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A Methodology for Determinig the Length of Ship and Shore Ramp for Roll on Roll off Ships

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Abstract

A short sea Roll on Roll off ship could have either (a) internal access like internal ramps and/or elevators for transfer of cargo between decks or (b) no internal access for which a shore based link span connectable to both decks would be needed. The lengths of the ship and shore ramps that are needed for uninterrupted cargo handling depend on ships threshold variation, tidal variation at ports, ramp gradient and the thickness of the ship ramp outer end. Some formulae have been derived in this paper on the basis of BSI standard to determine the length of ship-shore ramp for varying tidal variation at ports. Some cases have been studied showing the use of the formulae. The formulae would be useful to Naval Architects in the early stages of design of Ro Ro ships and also to Ro Ro owners and operators in deciding how much ramp would be needed in the ship and/or shore.

Introduction

During the recent rapid growth of Roll on/Roll off shipping, certain comptibility problems have arisen in the ship/shore interface. This problem has been studied by different interinational organisations in order to harmonize the interface between terminal and ship. In 1966, PIANC (Permanent International Association of Navigational Congress) gave a report which had a three fold objective[1]. These are (a) to lay down such standards of dimensions and principles of construction as would permit full interchangeability of ships between terminals, (b) to standardise in so far as it may be advantageous to do so, principal components of the site installation (c) to prepare a basic specification of levelling conditions and requirements with a view to its adaption by shipping lines and their naval architects as a standard. In 1971 PIANC set up an International Study Commission to study the problem in more detail and to put forward a further recommendations arising from the development and changes in operational requirement and ship design that had taken place since the 1966 report. Among other findings and recommexdations of the PIANC study commission, two classes of ships were proposed : A-draft not exceeding 6.0 m mimimum depth of water at the berth at low water of 6.5 m, B-draft in axcess of 6.0 m, capable of accommodating ships with drafts of up to 12.0 m for which the minimum depth at low water should be 13.0 m. Maximum gradient of 1 in 10 was preferred.

In October 1976, IAPH (International Association of ports and harbours) published a report

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on this problem. Instead of classing the ships, they snggested different classes of shore ramps on the assnmption that ships can cope with their own threashold height variation together with a veriation in water level of up to 1.5 m without the need for assistance from a moveable bridge ramp. At this stage it was felt that coordination should be made between different organizations involved in the study of the problem and also an international standard in this regard woule be necessary. An international standard body was set up and a draft proposal was made for an international standard for Roll on/Roll off ship to shore connection (2). This proposal was based on the replies of the questionnaires sent to different Ro Ro ship owners and port operators. The data of different ship and shore ramps collected from the replies was compiled (1). This broughf together for the first time technical details of over one thousand Roll on/Roll off ramps in ports and on ships throughout the world. In 1980, the BSI (British Standard Institution) made a draft standard (3) which is identical to the draft international standard. The aim of this international standard is the harmonization of the interface between the terminal and the ship and to lay down certain major dimensions and principles of design concerning the Roll on/Roll off ship to shore connection. In the absence of any other standard with regard to ship/shore connection, this draft proposal has been used to find out the ship/shore ramp lengths. In a short sea Roll on/Roll off ship there could be alternative combination of length of ship ramp and shore ramp that would be needed for uninterrupted cargo handling. The length of ship/shore ramp is again influenced by the tidal variation if any at the ports. In case of two deck link span system which doesn't have any internal access between the decks the shore ramp is to cope up with the variation of threshold height due to draft variation of the ship during cargo handling and also the tidal variation if any at the ports. In this cass the ship will have no stern ramp but only a stern door to be placed on the adjustable link span in the shore. An alternative is to having no shore ramp but a ship ramp for a tidal range upto 1.5 m and having a combination of ship ramp and shore ramp for higher tidal range. The object of this paper is to show the methodology for finding the alternative combination of ship/shore ramp for different internal access option and for varying tidal ranges on the basis of the standard laid down by BSI. Some case studies have also been shown.

