ISSN 0974-5904, Volume 10, No. 04

DOI:10.21276/ijee.2017.10.0430

International Journal of Earth Sciences and Engineering

www.cafetinnova.org

August 2017, P.P. 931-937

Development of Small Craft Berths in the Waves Exposed Region with Spending Beach in Port Basins

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Abstract*:* *Development of small craft berths in a port basin is necessary to accommodate berthing of small crafts, which are the integral part of port day to day operation facilities. At many major and medium ports even though port are in operation for a long period of time no exclusive berthing facilities are created for small crafts. In the absence of exclusive berthing facilities these small crafts are generally accommodated near the port dock arms where main cargo traffic are handballed. This causes traffic hindrance and also increases chances of collision of vessels. In order to avoid this it is desirable to develop exclusive berthing facilities within the port area. It is possible to develop small craft berths at the areas where it's not suitable to develop facilities for port main traffic thus without affecting the port revenue. Spending beaches within the port areas are the one of such locations which can be used effectively for these types of developments without losing the beneficial effects of the beach. Hydraulic physical model studies conducted for the development of small craft vessel berthing at New Mangalore Port is explained in this paper. Through model studies it was suggested to develop berths without loss of the spending beach by providing berthing structures with pilled jetty without removal of the beach by extending the jetties in the water front of port basin. The orientation of the pilled jetty berths were kept perpendicular to wave crest at this location to ensure maximum comforts for the berthed vessels. Since the selected location is directly exposed to harbour entrance, during storm it is suggested to berth these small craft vessels at dock arms. This is only for a brief period for about 10 days during South-West monsoon season. Thus it is shown that it is possible to create berthing facilities for small craft vessels within the harbour in areas which are not suitable for development of commercial berths.*

Keywords: *Small craft berth, Spending beach, wave tranquility, Pilled jetty.*

1. Introduction

1.1. Port development and need for small craft berthing facilities

The major Ports development in India was on need base optimising the investment cost to minimum. During the development stages of many major and medium ports, no separate berthing facilities were developed for small craft vessels. Small craft vessels like tugs, survey launches, multipurpose vessels, and mooring launches are the essential part of port day to day operations in the port area. In the absence of dedicated berthing facilities these small vessels were accommodated in the operative areas of the port where desired tranquillity and other facilities were available particularly at regions where main traffic is handelled.Due to this chances of accidents by collision of vessels are high and also it is a hindrance to port main traffic. In order to avoid these and to reduce the risk it is desirable provide exclusive berthing facility for the small vessels. Also from the port revenue point of view it is always advisable to develop such berths in the locations inside the port basin where major berthing facilities for port revenue are not lost due to these developments. In such cases the area where spending beaches are formed inside the basin are ideally suited due to the reason that it is always recommended to retain the spending beach for maintain wave tranquillity and also to avoid reflection effects in the harbour basin causing harbour resonance in some extreme cases. It is possible to retain the spending beach and its abortive capacity of waves without removing it but still develop berthing facility for the small craft vessels. For this purpose it is required to identify within the port basin such locations and carryout detailed studies with respect to wave tranquillity and directional distribution before finalising the development. One such case is New Mangalore Port on the western coast of India. It is an all-weather artificial lagoon type Major Port of India situated at Panambur about 10 Kms North of Old Mangalore port, in Karnataka state (Fig.1). The port development was initiated during early 1960's and port is being developed over last five decades adding berths and upgrading for deeper drafts to meet the traffic demand from time to time. At present there are fifteen cargo berths operational at the port of which eight are general cargo; five are POL, one each for iron ore and coal. The port traffic has increased from 1 million ton in 1975 to about 40 million tonne at present. The traffic did not see anticipated increase for the last few years due to the restriction on the export of iron ore. However the handling of coal for thermal

