SEISMIC EVALUATION OF TOTAL BRIDGE SYSTEM BEHAVIOR BY TRI-SECTION METHOD

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1. INTRODUCTION

In order to estimate the total bridge behavior during the earthquake, it is necessary to consider the boundary condition. However, almost all analysis neglects the effect of it. For that reason, we suggest the tri-section method as dynamic analysis for the total system. Tri-section method is the method of estimation of boundary condition for long elevated bridge. The purpose of the present study is the formulation of tri-section method and the examination of its applicability of this method based in the comparison of analysis with the record of observation.

2. OUTLINE OF TRI-SECTION METHOD AND ANALYSIS OF TOTAL BRIDGE SYSTEM

In tri-section method, firstly, we divide a bridge into three equal parts as shown in Fig.1 and center block B is taken for the analysis. Secondly, we calculate mass matrix, stiffness and damping matrix of block B. thirdly, and we input ground seismic motions into structures and estimate the response performance. In these calculations, the effects from the left block A and right block C are replaced by the equivalent boundary spring. We can calculate the total bridge system behavior by block B done by these boundary springs (Fig.2).

The mass matrix of the total system is denoted by M, the damping matrix C, the stiffness matrix K, and the displacement denoted by X(/x). According to Ref. [1], the equation of motion including the boundary springs is

$$\begin{bmatrix} \boldsymbol{M}_{22} & & \\ & \boldsymbol{M}_{BB} & \\ & & \boldsymbol{M}_{33} \end{bmatrix} \begin{Bmatrix} \ddot{\boldsymbol{x}}_2 \\ \ddot{\boldsymbol{X}}_B \\ \ddot{\boldsymbol{x}}_3 \end{Bmatrix} + \begin{bmatrix} & & \\ & \boldsymbol{C} & \\ & & \end{bmatrix} \begin{Bmatrix} \dot{\boldsymbol{x}}_2 \\ \dot{\boldsymbol{X}}_B \\ \dot{\boldsymbol{x}}_3 \end{Bmatrix} + \begin{bmatrix} \boldsymbol{K}_{22} - \boldsymbol{K}_{2A} \cdot \boldsymbol{K}_{AA}^{-1}(\alpha \boldsymbol{K}_{A1} + \boldsymbol{K}_{A2}) & \boldsymbol{K}_{2B} & \\ \boldsymbol{K}_{B2} & \boldsymbol{K}_{BB} & \boldsymbol{K}_{B3} \\ & \boldsymbol{K}_{3B} & \boldsymbol{K}_{33} - \boldsymbol{K}_{3C} \cdot \boldsymbol{K}_{CC}^{-1}(\boldsymbol{K}_{C3} + \beta \boldsymbol{K}_{C4}) \end{bmatrix} \begin{Bmatrix} \boldsymbol{x}_2 \\ \boldsymbol{X}_B \\ \boldsymbol{x}_3 \end{Bmatrix} = \begin{Bmatrix} \boldsymbol{f}_2 \\ \boldsymbol{F}_B \\ \boldsymbol{f}_3 \end{Bmatrix} \quad (1)$$

where subscripts A, B, C mean block A, B, C and subscripts 1,2,3,4 mean boundary node 1,2,3,4. α and β are the boundary spring constant matrices.

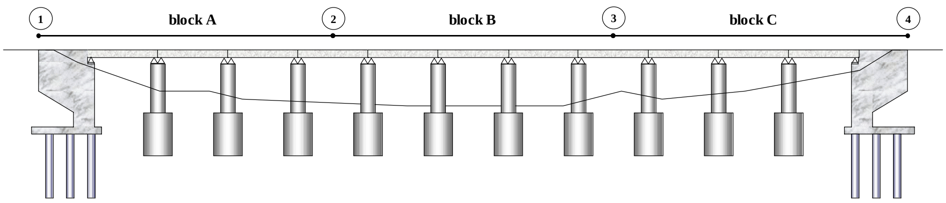


Fig.1 Concept of tri-section method

3. IMPUT SEISMIC DATA AND ANALYZED MODEL

The analysis of this paper was calculated by using the record of the observation on the 222nd pier in the Oodaka line in the Nagoya expressway on February 23rd, 2001 (Fig.3).

