CONSTRUCTION OF BREAKWATERS AT KALPENI AND ANDROTH ISLANDS OF LAKSHADWEEP

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ABSTRACT

Construction of marine structures such as breakwaters, seawalls, jetties is difficult as compared to land structures. It is even more difficult when such structures are constructed in remote areas such as the islands of the Lakshadweep group off west coast of India in the Arabian sea. With non-availability of construction materials like stones, cement and also of suitable equipment for construction, there are additional constraints in constructing breakwaters or jetties at these islands. While planning and executing construction of breakwaters at these islands there are many constraints which need to be considered; these are: long transportation involved, shortage of space in these tiny islands, limited working period and the environmental regulations. The difficulties encountered in construction of breakwaters at Kalpeni and Androth Islands [Lakshadweep Group] have been described in this paper.

1.0 INTRODUCTION

The Lakshadweep group of islands is located off the west coast of India in the Arabian sea [Figure 1] and is an archepelago consisting of 12 atolls, 3 reefs and 5 submerged banks. Out of the total of 36 islands only 10 are inhabited; these are Androth, Amini, Agathi, Bitra, Chetlat, Kadamath, Kalpeni, Kavaratti, Kiltan and Minicoy. These islands are located in the quadrant bounded by 8 degrees and 12 degrees 13' North latitudes and 71 degrees and 74 degrees East longitudes. These islands are situated at a distance varying from 232 to 440 kilometres [km], from the port of Cochin in Kerala State along west coast of India [mainland]. The total area of these islands taken together is 32 square kilometres [sq km] only. However, these islands have the lagoons, submerged banks and the reefs spreading over an area of 4200 sq km. The population of these islands is about 50,000 persons. Government of India have plans to develop these islands and various types of developmental works have been started since 1960s. Systematic development in the essential sectors such as agriculture, industries, transport and communications, water supply and electricity, education, health and fisheries, has been taken up.[Vide Reference 1]

Initially the Government of India had decided to develop immediately four of the islands viz. Kavaratti, Minicoy, Androth and Kalpeni. From the geographical position of the islands it is clear that the islands depend heavily on surface transport for movement within the islands and from India [Mainland]. As the sea is the highway to these islands, ship services as well as development of harbour facilities assumed a major role in the development of these islands. All the islands except Androth have North-South to North-Easterly orientation and have lagoons encircled by coral reef on the western side. Only Androth Island

has East-West orientation and there is no lagoon in this island. Considering the above aspects the details of development of harbour facilities at Kalpeni and Androth islands and the difficulties faced in construction of breakwaters at these locations, are described in this paper.

2.0 ECONOMIC IMPORTANCE OF THE ISLANDS

Though the islands have an area of only 32 sq km, their lagoons and economical zones are replete with marine life, are rich in seaweeds of commercial value and are blessed with large mineral resources. The Lakshadweep waters have a large potential for fish catch - estimated to be 400,000 tonnes per annum, yet to be exploited and consists of various varities of coral fish in addition to usual sea fish. The islands are surrounded by a large expanse of coral reef, crystal-clear water and have un-polluted coastlines. This makes the Lakshadweep one of the most beautiful spots in the country, rightly known as Coral Paradise of India. The greatest potential of these islands lies in the promotion of tourism and therefore, the development of these islands would be extremely helpful in promoting tourism. In order to provide facilities for fishing industries and tourism and also for communication and transport, development of harbour facilities has been given priority by the Government.

2.1 Kalpeni and Androth Islands

Kalpeni and Androth islands [Figures 2 and 3] are situated at a distance of 297km and 293km respectively from Cochin Port on the west coast of India, Kalpeni has a beautiful lagoon having an area of 10.9 sq.km, fringed by a coral reef and is being developed as a tourist centre. Andorth is the biggest island with the largest population in the Lakshadweep group of Islands. Unlike other islands, Androth does not have any lagoon and the island itself occupies the interior of the coral reef. It is surrounded on all sides by a flat coral reef, which is exposed during low tides. Androth has the maximum cargo traffic. In addition to tourism, immense potential is available for industrial and fisheries development in Androth.