Received: March 15 2017; Accepted: June 29, 2017; Published: August 30, 2017
International Journal of Earth Sciences and Engineering, 10(04), 931-937 2017, DOI:10.21276/ijee.2017.10.0430

power and other POL traffic are on an increasing trend and the port is anticipating handling about 50 million tonne in the near future. The port is also contemplating to increase the draft from -15.4mCD at present to -19mCD and planning for development of deep draft berths in the port basin and additional berths in the western dock arm are under progress. The creation of additional draft, increase in number of berths will eventually lead to increase in the size and number of vessels to be handled in the port in the coming years. At New Mangalore Port there are 16 small craft vessels of varying sizes are being used at present for various day to day operational requirements. It is expected that these numbers will increase with additional traffic in the near future. At present there are no dedicated berthing structures for these small craft vessels. In the absence of exclusive berthing facilities these are berthed in the rear ends of existing port dock arms. The movement of these small craft berths along the dock arm interference with main cargo handling ships causes traffic nuisance and there are chances of accidents in few extreme events. Thus to avoid this and also to give comfortable berthing and infrastructure for the personnel operating the small crafts it is desirable to create an exclusive berthing facility for small crafts operative in the port basin.

The main constraint in development for creating separate dedicated berthing facilities is, since it a not a revenue earning berth. Thus Port authority may not ear mark a good location in the Port basin where revenue earning berths are more be preferred to small craft vessels berths.

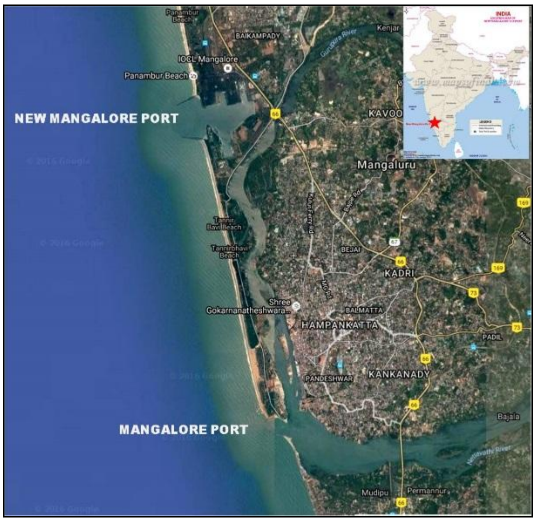

Figure 1.*Satellite image showing location of Old and New Mangalore Ports (Source: Wikimapia)*

1.2. Proposal for Exclusive berths for Small Craft Vessels

The small vessels are presently accommodated along the East-West faces of the existing Eastern and Southern dock arms. The draft requirements of these vessels are Tugs (draft 3.1m to 5.08m), Pilot/ multipurpose vessels/ survey launch (draft 1.0m to 2.1m) and mooring launches (draft 1.0m). A location on the eastern side of the port basin having a spending beach was identified for small craft berth development. This area is directly facing the harbour entrance, thus it has direct exposer to the waves entering the port basin. The existing spending beach in this region is serving very well as a wave absorptive region and this is useful in maintaining the wave tranquility in the port basin. Within the lagoon area prior to development of different berths and dock arms there were formation of spending beach seasonally along these region and this was also functional for wave energy absorption for about 9 months annually, the spending beach along this region used to vanish off during South-West monsoon and again rebuild during the calm periods. But the development of berths and dock arms permanently removed the spending beach. But for maintaining the overall wave tranquility within the isolated harbour basin maintain the spending beach is very vital and particularly during storm conditions these spending beaches helps in absorbing wave energy entrapped within the basin and effecting in reducing wave effects on the moored ships and berthing comforts for the ships within the port basin will also get benefited from this. The absorption of wave energy at spending beach is beneficial in reducing chances of phenomenon of harbour resonance.

The proposed area of development of flotilla berths cannot be utilized for the development of berth for the main port traffic considering the wave approach angles and also for retaining the existing spending beach to prevent reflection of waves along this face in the port basin. As this location is directly facing the harbour entrance and the wave front entering the port basin through the harbour entrance propagate along the port basin and spends considerable wave energy along this spending beach and thus this is very useful and contributing in a big way for maintaining harbour wave tranquility. Considering the area available for the proposed small craft berths and the size of the small crafts three finger jetties were conceptually planned. Sufficient margin of space is provided adjacent to existing berths so that the development of berthing structures should not pose any hindrance to movement/maneuvering of the vessels inside the port basin. Considering the wave approach angle and to take advantage of the spending beach, three finger jetties of length 150m each with a clear distance of 50m face to face of each jetty structure are proposed (Figure 2).

