Dynamic characteristics of PC girder at different stages of bridge construction

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1. Introduction

One of the major advancement in modern bridge engineering is the development and use of prestressed concrete. Prestresssed concrete bridge offer a board range of engineering solution and a variety of aesthetic opportunities. Prestressed concrete girders are being widely used in the bridge construction due to their construction, structural and field application advantages. Girders are the key elements for the single span bridge because they ultimately transfer the loads coming on bridge to abutments. Bridges are subjected to dynamic loads in the form of vehicular traffic, which causes bridges to vibrate. When a vehicle passes over a bridge, certain impact or dynamic amplification effect will be induced, which needs to be taken account in the design of bridge. So for dynamic loading, dynamic analysis is necessary. The study of dynamic properties of prestressed concrete girders should be done from initial phase of bridge construction to its design life to know the actual performance of the bridge.

The primary objective of this paper is to clarify the change in dynamic properties of prestressed concrete girders at different stages of construction of bridge using microtremor. It includes the comparison of Fourier spectra at various phases of bridge construction. The study area is Yoshida Bridge which is being constructed. Yoshida Bridge is located at Oaza Nishiyama Kikuma town of Imbari city. The overall dimension of bridge is 17.2m length, 15.719m wide at south end and 11.983m wide at north end. It consists of 14 numbers of prestressed concrete box girders of length 17.14m. Plan of Yoshida Bridge is shown in Fig.1.

2. Methodology

Microtremor measurements were carried out at different major stages of bridge construction. Following were the major stages at which microtremor measurement were carried out.

1. Measurement of individual girder at factory.
2. After placement of girders at site.
3. After the transverse prestressing of girders.
4. After the grouting of duct provided for prestressing.
5. Before casting of curve portion of bridge.
6. After the monolithic casting of curve portion of bridge.

During the microtremor measurement of individual prestressed concrete girder at factory, sensors were placed at each quarter span of girder. Sensors were able to measure three dimensional microtremor and X was always set in longitudinal direction of girder.

During measurement at site, sensors were placed at mid span of each
girder named with G1,G2….G13,G14 and one sensor was placed at abutment of the bridge. The configuration of sensor was shown in fig.2. Measurement was taken by giving impact on girder by hammer. The length of measurement was 3minute with sampling frequency of 200Hz. Velocity time history was drawn for each girder. Then predominant frequency and damping ratio were calculated from extracted data.

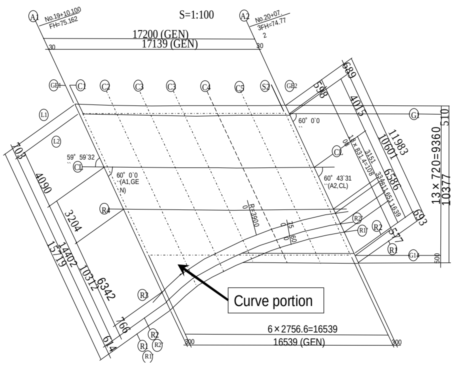

Fig.1 Plan view of Yoshida Bridge

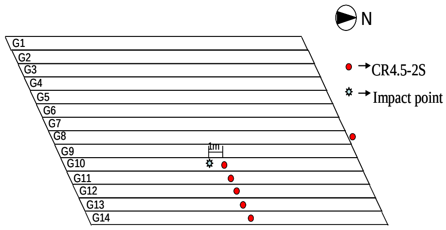

Fig.2 Configuration of sensors

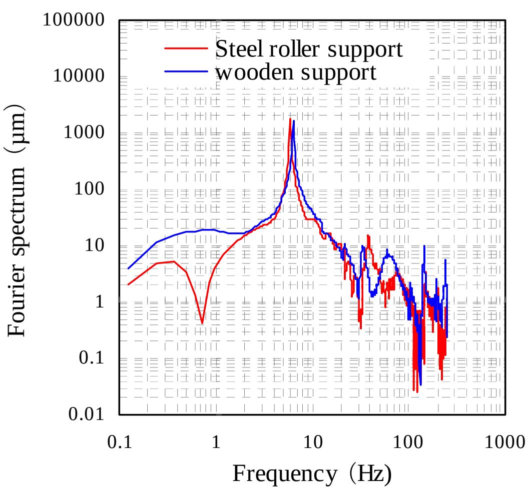

Fig.3 Fourier spectrum of G9 and G11

3. Results and discussions

The results obtained at each stage of microtremor observation were described in following sub heading.

