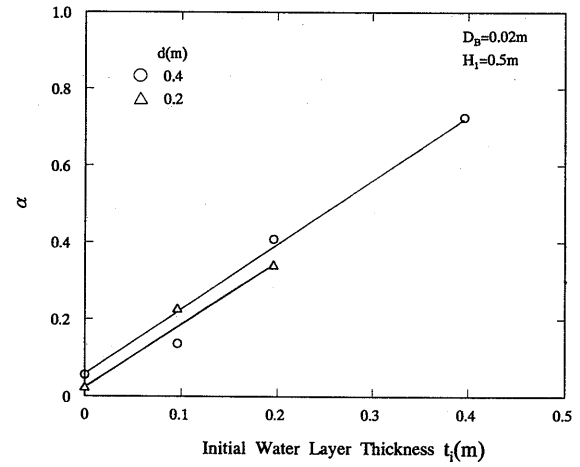


(a)



(b)

Fig. 30 Effect of t_i on α and Q_p/Q_T

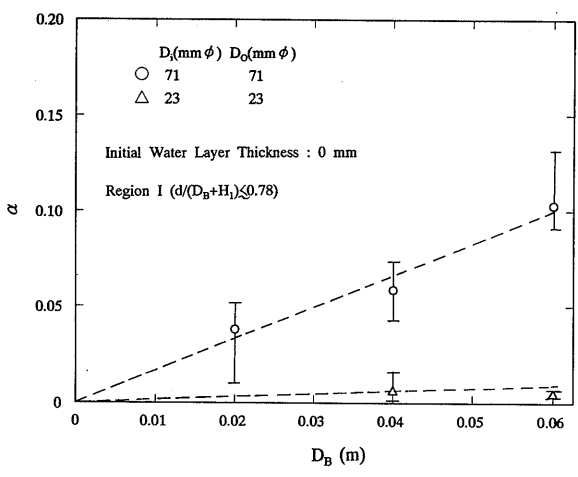
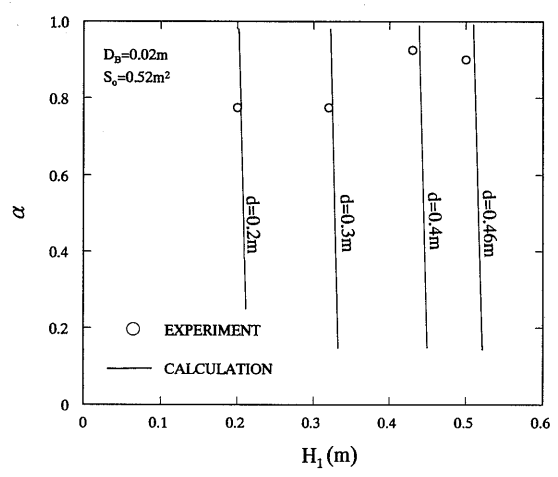
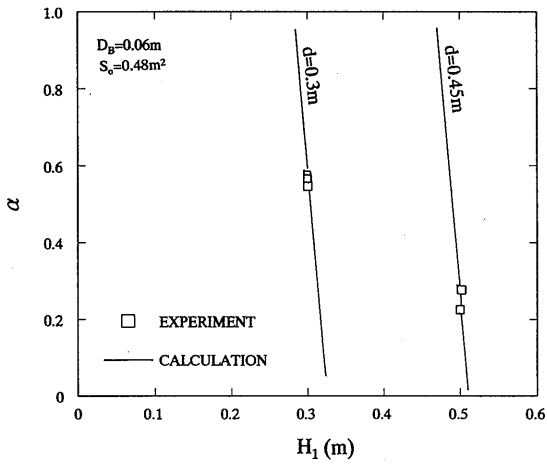


Fig. 31 The value of α in low $d/(D_B+H_1)$

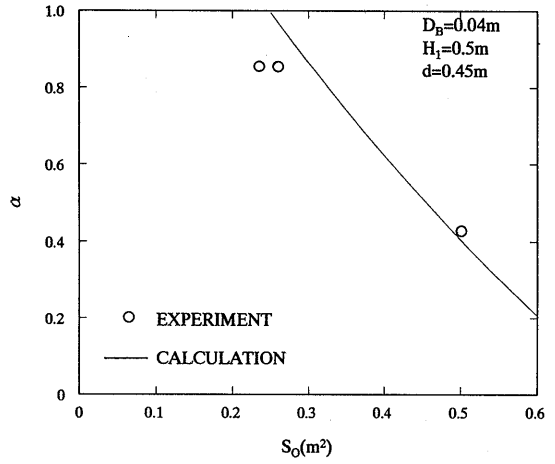


(a)

Fig. 32 The value of α in high $d/(D_B+H_1)$ comparing with prediction



(b)



(c)

