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DAMAGES CAUSED BY CYCLONIC STORM AND REMEDIAL MEASURES AT TUTICORIN PORT

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ABSTRACT

After a gap of 31 years a tropical cyclone crossed directly over Tuticorin in November, 1992, after passing the landmass of Sri Lanka bringing incessant rains with gusts upto 113 kmph and stormy weather. Tuticorin Port which is an artificial harbour, having two long breakwaters, reclaimed approach arms, pier heads and rubble noses got the direct hit and hence effect of the cyclone. Certain portions of the breakwater and approach arm were damaged. The observed waves were about 4.2 m. Also a storm surge of about 0.5 m to 1.0 m was noticed. Breakwater sections at some points breached upto high waterlines and rubble nose and pierheads damaged due to dislodging of concrete blocks. Port got the advice of Development Adviser (Ports), Ministry of Surface Transport, The Tuticorin Port, Central Water & Power Research Station, conducted requisite model studies at CWPRS, Pune and completed remedial measures including constructing a deflector type concrete parapet wall along the EBW in 1994 thus ensuring safety against such cyclones.

INTRODUCTION

Tuticorin Port is an artificial harbour formed with a breakwater system having two long parallel breakwaters nearly 4000 m each and 1275 m apart encompassing 400 ha. of water area. Six alongside berths and three dry bulk/liquid cargo jetties have been constructed in the end of the breakwater system. Tuticorin Port handled a traffic of 9.17 million tonnes during 1996-97. Coal for the Tuticorin Thermal Power Station forms about 60% of traffic. The other cargoes are POL products, chemicals, fertilizers and fertilizer raw materials, general cargoes and Containers. Container traffic is fast growing due to Tuticorin Port's proximity to International Shipping route, inherent trade demands, etc. Additional infrastructural facilities to cater to containers, coal, oil, etc are being put up within existing harbour basin with which the port traffic is expected to reach 16.50 million tonnes by 2001-02.

BREAKWATERS AND LAYOUT EVOLUTION

The layout of Tuticorin Port was conceived, designed, studied in hydraulic model and executed using indigenous expertise and technology. After studying various options available like caissons, the final selection was in favour of rubble mound breakwaters due to the

reasons of lesser cost, availability of good quality of stones, simplicity in construction without involving specialised equipments and local labour. The layout was so evolved to provide tranquil harbour basin and before implementation, the layout was checked for its tranquility against the principal wave directions in the hydraulic models of Central Water and Power Research Station (CWPRS), Pune during the year 1964-65.

The hydraulic model studies were conducted for wave directions of East North East, East South East and South South East, coinciding with the refracted waves from deep water arising due to monsoon conditions in the deep water. The sea conditions in Tuticorin are such that Tuticorin is well protected against a direct cyclonic effect due to the presence of the island of Sri Lanka on the east about 150 km. The directions of wave height and the existing layout area shown in Figs. 1 and 2.

The rubble mound breakwaters were designed for the following marine conditions:-

Deepwater Wave height (Ho)	:	4m
Wave period (T)	:	10 s
Chart Datum (LWOST)	:	0.0m
HWOST	:	+1.07m
Refraction Coefficient (K_r)	:	0.80
Specific Gravity of rubble	:	2.65
Unit Weight of rubble formation (with 40% voids)	:	1.60T/Cum
Specific weight of sea water	:	1.03

The breakwater cross-sections after hydraulic studies for different depth were tested in wave flumes at CWPRS for 8', 10', 12', 13' and 15' wave heights for both over-topping and non-overtopping conditions. Especially the North breakwater (NBW) was designed for overtopping conditions for the reasons that the jetties provided on the lee side of the breakwater would not get affected due to overtopping conditions. The adequacy of the breakwater sections tested in wave flume were, however, during the actual execution, slightly modified to suit the site conditions and within the overall design framework, and the modified sections were again tested for adequacy before execution. The typical cross sections of the north and south breakwaters are shown in Fig. 3 and Fig. 4 respectively. However, the section of the South Breakwater (SBW) between Ch. 2500 m to 3800 m designated as Eastern Breakwater (EBW) was designed with a parapet wall with crest elevation upto +7.03 m over the rubble mound. During the model studies, it was also observed that the breakwater with crest level at 4.65 m would overtop only with continuous wave of over 12' high.

