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BANK EFFECTS ON VESSEL INTERACTION FORCES

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ABSTRACT

Some preliminary model tests have been carried out primarily to identify the effects that bank proximity has on the interaction forces experienced by a moored vessel when another vessel passes.

Forces were measured on a model of a moored vessel during the passage of a model of a passing vessel under conditions that were similar for different runs except for the presence or absence of banks defining a channel. The results from these tests show clearly that there are significant differences between the interaction forces when banks are present and interaction forces when banks are absent.

Other tests were carried out to investigate the relative effects of underkeel clearance (ukc) of each vessel and of vessel separation with the banks present.

NOTATION

X = surge force
Y = sway force
N = yaw moment
V = passing velocity
D = longitudinal separation distance
S = lateral separation distance
L = length between perpendiculars
T = draft
B = beam
ukc = underkeel clearance
$C_X = X/(\frac{1}{2}\rho\ TBV^2)$
$C_Y = Y/(\frac{1}{2}\rho\ TBV^2)$
$C_N = N/(\frac{1}{2}\rho\ TB^2V^2)$
Fr = Froude No $(V/\sqrt{gL})$

Positive directions for X, Y and N are shown in Figure 1.

INTRODUCTION

A moving vessel produces an unsteady flow field that travels with the vessel. When the moving vessel passes a stationary (moored) vessel, the flow field gives rise to surge and sway forces and a yaw moment on the stationary vessel of the general form shown in Figure 2. The horizontal axis in Figure 2 can be interpreted as the longitudinal distance D (see Figure 1) or time (D divided by the speed of the passing vessel). These force and moment components are referred to collectively as interaction forces.

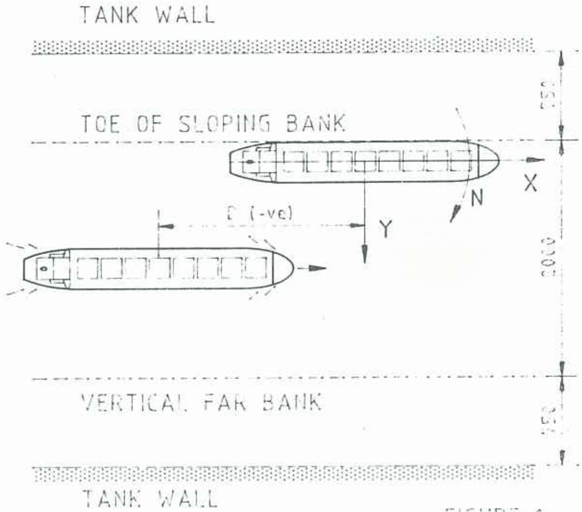

FIGURE 1

Existing work on this topic, References 1 - 3, has indicated that the relative magnitude of the maximum X and the maximum Y forces are as shown in figure 2.

In a river port interaction forces may be more significant that environmental forces when limiting conditions for loading or unloading operations are being established. Observational data collected at the Port of Newcastle indicated that the interaction forces may be significantly affected by channel geometry, and that the force in the X direction was much larger compared to the force in the Y direction than that indicated in Figure 2. A preliminary model investigation was therefore carried out to establish qualitatively the general effects of channel geometry on interaction forces.