Alternative Ship/Shore Ramp According to BSI Standard

It has been proposed that ships should be so equipped that they are able to cope with their own threshold height variations together with a variation of water level relative to the shore ramp of at least 1.5 m total. Any greater variation than 1.5 m in total should be compensated for by the terminal providing shore facilites called link span operating in all weathers and in some of the highest tidal ranges in the world. The link span calls for limited site construction-a steel pile for the hydro statically operated slewing arm and a simple concrete seating for the shore and hinge very quickly, the outer end can be adjusted vertically and laterally by operation of the slewing arm and blowing or filling of the buoyancy tank to suit the beam and freeboard of the approaching vessel. Terminals with a normal waterlevel variation of less than 1.5 m in total may provide berthing facilities with fixed shore ramps to receive ship ramps. Thus, there can be a number of alternatives depending on the amount of water level variation at port. If the water level variation is less than/equal to 1.5 metres in port, the system can have either.

(i) A ship ramp to cope with the tidal variation and ships own threshold height variation with a fixed shore ramp and internal ramp for lift within the ship or.

(ii) no ship ramp but an adjustable shore ramp to cope with the tidal variation. ship's own threshold height variation and the depth between upper and lower decks of the ship.

If the water level variation is more than 1.5 metres, the system can have either.

(i) a ship ramp to cope with the ships own threshold height and a tidal variation of 1.5 metre, with an adjustable shore ramp to cope with the remaining tidal variation and internal ramp of lift within the ship or

(ii) no ship ramp and an adjustable shore ramp to cope with the total tidal variation, ships own threshold height variation and the depth between the upper and lower decks.

Fixed and Adjustable shore Ramps

Two classes of fixed shore ramps have been proposed when the normal water level variation is less than 1 5 metres. This situation allows ports some flexibility when constructing fixed shore ramps and imposes no further restriction on ships complying with the requirements of this standard. This enables a port authority, which for one reason or another wants to have one single ramp, to accommodate ships with low as well as high threshold heights to some extent and depending on the ships expected to call at the terminal to make a choice between class A and class B ramps.

Class A([3]) comprises fixed shore ramps for ships where the outer end of the ship ramp can reach the levels of 0.25 m to 1.75 m above water line in all loaded conditions (see Fig. 1).

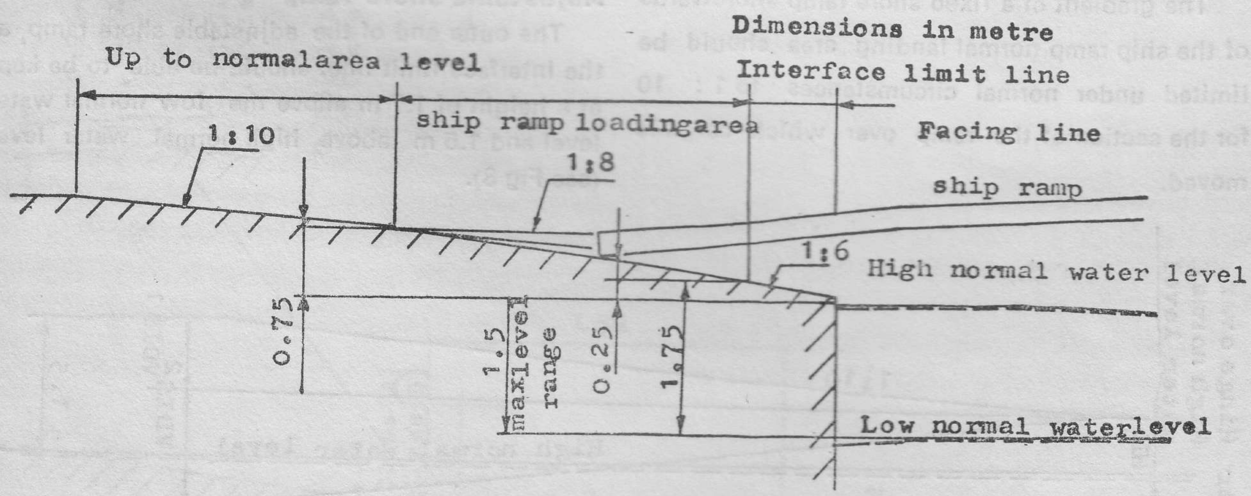

Fig. 1 Fixed shore ramp class A

Class B([3]) comprises fixed shore ramps for ships where the outer end of the ship ramp can reach the levels of 1.5 m to 3.0 m above water line in all loaded conditions (see Fig. 2).