The Technical Advisory Committee (TAC) constituted for the Tuticorin Port during a review meeting in August, 1973, considered that occurrence of 3.96 m wave height in Tuticorin being extremely limited, the crest of the breakwater can be limited to the sections as constructed i.e., the NBW at +4.65 m level, the SBW at +4.65 m level and the EBW at +3.65m level for operational reasons and to oversee the function of the breakwaters for the external wave conditions in the cyclonic periods for 5 years. The cross-section of SBW as

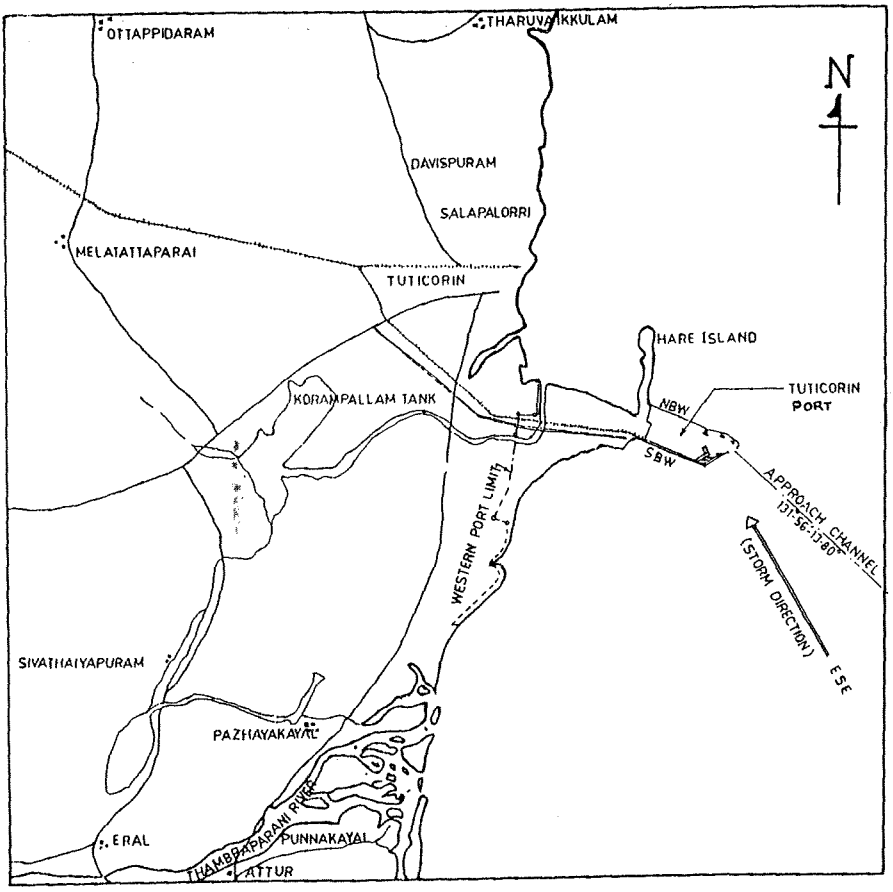

Fig.1 Location of Tuticorin Port

executed in shown in Fig. 5. Consequent to the decision, the construction of parapet wall over the EBW was deferred. During the watch period of 5 years and another 14 years totalling 19 years there was no effect due to the cyclonic storms that normally passed between Pamban and Tuticorin till the storm that passed directly over Tuticorin on 13.11.1992. The previously recorded storm affecting Tuticorin was observed in the year 1961 i.e., before physical planning of the major port.