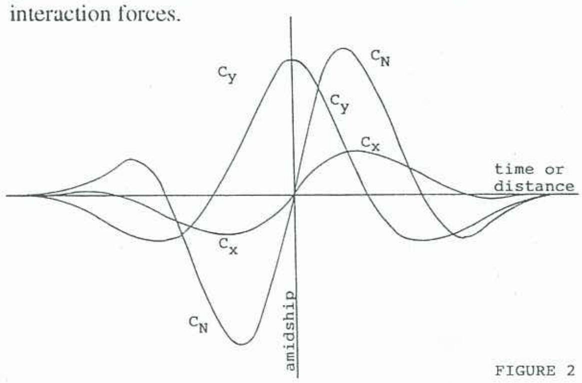

FIGURE 2

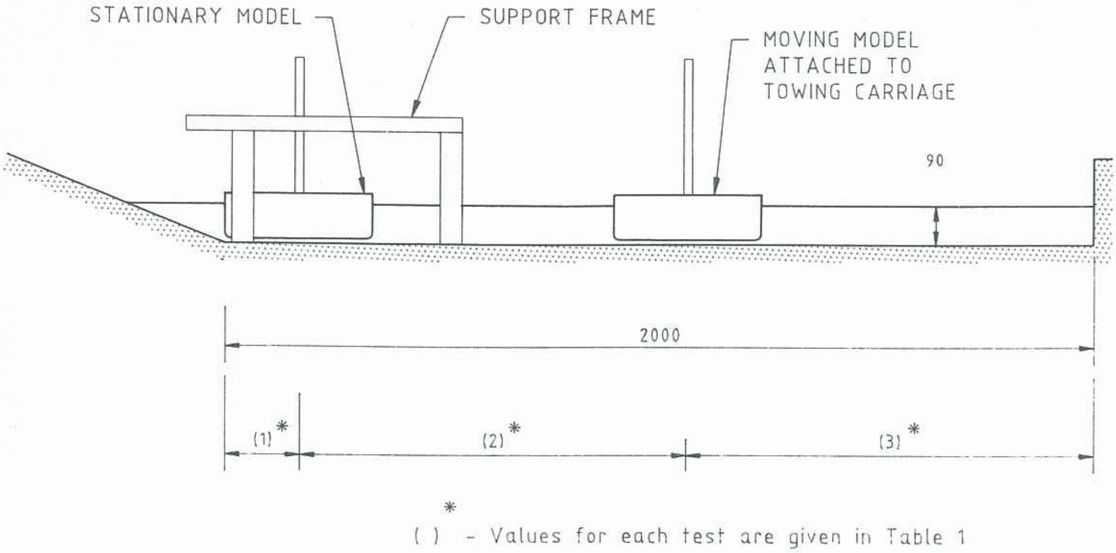

FIGURE 3

OBJECTIVES

The primary objective of the investigation was to determine if channel geometry especially bank proximity has a significant effect on interaction forces. Other objectives included gaining insight into the interaction phenomena and establishing requirements for a full, quantitative model study.

TEST FACILITIES

The tests were carried out in the 60m long Towing Tank at the Australian Maritime College (AMC) using two available 1/150 models of typical 130,000 dwt bulk carriers. The tank was drained to provide the shallow water conditions required. Metal sheets supported on frames were installed within the 3.5m wide towing tank to provide the channel cross-section shown in Figure 3.

A sloping bank was used adjacent to the stationary model to represent the bank geometry at a typical berth while a vertical far bank was used on the assumption that the results would not be significantly affected by the detailed geometry of the far bank. The toe of the sloping bank was 750mm from one tank wall and the face of the vertical bank was 750mm from the other wall as shown in Figure 1.

The framework shown in Figure 3 was constructed to support the stationary model and another framework was constructed to attach the moving model to the towing carriage.

Available equipment was used for measuring surge, sway and yaw on the stationary model, speed of the passing vessel and for data acquisition. Software for controlling data acquisition and for analysis of the results was developed specifically for the tests.

TEST PROGRAMME

The test programme was carried out on an ad hoc basis to obtain as much qualitative information as possible in the time available. As well as various channel geometries, the effects of ukc and lateral separation distances were investigated.

Tests were carried out for the various conditions given in Table 1.

The distances in the table are:

(1) centreline of stationary vessel to toe of near bank,
(2) lateral separation of vessels (centreline to centreline) and
(3) centreline of passing vessel to far bank.

For underkeel clearances (ukcs)

(1) is the value for the stationary vessel and
(2) is the value for the passing vessel.

TEST RESULTS

Examples of data for the X and Y forces from two runs are given in Figures 4 and 5. Figure 4 has been obtained from the open water condition which has been the subject of earlier work, References 1 - 3 illustrated schematically in Figure 2. Figure 5 on the other hand has been obtained from an experimental set up representing the Port of Newcastle, where it can be seen that the presence of the banks significantly increases the force in the X direction and decreases that in the Y direction.

The results are summarised in Tables 2 - 4, each being an average from 2 or 3 separate runs with Froude numbers in the range 0.05 to 0.12.

