Permanent International Association of Navigation Congresses
PIANC

International Association of Ports and Harbors
IAPH

International Maritime Pilots Association
IMPA

International Association of Lighthouse Authorities
IALA

# APPROACH CHANNELS

## A Guide for Design

Final Report of the Joint PIANC-IAPH
Working Group II-30 in cooperation
with IMPA and IALA

# TABLE OF CONTENTS

# FOREWORD

Modern design of approach channels came into existence as a separate discipline in the 1960's, particularly for the development of deepwater ports.

The design of channel dimensions was first considered by Working Group 2 of the Permanent International Association of Navigation Congresses (PIANC) International Oil Tankers Commission (IOTC) and the report was published in 1973. The IOTC work was then reviewed some years later by Working Group 4 of the PIANC International Commission for the Reception of Large Ships (ICORELS), whose report was published in 1980. The ICORELS Report contained a detailed review, but the Commission concluded that in the state of knowledge as it then stood, its general recommendations would have to be conservative, but it left open the possibility that its recommendations might be capable of refinement as knowledge developed.

Since the ICORELS Report, there have been considerable developments, not only in knowledge, but also in technology and analytical techniques:

- firstly, in research as to ship behaviour and in the development of guidance systems
- secondly, in computer technology and in mathematical and physical modelling systems (using the research on ship behaviour), enabling vessel tracking to be predicted taking account of human factors
- thirdly, in experience of large ships transiting port approach channels over a number of years, including some channels which have lower width/design ship beam ratios than the ICORELS general recommendation.

Recognising the need for a review of the recommendations presented in previous reports, PIANC and the International Association of Ports & Harbors (IAPH) set up a joint Working Group (No. 30) and invited the participation of the International Maritime Pilots Association (IMPA) and the International Association of Lighthouse Authorities (IALA) to assess and, if necessary, update existing reports, to provide practical guidelines for the design of approach channels and fairways. Central to this work were the results collected by an earlier PIANC Working Group (No. 7) and these have been combined with recent developments in design techniques to form the basis of this report.

Its intention is to provide practising engineers with guidelines and data which will allow them to design a channel for a given ship or mix of ship types or, alternatively, enable assessment of the suitability of an existing channel for a proposed change in ship type or operation. The intention has been to provide practical guidelines which are readily usable and easy to understand and justify.

In accordance with the Terms of Reference which are given in Chapter 9, a preliminary Report was prepared dealing with aspects of Concept Design, and this Report was published jointly by PIANC/IAPH in April 1995. However, the present report covers all aspects of Channel Design (Concept and Detailed Design).

The members of Working Group No. 30 were:

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**Table 5.2 - Additional Widths for Straight Channel Sections**

| WIDTH $w_i$ | Vessel Speed | Outer Channel exposed to open water | Inner Channel protected water |
|---|---|---|---|
| **(a) Vessel speed (knots)** | | | |
| - fast > 12 | | 0.1 B | 0.1 B |
| - moderate > 8 - 12 | | 0.0 | 0.0 |
| - slow 5 - 8 | | 0.0 | 0.0 |
| **(b) Prevailing cross wind (knots)** | | | |
| - mild ≤ 15 (≤ Beaufort 4) | all | 0.0 | 0.0 |
| - moderate > 15 - 33 | fast | 0.3 B | - |
| (> Beaufort 4 - Beaufort 7) | mod | 0.4 B | 0.4 B |
| | slow | 0.5 B | 0.5 B |
| - severe > 33 - 48 | fast | 0.6 B | - |
| (> Beaufort 7 - Beaufort 9) | mod | 0.8 B | 0.8 B |
| | slow | 1.0 B | 1.0 B |
| **(c) Prevailing cross current (knots)** | | | |
| - negligible < 0.2 | all | 0.0 | 0.0 |
| - low 0.2 - 0.5 | fast | 0.1 B | - |
| | mod | 0.2 B | 0.1 B |
| | slow | 0.3 B | 0.2 B |
| - moderate > 0.5 - 1.5 | fast | 0.5 B | - |
| | mod | 0.7 B | 0.5 B |
| | slow | 1.0 B | 0.8 B |
| - strong > 1.5 - 2.0 | fast | 0.7 B | - |
| | mod | 1.0 B | - |
| | slow | 1.3 B | - |
| **(d) Prevailing longitudinal current (knots)** | | | |
| - low ≤ 1.5 | all | 0.0 | 0.0 |
| - moderate > 1.5 - 3 | fast | 0.0 | - |
| | mod | 0.1 B | 0.1 B |
| | slow | 0.2 B | 0.2 B |
| - strong > 3 | fast | 0.1 B | - |
| | mod | 0.2 B | 0.2 B |
| | slow | 0.4 B | 0.4 B |
| **(e) Significant wave height $H_S$ and length $\lambda$ (m)** | | | |
| - $H_s \leq 1$ and $\lambda \leq L$ | all | 0.0 | 0.0 |
| | fast | ≈ 2.0 B | |
| - $3 > H_s > 1$ and $\lambda = L$ | mod | ≈ 1.0 B | |
| | slow | ≈ 0.5 B | |
| | fast | ≈ 3.0 B | |
| - $H_s > 3$ and $\lambda > L$ | mod | ≈ 2.2 B | |
| | slow | ≈ 1.5 B | |
| **(f) Aids to Navigation** | | | |
| - excellent with shore traffic control | | 0.0 | 0.0 |
| - good | | 0.1 B | 0.1 B |
| - moderate with infrequent poor visibility | | 0.2 B | 0.2 B |
| - moderate with frequent poor visibility | | ≥ 0.5 B | ≥ 0.5 B |
| **(g) Bottom surface** | | | |
| - if depth ≥ 1.5T | | 0.0 | 0.0 |
| - if depth < 1.5T then | | | |
| - smooth and soft | | 0.1 B | 0.1 B |
| - smooth or sloping and hard | | 0.1 B | 0.1 B |
| - rough and hard | | 0.2 B | 0.2 B |
| **(h) Depth of waterway** | | | |
| - ≥1.5T | | 0.0 | ≥1.5T 0.0 |
| - 1.5T - 1.25T | | 0.1 B | <1.5T-1.15T 0.2 B |
| - <1.25T | | 0.2 B | <1.15T 0.4 B |
| **(i) Cargo hazard level** | | | |
| - low | | 0.0 | 0.0 |
| - medium | | ~ 0.5 B | ~ 0.4 B |
| - high | | ~ 1.0 B | ~ 0.8 B |