3.0 HARBOUR FACILITIES AT KALPENI AND ANDROTH

3.1 Kalpeni

The island of Kalpeni has an area of approximately 2.3 sq km and is located at a distance of 361 km from Mangalore Port from where the materials for breakwater construction is transported. The present harbour facilities provided on the western side of Kalpeni island are: a permanent RCC jetty of 149 metres [m] length, for berthing of vessels drawing upto 1.2m draft. The approach channel to the jetty is about 3500m long and except for the short stretch of about 300m in the proximity of the jetty, the channel has a depth of only about 1.4m which does not permit vessels drawing more than 1.8m to go alongside the jetty throughout the year. These facilites can be used only in fair weather season [October to May]. During rough weather, in south west monsoon, embarkation and disembarkation is carried out from eastern side where the sea is very deep immediately from the shore. To resolve this difficulty, model studies were conducted

at the Central Water and Power Research Station [CWPRS], Pune, India, for the development of Kalpeni island and a "L" shaped breakwater of 155m length was recommended for construction with the berth located on the leeside of the breakwater between contours of -3.5m and -4.0m [Figure 4]. With this, it will be possible to berth alongside the jetty ships having a draft of 1.8m. Construction of this breakwater is in progress at Kalpeni.

3.2 Androth

The island of Androth has an area of approximately 4.8 sq km and is situated at a distance of 257 km from Mangalore port. The harbour facilities presently available in Androth are on the northern side of Island where there is a shallow entrance which is used for maritime activities. These facilities consist of a permanent jetty of 77m length catering to vessels drawing upto 2.2m draft. Construction of two small breakwaters flanked on each side of the jetty; the western breakwater of 155m and the eastern breakwater of 120m length; was taken up in 1988. In addition, the cargo shed, passanger hall and suitable navigational aids for the vessels have been provided. Extensive model studies were conducted at CWPRS, for deciding the suitable alignment of the breakwater for further development. On the basis of these studies it was suggested to extend the western breakwater by 375m [total length 530m] to provide facilities for entry of vessels drawing upto 1.8m throughout the year [Figure 5]. This proposal would facilitate further development of the harbour basin to bring in vessels drawing upto 6.0m. In fact, studies by extending the breakwater beyond 350m, to a total length of 950m, were also conducted in case required in future. The construction of the 530m long breakwater is in progress.

4-0 DESIGN AND CONSTRUCTION OF BREAKWATERS

4.1 On the basis of studies conducted at CWPRS the design of breakwater at Kalpeni has been evolved to withstand the wave attack of about 5m high waves. The major portion of the length of the breakwater runs between -3m and -5m contours except the first 60m length, which extends upto -1m contour. The section for deep water consists of 8 tonne [t] tetrapods in the armour layer supported by a toe of 2 to 3t stones. The secondary layer stones consist of 500 to 1000 kilograms [kg] stones and the core consist of 10 to 100 kg stones. The super - structure over the breakwater consists of a roadway slab with a monolithic parapet of about 2.5m height. The details of the design are shown in Figure 4.

4.2 The breakwater at Androth has also been designed to withstand wave heights upto 5m and the major portion of the breakwater runs beyond -4m contour. The first 100m, however, are above the low water level. The section of the breakwater consists of 8t tetrapods in the armour layer supported with the a of 0.5 to 1.0t stones. The secondary layer stones and core stones consist of 100 to 300 kg and 10 to 100 kg stones respectively. Like Kalpeni, in this case also the super - structrure consists of a concrete roadway having a monolithic parapet of 2.5m height [Figure 5]. The initial reach of the breakwater consists of monolith concrete blocks, cast-in-situ for the length of about 50m. Beyond 50m to about 100m the section consists of 1.5t tetrapods in the armour layer.

4.3 Equipment Required

For constructing such breakwaters, ideally trawler mounted cranes which can travel over the rubblemound and have the capacity to place the 8t tetrapods at the desired distance, [about 20m] are required. Alternatively floating cranes of appropriate capacity are necessary. For the secondary layer stones and mainly the core, side dumping barges or bottom opening barges are essential. However, the equipment available with the Lakshadweep Authorities for construction of these breakwaters are very meagre. These consist of one jetty crane and some boats, at Androth and Kalpeni Islands. Another important factor is the requirement of facilities for loading [unloading] of construction materials - tetrapods, stones, cement etc; for transporting from shore to the actual site. For this purpose space is required to provide stacking yards, jetty, slipway, and appropriate equipment such as cranes, dump-barges, pontoons, loaders etc. The list of equipment procured for construction of breakwaters at these islands is given in Table I.

