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Added Mass of Two Dimensional Cylinders with the Sections of Straight Frames Oscillating Vertically in a Free Surface

(Continued)

by

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直線肋骨型船斷面을 가지는 柱狀體의 自由水面에서의 上下動에 隨伴되는 附加質量 (續)

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直線肋骨 및 單一背骨을 가지는 배의 斷面과 同一한 斷面을 가지는 2次元 柱狀體가 高振動數로 理想流體의 自由水面에서 上下動을 할 때의 附加質量係數 (K_2)를 特定한 船底角을 支配하는 係數(β)의 各各에 對해서 幅一吃水比(B/H)와 斷面積係數 (σ)로 表示하였으며 Lewis form 및 金이 提示한 曲線肋骨 및 背骨을 가지는 배의 斷面과 同一한 斷面의 2次元柱狀體에 對한 結果와 比較檢討하였다.

The added mass coefficients K_2 of two-dimensional cylinders of straightline-element sections for vertical viblation are presented as functions of parameters such as the beam-draf ratio B/H and the sectional area coefficient σ. The results are compared with those of Lewis forms and curvilinear-elements sections with single chine.

1. Introduction

The author, calculating the added mass of two-dimensional cylinders of straightline-element sections with single chine oscillating vertically in a free surface of an ideal fluid at high frequency by employing the Schwarz-Christoffel transformation, presented the curves of added mass coefficients for vertical oscillation as functions of beam-draft ratio and parmeters controlling angles of bottom deadrise and at chine in the previous paper[1].

There is a certain geometrical relation among the sectional area coefficient, beam-draft ratio and the parameters controlling angles of bottom deadrise and at chine for the straightline-element section with chine. The magnitude of parameters controlling angles of bottom deadrise and at chine of hard chine ship section is material to added mass as well as the other parameters such as beam-draft ratio and sectional area coefficient do as shown previously. In this report, the added mass coefficients are presented as functions of

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** Numbers in brackets designate references at the end of the paper.

parameters such as the sectional area coefficient and the beam-draft ratio, from which the added mass coefficient for a particular chine-type section of the same bottom angle can be read easily.

2. Added Mass Coefficients for Vertical Vibration

The added mass coefficient K_2 (C_v by Kim, or Landweber and Macagno) of the straightline-element section for vertical oscillation at high frequencies is represented by, employing the same notations as those of [1],

$$K_2=\frac{8}{\pi B^2}\left[k^{2(2-\beta)}\sin(2-\beta+\gamma)\pi\frac{\Gamma(\gamma)}{\Gamma(1-\beta)}\sum_{n=0}^{\infty}\frac{\Gamma(3-\beta+\gamma+n)}{(2-\beta+n)(1-\beta+n)}\frac{k^{2n}}{n!}\right.$$

$$\left.+(1-k^2)^{2\beta+\gamma-1}\sin(1-\beta)\pi\frac{\Gamma(\gamma)}{\Gamma(\beta+\gamma-2)}\sum_{n=0}^{\infty}\frac{\Gamma(\beta+n)}{(\beta+\gamma+n-1)(\beta+\gamma+n-2)}\frac{(1-k^2)^n}{n!}-A\right]$$

where the conditions $\frac{1}{2}\leq\beta<1$, $1<\gamma<\frac{3}{2}$, $\frac{3}{2}<\beta+\gamma<2$ and $|k|<1$ should be satisfied [1].

For the wall sided sections K_2 can be reduced to be

$$K_2=\frac{8}{B^2}(1-k^2)\ (1-\beta)+\frac{4}{\pi}\sigma\lambda \tag{2}$$

where

$$\sigma=\frac{1}{2}+\frac{\lambda\left[\frac{1}{2\lambda}-\tan(2-\beta+\gamma)\pi\right]\cdot\left[1-\frac{1}{2\lambda}\tan(\beta-\frac{1}{2})\pi\right]}{1-\tan(\beta-\frac{1}{2})\pi\cdot\tan(2-\beta+\gamma)\pi} \tag{3}$$

Thus, the profile of the straight-element section with single chine is determined by the four variables; σ, λ, β and γ.