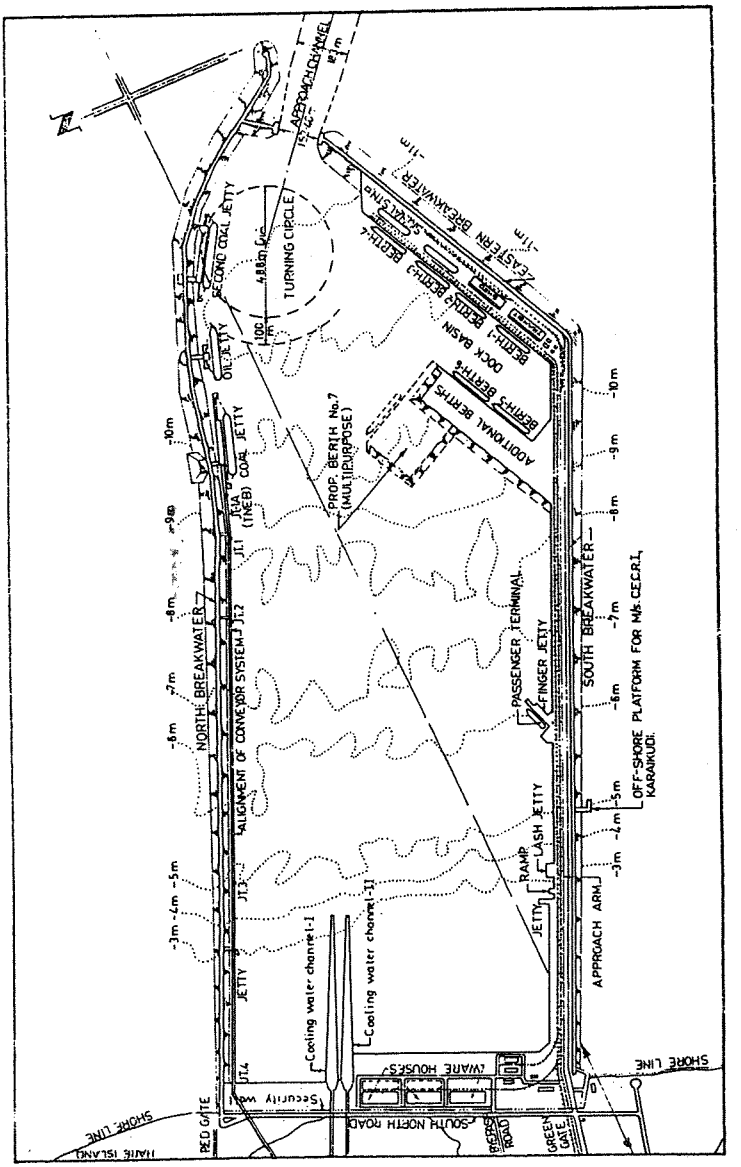

Fig.2 Lay out of port of Tuticorin

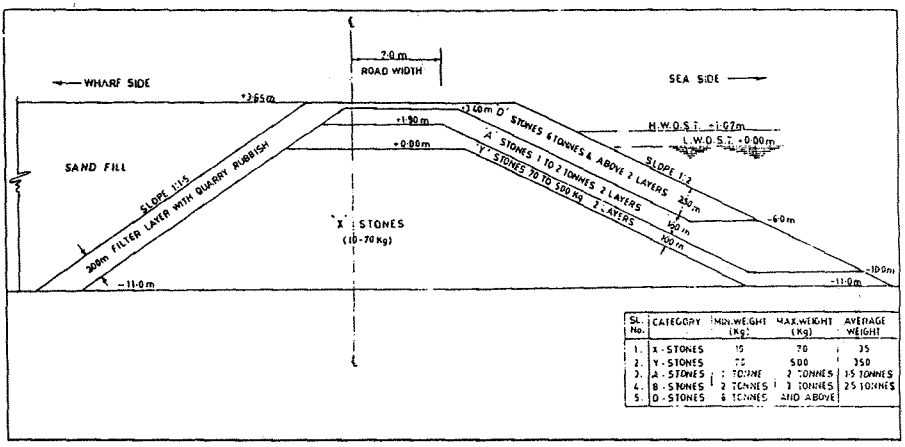

Fig.3 Cross section of North Breakwater

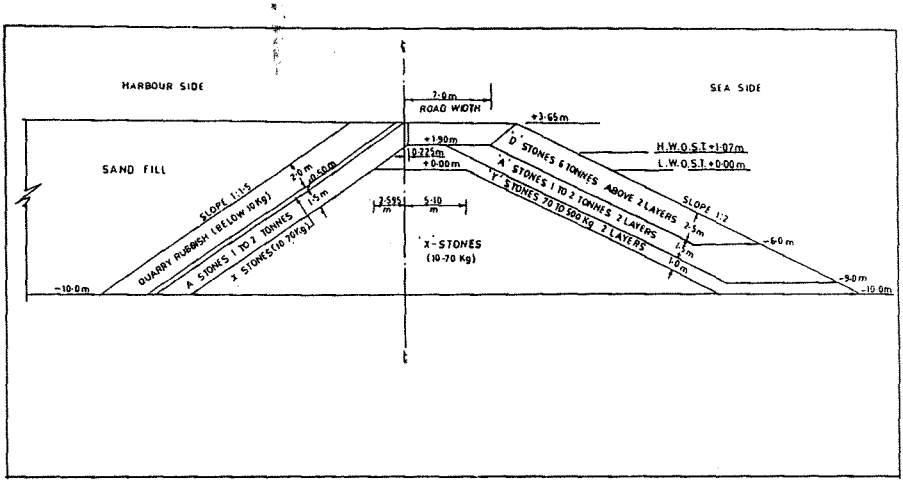

Fig.4 Cross section of south breakwater

EFFECT OF STORM

The day of cyclone overpass viz., 13.11.92 was a rainy day and the total rainfall recorded in the Port Observatory was 36.1 mm. Eventhough the Port didn't have wave height recorded, the wave height observed at the peaktime from the observations from the ships' Captains present within the harbour at the time of cyclone was about 4 m with a storm surge of 0.5 m to 1.0 m. The unusual coincidence of wave set up generated by the cyclone and the storm

surge aggregating to the height of about 4.5 m to 5.0 m might have been the cause for such a quantum of overtopping on the eastern arm of SBW. A sheet of about 1 to 1.5 m thick water passed over the VOC wharf tossing the stacked container boxes here and there. The B.T road atop the Eastern Breakwater and the formation stones (10-70 kg.) got dislodged for depth of about 0.3 m - 0.5 m. There was a breach at the junction of the approach arm and the VOC wharf causing temporary suspension of the road transport to the VOC wharf and vice versa. In the eastern breakwater armour stones were disturbed in three locations for lengths of 20 m to 30 m upto the water level.

A few concrete blocks at the entrance pier heads found slid causing minor damages, so also the blocks around the rubble nose of the north breakwater. On account of cyclone, navigation remained temporarily suspended to ensure safety of vessels. A sketch showing damages in the breakwaters and wharves is shown in Fig.6.

Meteorological Data collected from the Port's Observatory with stage by stage detail during the passage of the storm is presented in Table 1. However, it may be to note that the storm which crossed the west coast of Sri Lanka developed into a concentrated low pressure and moved directly over Tuticorin within a short span of 8 hours. Consequent to the storm, it was reported by the Captain of one of the ships which was tied up in the berth that a surge of water to about 1 m occurred coinciding with the high tide in the afternoon. The external wave height off the breakwater was also reported to be around 4.2 m

STRENGTHENING OF BREAKWATERS

The damages caused to the breakwaters, rubble nose were assessed , soundings taken along the slope of the breakwater and initially studied at the site with experts and referred to the CWPRS, Pune for wave flume studies for the strengthening and remedial measures.

In the CWPRS, the wave that could have occurred during the storm was hindcasted with the available data such as synoptic charts and storm tracks from the Indian Meteorological Department, Pune. Flume tests were conducted on the cross sections of the breakwaters/pier heads to evolve suitable armouring system with rock boulders or concrete blocks/tetrapods. It was then decided that a storm surge of about 0.5 m would have occurred coinciding with the high water level during the passage of cyclone on 13.11.1992 and the external wave height would have been around 4.2 m.