5.0 DIFFICULTIES ENCOUNTERED

As already mentioned, because of the typical location of the islands, all the materials for develomental works, even the essential commodities like ration, LPG etc for the day-to-day requirement for the public, are brought from the mainland [India]. In case of a port in mainland, for construction of such a breakwater the casting and the stacking yards, for concrete armour units like tetrapods are normally adjacent to the breakwater, on the shore. In case the tetrapods are to be cast on the island the difficulties are: there is acute shortage of land and no place is available for casting of tetrapods [particularly 8t and above] and no proper facilities exist for storing of construction materials such as granite jelly, river sand and cement. Yet another difficulty is the non-availability of fresh water which is required for casting and curing of tetrapods. Fresh water cannot be obtained for this purpose in the islands, since there are strict environmental regulations prohibiting tapping of ground-water on these islands. Some times the rain water is stored and used for this purpose but this has also some limitations. In view of these problems there is no option but to cast the tetrapods at the mainland - port and transport the same to the island. For transporting the materials a couple of steel pontoons and tugs are required. With all this, the total cost of one 8t tetrapod consisting of transportation from mainland to Androth/Kalpeni Islands including casting and placing, works out to Rs. 8790.00. The same tetrapod would cost about 40% less on a main land-breakwater. A peculiar difficulty is sometimes encounterd on transporting the tetrapods to the islands. At many of the islands, double handling is required since the tetrapods are brought on the eastern side of the island, where the sea is relatively deeper near the shore and these pantoons can be brought closer to the island for unloading. Then the tetrapods are carried to the western side, to the site of construction, thus requiring double handling. All these factors obviously increase the cost of tetrapods vis-a-vis the total cost of the project. Since such costly projects cannot be executed with the limited funds, a trade-off needs to be struck in which either small size of tetrapods requiring no transportation cost are to be used. Use of small tetrapods makes the breakwater

stable only upto certain wave heights smaller than the design wave height, contemplated earlier. It must be pointed out here that such structures, which are constructed in remote areas are required to be designed ensuring the maximum safety of the structure as well as minimising the maintenance. Similarly rocks of different categories are also required to be brought from the mainland and placed directly at site. This operation, however, reduces the working time of construction of the breakwater because construction has to be adjusted with tidal stages for appropriate depth/draft requirement. Cumulative result of all these difficulties is that the project takes longer time for completion and the cost also increases.

6.0 ALTERNATIVE TO RUBBLEMOUND BREAKWATER

As an alternative, if caisson type breakwaters are considered at the Islands, instead of rubblemound breakwaters, the same are to be designed to withstand about 70% higher waves than the designed wave height for rubblemound breakwater. This precaution needs to be taken since a caisson type breakwater is a rigid structure and the failure of the same would amount to failure of complete breakwater/port. In case of rubblemound structures which are flexible structures, some amount of damage can be accepted without affecting the functioning of breakwater/port. In case of caisson type breakwaters, the caissons are required to be towed from the dock [where it is constructed] to the site and then sunk at site. This involves skill, sophisticated equipment and additional time since the towing and sinking operation has to be adjusted with tidal stages as also the wave climate.

Two caissons of sizes 25 x 10 x 12 metres and 15 x 10 x 8 metres were considered as alternative to rubblemound. The bigger size caisson would be used in deeper reach while the small size would be used in shallow reach of the alignment. The costs of the rubblemound breakwater and the caisson type breakwater at the same location [island] are indicated in Table II.

7.0 PRESENT STATUS AND CONCLUDING REMARKS

7.1 At Kalpeni, presently only 6 monolith blocks out of the initial portion of 45m length consisting of 9 concrete monolith blocks, have been completed. In order to allow for a smooth operation of the crane, the crest levels at the shore and that of the last concrete block are, being adjusted. This would provide a slope of 1:20 which would allow easy movement of crane/vehicles. Construction of rubblemound beyond concrete blocks is in progress. It would be necessary to protect this partly constructed breakwater by a temporary roundhead before the onset of monsoon. At Androth, out of the 530 m long breakwater, the initial 155m length consisting of 1.5 t tetrapods in the armour, had been already completed and additional 85 metre length beyond this has been completed by dumping only core stones and secondary stones, by end-on method during the last season. A temporary roundhead would need to be constructed at the end of the partly constructed breakwater to prevent damage during the monson.

Due to certain constraints at the mainland port, from where the material is transported to the islands, the cost of 8 t tetrapods

is likely to be increasd further. This is expected to affect the construction programme as the funds available for construction are limited, however, some adjustment would be made to continue the programme of construction. There is also a difficulty in obtaining the fresh water for casting and curing of tetrapods/concrete blocks. Some arrangements for storing rain water are being made, so that the casting and curing of concrete blocks and small tetrapods could be continued. Due to shortage of materials, time and other constraints, the other connected works such as foreshore works, providing concrete road slabs for the rubblemound portion already completed, would be taken up simultaneously with the dumping of stones and placing of tetrapods in the deeper reaches so as to complete the construction programme within the stipulated period. Moreover, the gradation of stones are chosen so as to be continuous i.e. 10-100 kg, 100-500 kg, 500-1000 kg, in order to make the maximum use of the quarry output.

