Some Aspects of Fishery Harbour Siting and Protective Structure Layout Design

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Introduction

The main purpose of a fishery harbour is to offer a sheltered area of water where fishing craft can anchor, come alongside jetties or quay walls to unload their catch and obtain services such as cold storage facilities, ice, water, fuel and boat repairs.

The siting of a fishery harbour and designing the layout of its protective structures are two of the important items in their design. Many problems will arise if the harbours are not properly sited and their layout improper. Some of the effects on the neighbouring coast may be irreversible, resulting in loss of beaches, land and property.

At present the location of a fishery harbour (that is, the town or electorate in which it is located) is primarily governed by social and political consideration which are beyond the control of the Engineer. However the siting of the harbour in the location chosen by the Government is his responsibility.

Once the site of the harbour is decided, the layout of its protective structures should designed to that the harbour will be satisfactory from the navigational and functional points of view, as well as having the minimum effect on the neighbouring coast.

By "protective structures" is meant structures such as breakwaters which are constructed essentially to obtain a calm water area within the harbour. Of course, the structures may have many other functions in addition to serving as breakwaters, but usually in fishery harbours this is not the case.

Some of the navigational and coastal engineering problems of siting and protective structure layout design are described in brief in the following.

2. Location & Siting

Location of a fishery harbour requires the understanding of the traditions, prejudices and life styles of the fishermen. In Sri Lanka as in many other countries the fishing communities are dispersed right round the coast. Most of the fishing craft owned by the local fishermen and co-operative societies have only a limited range of operation. Therefore, harbours spaced far apart would force the fishermen, who invariably have a strong tendency to group into small communities and identify themselves with one locality, to shift to another where they would be treated as intruders.

Even if the fishermen were to reside in their own area and use a harbour in another village several miles away, he cannot be expected to anchor the boat in that harbour and come back to his native village after a strenuous operation at sea. Nor can he be expected to leave his family at his native village and come into temporary residence at the location where the harbour is situated since in this country fishing is a family industry with all the members of the family contributing to the effort in some form such as boat and fishing gear repair etc. The time of setting out to sea is also governed by many local customs and prejudices as well as the prevailing weather conditions. Thus, invariably the need arises to construct fishery harbours at every major fishing village and there is in fact considerable pressure on the politicians to order such constructions.

However, economic conditions of the country do not permit this extravagance. Therefore, directions are given by the government to construct fishery harbours in locations which are considered suitable.

Once a location for a harbour is given, it is the Engineer's responsibility to select a suitable site for the harbour.

In siting a harbour, the following have to be looked into:

— Analysis of the numbers and types of boats operating in the area and their catch, programme of introduction of boats by the government, the anticipated increase in the number of boats and the catch due to proposed anchorage.
— Seaside accessibility (good navigable approach away from rocks, coral and other obstructions)
— Availability of adequate depths close to the shore (to minimise the construction and dredging costs)
— Soil conditions (to minimise foundation costs and related problems)
— Degree of exposure to the rough conditions of the sea (to minimise problems and costs related to protective structure construction, as well as navigation)

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— Land side accessibility (proximity to a main road is preferred)
— Availability of power and water (for services to be provided)
— Back-shore area (for construction of shore facilities)
— Availability of construction materials close to the site (site with good quarry near by is preferred)
— Effect on the neighbouring coast (should be minimised)
— Cost of construction (should be minimised)
— Cost of maintenance, during the designed life period (should be minimised)
— Time required for execution of the project, including period of field investigations and model studies necessary (should be minimised)

The next step should be to evaluate the economic implications of the above factors in respect of each suitable site in the location named by the government. But due to various reasons (which are beyond the control of the Engineer) this has not been possible so far in this country. At present the Engineer has to be content with analysing the above factors with respect to each site and choosing the one which satisfies most of them. The decision is based on his experience and judgement with only a rough idea of the economic implications being made available to guide him.

3. Classification of Fishery Harbours

As regards the type of fishing craft using the harbours and also considering the layman's point of view, the following classification is adopted in Sri Lanka (See Table 1).