Fig. 32 The value of α in high $d/(D_B+H_1)$ comparing with prediction

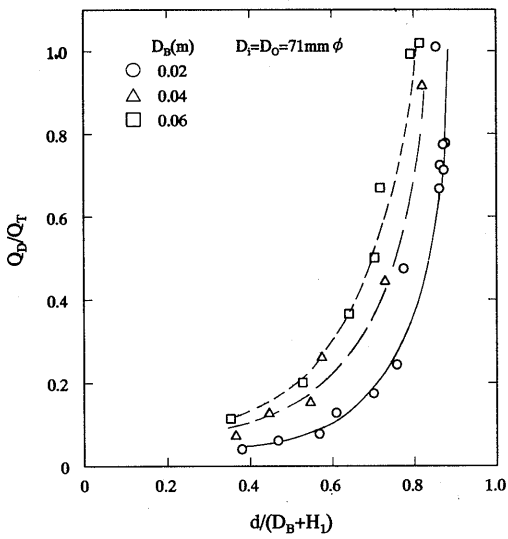


Fig. 33 Effect of double bottom height on Q_D/Q_T

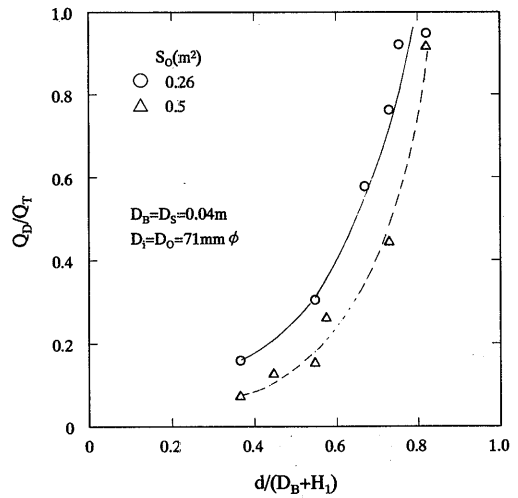


Fig. 34 Effect of S_0 on Q_D/Q_T

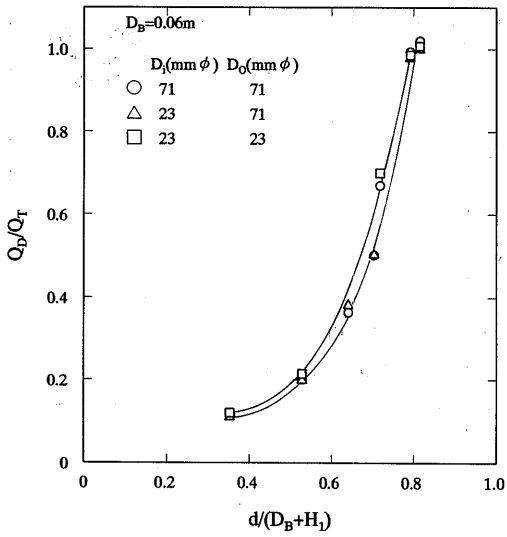


Fig. 35 Effect of rupture diameter on Q_D/Q_T

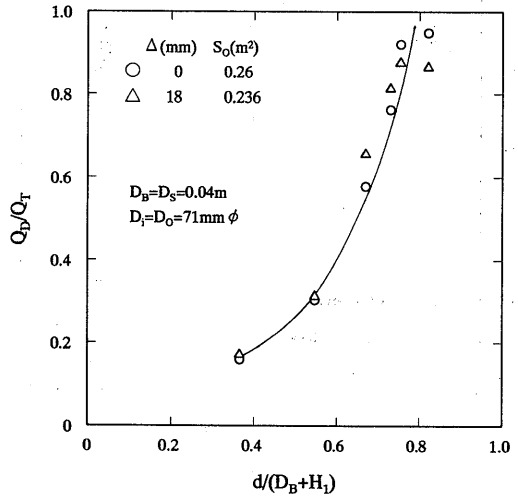


Fig. 36 Effect of Δ on Q_D/Q_T

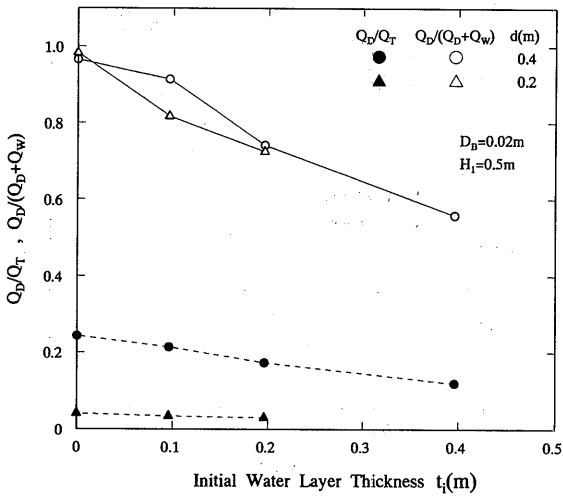


Fig. 37 Effects of t_i on Q_D/Q_T and $Q_D/(Q_D+Q_w)$

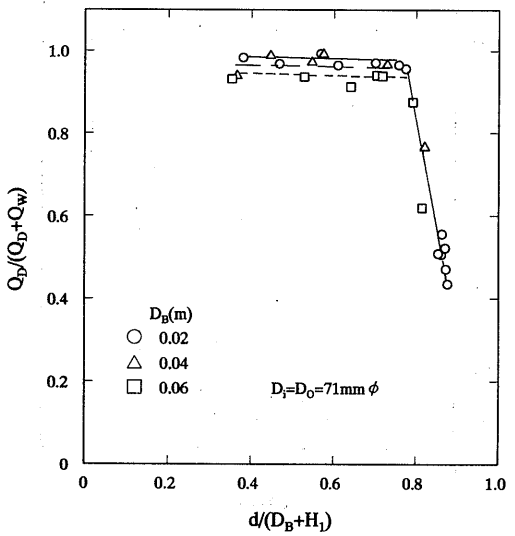


Fig. 38 Effect of D_B on $Q_D/(Q_D+Q_w)$

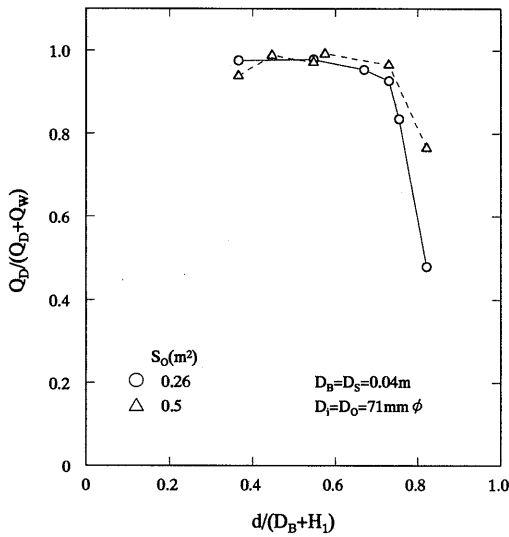


Fig. 39 Effect of S_o on $Q_D / (Q_D + Q_W)$

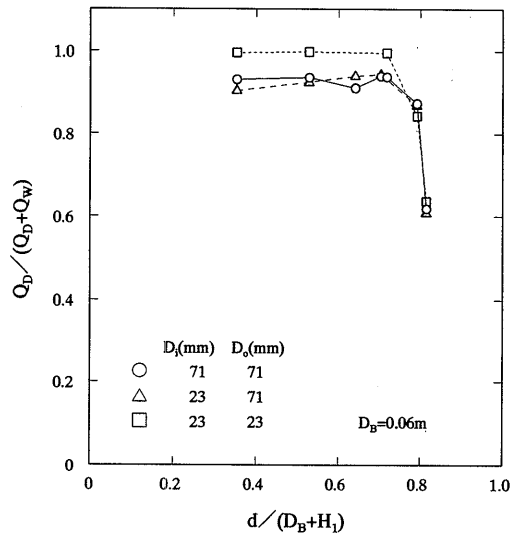