7.2 In view of the peculiar location of the islands and their strategic importance, these harbour facilities would be the only essential basic amenity for the development of islands. The economic viability in terms of cost benefit ratio of this project, therefore, need not be given importance. The project will provide employment opportunities to a number of islanders who otherwise have to depend only on the fishing and coconut plantation [which are affacted by vagaries of nature]. The only goal of providing all weather facilities at these islands is to give a boost to the morals of the islanders and help the Government as well as the islanders to plan further development of the Islands.

8.0 ACKNOWLEDGEMENTS

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9.0 REFERENCES

[1] Development Project Reports of Kalpeni and Androth Islands prepared by Lakshadweep Harbour Works for Kalpeni and Androth Islands

[2] Navigation Study for the Proposed Harbour Facilities at the Lakshadweep Islands, prepared by Delft Hydraulics for Government of the Netherlands, Ministry of Foreign Affairs [Directorate General for International Development Cooperation]

TABLE -I

EQUIPMENT PROCURED FOR CONSTRUCTION OF BREAKWATERS AT KALPENI AND ANDROTH ISLANDS

Sr.No.	Particular	Quantity
i]	Hopper barges - 25 t capacity - -	2 Nos.
ii]	Dump barges - 50 tonne capacity - -	2 Nos.
iii]	Tugs - -	1 No.
iv]	Pontoon mounted cranes - 12 t capacity - -	1 No.
v]	mobile crane - 12 t capacity - -	2 Nos.
vi]	Gantry crane - 10 tonne capacity - -	1 No.

TABLE II

COMPARISON OF COSTS OF RUBBLEMOUND AND CAISSON TYPE BREAKWATERS [Length 375 m]

1] RUBBLEMOUND BREAKWATER

i]	Stones	Rupees.	1,61,17,130.00
ii]	Transporting of stones	Rupees.	7,07,76,536.00
iii]	Casting of Tetrapods etc.	Rupees.	2,87,43,990.00
iv]	Transporting of tetrapods, etc.	Rupees.	1,13,64,330.00
v]	Concrete parpapet and contingencies	Rupees.	1,48,21,952.00
	Total	Rupees	14,18,23,938.00

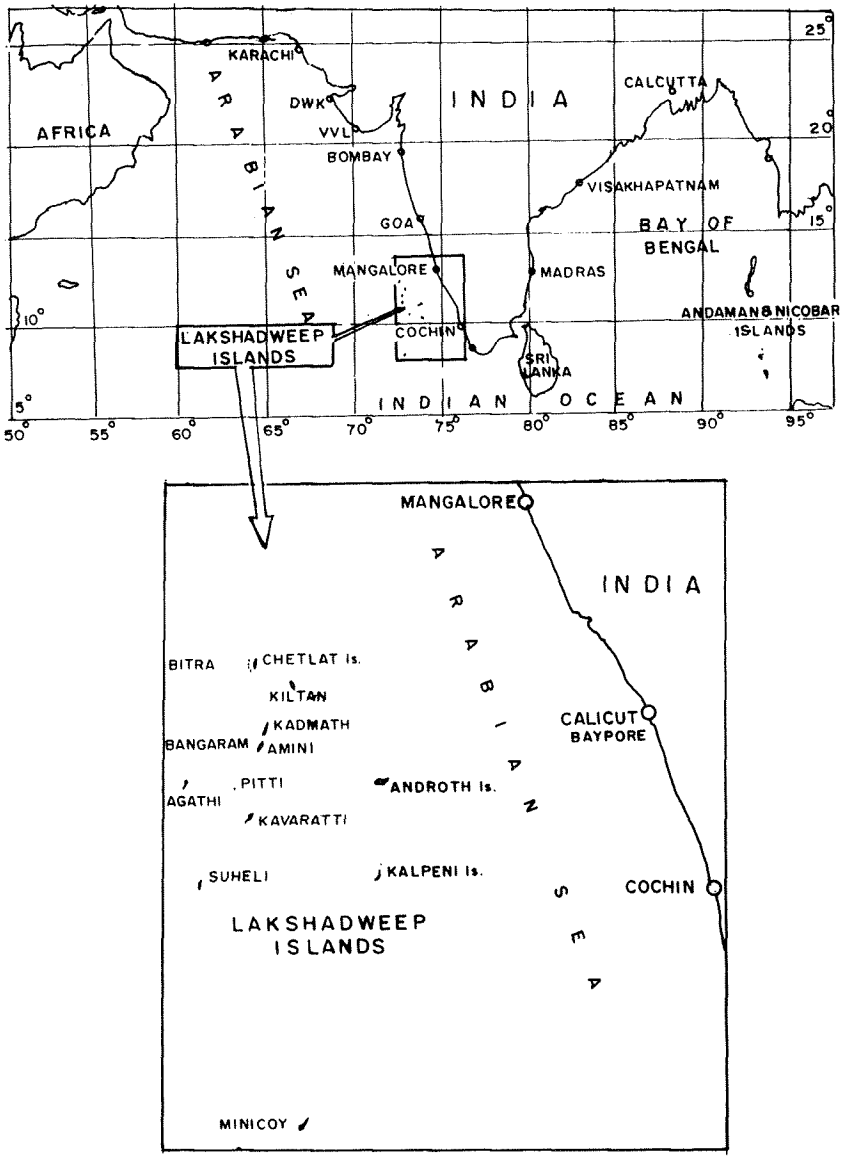
Cost per metre length = Rs. 3,78,200.00 (US $1 = Rupees 32/-)