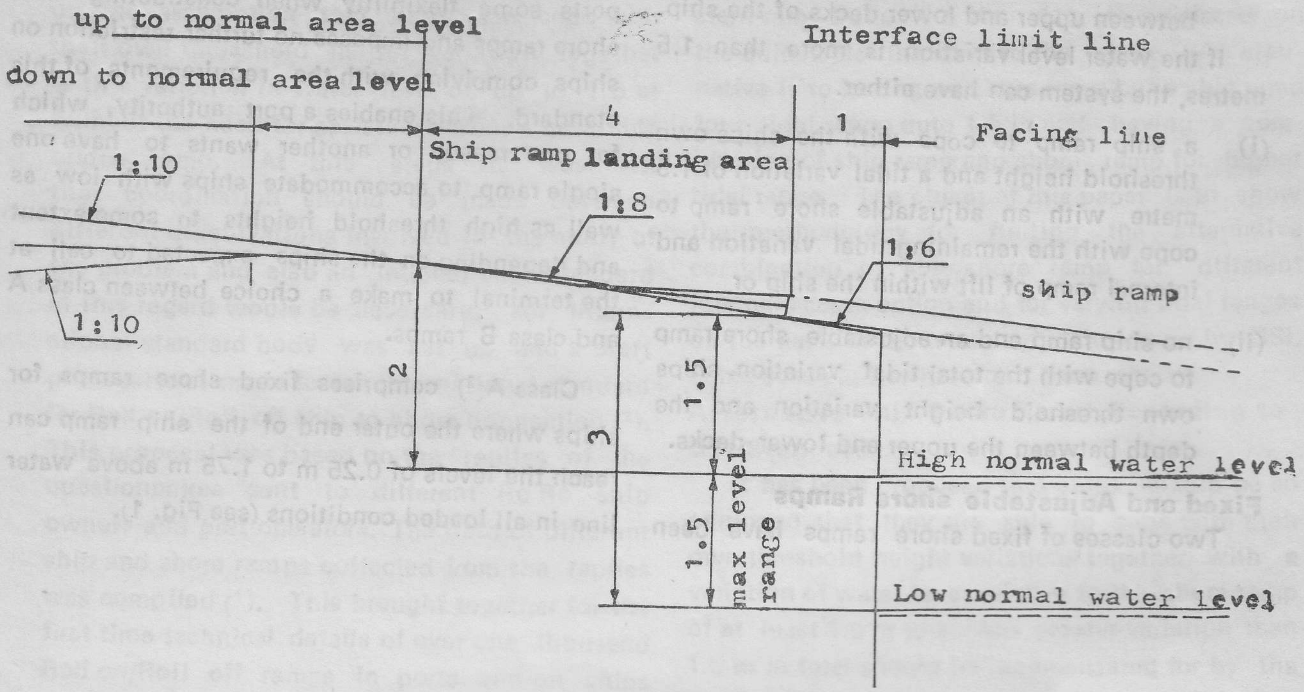

Fig. 2 Fixed shore ramp class B

The gradient of a fixed shore ramp shorewards of the ship ramp normal landing area should be limited under normal circumstances to 1 : 10 for the section of the ramp over which cargo is moved.

Adjustable shore ramp

The outer end of the adjnstable shore ramp, at the interface limit line, should be able to be kept at a height of 1.7 m above the low normal water level and 1.5 m above high normal water level (see Fig 3).

