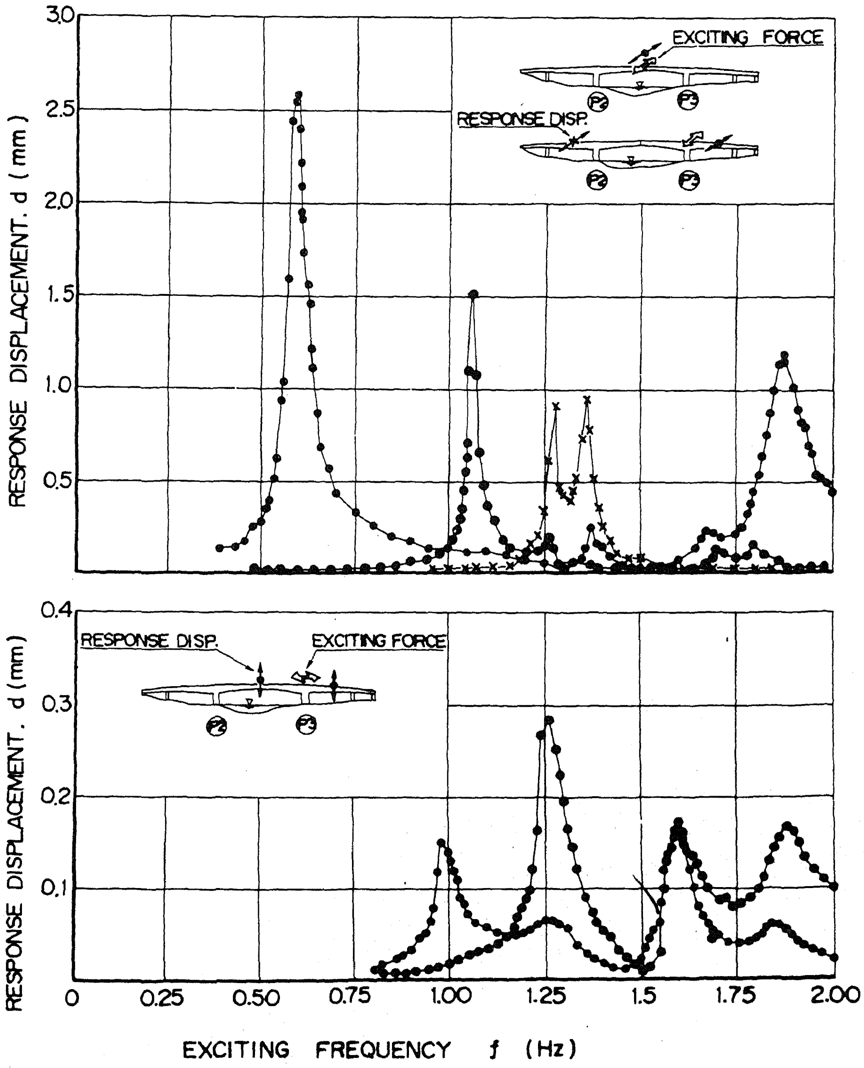


Figure-1 Examples of Resonant Curve

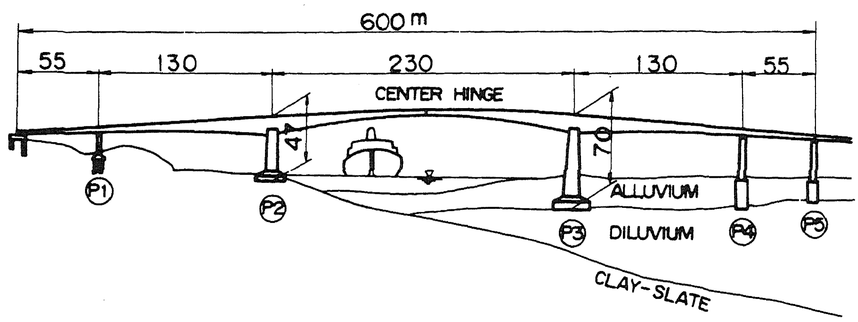
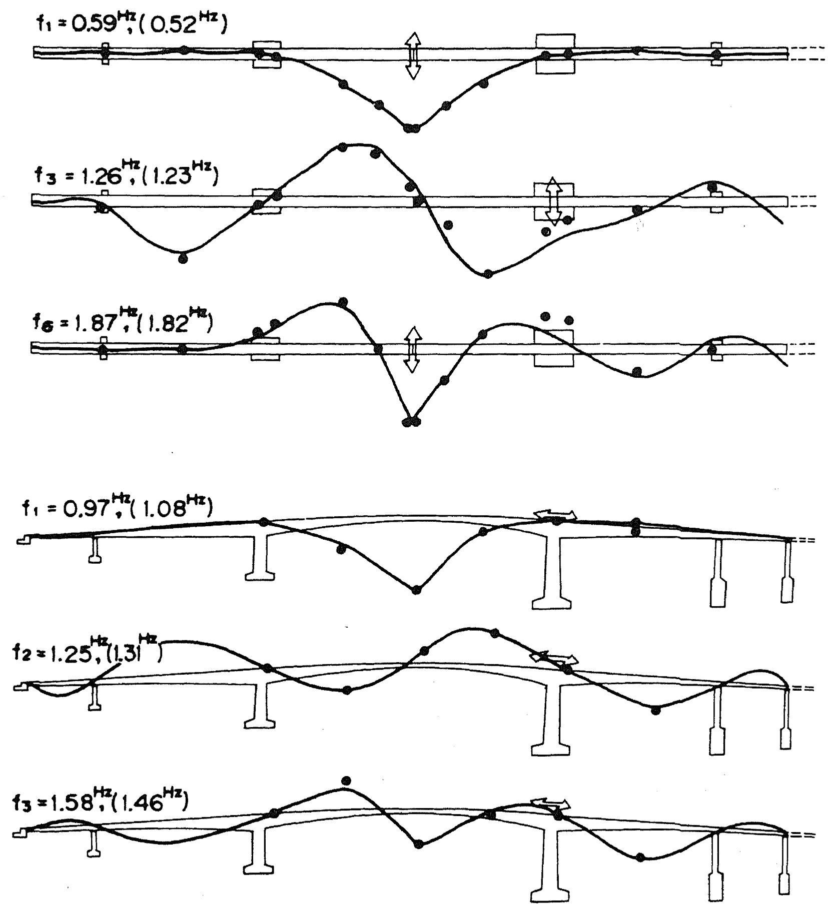


Figure-2 Side View of Urado Ohashi Bridge



NOTE : RESONANT MODE ---- MEASURED (⊙), CALCULATED (⁓)
RESONANT FREQUENCY ---- MEASURED (f), CALCULATED IN THE BLACKETS
EXCITING FORCE ---- (⇔)

Figure-3 Examples of Resonant Mode and Frequency