Fig. 40 Effect of rupture diameter on $Q_D / (Q_D + Q_W)$

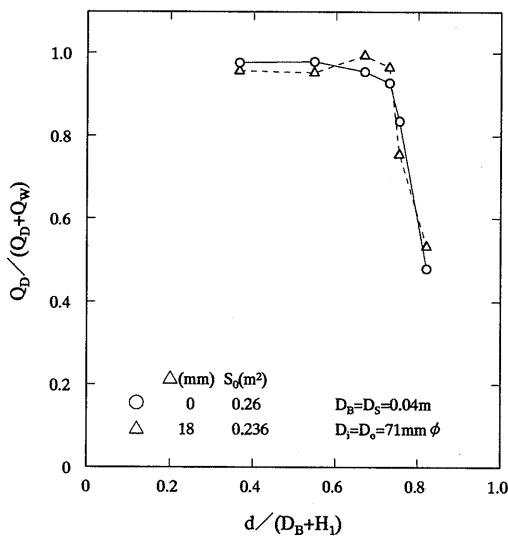


Fig. 41 Effect of Δ on $Q_D / (Q_D + Q_W)$

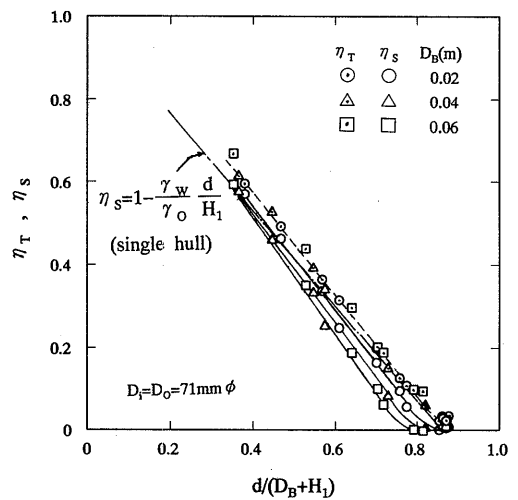


Fig. 42 Effect of D_B on η

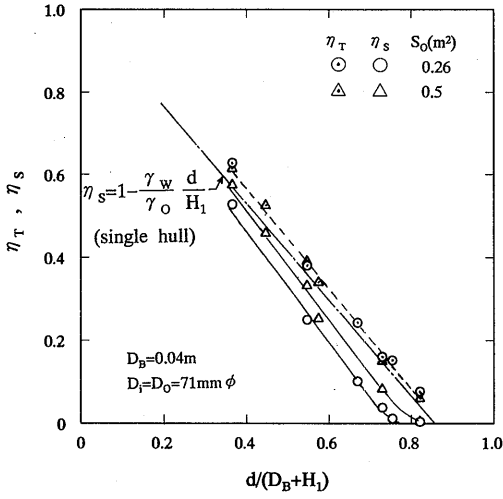


Fig. 43 Effect of S_0 on η

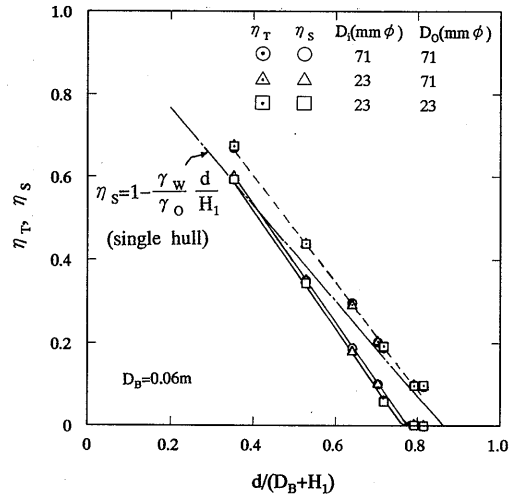


Fig. 44 Effect of rupture diameter on η

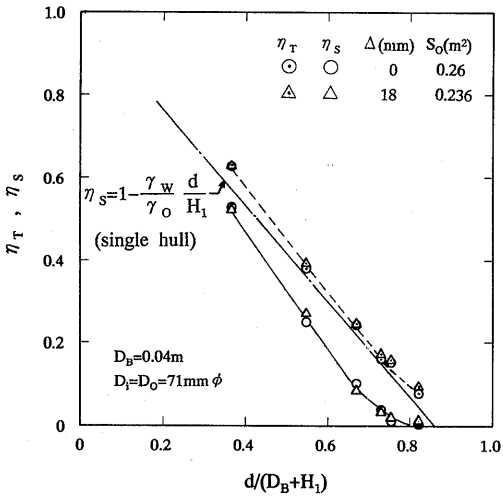


Fig. 45 Effect of Δ on η

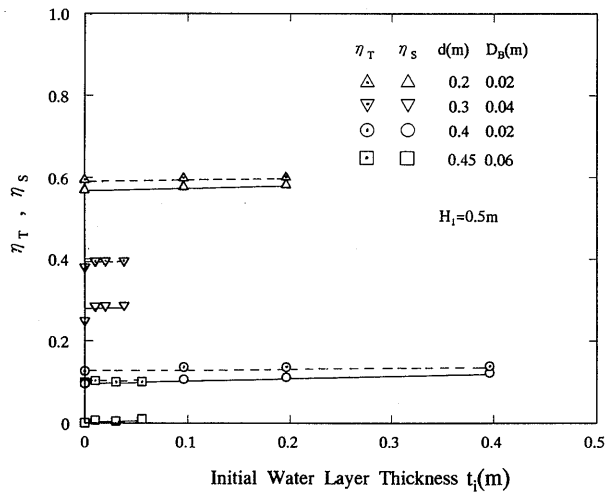


Fig. 46 Effect of t_i on η

9. CONCLUSIONS

Oil spills and oil-water mixing were investigated by using ruptured ship tank model with double hull for various accident scenarios, tank configurations and cargo loading conditions. The effects of various parameters on oil spills were found. Methods for predicting the oil spills and for interpreting experimental results are presented.

The principal conclusions are as follow.

For groundings:

- (1) Oil spills decrease with a decrease in the difference of oil and water levels.
- (2) Oil containment in double hull space increases remarkably with an increase in double hull space and with a decrease in cross-sectional area of cargo oil tank, resulting decrease in oil spills.
- (3) Oil spills can be predicted by introducing the non-dimensional thickness of water layer α .
- (4) α is a function of tank configuration, tank dimension, rupture area and liquid level.