To maintain the spending beach the jetties are planned on piles without disturbing the wave processes and currents along this location. The length of the proposed jetties were terminated before the Eastern face of the existing Eastern dock arm since any projection beyond this limit may obstruct the ships entering or leaving the dock arm. This type of development essentially has varying draft for the proposed jetties from western to eastern end. This can be beneficially used to accommodate vessels of different drafts as per actual requirements of small crafts as mentioned above. It was also suggested to develop these finger jetties in a phased manner and the operative experience at site for the jetty constructed first can be used to refine the design and development of the other finger jetties. Small vessels are very sensitive to water movements in the harbour and particularly wave action and resonance effects; it is therefore common to undertake model studies (Per Bruun, [7]).

Comprehensive hydraulic physical model studies were conducted at CWPRS for the development of small craft finger jetties by utilizing shallow basin physical wave model. The advantages of pilled jetty in preserving the existing spending beach and need for protecting the beach while finalizing the jetties is the essence of the present study.

Figure 2. *Plan showing location of Flotilla Berths and adjoining Berth Nos. 1 and 8*

2. Description of the model

The model facilities comprise 3D hydraulic physical model scale (1:120 GS) housed in a hangar of size 72m x 45m). The model layout is as shown in Fig.3 and Fig.4 shows an over view photograph of the model. It is a rigid bed model with latest bathymetry simulated and was equipped with random wave generation facilities from three directions namely West, South West and North West. Model is facilitated with random sea wave Simulation System. PC based Random Sea Wave Generation (RSWG) and Data Acquisition System (DAS) was provided. This system generates the command signal based on desired wave simulation with electro-hydraulic servo system. RSWG system interfaced with USB module with built-in Digital to Analog Converter (DAC) for giving the command signal i.e. driving wave train to wave board through servo-hydraulic system and sixteen channels Analog to Digital Converter (ADC) for simultaneously acquiring the data from wave height sensors, which are installed at salient locations in the wave model.

Complete Wave simulation software containing software for wave synthesis, random/ regular wave generation and data acquisition system, data analysis (frequency domain – spectral analysis, time domain - wave height analysis) and data plotting system was installed. The software comprises of modules for Simultaneous wave generation and data acquisition and Calibration of wave height sensors. By acquiring the wave data at different locations and on analysing the wave data with software provide**,** graphical picture of the wave pattern at various wave sensors installed in the wave basin. The wave data was analysed using Fast Fourier Transform technique and spectrum match is achieved to validate the entire process of random wave simulation in the physical wave model. Thus for any variation in the water level in front of the wave board the incurring error in wave generation could be immediately noticed and necessary precautions would be exercised to avoid erroneous results in the experiments.

Additionally electronic water level indicator is provided in the model tray by constructing a stilling well and display unit of the same is provided at the data cabin for knowing the variation in water level during the course of the experiments. Experiments are generally run for five frames (each frame is 100 second duration). For the purpose of recording the model results it is very important to identify the frame number which gives best comparable result. Normally this is done by iterative process after constructing any wave model, data will be collected for different frames and after analysing and comparing the results with standard values available results for the model or from the prototype if available or based on the experience of a model engineer the best suited frame/s will be identified and the experimental recording will be done for this frame on a regular basis for a given model study. Normally the frame number for which the recording to be done depends on the model size, model boundary simulation etc., for the present condition in the model second and third frame were recorded. If the size of the model is very big then the waves generated from the wave generation point takes more time to travel the model boundaries thus normally for the first frame the effect of the complete wave build-up on the model is lacking and chances of variation due to laboratory effects will be more. On the contrary if one collects the records after a very long time like after fifth frame normally the effects of reflected waves from the boundary of the model will have a noticeable effect on the results as well.

Wave heights are measured using capacitance type wave probes and signal conditioner. The capacitance type wave height sensors are enamelled copper wire type. The copper wire and water acts as two conductors separated by the enamel dielectric. The surface area of the copper wire changes with change in water level fluctuations. Variation due to change in the water level (column) thus gives the change in capacitance, which in turn provide change in the voltage. The probe is excited by AC signal and voltage output from the bifilar winding which is amplified and filtered for high frequency components and fed to multi-channel ADC in the USB module. It is necessary to keep the wire surface clean always to ensure proper measurement of wave data; it mainly depends on the dirt and dust present with water taken on the model for hydraulic studies.