Fig.4 shows the analyzed models. Model-1 has 2 nodes and 6 degrees of freedom and Model-2 has 16 nodes and 48 degrees of freedom. In Model-2, boundary springs exist at the edges. In these models, Raileigh damping is adopted as damping

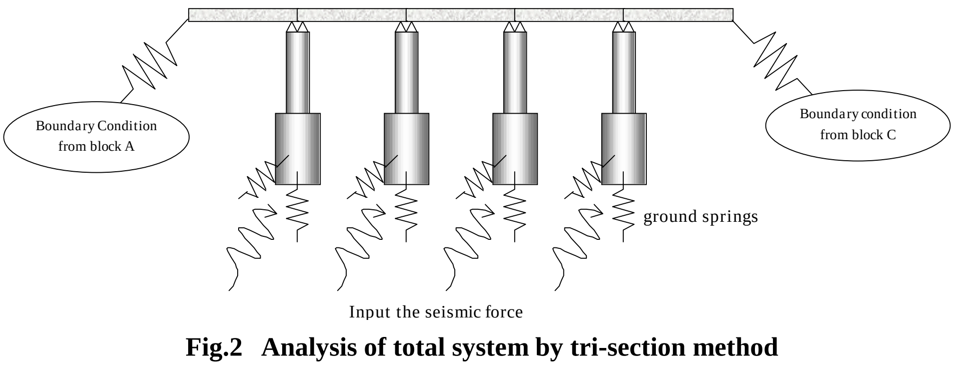


Fig.2 Analysis of total system by tri-section method

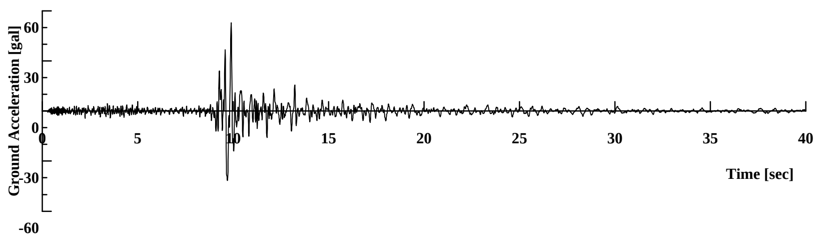
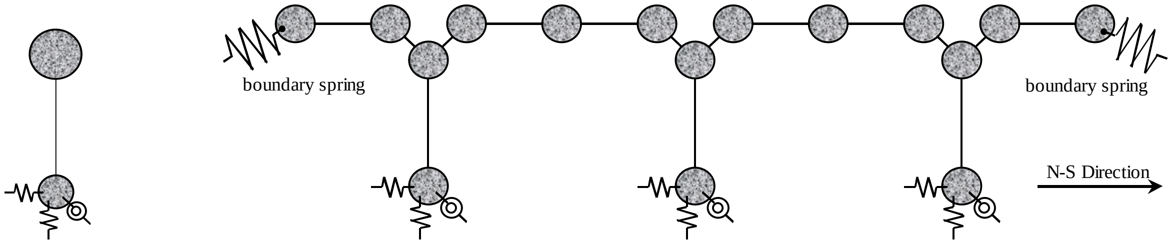


Fig.3 Ground Acceleration [2001/02/23 : N-S direction]



Model-1 **Model-2**

Fig.4 ANALYZED MODEL

matrix (damping factors are 0.03). The nodes under ground are supported by ground springs(Ref.2).

4. ANALYSIS RESULT

Analysis result is shown by the solid line in Fig.5 (Model-1) and Fig.6 (Model-2) in comparison with the records of the observation.