For collisions:

- (1) All amount of oil below the rupture spills.

Further experimental work is required to study the variation of α with actual accident data or the full-scale test for the grounding accidents.

NOMENCLATURE

| | |
|--------------|--|
| A_0 : | area of rupture |
| D_i : | diameter of inner hull plating rupture |
| d : | draft |
| D_o : | diameter of outer hull plating rupture |
| D_B : | double bottom height |
| D_S : | double side width |
| H : | height of oil level after oil spills |
| H_1 : | initial height of oil level |
| K : | parameter denoting the configuration of the double bottom K=1; J type, K=2; U type |
| l : | longitudinal length of oil tank |
| L_D : | oil tank breadth |
| N : | number of division of oil tank |
| Q_T : | quantity of oil leaving from oil tank |
| Q_W : | quantity of water flows into double hull space |
| S_0 : | cross-sectional area of oil tank |
| t_f : | thickness of water layer in double hull after oil spills |
| t_i : | initial thickness of water layer in double hull |
| V_O : | volume of oil tank |
| V_D : | volume of double hull space |
| α : | non-dimensional thickness of water layer ($= t_f/D_B$) |
| γ_o : | density of oil |
| γ_w : | density of water |
| Δ : | offset value of inner and outer shell plating rupture |
| η_S : | oil spill fraction ($= Q_S/H_1 S_0$) |
| η_T : | oil leaving fraction ($= Q_T/H_1 S_0$) |

ACKNOWLEDGEMENTS

A part of this work was performed as the research program of the Shipbuilding Research Association of Japan. The authors express their appreciation to Prof. H. Otsubo, chief of the committee, and to the other committee members of SRA RR761 for helpful discussions. The authors also are grateful for the encouragement of the head of the Ship Equipment and Marine Environment Division, Ship Research Institute, Dr. O. Nagata.

APPENDIX

Graphical presentation of the experimental data correlated by d/H_1 and $(d-D_B)/H_1$