The most common laboratory effects that affects model results is reflection of wave energy from boundaries or from model structures [3] and dealing with wave reflection needs from right behind wave generation. The waves generated by the wave flaps in the model basin will have its effect behind it also, so the region behind generators is provided with rubbles to have proper absorptive effects [4].

Truncated approach channel was simulated in the model for a distance of about 4000m from port basin entrance point to a depth of -11.0mCD.The breakwaters were simulated using stone aggregates with appropriate sizes and slopes to match the rubble mound breakwater existing at site [9]. The model boundary was provided with stone aggregates and sand beaches for simulating the wave absorption as in the prototype [8]. The proposal of development of small craft berth was tested in the model by conducting experiments from three directions to know the wave field near the berths for different seasons since these berths are used all round the year.

3. Model Studies

The predominant wave directions are South-West, West and North-West. Based on the field wave data and pilot model studies conducted on physical model (1:150 G.S.) the wave condition adopted for the studies at the boundaries are HS = 2.5m and TP = 10 sec[1]. For the proposed, studies were conducted by maintaining HWL (+1.50m) in the model.

3.1. Wave Tranquility Limits

The acceptable wave heights recommended by Permanent International Association of Ports and Harbors (PIANC) and IS 4651 [5] based on wave approach angles for different types of vessels are referred for the studies [2]. The wave tranquility limit for small craft vessels varies from 0.3m to 0.5m depending on the sizes of the vessels and wave approach angle. A permissible limit of 0.5m was considered for the tugs and 0.3m for the other small vessels for this study by taking the advantage of the angle of wave approach being nearly parallel to the proposed finger jetties.

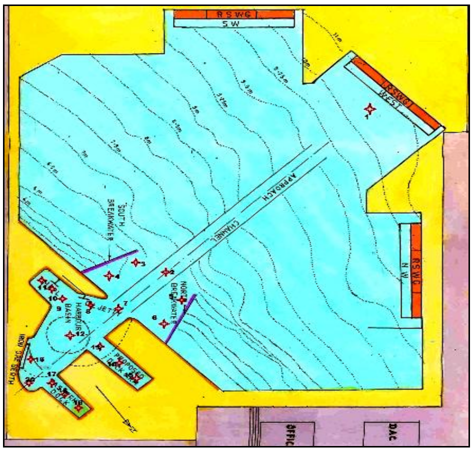

Figure 3. *Physical Model Layout [Model scale 1:120 GS]*

Figure 4. *Photo showing overview of Physical Model*

Figure 4. *Photo showing Flotilla Berths in the Physical Model*

3.2. Details of Model studies

Initially model was run without simulation of the finger jetties and the direction of wave crest approach at the proposed location in the model was sketched by generating waves from three directions. The jetties were placed at this location and fine-tuned for the alignment such that no broad side incidence of wave occurs for the vessels at berth. In order to retain the spending beach at the proposed location finger jetties with piles are recommended. Three berthing jetties were simulated in the model as per the dimensions and alignment to accommodate the small crafts sizes to be berthed. The alignment, spacing and dimensions are as shown in fig. 2 and photo view is as shown in fig. 5. A typical wave crest pattern sketch and view of the physical model is shown in figure 6 & 7 respectively. For sketching the wave crests regular waves were generated. Sketching of wave crest is easier with regular waves as the pattern is more clearly seen compared to random waves [6]. Wave tranquility studies were carried out by conducting experiments from West, South-West and North-West directions by generating regular and random waves. For regular wave H=2.5m/ T=10sec were adopted and for random wave test condition of wave height Hs = 2.5m / T_p=10sec, at model boundary was the critical testing condition for port wave tranquility. This corresponds to Hs = 3.66m / T_p=10sec in deep water wave condition [1].