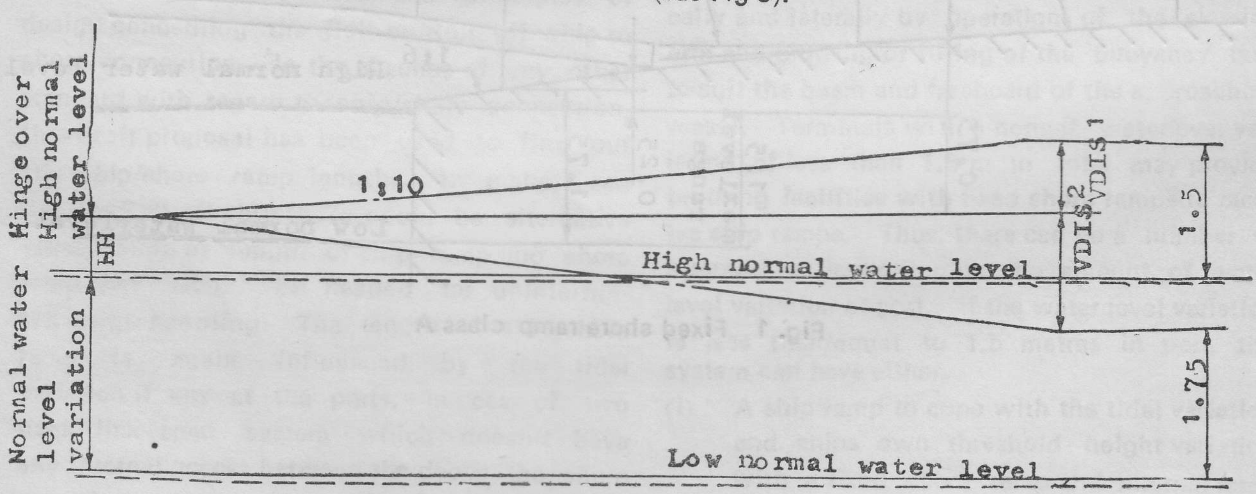

Fig. 3 Adjustable shore ramp, height above water.

Derivation of formula for calculating length of ship ramp and shore ramp.

The length of ship/shore ramp is normally governed by the tidal range ; the variation in freeboard of the vesseles likely to be used and the maximum operating gradient for the vehicles. In order to provide the best fit for the two classes of fixed shore ramps, the length of the ship ramp can be calculated as follows in relation to the threshold height when the ship is in light and loaded conditions and at high and low normal water levels. According to ref(3)

For Clsss a ramp (See Fig.4)

$$TL1 = 0.75 + \frac{LSR-6}{10} + t + LSR/G \qquad (1)$$

$$TL2 = 0.25 + TIDR + t - LSR/G \qquad (2)$$

The maximum of the values LSR found from Eqns. 1 and 2 is the length of ship ramp that

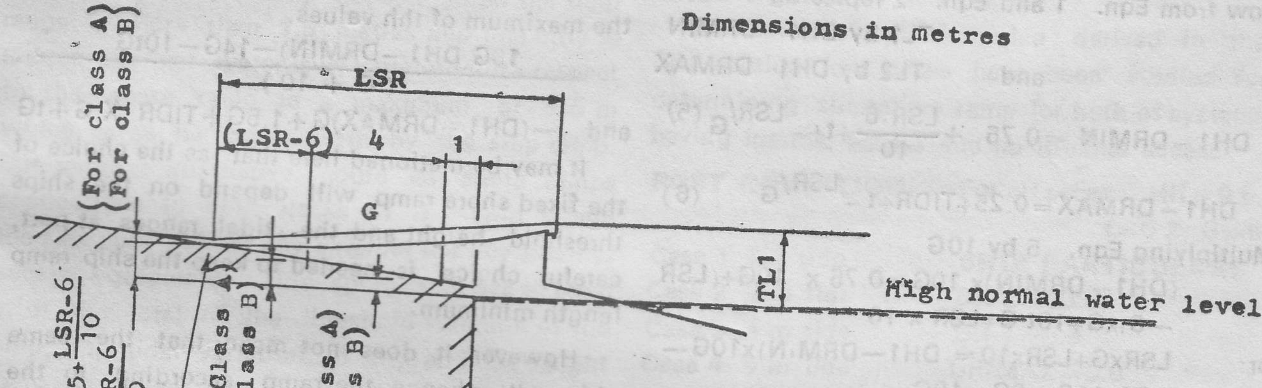

Fig. 4 Ship ramp length determination.

will be needed for a tidal varition greater than 1.5 m and with Class A fixed ramp at shore. According to rof (3)

For class B ramp (See Fig.4)

$$TL1 = 2 + \frac{LSR\text{-}6}{10} + t + {}^{LSR}/_G \quad (3)$$

$$TL2 = 1.5 + TIDR + t - {}^{LSR}/_G \quad (4)$$

The maximum of the values of LSR found from Eqn. 3 and Eqn. 4 is the length of the ship that will be needed for a tidal variation greater than 1.5 m and with class B fixed ramp at shore.