TABLE 1
Test Conditions

TEST ID	Port Bank	DISTANCES (mm)			ukc (mm)	ukc (mm)
		(1)	(2)	(3)	(1)	(2)
A	sloping	170	830	1000	6	6
B	sloping	170	830	1750	6	6
C	vertical	920	830	1750	6	6
D	sloping	170	830	1000	13	6
E	sloping	170	830	1000	13	13
F	sloping	170	680	1150	13	13

TABLE 2
Bank Effects

TEST ID	C_X Min	C_X Max	C_Y Min	C_Y Max	C_N Min	C_N Max
A	-0.6	0.4	-0.7	1.1	-1.1	1.0
B	-0.5	0.3	-0.7	1.1	-1.2	1.4
C	-0.3	0.3	-0.7	1.4	-1.6	1.0

TABLE 3
UKC Effects

TEST ID	C_X Min	C_X Max	C_Y Min	C_Y Max	C_N Min	C_N Max
A	-0.6	0.4	-0.7	1.1	-1.1	1.0
D	-0.5	0.3	-0.4	0.7	-0.8	0.7
E	-0.4	0.4	-0.4	0.6	-0.6	0.8

TABLE 4
Separation Effects

TEST ID	C_X Min	C_X Max	C_Y Min	C_Y Max	C_N Min	C_N Max
E	-0.4	0.4	-0.4	0.6	-0.6	0.8
F	-0.5	0.4	-0.5	0.7	-0.9	0.9

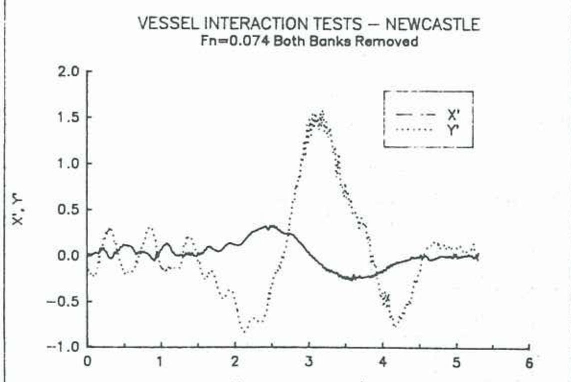

Figure 4

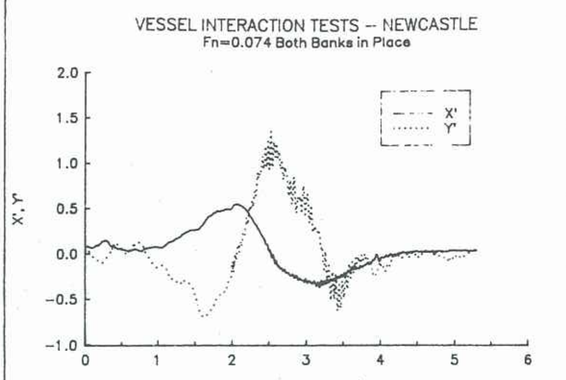

Figure 5

Table 2 shows peak values (minimum and maximum) of the force coefficients with three different bank arrangements; A is the test channel (as shown in Figure 3), B is with the far bank removed and C is with both banks removed.

A comparison of the results from tests A and C indicate that the banks have a significant effect with the surge component, X, being increased relative to the sway component, Y. This is consistent with the requirement that the flow near a bank must be parallel to the bank. The results from test B indicate that the far bank has a relatively small effect.

Table 3 shows the peak values from the tests with different ukcs (and all other conditions the same).

As expected larger forces are associated with smaller ukcs. There is an indication that the forces are more sensitive to the ukc of the stationary vessel.

Table 4 shows the peak values from two tests with different separations (and all other conditions the same).

As expected the larger forces are associated with the smaller separation.

CONCLUSIONS

The results from the preliminary model study tend to confirm the inferences drawn from the observational data that the presence of the channel bank next to the moored vessel increases the relative size of the interaction force in the X direction compared to that in the Y direction.

The results also indicate that both a decrease in separation distance and a decrease in ukc results in an increase in interaction forces, with the ukc of the moored vessel being more significant than that of the passing vessel.

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