To strengthen the existing breakwater for protection against future similar cyclones, the CWPRS proposed the Eastern breakwater be provided with the curved parapet with top elevation at +5.65 m as shown in Fig.7 with 10T concrete blocks on the sea side (with slope 1:2) and 6T blocks on the Lee side side (with slope 1:1.5). The parapet would be laid monolith with a roadway of 6.5 m wide and a lip on the road over breakwater and with necessary drainage arrangements. The section has been found to be safe with 1% damage to the 10T and 6T concrete blocks for HWL of +1.07 m and 4.2 m waves with 0.5 m storm surge with certain overtopping conditions. However, the cross section as such was found stable for storm duration.

Table 1. Meteorological data on 13.11.1992

Time in hrs	Maximum wind speed Kmph	Direction	Atmospheric Pressure 12.11.92 mbs	13.11.92 mbs
08.00	53.0	N	1010.8	1004.8
09.00	78.0	N	1010.0	1004.7
10.00	70.0	NE	1010.5	1005.2
11.00	74.0	ENE	1010.4	1004.3
12.00	68.0	ENE	1009.0	1003.1
13.00	69.0	ENE	1008.6	1002.1
14.00	80.0	ENE	1007.8	1000.2
14.25	102.0	ENE	-	-
15.00	98.0	ENE	1006.6	997.4
15.25	103.0	ENE	-	-
16.00	100.0	ESE	1006.1	996.2
16.10	113.0	ESE	-	-
17.00	90.0	SE	1006.8	996.1
18.00	70.0	SE	1007.0	998.9
19.00	70.0	SSE	1007.8	1000.3
20.00	54.0	SSE	1008.5	1001.9

With regard to roundhead rubble nose portion of the north breakwater the CWPRS suggested to dismantle the end portion of about 5 m of the concrete roadway and to provide a suitably dressed berm with 12T concrete blocks as armour units with a slope of 1:2 as shown in Fig. 8 and accordingly the 12T concrete blocks were placed in all the quadrants of the roundhead, and the concrete capping/roadway reconstructed suitably after placing of the concrete blocks.