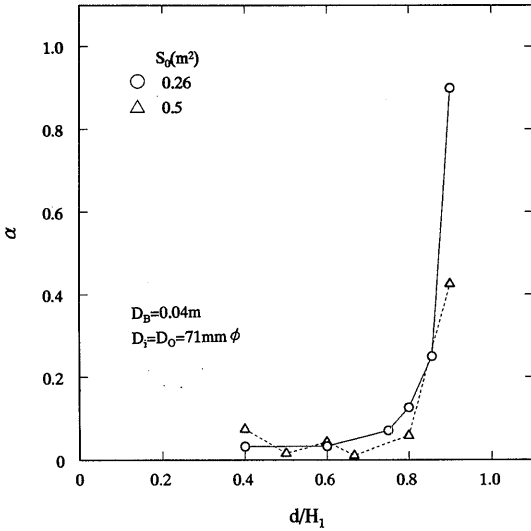


Fig. 27A

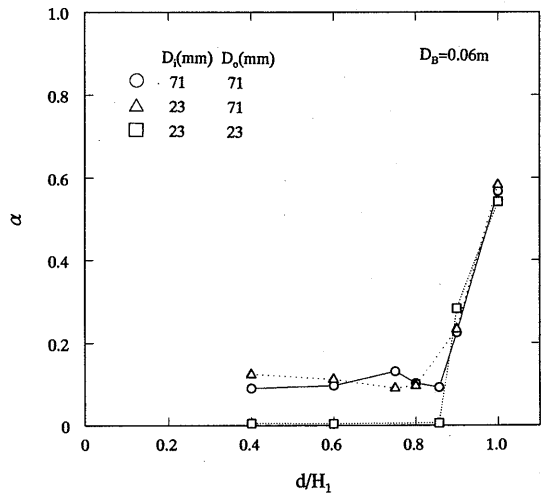


Fig. 28A

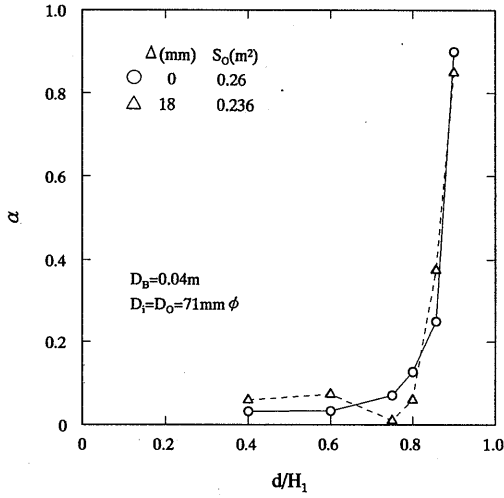
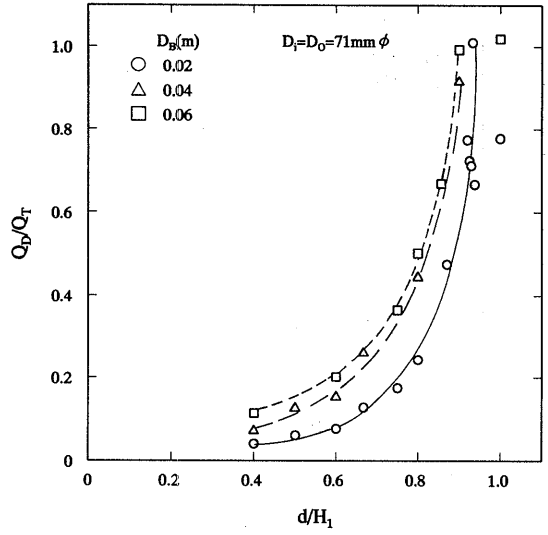
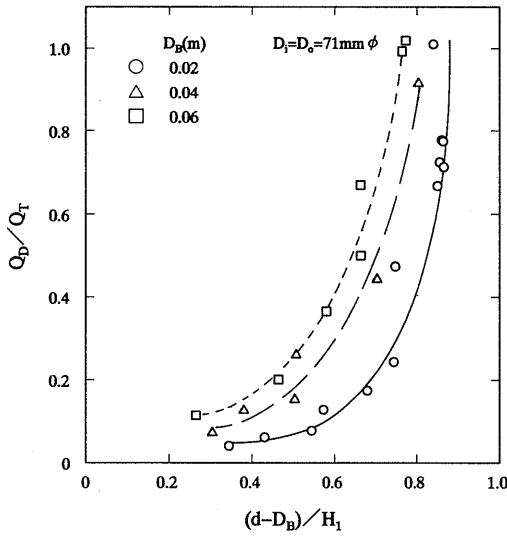