6. Twin screw / twin rudder ships generally have good manoeuvrability and control at all speeds.
7. Twin screw / single rudder ships may have good manoeuvrability at service speed, but poor manoeuvrability at low speeds.
8. Ships fitted with adequate bow or other thrusters may have very good low speed manoeuvrability. Ships with omni-directional thrusters will generally have excellent low speed manoeuvrability.

#### 5.3.6.2 Table 5.2 - Channel, Fairway, etc.

'Channel' and 'Fairway' are defined in Figure 5.10. In many dedicated channels the aids to navigation will be close to the edge of the channel to indicate the limits of safe navigation, but on those with a range of traffic, the fairway markers may be positioned to allow the passage of smaller vessels on either side of the dredged channel. In yet other cases both the deep water channel and the outer lanes for smaller vessels may be marked.

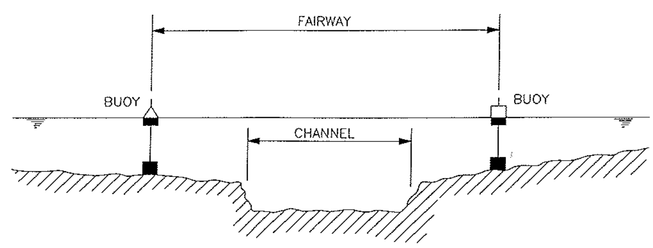

*Figure 5.10 - Channel and Fairway Definitions*

The three elements of channel width are defined in Figure 5.11.

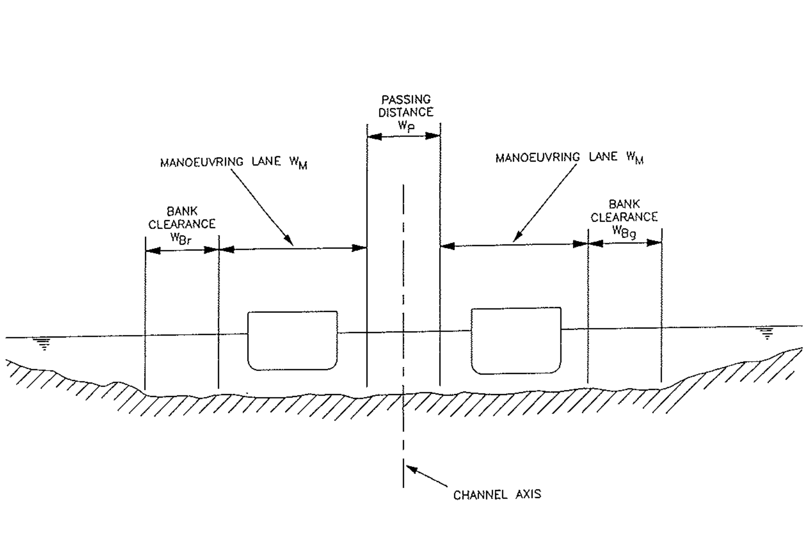

*Figure 5.11 - Elements of Channel Width*

***Inner and Outer Channel***

An Outer Channel is one exposed to wave action which is such as to produce important vessel motions. Usually these will be of pitch, heave and roll and will be of a magnitude to reduce underkeel clearance by a significant amount.

An Inner Channel is one which is not subject to wave action of any significance and is generally sheltered.

**Box (b) : Prevailing Cross Wind**

This should be taken from the wind records appropriate to the site of the channel and should be of the dominant one hour mean value.