The results of the numerical calculations are shown in Fig. 1 (a) through Fig. 1 (g) in the form of K_2 vs. σ curves taking B/H as the parameter for each β value of 0.50, 0.55, 0.60, 0.65, 0.70, 0.75 and 0.80. It is easily seen that the added mass coefficients are influenced by the beam- draft ratio, the sectional area coefficient and the parameters controlling angles of bottom deadrise and at chine for hard chine ship sections as mentioned previously.

3. Discussion

Prohaska [2] and Kim [3] investigated added mass of the curvilinear-element section with single chine by employing the transformation

$$z(\zeta)=\zeta+a_1\zeta^{-1}+a_7\zeta^{-7} \tag{4}$$

where $\zeta=re^{i\theta}=e^{i\theta}$ for $r=1$, $|a_1|<(1-7a_7)$, and $0\leq a_7<\frac{1}{7}$.

For the section derived from (4), the added mass coefficient associated with vertical vibration and the sectional area coefficient are determined by

$$K_2=2+(\alpha-\lambda')\ (2\alpha-2\lambda'-3) \tag{5}$$

and

$$\sigma=\frac{\pi}{8\lambda'}[-3\alpha^2+7\alpha(1+\lambda')-2(2+3\lambda'+2\lambda'^2)] \tag{6}$$

where $\lambda'=2H/B$ and $\alpha=4/B$.

In Fig. 2, the added mass coefficients for straightilne-element sections are compared with those of curvilinear-element sections with single chine [3] and of Lewis forms [4], [5] for vertical oscillation for the case of $B/H=2$.

The added mass coefficients of the straight-element secions vary over wide range at the constant beam -draft ratio and the sectional area coefficient, and those of curvilinear-element sections [4] give almost average