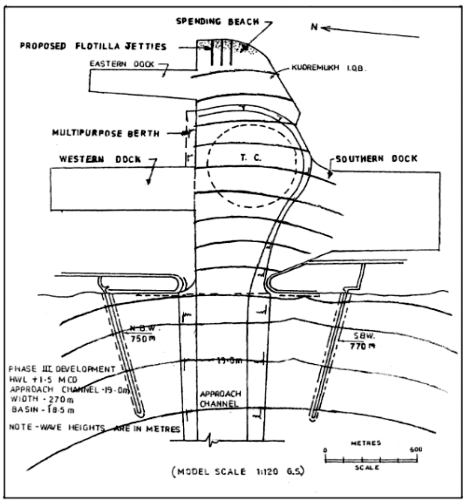

Figure 6.*Wave patteren sketchnear Proposed Flotilla Berths*

Figure 7. *Model Photo showing wave crest near Proposed Flotilla Berths*

The regular wave model studies were useful in sketching the wave crest pattern at the proposed berthing locations and random wave model studies were useful for the wave tranquillity assessment at various salient locations in the model. Studies were conducted by simulating a wave absorptive surface on the eastern region of the proposed jetty by suitably placing the fine aggregates with sufficient wave run up to avoid reflection of incident waves from this region, resembling it to the beach absorptive effect at the site in the presence of spending beach.

The results of wave tranquillity for three directions are shown in figures 8, 9 and 10.

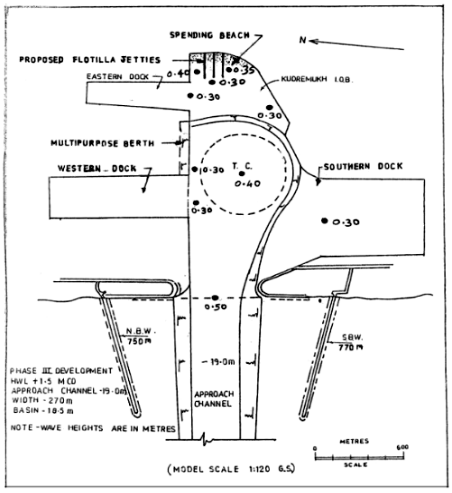

Figure 8.*Wave tranquility for Westerly waves for the proposed Flotilla berths*

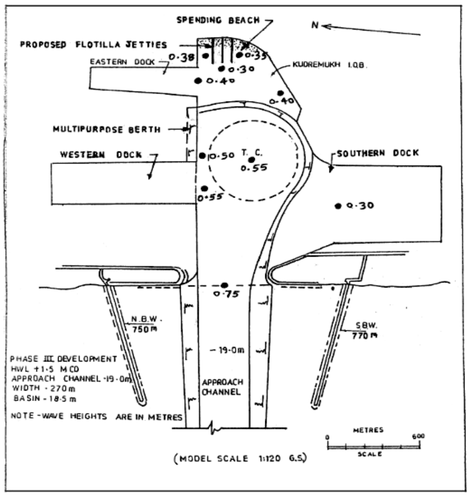

Figure 9.*Wave tranquility for South-Westerly waves for the proposed Flotilla Berths*

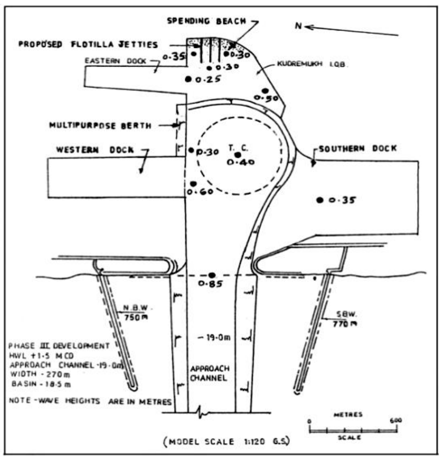

Figure 10.*Wave tranquility for North-Westerly waves for the proposed Flotilla Berths*

4. Discussions on the results

The wave crest sketching and fine tuning of the berths were useful for finalization of optimum alignment of the berths with waves approaching the berths almost parallel to the berthed vessels. This helps in decreasing the vessel motion at berths thus increased comforts can be achieved at berths. The wave approach angle at proposed berths is similar due to wave transformation along long approach channel and the refraction on the shallow regions adjacent to berthing location.

The studies for wave tranquility indicated the wave disturbance near proposed flotilla berths will be within 0.5m for the tested conditions from all three directions. The berthing faces facing existing berths in the harbor basin have relatively higher disturbance, this can be attributed to the reflection from the existing berth faces. Also the wave disturbances are little higher at the eastern side of the proposed berths as compared to western side, this is due to wave breaking and reflective effects from the spending beach adjacent to eastern side of the berths.