2] COST OF CONCRETE CAISSON [Two units: 25 x 10 x12m and 15 x 10 x 8m sizes]

i] Concrete and other materials	16,79,292.00
ii] Transporting charges of caissons from Mainland to Islands	1,15,65,000.00

Total cost for full length Rs. 27,66,62,825.00

Cost of caisson breakwater per metre length = Rs. 7,37,765.00



LAKSHADWEEP ISLANDS

FIGURE 1 : INDEX MAP AND LOCATION PLAN

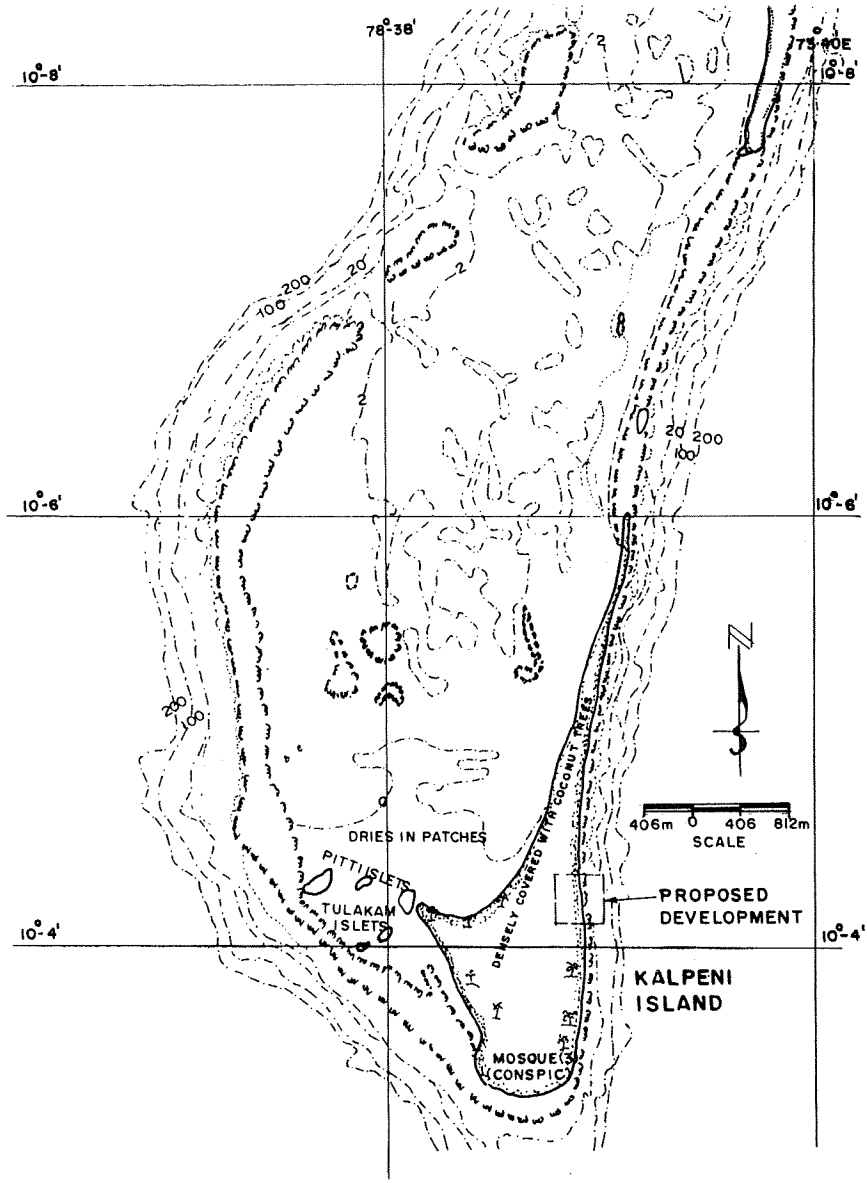


FIGURE 2 : KALPENI ISLAND

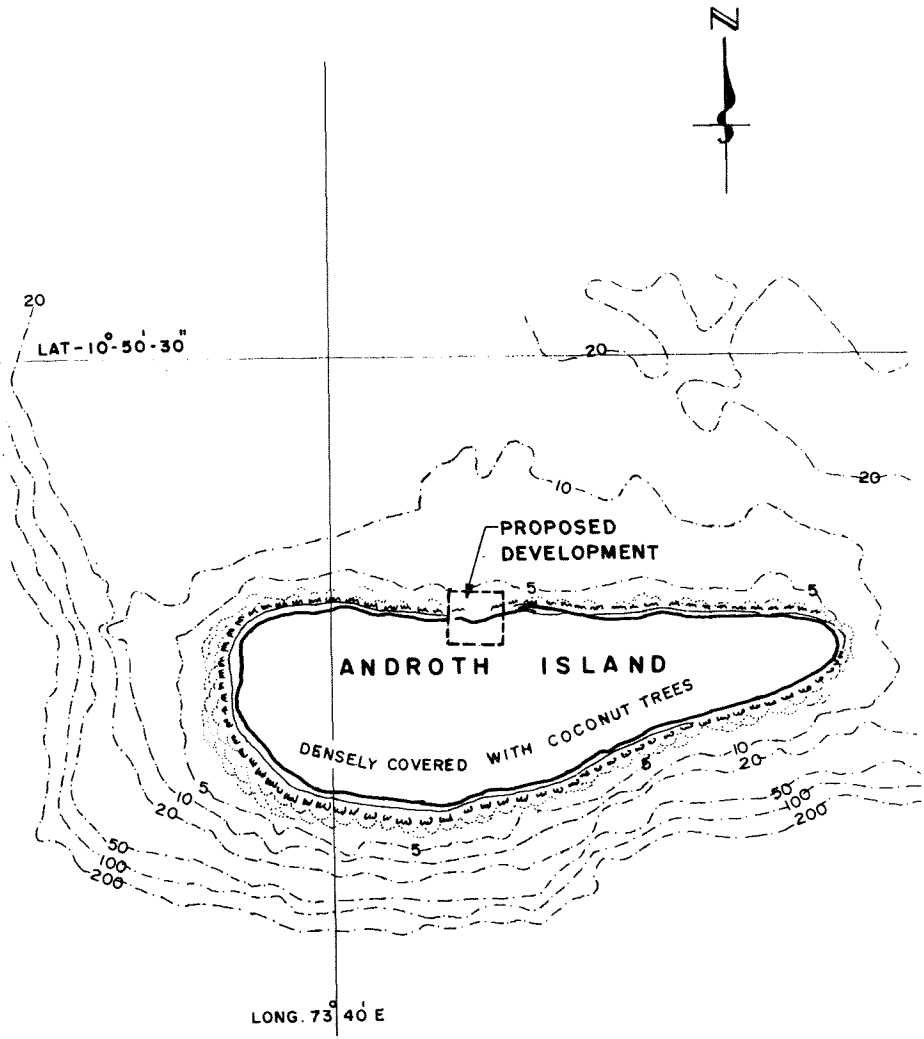
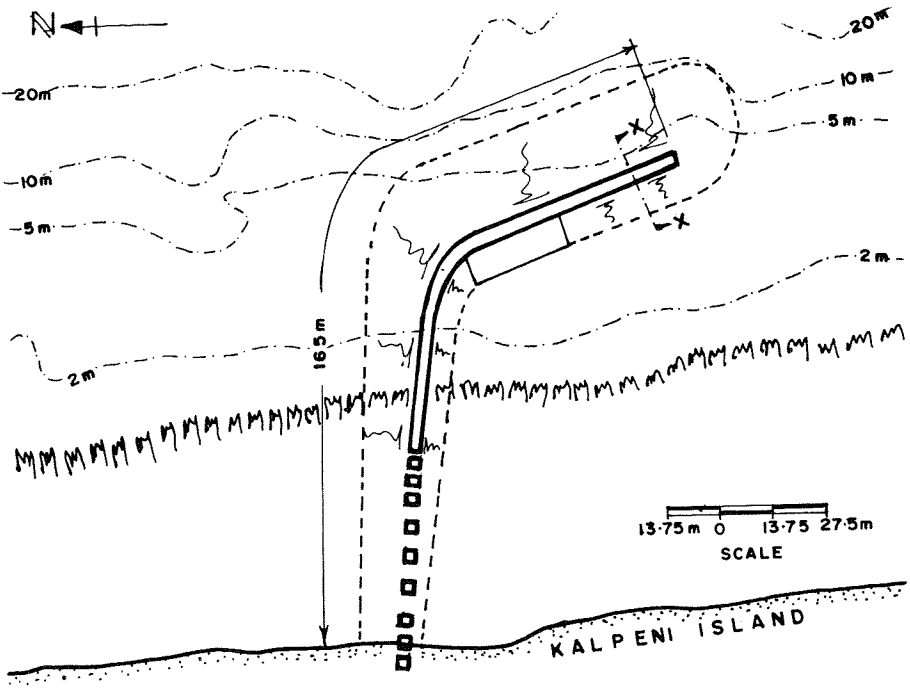
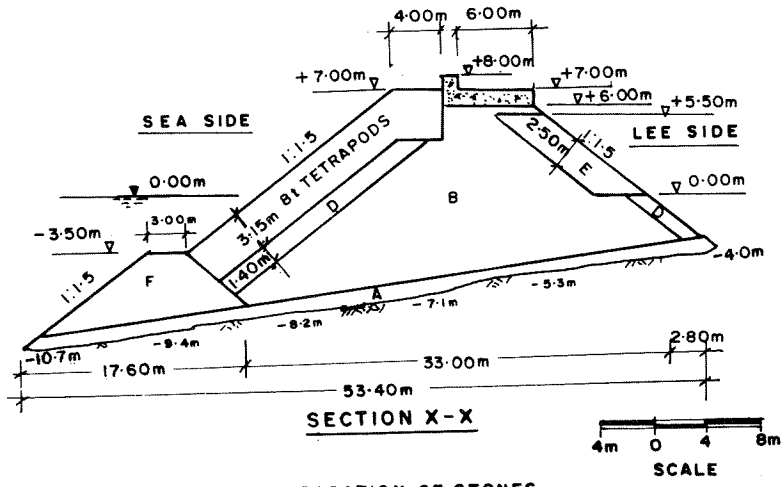


