A STUDY ON THE EFFECTS OF FOUNDATION UPLIFT ON THE STRUCTURE USING MACROELEMENT MODEL

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1. INTRODUCTION

Foundation uplift may occur when a structure supported by a basemat foundation is subjected to strong ground motion. The nonlinear phenomenon may be beneficial or detrimental for the structure system. Hatashi (1996) studied damage reduction effect due to base mat uplift of buildings subjected to strong ground motions. Inoue and Mikami (2014) studied stress reduction effects induced on bridge piers due to basemat uplift and soil yielding. Foundation uplift may benefit the structure by shifting its resonant frequency to a different frequency. In this case, the foundation uplift phenomenon works as a seismic isolation for the system. However, the opposite phenomenon may occur, that is, the foundation uplift may shift its natural frequency close to the resonance frequency. These phenomena would depend on the parameters related to the natural frequency of the system and the predominant frequencies of the input motions. This study conducts a parametric study to find out which combination of parameter sets may make the structure more dangerous.

2. ANALYSIS MODEL

2.1 Model Parameters

The analysis model consists of a structure supported by a basemat foundation as shown in Fig.1. The structure is modeled by a single degree of freedom system in which the mass is assumed to be 10 ton and the stiffness is 395 (kN/m). The foundation-soil system is described by a macroelement model. The parameters describing the foundation-soil system is determined referring to the PWRI report (2008) as shown in Table 1 where K_v is the vertical spring constant, K_h is the horizontal spring constant, K_r is the rotational direction spring constant, C_v is the vertical damping coefficient, C_h is the horizontal damping coefficient and C_r is the rotational direction damping coefficient. The natural frequency of the system is estimated as approximately 2 Hz. This study used a macroelement model developed by Nakatani et al. (2008)

Table 1 The Parameters of The Model

Parameter	M_1	M_2	K	K_v	K_h	K_r	C_v	C_h	C_r
Unit	(ton)	(ton)	(kN/m)	(kN/m)	(kN/m)	(kNm/rad)	(kNs/m)	(kNs/m)	(kNs/rad)
Value	10	0.00001	395	89179	72794	4420	130	90	1

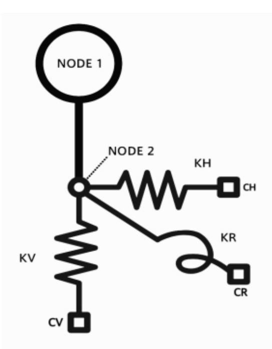

Fig. 1 Analysis the model

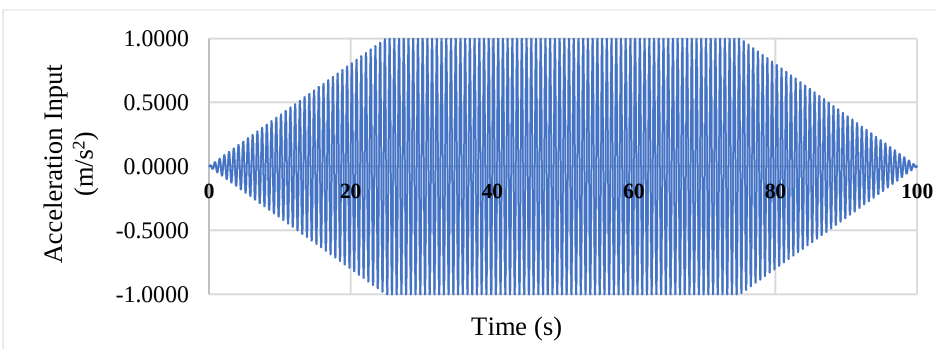

Fig.2 An Example of Sine Sweep Input Wave (1.5 Hz., Max Amp. =100gal Case)

2.2 Input Motion

The input motion of 1.5Hz sine sweep wave was prepared as shown in Fig.2. The maximum amplitude of the input wave was increased from 10gal(cm/s^2) to 500gal(cm/s^2). In addition, sine sweep waves that have other predominant frequency (2Hz) were prepared for the comparison.