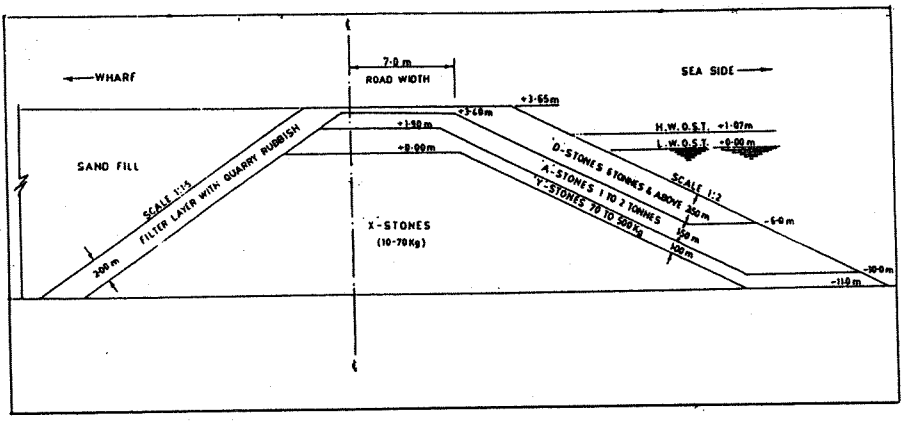

Fig.5 Cross section of eastern breakwater

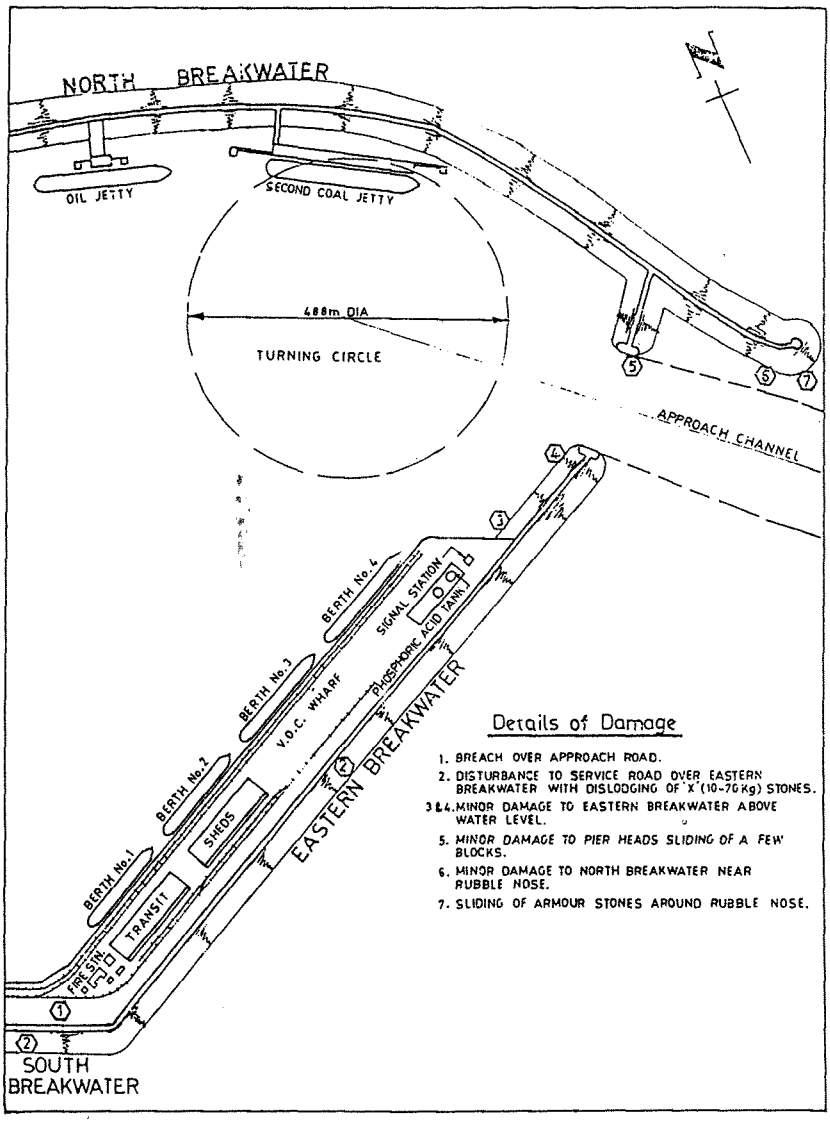

Fig.6 Damages due to storm

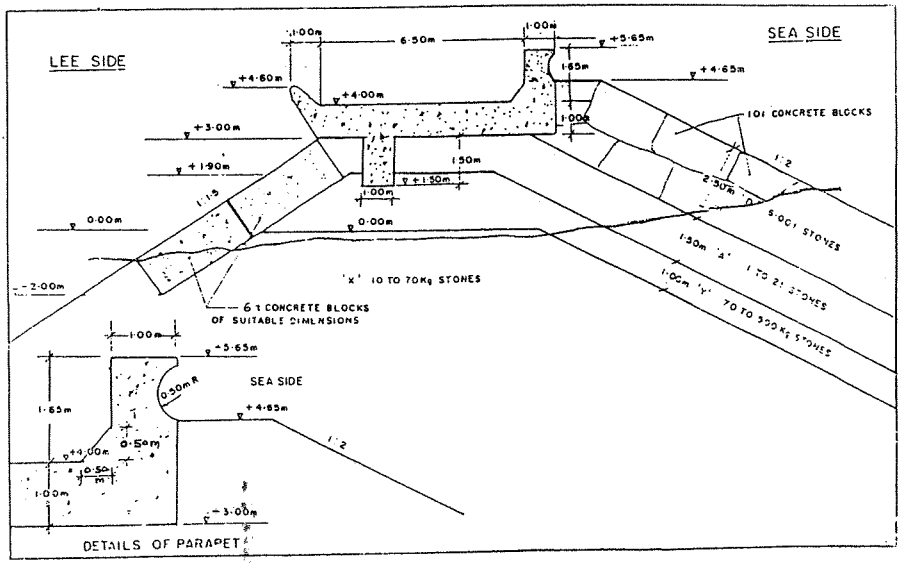

Fig.7 Measures to repair eastern breakwater

The section so constructed was previously studied by the CWPRS in wave flume for waves of 3.8 m and 4.2 m with storm surges of 0.5 m and 1.0 m With 3.8 m waves there was practicably no damage at all water levels. With 4.2 m waves there was no damage at low and high water levels. However, with the storm surge and high water there was damage to the main armour by way of disturbance to the blocks placed in slope, but the lee of the rubble nose was not affected. As such, modified sections were again tested in the wave flume and the acceptable section communicated for execution.