The measurement of wave disturbance at other locations in the port basin also indicated that there is no adverse effect on wave tranquility due to the development of flotilla berths. This is mainly due to pile jetties adopted for the proposed finger jetties which will minimize the reflective effects from the proposed development. It is also important to retain the spending beach on the eastern side of the berths to have wave absorptive effect reducing reflection effects and resonance phenomenon. Construction of any reflective structure in this region may lead to increased wave near the proposed berths and will increase the wave heights near the existing berths and also will have adverse effect on over all wave tranquility effect in the harbour basin.

The wave tranquility studies were conducted for Hs=2.5m at generator (which corresponds about 3.66m at deep water) is very rare from North-West direction and from South-West direction it may occur for about 10 days in a year. Thus the proposed berths can be used throughout the year.

The tested wave condition prevails for the major part of the year. In the event higher incident waves during stormy weather conditions berthing of these vessels may be shifted to dock arms for a brief period.

5. Concluding Remarks

The wave tranquility and directional propagation studies conducted on the physical model were very useful in proper planning of finger jetties, its orientation at site without disturbing the existing spending beach.

The proposed berths will be utilized by different types of small crafts of varying in sizes and draft according to the tranquility requirements. Thus the berth utility may be suitably planned as per the requirements at site. The wave disturbance near the spending beach is comparatively more than that near the western end of the proposed jetties, hence the small crafts like mooring launches, and survey vessel etc. may be accommodated near the calm water regions for better operational conditions. For the proposed berths would have adequate wave tranquility for the incident waves from three predominant directions viz., West, South-West and North -West for the tested condition and assumed tranquility limits.

The tested wave condition of Hs = 2.5m/Tp=10sec, from each of the directions is the design condition for the port operation. However wave of this magnitude are very rare from North-West direction and may occur for about 10 days from the other directions. Thus the proposed jetties will have good wave tranquility for most part of the year. However during the storm/ severe wave conditions the small crafts may be berthed inside the dock arms.

The study indicates that it is possible to create dedicated berthing facilities within the port basins without disturbing the effects of spending beach and in the locations which are not feasible for commercial traffic without affecting the port revenue. Similar to this it is possible to explore suitable sites within the port basins and dedicated berthing facilities may be created for small craft vessels at different ports. Studies by the help of sophisticated physical models will be very helpful in finalizing the berthing structure and its alignment.

6. Acknowledgement

The authors are thankful to the Director of National Institute of Technology Karnataka, Surathkal and Head of the Department of Applied Mechanics and Hydraulics for the permission granted to publish the paper. Also the authors would like to sincerely thank Director, CWPRS for the permission granted to carry research work and to use the model data. Thanks are also due to the Chief Engineer (Civil), New Mangalore Port Trust for sponsoring the model studies.

References

[1] CWPRS Technical report No. 5159, “Hydraulic Physical model studies for flotilla berths at New Mangalore Port, Mangalore, Karnataka, India”, 2014

[2] CWPRS Technical report No.4298, “Model studies (1/120 G.S.) for the development of deep draft multipurpose berth at New Mangalore Port, Mangalore, Karnataka, India”, 2006

[3] Dalrymple, R. A. "Introduction to physical models in coastal engineering. Physical Modeling in Coastal Engineering." *Ed., A A Balkema,* Rotterdam, Netherlands, 1985

[4] Helmut Kobus, Hydraulic Modeling, bulletin 7, German Association for Water Resources and Land Improvement, 1980

[5] IS 4651 (Part V), Code of practice for planning ports and harbour: Layout and functional requirements, 1980

[6] Liu, X., Lin, W., and Huang, P., "Laboratory Study of Low-Frequency Waves Induced by Random Gravity Waves on Sloping Beaches." Journal of Waterway, Port and Coastal, Ocean Engineering, ASCE, 2009
[7] Per Bruun, Port Engineering, "Gulf Publishing Company", Houstan, Texas, USA, Vol.2, 1990
[8] Steven A. Hughes, "Advanced Series on Ocean Engineering, Physical Models and Laboratory Techniques in Coastal Engineering", World Scientific, Vol. 7, 2005
[9] Straub, L.G., Bowers, C.E., and Herbich, J.B. "Laboratory Tests of permeable wave absorbers" proceedings of the 6th Coastal Engineering Conference, Council on wave research, The Engineering Foundation, pp 729-742, 1957