3.1 Measurement of individual prestressed concrete girder at factory

At prestressed concrete manufacturing factory, microtremor measurement of two girders named G9 and G11 of Yoshida Bridge were taken. The predominant frequency of G9 girder was 6.34Hz and that of G11 girder was 5.85Hz. Fourier spectrum was shown in fig.3. All the conditions during the measurement were identical expect the wooden support for G9 girder and steel roller support for G11 girder. From this observation, it can be concluded that the support condition (boundary condition) has a significant influence on the predominant frequency of prestressed concrete girders.

3.2 After placement of girders at site

The Fourier spectra at different phases of bridge construction were shown in fig.4. The summary of predominant frequencies and damping ratios at different phases of bridge construction were shown in fig.5 and fig.6 respectively. After installation of girders at site, the average predominant frequency and damping ratio were observed as 6.09Hz and 0.02 respectively.

3.3 After transverse prestressing

Immediately after the transverse prestressing of girders, the average predominant frequency was 6.64Hz. There was an increment of 0.55Hz after prestressing. Therefore, flexural rigidity of girders has increased after prestressing. By taking the ratio of above two frequencies before and after prestressing, it can be concluded that about 18% stiffness was increased by prestressing. However, damping ratio was found to be decreased. The average damping ratio was 0.015.

3.4 After grouting of duct

Microtremor measurement was taken immediately after completion of grouting of duct. The average predominant frequency was 6.64Hz and average damping ratio was 0.017. With reference to these data, it can be concluded that grouting has no significant effect on predominant frequency.

3.5 Before and after casting of curve portion

Average predominant frequency and damping ratio before concreting of curve portion of Yoshida Bridge were 6.68Hz and 0.18 respectively. The average predominant frequency of girder was 7.08Hz after casting of curve portion and average damping ratio was 0.015. Therefore it can be concluded that additional RC curve portion has contributed for the greater flexural rigidity of the integrity of bridge.

In general, the predominant frequency was increasing from initial stage of installment of girder at site to concreting of curve portion but in contrast to it, damping ratio was in decreasing trend.

4. **Conclusions**

The support condition (boundary condition) has significant influence on the predominant frequencies of PC girders. The predominant frequencies of prestressed concrete girders have increased significantly after transverse prestressing. Therefore, prestressing has contributed to greater flexure rigidity of structure after installment. But damping ratio was decreased after prestressing. Additional RC member to prestressed girder has also increased the flexural rigidity of bridge.

5. Acknowledgements

The authors would like to thank Road Management Department of Ehime Prefecture for providing the opportunity to develop a new technique to evaluate existing bridges in Ehime Prefecture.