Grade A: Harbour with shore facilities, jetties, quay walls and dredged depth 6 m.
Grade B: Harbour with shore facilities, jetties or quay walls and dredged depth 3 m.
Grade C: Anchorage—sheltered area with dredged depth upto 3 m but with neither shore facilities nor alongside berthing.

As regards the siting and from the engineering point of view, the fishery harbours may be classified into the following groups:

(*a*) Harbour along an open coast or in a bay
(*b*) Harbour at a river mouth
(*c*) Harbour along a river or canal
(*d*) Harbour in a lagoon

Depending on the siting, following are some of the more important hydrographical and morphological factors which affect the design of the layout of the protective structures

— Wave climate (heights, directions, frequency of occurrence etc.)
— Wind (speeds, directions, duration of storms, frequency of occurrence etc.)
— Off shore and near shore currents
— Drift of sand and silt (littoral drift) along the coast
— Bottom contours and composition of bottom material
— River floods and currents (where applicable)
— Occurrence of long period waves
— Rise in water level and the frequency of occurrence of such phenomena (due to astronomical, storm or flood conditions)

4. Navigational Aspects

A fundamental requirement of any harbour siting or layout design is that it must be satisfactory from the navigational point of view.

The approach channel of the harbour, as well as the harbour basin itself should satisfy the main requirement that the fishing craft should be able to enter and leave the harbour under design conditions without any difficulty to the operator and damage to the craft. In evaluating the navigational requirements, the opinion of an experienced master fishermen who has navigated the type of vessel for which the harbour is being designed will be very valuable.

The main difficulty in arriving at a satisfactory design as regards navigation is that the engineer who executes the design is not usually conversant with the art of navigating. Hence the navigational problems appear deceptively simple to solve and some of the requirements appear unnecessary. But experience has shown that their solution is much more complicated than they appear. The draught of the vessels in motion increases due to the phenomena of "Squat". The bottom contours of the approach channel and the harbour basin vary due to movement of bed material in the channel and the harbour, dredging tolerances, stirring up of bottom sediments by the propellers, siltation and sunken objects thrown overboard by the fishermen.

As regards widths required, the suctional effects between the channel banks and the vessel in motion and also between two vessels when they pass each other have to be considered. Moreover, the manoeuverability of fishing vessels (specially since they have only a single propeller) are limited during the low speeds encountered during entering and leaving the harbour.

In addition both the draught and width requirements have to be assessed keeping in mind that floating vessels have six degrees of freedom of motion. Vessels are affected by forces of wind, waves and currents all of which are stochastic in nature.

It is nearly impossible to investigate all the aspects of navigation and often in restricted situations small-scale model studies have to be carried out.

In other cases the values tabulated in Table 2 and 3 may be taken as minimum basin depths and channel widths for fishery harbour designs. The tolerances should be increased if the sea bed is composed of hard material such as rock or coral.

TABLE 1—FISHERY HARBOURS IN SRI LANKA
(as at January 1979)

Location	Class	Grade	Site	Protected basin area (ha)	Designed dredged depth (m)	Approach Channel depth (m)
1. Colombo	Harbour	Grade A	Open coast	1.2	6	7
2. Galle	Harbour	Grade A	Bay	5	6	7
3. Cod Bay (Trincomalee) ..	Harbour	Grade A	Bay	20	6	7
4. Mirissa	Harbour	Grade B	Bay	7	1.5 to 3	4.5
5. Tangalla	Harbour	Crade B	Bay	2	3	3.5
6. Beruwala	Harbour	Grade B	Bay	10	1.5 to 3	3.5
7. Mylinddy	Anchorage	Grade C	Open coast	3	1.5 to 3	4.5
8. Kalmunai	Harbour	Grade B	Open coast	3.5	1.5 to 3.5	5
9. Mannar	Harbour	Grade B	Lagoon	3	1.5 to 2.5	2.5
10. Wennappuwa	Anchorage	Grade C	River mouth	3	1.5 to 3	4

Notes : 1 to 5 — in operation
6 to 7 — under construction
8 to 10 — design stage

After the depth and width are chosen the approach to the harbour is laid out to be straight as possible without sudden curves or bends. Areas clear of rocks, coral and strong cross-currents are chosen as far as is practically possible. Wherever possible the natural channel alignment is used since changing the direction of natural flow may prove diffcult and costly.