FIGURE 3: ANDROTH ISLAND

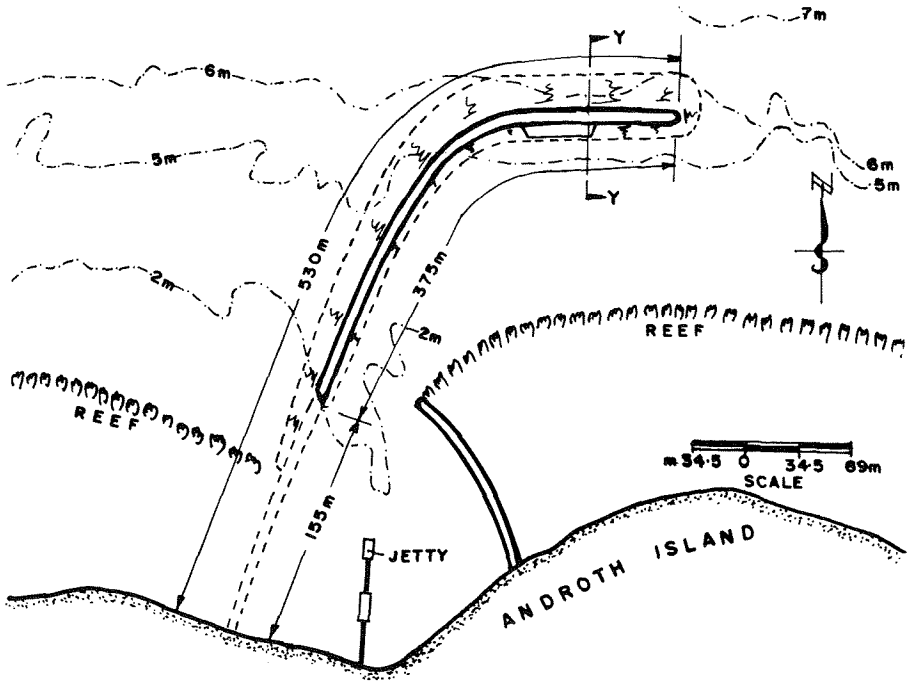


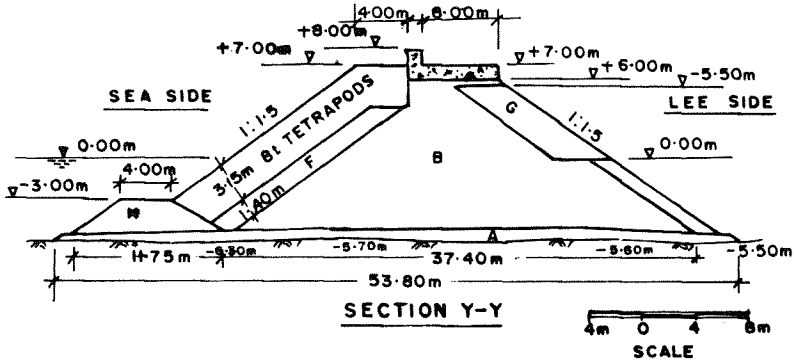


GRADATION OF STONES

A - 1 TO 10Kg	D - 500 TO 1000Kg
B - 10 TO 100Kg	E - 1 TO 2t
C - 100 TO 500Kg	F - 2 TO 3t

FIGURE 4: LAYOUT AND DESIGN OF BREAKWATER, KALPENI Is.

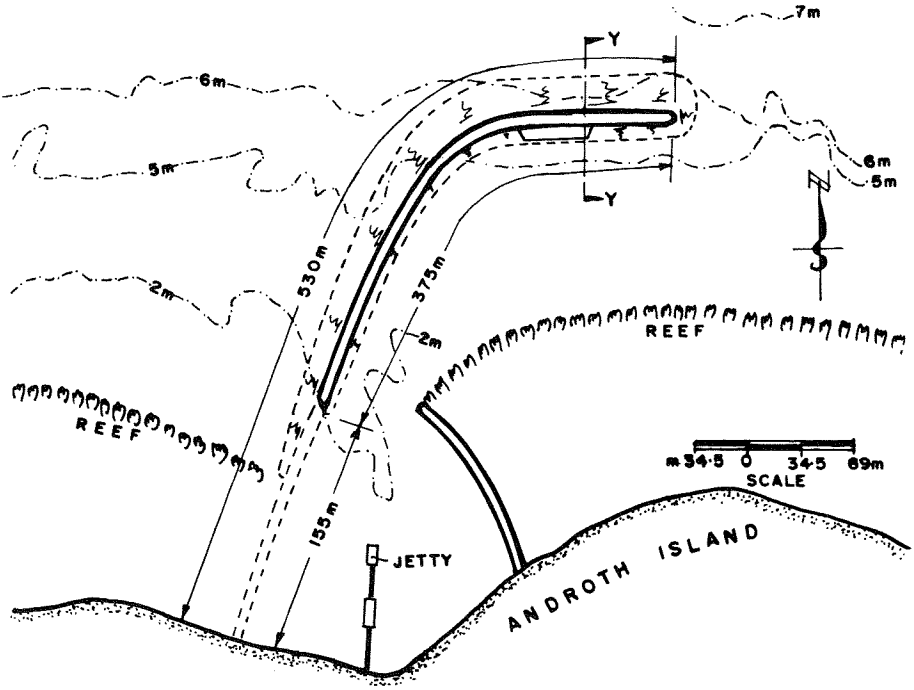


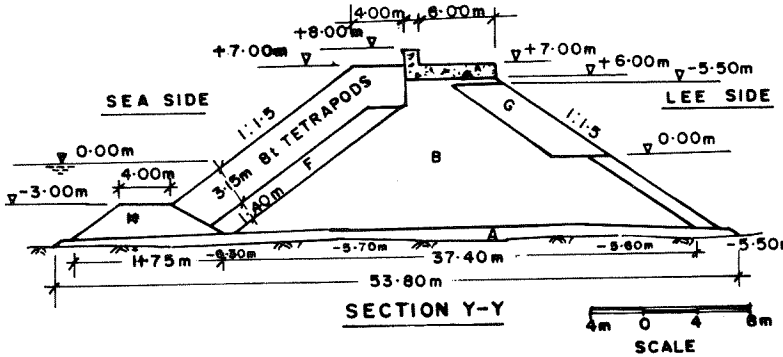


GRADATION OF STONES

A – 1 TO 10Kg	E – 600 TO 1000Kg
B – 10 TO 400Kg	F – 500 TO 1000Kg
C – 100 TO 300Kg	H – 1 TO 2t
D – 300 TO 600Kg	G – 2 TO 3t

FIGURE 5 : LAYOUT AND DESIGN OF BREAKWATER, ANDROTH Is.





GRADATION OF STONES

A – 1 TO 10Kg	E – 600 TO 1000Kg
B – 10 TO 600Kg	F – 500 TO 1000Kg
C – 100 TO 300Kg	H – 1 TO 2t
D – 300 TO 600Kg	G – 2 TO 3t

FIGURE 5 : LAYOUT AND DESIGN OF BREAKWATER, ANDROTH Is.