Now from Eqn. 1 and Eqn. 2 replacing

TL1 by DH1—DRMIN

and TL2 by DH1 - DRMAX

$$DH1 - DRMIN = 0.75 + \frac{LSR\text{-}6}{10} + t + - {}^{LSR}/_G \quad (5)$$

$$DH1 - DRMAX = 0.25 + TIDR + t - {}^{LSR}/_G \quad (6)$$

Multiplying Eqn. 5 by 10G

$$(DH1 - DRMIN) \times 10G = 0.75 \times 10G + (LSR - 6) \times G + 10t\,G + LSR \times 10$$

or $$LSR \times G + LSR \times 10 = (DH1 - DRMIN) \times 10G - 0.75 \times 10G + 6G - 10G.$$

or $$LSR\,(G+10) = (DH1 - DRMIN) \times 10G - 7.5G + 6G - 10tG$$

or $$LSR = \frac{(DH1 - DRMIN) \times 10G - 1.5G - 10tG}{G + 10} \quad (7)$$

Multipying Eqn. 6 by G

$$(DH1 - DRMAX)G = (0.25 + TIDR)\,G + t\,G - LSR$$

or $$LSR = -(DH1 - DRMAX)\,G + (0.25 + TIDR)\,G + t\,G \quad (8)$$

The length of the ship ramp that will be required in the case of a fixed shore ramp class A is the maximum of the values.

$$\frac{(DH1 - DRMIN) \times 10G - 1.5G - 10t\,G)}{G + 10}$$

and $-(DH1 - DRMAX)\,G + (0.25 + TIDR)G + tG$

Now from equation 3 and equation 4 relpacing TL1 by DH1-DRMIN and TL2 by DH1-DRMAX

$$DH1 - DRMIN = 2 + \frac{LSR\text{-}6}{10} + t + {}^{LSR}/_G \quad (9)$$

$$DH1 - DRMAX = 1.5 + TIDR + t - {}^{LSR}/_G \quad (10)$$

From equation 9 (multiplying by 10G)

$$10G\,(DH1 - DRMIN) = 2 \times 10G + (LSR\text{-}6)G + t \times 10G + LSR \times 10$$

or $$LSR\,(G+10) = 10G(DH1 - DRMIN) - 20G + 6G - 10tG$$

or $$LSR = \frac{10G(DH1 - DRMIN - 14G - 10tG}{(G+10)} \quad (11)$$

Multiplying both sides of equation 10 by G

$$(DH1 - DRMAX)\,G = 1.5\,(G) + tG - LSR + TIDR \times G$$

or $$LSR = -(DH1 - DRMAX)\,G + 1.5(G) + TIDR \times G + t\,G \quad (12)$$

Therefore the length of the ship ramp that will be required in case ef a fixed shore ramp class B is the maximum of thh values.

$$\frac{10G\,(DH1 - DRMIN) - 14G - 10tG}{(G + 10)}$$

and $-(DH1 - DRMAX)G + 1.5G + TIDR \times G + tG$

It may be metioned here that as the choice of the fixed shore ramp will depend on the ships threshold height and the tidal ranges at port, careful choice is needed to keep the ship ramp length minimum.

However it does not mean that the same ship will change the ramp according to the tidal range and the port, rather in the present model it has been assumed that the ship will have the ramp of minimum length to cope with the tidal variation and its own threshold height and it will be facilitated by the appropriate class of fixed shore ramp at the terminal.

Calculation of the length of the adjustable shore ramp (Internal access option)

As has been mentioned earlier, terminals with a normal water level variation greater than 1.5 m shall provide on shore an adjustable shore ramp, with a range of movement, that reduces the net water level variation with respect to the shore ramp to not greater than 1.5 m. From fig. 3 it is clear that the length of the adjustable shore ramp will depend on the values of VDIS 1 and VDIS 2.

Now $$VDIS\,1 = 1.5 - HH \quad (13)$$

$$VDIS\,2 = TIDR - 1.75 + HH \quad (14)$$

So the length of the adjustable shore ramp will be, from Eqn. 13 and 14.

$$LASR = 1.5 - HH) \times G \quad (15)$$

$$LASR = GX\ TIDR \quad 1.75 + HH) \quad (16)$$

Now the maximum of the values of the right hand side in equation 15 and 16 is the required length of the adjustable ramp.