5. Basin area of a Fishery Harbour

The sheltered water area required for the satisfactory operation of a harbour is referred to as the basin area. This is arrived at by evaluating the space required for alongside berthing of vessels and midstream anchoring for the type and number of fishing craft which are to use the harbour. To this is added the space required to enter and leave the harbour without damage, space for facilities such as slipways, space necessitated by the type of construction and room for expansion. In evaluating these space requirements it has to be borne in mind that unlike ships, fishing vessels do not use tugs to berth, that they have only a single propeller, they are very light and therefore readily subjected to wind effects and that they are operated mostly by untrained personnel who are not well versed in navigation. Therefore the safety margins have to be different from those used for commercial harbour design.

The basin area of a harbour could considerably be reduced by providing alongside berthing arrangements for each boat (slip and berth arrangement) or by a well laid down system of moorings. Unfortunately, no fishery harbour constructed to date in this country has adopted these systems. Consequently a majority of the boats have to anchor mid-stream using their own anchors. Fishing craft use only one anchor and as a result they need a large area on a per boat basis compared to their size. In these cases, the only solution is to establish a mooring system so that the fishing craft could moor in an organised manner utilising space more economically.

When undertaking new projects, a number of possible basin layouts are made and by a process of elimination the one which provides the services to the greatest number of boats in the minimum space at the least cost is chosen.

TABLE 2—SUGGESTED MNIIMUM DEPTHS FOR FISHERY HARBOUR DESIGN

Draught of Craft (m)	Minimum Depths (m)			Type of Fishing Craft
	Approach channel	Main basin Channel and Anchoring Area	Along-side Berths	
Upto 1	2.5	1.8	1.5	Upto 28 footers
Upto 1.75	3	2.8	2.3	Upto 34 footers
Upto 4	5.3	5	4.5	Medium size trawlers and most coastal naval vessels

The above depths should be increased depending on heights of waves occurring in the area under consideration and bed material.

TABLE 3—SUGGESTED MINIMUM WIDTHS FOR FISHERY HARBOUR DESIGN
(Channels)

Area	Condition	Miniumm width
Approach/entrance	1 boat lane	5 B
Channel	2 boat lanes	12 B
Channel	1 boat lane	3 B
Basin	2 boat lanes	8 B

B = Beam (width) of boat

6. The Layout of Protective Structures

More often than not the basin area of a harbour has to be obtained by the construction of one or more breakwaters in the sea or, in the case of harbours along rivers and inside lagoons, by the construction of a system of groynes to secure a permanent navigable passage.

In this country, except in the case of the Cod Bay (Trincomalee) fishery harbour all other fishery harbours constructed to date have necessitated the construction of breakwaters and groynes. The breakwaters are laid out around the harbour basin so that it is protected from the ravages of the sea. If the selected site offers natural protection to a degree, the cost of breakwater construction can be reduced to that extent since the size of required breakwaters will be reduced

In Sri Lanka it has been found that there is a considerable amount of littoral sand drift along both the west and east coasts and therefore any structure such as a breakwater built into the sea would invariably interrupt this drift. The resultant effect is the erosion of the down drift side of the construction. In the design of the layout of protective structures this aspect should be taken into account, and wherever possible the maximum sea-ward limit of the structures should be restricted in order to limit erosion to as short, a distance as possible along the coast. In any case, whenever the littoral drift is interrupted, the need will arise to design a system of coast protection works to prevent or arrest erosion on the down drift side.

Artificial sand by-passing, which essentially is a process of pumping sand from the entrapped side of the harbour to the down drift, may also be adopted. This method would have the advantage of interfering least with the coastal environment.

These coast protection works too would invariably form a part of the fishery harbour.

7. The Location and Dimensions of the Harbour Entrance

The location and dimensions of the harbour entrance form an essential aspect of harbour layout design. The principal factors governing the location are the availability of natural depths, the character of waves approaching the harbour, the littoral drift at the site along the coast, and currents, if any.

The availability of adequate depths will obviously decrease the cost of dredging required and siting it in a much greater depth than required will increase the construction cost.