In Model-2, the envelope curves are very similar and their eigenperiods are almost same (Fig.8). Furthermore, maximum acceleration of analysis is nearly equal to the observation. (analysis: 68.24[gal]:20.04[sec] / observation: 69.34[gal]:20.01[sec]) . However, in Model-1, the difference between analysis and observation is remarkable. These differences are caused by the analysis model.

5. CONCLUSIONS

1) Using tri-section method, it is possible to represent the behavior of the bridge to a certain extent.

2) The observation results gives the information of tri-section parameter α and β. Once we get these parameters, we would be able to estimate the seismic behavior.

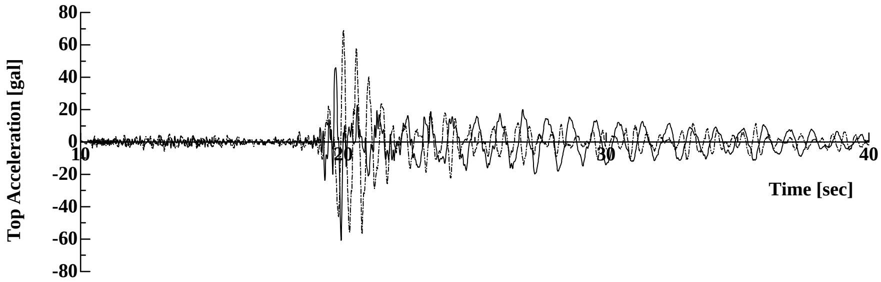


Fig.5 Top Acceleration [Model-1]
(dotted line: observation / solid-line: analysis)

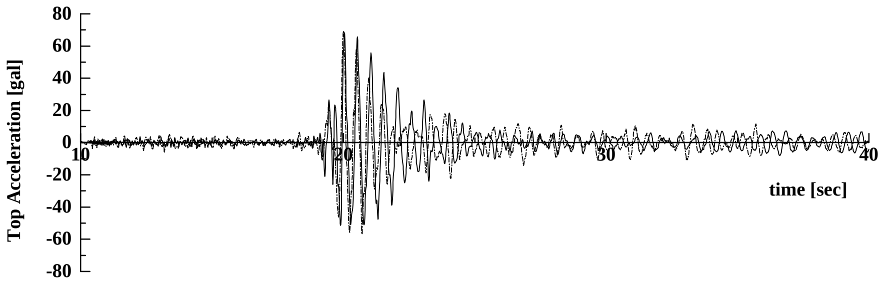


Fig.6 Top Acceleration [Model-2]
(dotted line: observation / solid-line: analysis)

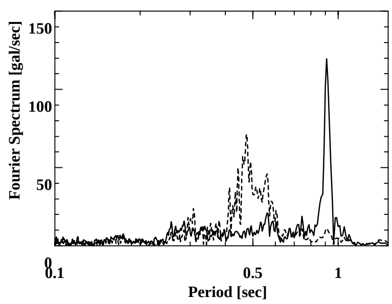


Fig.7 Fourier Spectrum [Model-1]

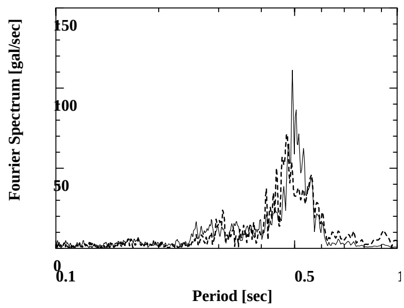


Fig.8 Fourier Spectrum [Model-2]

ACKNOWLEDGEMENT

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REFERENCES

1. Nakano,T., “Observation of RC Bridge Piers Behavior during the Earthquake and Nonlinear Dynamic Analysis of RC Piers by Flexibility Method” , Master thesis, School of Engineering, Nagoya Univ., 2000 (in Japanese)
2. Japan Road Association, “Specifications for Highway Bridges Part Ⅲ”, Japan Road Association, 1997 (in Japanese)