Length of the adjustable shore ramp connectable to both decks of the ship (No internal access system)

The above calculation for the length of the adjustable shore ramp has been made according to Ref. (2) and (3) which say that the adjustable shore ramp is only needed when the tidal range is more than 1.5 metres and this only to reduce the net water level variation with respect to the shore ramp to a maximum of 1.5 m which is to be coped with by the ship ramp. But another alternative could be shore ramps connectable to both decks of the ship where the ship has neither any external nor any internal access equipment. This shore ramp has to cope with the total of the threshold variation of the ship, the tidal variation, if any and the height between lower and upper decks. The shore ramp will in this case be much longer than in the previous cases. The location of the ramp hinge over the high water level at port will be in such a position that the vertical distance of the hinge from the upperdeck of the light ship at high water level is equal to vertical distance of the hinge from the lower deck of the loaded ship at low water level The length of the shore ramp in this case is

$$LASR\ 2 = \frac{(DH2 - DH1 + TIDR + DRMAX - DRMIN)}{2} \times G \quad (17)$$

All the formulae required for ramp length evaluations are then known.

CASE STUDIES

According to the formulae derived in the last section four cases have been studied for determining ship-shore ramp for both of systems having internal access and no internal access.

PORT CONDITION For all cases HH = 0.5, t = 0 2, G = 6

Case 1 No tide	**SHIP PARTICULARS**
Case 2 2 m tide	DH 2 = 10.6
Case 3 4 m tide	DH 1 = 5.9
Case 4 6 m tide	DR MAX = 5.0
	DR MIN = 3.0

The results have been shown in Table 1.

Table - 1. Length of ship-shore Ramp for Different Internal Access option and varying tidal ranges.

INTERNAL ACCESS OPTION	Case 1 No tide at both ports — length of Ship ramp	Case 1 — length of shore ramp (at both ports)	Case 2 2m tide at both ports — length of Ship ramp	Case 2 — length of Shore ramp (at both ports)	Case 3 4m tide at both ports — length of Ship ramp	Case 3 — length of shore ramp (at both ports)	Case 4 6m tide at both ports — length of Ship ramp	Case 4 — length of shore ramp (at both ports)
two deck link span (Nointernal access)	x	33.5m (Eq.17)	x	43.5m (Eq. 17)	x	53.5m (Eq. 17)	x	63.5m (Eq. 17)
Internal Access System	x	x	12.75m (Eq. 7 and 8)	10m (Eq.15 and 16)	12.75m (Eq. 7 and 8)	27.5m (Eq. 15 and 16	12.75m (Eq. 7 and 8)	47.5m (Eq. 15 and 16)

Conclusion

The object of this paper was to show the methodology for calculating the length of ship ramp and shore ramp for short sea Roll on Roll af ships having no internal access between decks and having that between decks for varying tidal ranges in the ports. This has been accc-mplished and it has been shown that for any specific tidal range a Ro Ro operator would have a choice of having all ternative ship-shore ramp combination.

The basis of derivation of the formulae is the standard laid down by BSI which is identical with the International draft standared based on the replies of the questionnaires sent to different Ro Ro ship owners and port operators.

The formulae that have been derived in this paper could be successfully used for deciding on the external access option in the Ro Ro ships which should be based on the length of the ship/shore ramps their costs and utilization. The author feels that the methodology derived in this paper could be helpful to Naval Architects in their early stages of design of Ro Ro ships and also to ship owners, port operators and equipment manufacturers for profitable operation of their trades.

Nomenclature

DH1	Height of lower deck from keel (metres)
DH2	Height of the upper deck from keel (metres)
DRMAX	Loaded draft of the ship (metres)
DRMIN	Light draft of the ship (metres)
G	Inverse of ramp/link span gradient
HH	Height of the hinge of adjustable shore ramp over high water level
LASR	Length of adjustable shore ramp for internal ramp and lift options (metres)
LASR2	Length of adjustable shore ramp connectable to both decks (metres)
LSR	Length of the ship ramp (metres)
t	thickness of the ship ramp outer end (metre)
TIDR	Tidal range at port (metres)
TL1	Light ship threshold height (metre)
TL2	Loaded ship threshold height (metre)

References

1. ICHCA "Ro Ro shore ship ramp characteristics" An ICHCA survey, 1978.

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3. BSI "Roll on/Roll of ship to shore connection" ISO/DIS 6812, British standard Institution, August 1982.