The strengthening measures to the EBW (with curved parapet wall cum roadway) and to the rubble nose of the NBW were taken up and executed before the on-set of the monsoon of the year 1994.

CONCLUSION

The storm effects in reality were seen practically as a challenge to the engineering constructions in the port getting affected and the same were not met effectively to nullify and make substantial remedial measures with the help of model studies conducted at CWPRS, Pune, the port was in fact with full readiness to execute the remedial measures including a Rs.5 crores worth parapet wall done in a record time and also well in time to face any further onslaughts of the nature's furies.

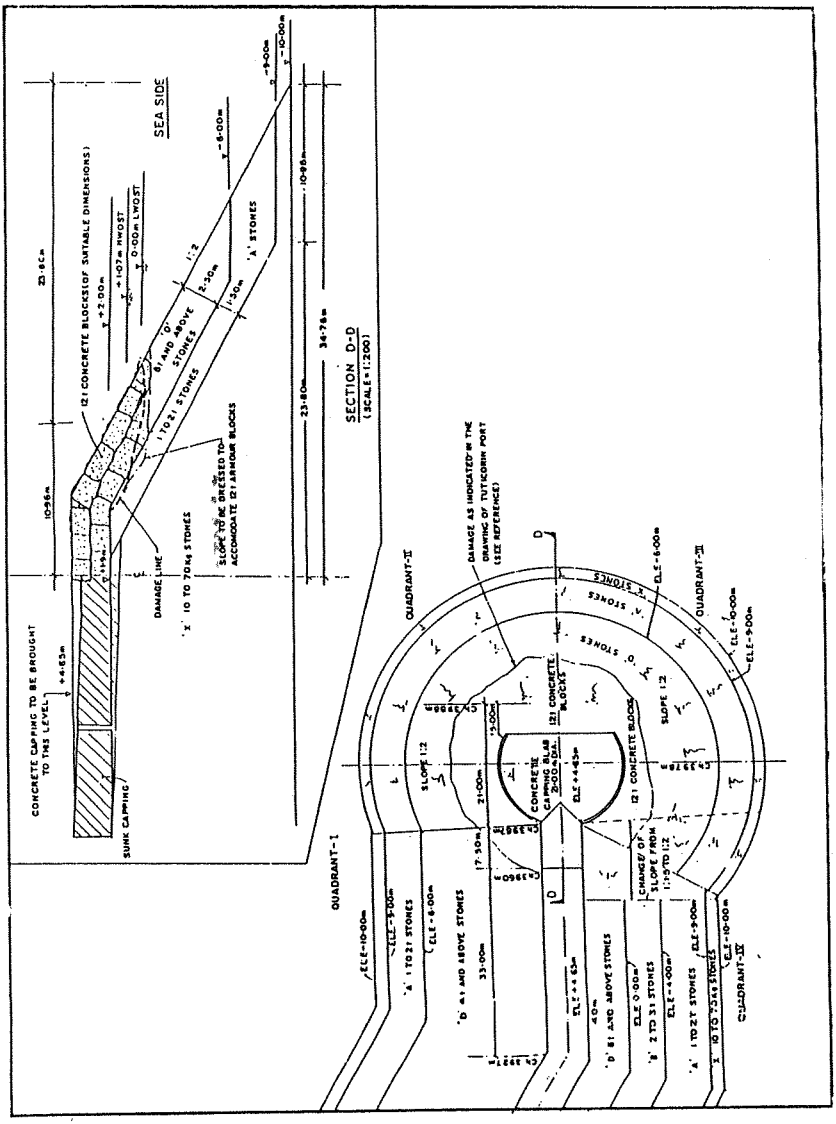

Fig.8 Design of rubble round head (nose) of north breakwater

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Specific Notes, CWPRS, Pune on Tuticorin Port Layout evluation, evaluation of breakwater sections etc.

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