Fig. 29A



(a)
Fig. 33A



(b)
Fig. 33A

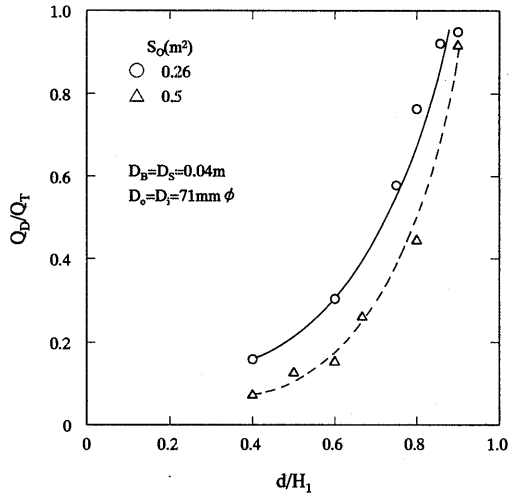


Fig. 34A

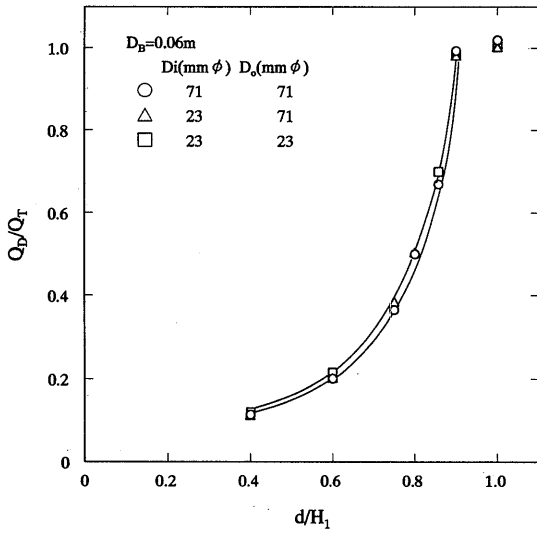


Fig. 35A

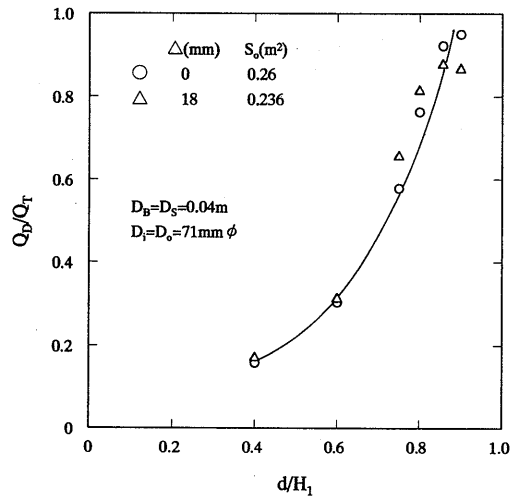
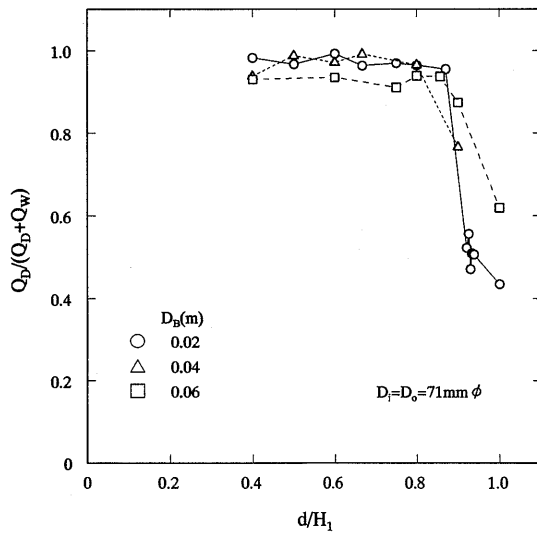
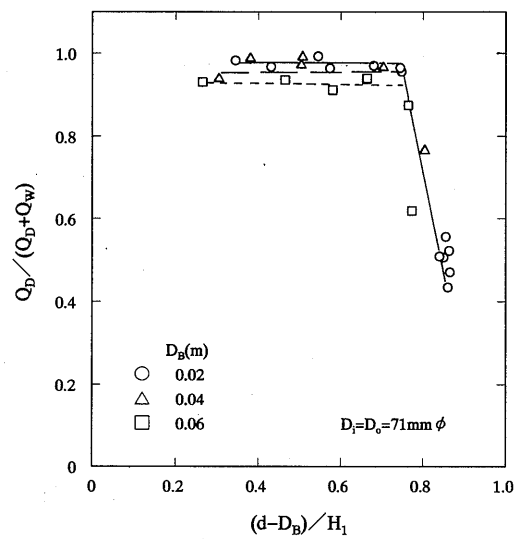


Fig. 36A



(a)



(b)