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3. RESULTS

Fig. 3 shows the maximum uplift component calculated by using the model for various amplitudes of the input motions. The result shows that the foundation uplift increased drastically when the amplitude of input motion is larger than 220(gal) which is threshold value. Fig.4 and Fig.5 show the time history responses of the uplift component in rotation for two different cases. Fig.4 shows an example of the foundation rotation when input motion(=200gal) is less than the assumed threshold for 1.5Hz case. Fig.5 shows when input motion(=260gal) is larger than the threshold. From Figs. 3 to 5, we understand that the uplift component of the foundation differs significantly depending on both amplitudes and frequency characteristics of input motions.

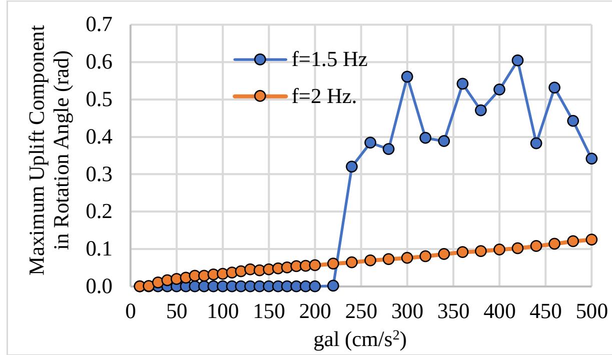

Fig.3 Comparison the Maximum Uplift Component in Rotation Angle between f=1.5Hz and f=2Hz.

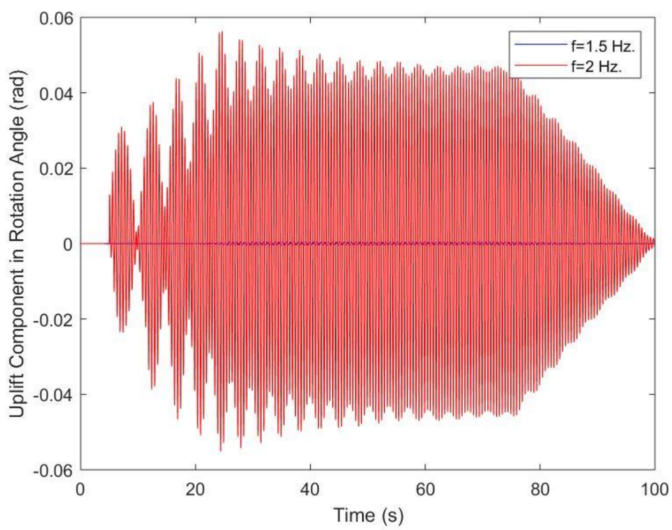

Fig.4 Comparison of the Uplift Component in Rotation Angle between f=1.5Hz and f=2Hz when Input Motion equal 200 gal(cm/s^2)

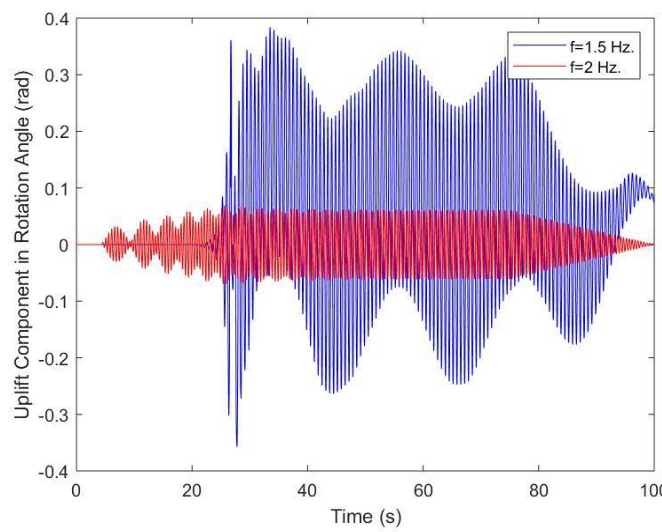

Fig.5 Comparison of the Uplift Component in Rotation Angle between f=1.5Hz and f=2Hz when Input Motion equal 260 gal(cm/s^2)

4. CONCLUSIONS

This study showed two different examples of responses of a structure which was subjected to two input motions of different frequency characteristics. The structure is supported by a basemat foundation considering foundation uplift by using macroelement model. Considering various amplitudes of input motions, threshold value was found, and the foundation uplift significantly increased when the amplitude of the input motion exceeds the threshold for a case.

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