As mentioned above, the behaviour of a ship in wind depends very much on its windage. Therefore, if a channel is used frequently by high-sided vessels, it would be advisable, for Concept Design, to classify them as having 'poor manoeuvrability' in Table 5.1.

**Box (c) and (d) : Current**

This is taken from the actual or predicted current records for the channel site. If the current varies along a long channel, it may be necessary to carry out width calculations at various key points along its length.

Although cross current magnitudes of up to 2.0 knots are shown in the Table, it is best to align the channel, if at all possible, to avoid such high cross-current velocities. On occasions high cross currents over a short section of the channel may be unavoidable, and in such circumstances the ship may have to pass through them as rapidly as possible to avoid deviating from its course. However, as a simple rule, cross currents greater than 1.5 knots across significant lengths of the channel should be avoided by re-alignment if possible.

**Box (e) : Waves**

This section gives rough indications only and should be used with a degree of judgement. Scatter tables will give the most likely significant wave heights ($H_S$) and periods ($T_W$) for the area. The general relationship between wave length $\lambda$ and wave period $T_W$ in water of depth h is:

$$\lambda = \frac{gT_w^2}{2\pi}\tanh\left(2\pi h/\lambda\right) \qquad (5)$$

In shallow water as h → 0 equation (5) becomes

$$\lambda = T_w\sqrt{gh} \qquad (6)$$

while in deep water, as h → ∞ equation (5) assumes the form

$$\lambda = gT_w^2/(2\pi) \qquad (7)$$

*sheer:*
the tendency of a ship to deviate from its chosen course. Usually this is caused by ship-ship interaction, bank effects, high velocity local cross currents or wind squalls.

*stranding:*
the consequence of a grounding in which the ship is left high and dry.

*striking:*
striking occurs when a ship underway hits a drifting floating object such as a ship at anchor, floating dock or buoy.

*swept track:*
the track swept out by the extremities of the ship when manoeuvring. It will generally be greater in bends than straight sections and in cross winds and currents. It will also be greater in deep water, under a given set of conditions, compared to shallow water.

*trade-off study:*
a study in which various (often competing) options are weighed against each other with the view to achieving an acceptable compromise solution.

*UKC:*
underkeel clearance

*window:*
the time period for which a channel is available for use.

*VTS:*
Vessel Traffic Service. An advisory service for mariners regarding ship operations in a port. Provided by an administration or Port Authority.

# 12. LIST OF SYMBOLS

| | | |
|---|---|---|
| $A_s$ | = | ship midship section area ($m^2$) |
| $A_{CH}$ | = | channel wetted cross-sectional area ($m^2$) |
| $A_w$ | = | $A_{CH} - A_S$ ($m^2$) |
| $\alpha$ | = | bend angle (deg), see Figure 5.1 |
| B | = | ship beam (m) |
| $C_B$ | = | block coefficient, see equation (2) |
| $\nabla$ | = | volume of displacement ($m^3$), see equation (2) |
| $\Delta_w$ | = | additional width in bends (m), see Figure 5.1 |
| $\eta$ | = | dynamic viscosity |
| $f_a$ | = | frequency of an accident |
| $f_g$ | = | grounding frequency |
| $f_{st}$ | = | striking frequency |
| $F_{nh}$ | = | Froude Depth Number, see equation (1) |
| h | = | water depth (m) |
| $H_s$ | = | significant wave height (m) |
| HW | = | high water |
| kn | = | knot (nautical mile/hour) |
| $K_s$ | = | constant in equation (8) |
| $\lambda$ | = | wave length (m) |
| L | = | ship length (m) |
| $L_c$ | = | channel length |
| $L_f$ | = | length of floating object profile along channel |
| $L_{PP}$ | = | ship length between perpendiculars (m) |
| $N_c$ | = | number of casualties |
| R | = | bend radius (m), see Figure 5.1 or turning radius over first 90° heading change, see Figure 5.8 |
| $t_a$ | = | ship arrival rate |
| $t_o$ | = | overall marine risk |
| S'2' | = | blockage ratio $A_s/A_w$ |
| T | = | ship draught (m) |
| $T_w$ | = | wave period (s) |
| V | = | ship speed through water (m/s) |
| $V_k$ | = | ship speed in knots |
| w | = | width of waterway at bottom (m), see equations (3) and (4) |
| $w_{Bg}$ | = | bank clearance on the green side of channel (m), see Table 5.4 and Figures 5.6 and 5.11 |
| $w_{BM}$ | = | basic manoeuvring lane (m), see Table 5.1 and Figure 5.2 |
| $w_{Br}$ | = | bank clearance on the red side of channel (m), see Table 5.4 and Figures 5.6 and 5.11 |
| $w_f$ | = | cross track error |
| $w_i$ | = | additional width for wind, current, etc., see Table 5.2 |
| W.L. | = | water line, see Figure 5.6 |
| $w_M$ | = | manoeuvring lane (m), see Figure 5.11 |
| $w_p$ | = | passing distance (m), see Table 5.3 and Figures 5.4 and 5.11 |