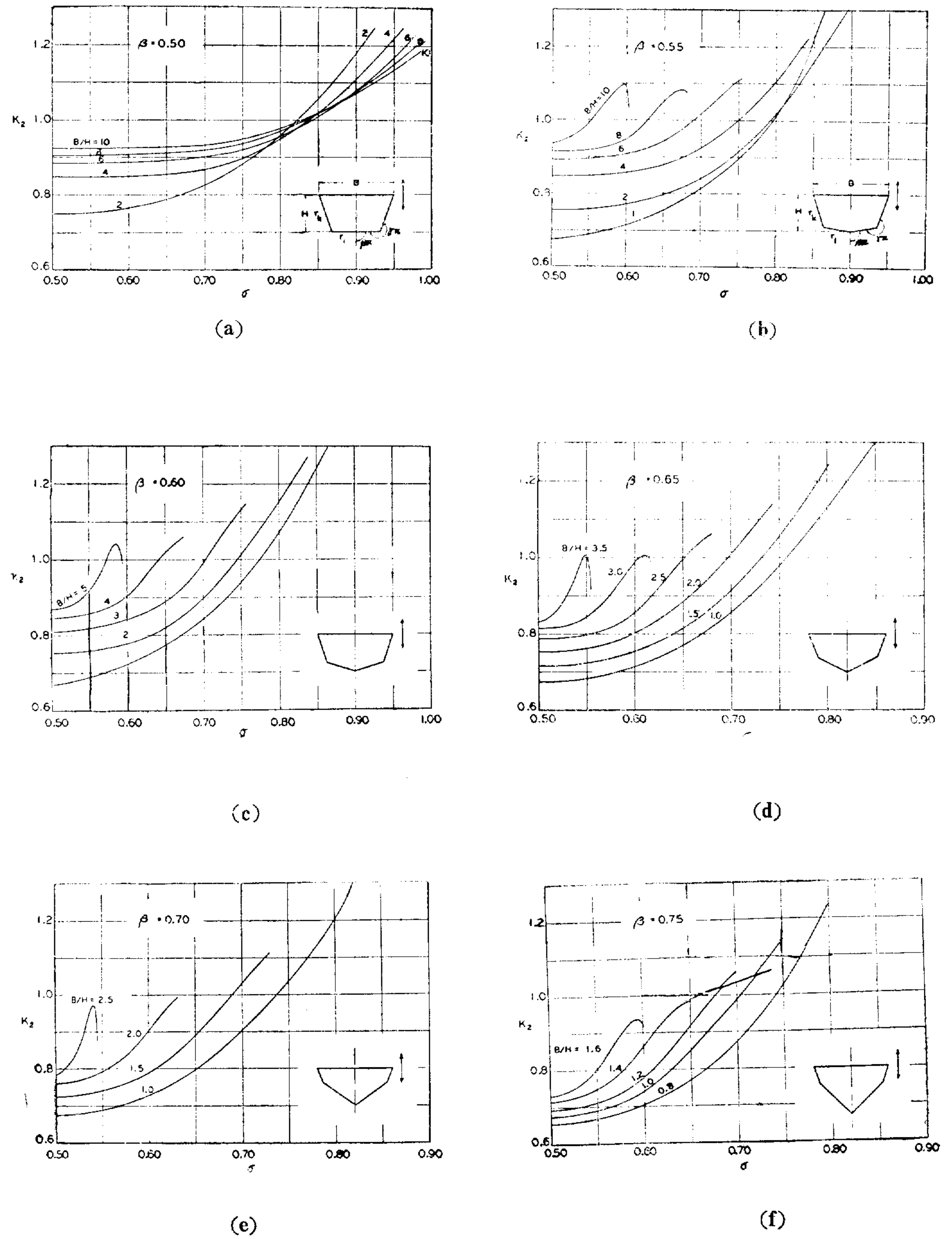

Fig 1. Added Mass Coefficients vs. Sectional Area Coefficients with Parameter B/H

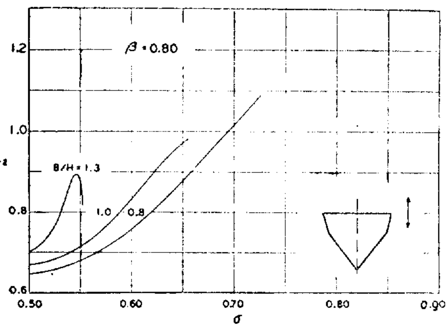

Fig. 1. (g)

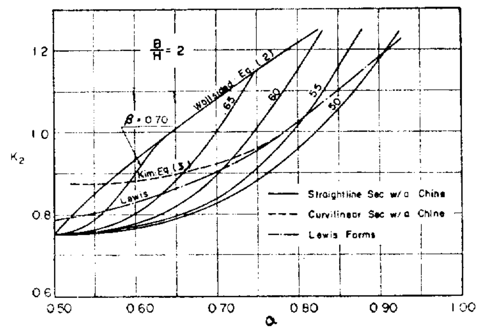

Fig. 2. Comparision of K_2 with those of Lewis Forms and of Curvilinear-Element Sections with Sigle Chine

values of those of straightline-element sections with various bottom angles or chine angles at constant beam-draft ratio. Further more, as Kim [3] pointed out, Lewis forms give always smaller values of K_2 than the curvilinear-element sections with single chine. Such tendency also holds for almost entire range of sectional area coefficients at constant beam-draft ratio for wall sided straightline-element sections. These tendencies well agree with Prohaska's suggestion [2] that V-type sections always give a greater C_v value than U-type sections for given values of B/H and σ. However, it should be noted that for the straightline-element sections with the side raked at the free surface the Prohaska's suggestion is not always met. It is supposed that the main reason of the above disagreement is due to the effects of angles of bottom dreadrise and at chine, i.e. that of the slope of the sides of the section on the added mass.

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