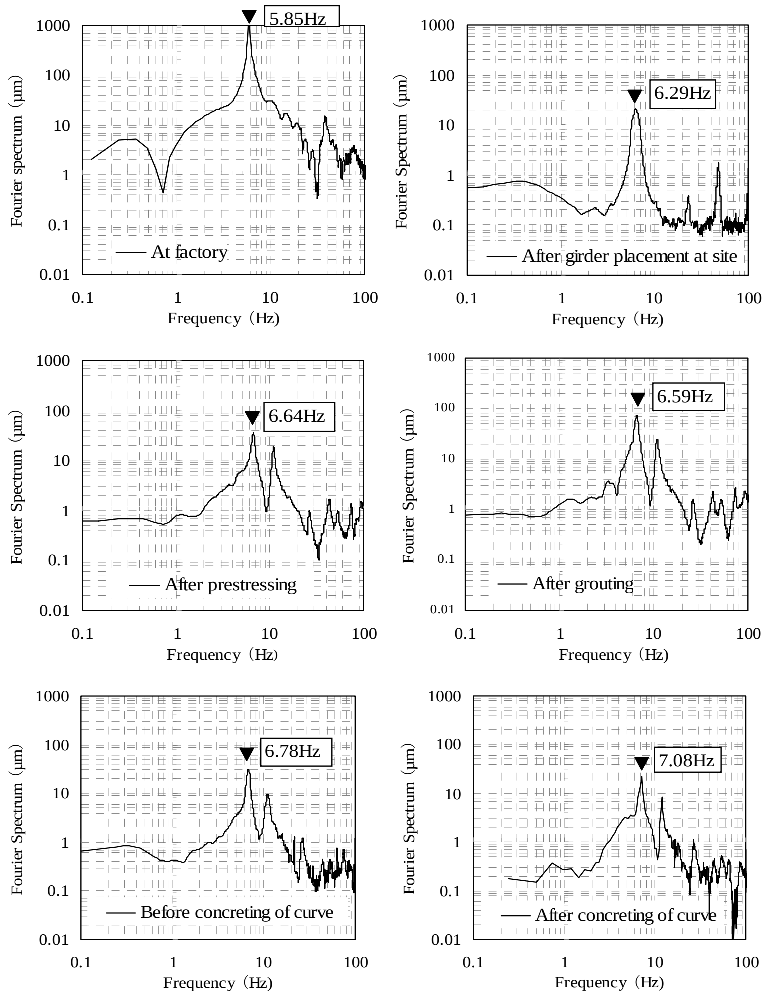

Fig.4 Fourier spectrum of PC girder G11 at different stages of bridge

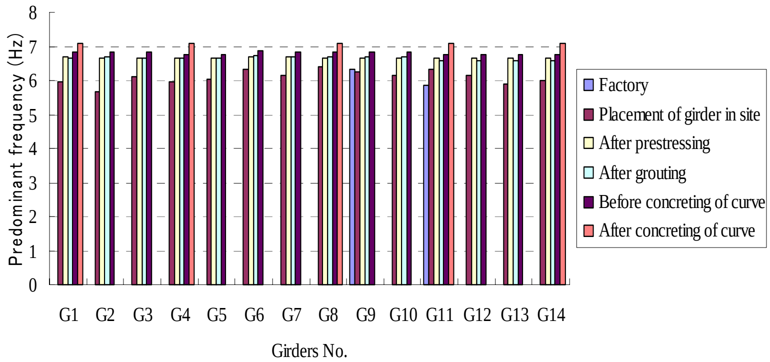

Fig.5 Predominant frequency of PC girders.

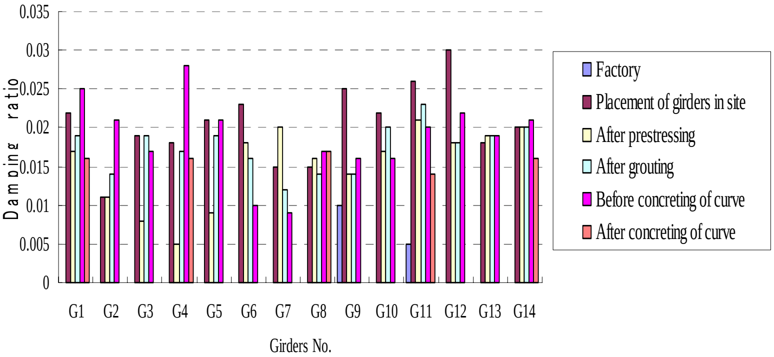

Fig.6 Damping ratio of PC girders.