The character of waves approaching the harbour determines the amount of wave energy entering the harbour. The waves inside the harbour should be of the non-breaking type. They could be as highas 0.5m in the mid-stream mooring area, away from locations where the boats come into contact with any structure such as a jetty. They should be limited to a maximum of 0.3 m where alongside berthing or other facilities are provided.

Studies of the hydrography of the area and deep-water waves generation should be carried out. They are used to evaluate the wave refraction pattern and also to construct the wave diffraction pattern inside the harbour. From the latter the height of waves at any location inside the harbour could be determined.

For some reason or the other, if the wave height inside the harbour cannot be reduced to the limits stated above it is possible in some cases to do so by devising suitable wave absorbing arrangements.

Cross-currents across the harbour entrance would cause navigational problems to the fishing craft, since in such cases, the vessels will be passing from a zone where its rudder has to be angled with respect to its direction of travel to a zone where the rudder should be nearly parallel to its direction of travel or vice versa. This would cause the craft to sway and yaw suddenly and due to the very nature of navigation, the vessel needs to cover a considerable distance before its path is corrected. Hence, the need arises to locate and dimension the entrance in such a way that currents across it are a minimum, and there is ample room for the vessels to manoeuvre while leaving and entering the harbour. In some cases, the need may arise to execute the layout of the protective structures in such a way that it shelters the fishing vessels from strong cross-currents at least during the most hazardous part of its harbour entering/leaving manoeuvres.

A knowledge of the littoral drift is necessary in order that the harbour entrance may be situated in such a location that the minimum amount of drift material enters the harbour. It also gives an indication of siltation which can be expected.

The spacing between the protective structures, that is the dimensions of the harbour entrance, generally referred to as the entrance width, is governed by the above mentioned requirements as well as the number and sizes of fishing craft utilising the harbour and the cross-sectional area necessary to maintain velocities of sufficient strength to prevent excessive siltation.

The location and dimensioning of the entrance should be carried out simultaneously with the approach channel design and again, it will be evident that conflicting requirements present themselves to the engineer and that he has to decide on the importance of each factor depending on the situation.

Finally the layout of outer structures should be carefully co-ordinated with the design of inner harbour layout, since each harbour is resonant to a specific wave period. It should be ensured that the harbour layout will not resonate to the wave periods likely to occur during most of the year (small fishing craft are highly responsive to certain specific wave characteristics).

It is never possible to solve the above problems theoretically due to the introduction of so many phenomena and therefore it will be necessary in most cases to carry out model studies to test the design.

8. Data Required for Design

From above, it would be apparent that most of the data required for the design of a harbour are not the type to be readily available in handbooks or such literature. Forces of nature which govern the design are stochastic in character. This necessitates the use of statisfical methods in the evaluation of the data in order to arrive at design criteria, rather than using the method of "safety factors" as is done in some other fields of engineering above.

The data required for each selected site has to be collected at the site for a period of one year at least in order to evaluate the effects of the two monsoons. A longer period of investigation is preferable.

A description of the type of data collected and the method of collecting data are beyond the scope of this article. However, a fair idea of the type of data needed could be obtained from sections 2 and 3.

9. Construction Equipment

The design must take into account and allow for the construction methods, techniques and equipment available in this country. In more affluent countries it is possible to design various types of protective structures to be constructed in the sea and then to obtain the equipment to construct them without much difficulty. However in Sri Lanka, our construction capacity is limited and so far it has not been possible to even obtain a floating crane for fishery harbour construction. All construction work of fishery harbours have been executed using mobile cranes. Therefore, the type of structure which could be designed is limited.

10. Conclusion

It will be evident from the foregoing that the siting and layout design of fishery harbour protective structures need the use of much judgement, experience and logic on the part of the engineer. He will necessarily have to be satisfied with compromises rather than with an ideal solution.

In the foregoing, only some of the major navigational, hydraulic and morphological aspects effecting the design are discussed. Other aspects such as the— stability of protective structures, scouring along their foundations, economic considerations, arrangement of facilities inside the harbour, construction techniques, investigation techniques, etc. have not been included.

References

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