VIBRATION OF LONG SPAN GATE BY WAVE ACTION

KUNIHIRO OGIHARA and YUKIHIKO UEDA

Prof. and Dr. of Engineering
Department of Civil and Environment Engineering, Toyo University,
2100 Kujirai, Kawagoe Saitama, Japan 350-8585
(Tel/Fax: +81-42-923-1395, e-mail: Ogihara@eng.toyo.ac.jp)
Dr. and adviser of design section of gate, Nihon jidoukikou, Urawa, Saitama Japan

The gate contracted at the river mouse affects by wave action from seaside and vibration occurs by wave force. Especially when sea level is near the bottom surface of the upper gate, which is consisted in two combined gate system as shown in figure 1. This gate gets the impulsive wave force such as bridge for ship yard. An impulsive uplift force by wave has been investigated by experiments but there are few reports on the response of gate by wave force. In this paper, theoretical analysis of response of gate motion by two types of wave forces as impulsive one and sinusoidal one.

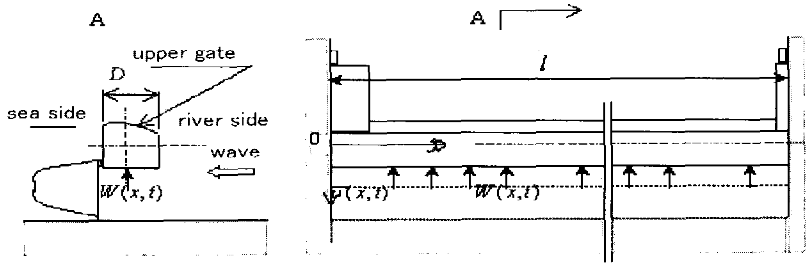

Fig. 1 gate section

When sea level is near the bottom surface of upper gate, the impulsive uplift force acts on the bottom surface of gate, and it has a triangular pressure curve in time domain. And its acting term is very short to compare to the natural period of gate system. So the force can be assumed as follows.

$$p(t) = p_0 e^{-at} \tag{1}$$

Here a is constant value and p0 is maximum pressure at t=0. The equation of motion of gate beam is written as equation (2) by taking the factors as follows; $W(x,t)$ is external force, ζ is damping constant and $\overline{\upsilon}(x,t)$ is deformation of beam.

$$EI\frac{\partial^4 \overline{\upsilon}}{\partial x^4} + \zeta I\frac{\partial^5 \overline{\upsilon}}{\partial t \partial x^4} + (m + m_0)\frac{\partial^2 \overline{\upsilon}}{\partial t^2} = W(x,t) \tag{2}$$

Here EI is rigidity of gate around the horizontal axis, m and m_0 are mass and added mass in unit length.

The term $\eta_M(l/2)$ is the ratio of dynamic bending moment $M_{l/2}$ and static moment

$M_s (= w_0 l^2/8)$ at the middle point of beam and it is plotted in figure 4 as the relation of parameter $\lambda l/\pi$, which is related to the natural frequency of beam.

It is clearly seen that the resonance occurs at the frequency of external force has odd numbers of natural frequency, but when it is even numbers, the resonance does not occur.

And the range of resonance becomes smaller as the higher order of frequency.

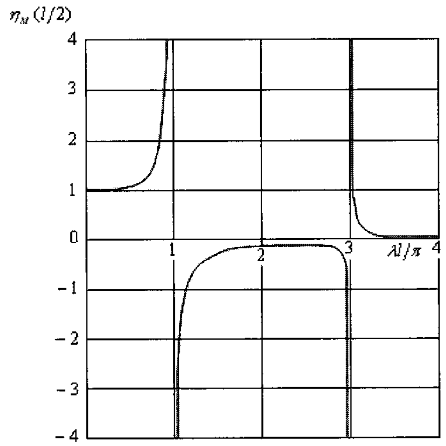

Fig.4 Response ratio of moment.

The results are follows;

When impulsive force acts on the beam, the response becomes the maximum at 0.1 seconds after the force applied on beam and it tends to sinusoidal motion rapidly.

The ratios between dynamic and static condition are derived as the deflection and the moment at the middle point of beam and the shear force at the support point. When the parameter of impulse becomes larger than 5, and motion becomes sinusoidal motion, dynamic moment is equal to the static moment under the condition of $a/p_1 \le 1/3$.

When the support is fixed and uniform sinusoidal force acts on gate, the resonance occurs at the frequency of external force becomes odd numbers of natural frequency and region of resonance becomes narrow at higher frequency zone.

When the sinusoidal distribution force acts on gate beam, there is only one resonance at the frequency of external force becomes same as the first order of natural frequency.

The dynamic response of long span gate installed near the river mouse by wave is made by theoretical analysis. Wave actions are considered as two types such as impulsive and sinusoidal one and these actions are found in model experiment. The air room under the bottom of gate makes good effect on vibration of gate. The investigation on the wave force acting on the gate with air room is preceded continuously.

Model test has been done in scale 1/25 and its results are shown in main text.

Keywords: Gate Vibration; Wave force; Impulse force and sinusoidal force; Air cushion; Forced vibration