Fig. 38A

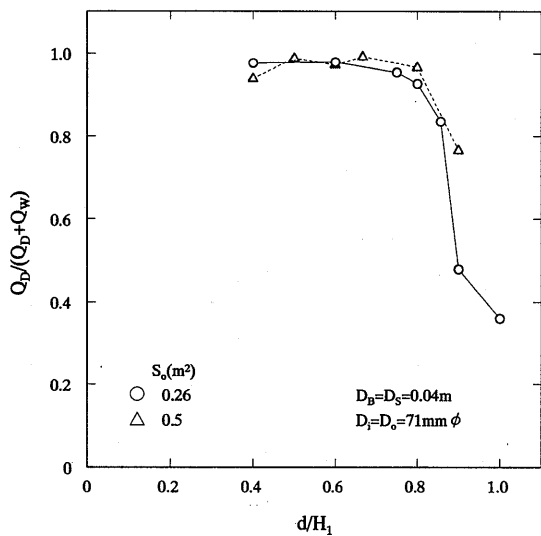


Fig. 39A

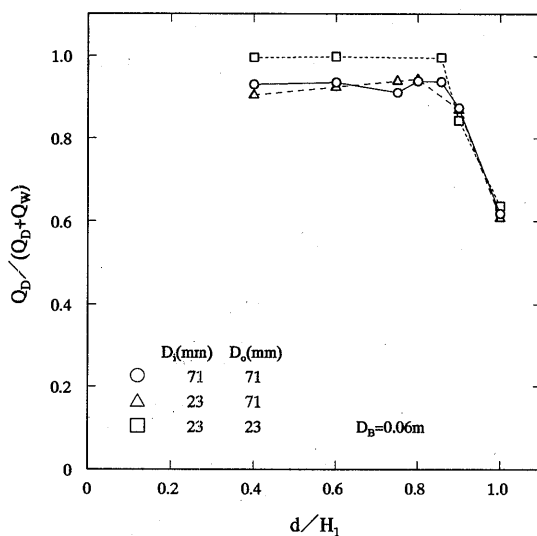


Fig. 40A

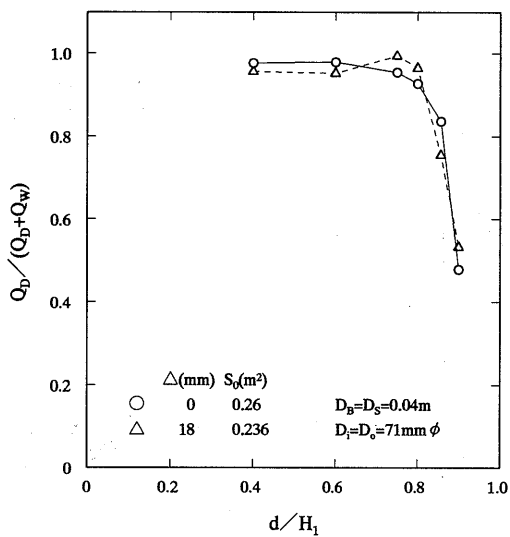
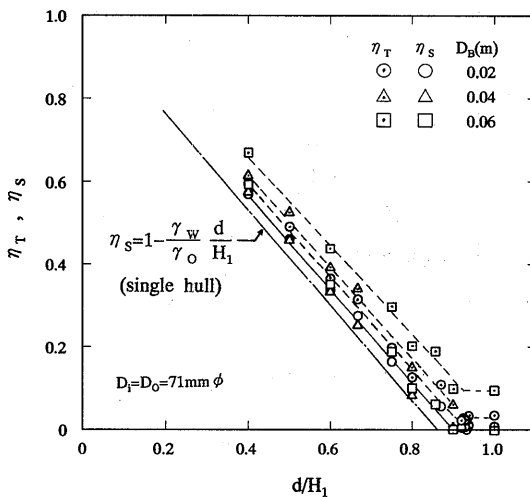


Fig. 41A



(a)

Fig. 42A

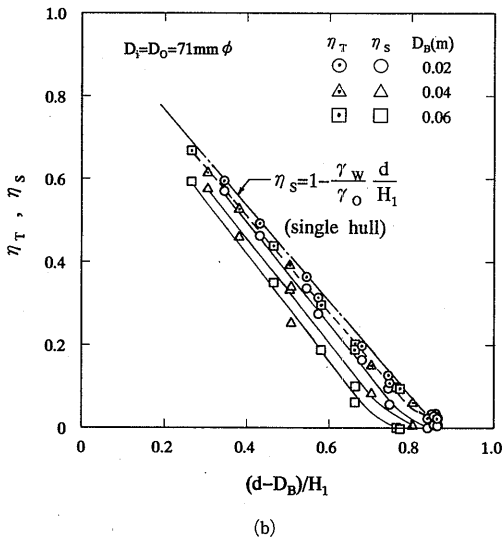


Fig. 42A

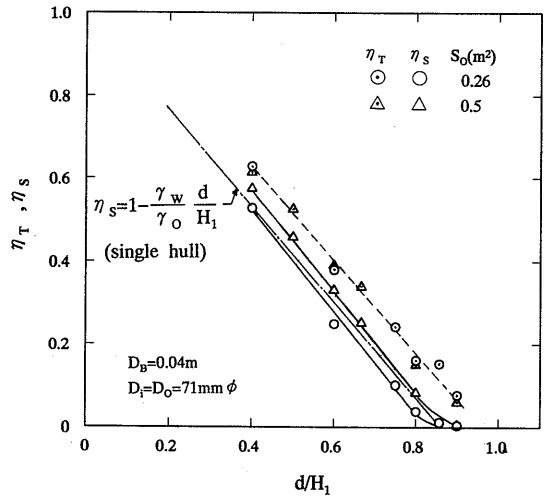


Fig. 43A

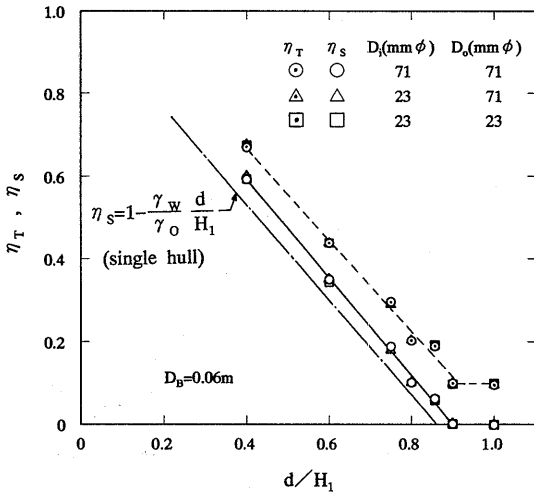


Fig. 44A

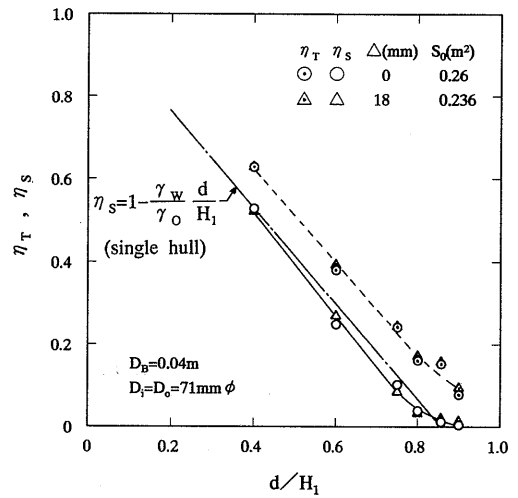


Fig. 45A