Annex F: New Facilities for Shore Protection and Rehabilitation

F.1 Facility Layout Maps

Figures F.1.1 to F.1.7 show the layout of shore protection facilities, which are presented in 5.6. The isobaths drawn in the figures are based on the bathymetric maps prepared by PROIECT S.A., CONSTANȚA in 1997. The present isobaths are expected to be different from those in these figures. When future projects are implemented with the facility plan in the Study, field studies of bathymetric and topographic surveys and inspection of existing structures should be carried out for reevaluation of the appropriateness of the proposed facility plan.

F.2 Preliminary Design of Standard Cross Sections

(1) Principles of structural design

The structural types of proposed facilities have been selected in consideration of the following fundamental conditions and on-site situation:

1) Construction materials that are easily purchased on site are chosen to reduce the construction cost.
2) In Romania marine construction works are not executed frequently and mobilization of working vessels for marine construction is rather difficult. It is expected that a few domestic vessels may not be operational for all the time. Therefore, selection is made for the facilities of structural types that can be built with construction equipment on land.
3) Jetties are designed to have the capability to accommodate people for walking, fishing etc. just like many of the existing groins.
4) Breakwaters, jetties, and artificial reefs should have sufficient resistance against wave actions, because quite a number of existing groins and jetties mainly built with stones have been damaged by waves.

The main construction material is stone. There are several limestone quarries at a distance of 50 to 60 km from Constanța in the north and some others exist in further north. They can produce a large amount of limestone and it is possible to get stones in 1 to 4 ton size. Granite, which is of better quality than limestone, can be obtained at a quarry in Sibiwara only. Existing groins and jetties are all built with limestone blocks, so that the structural type of rubble mound with limestone blocks is chosen as the principal design.

With regard to the second condition, the construction method of extending a rubble mound structure from the shore is selected as a standard procedure, except for submerged, detached breakwaters, i.e. artificial reefs.

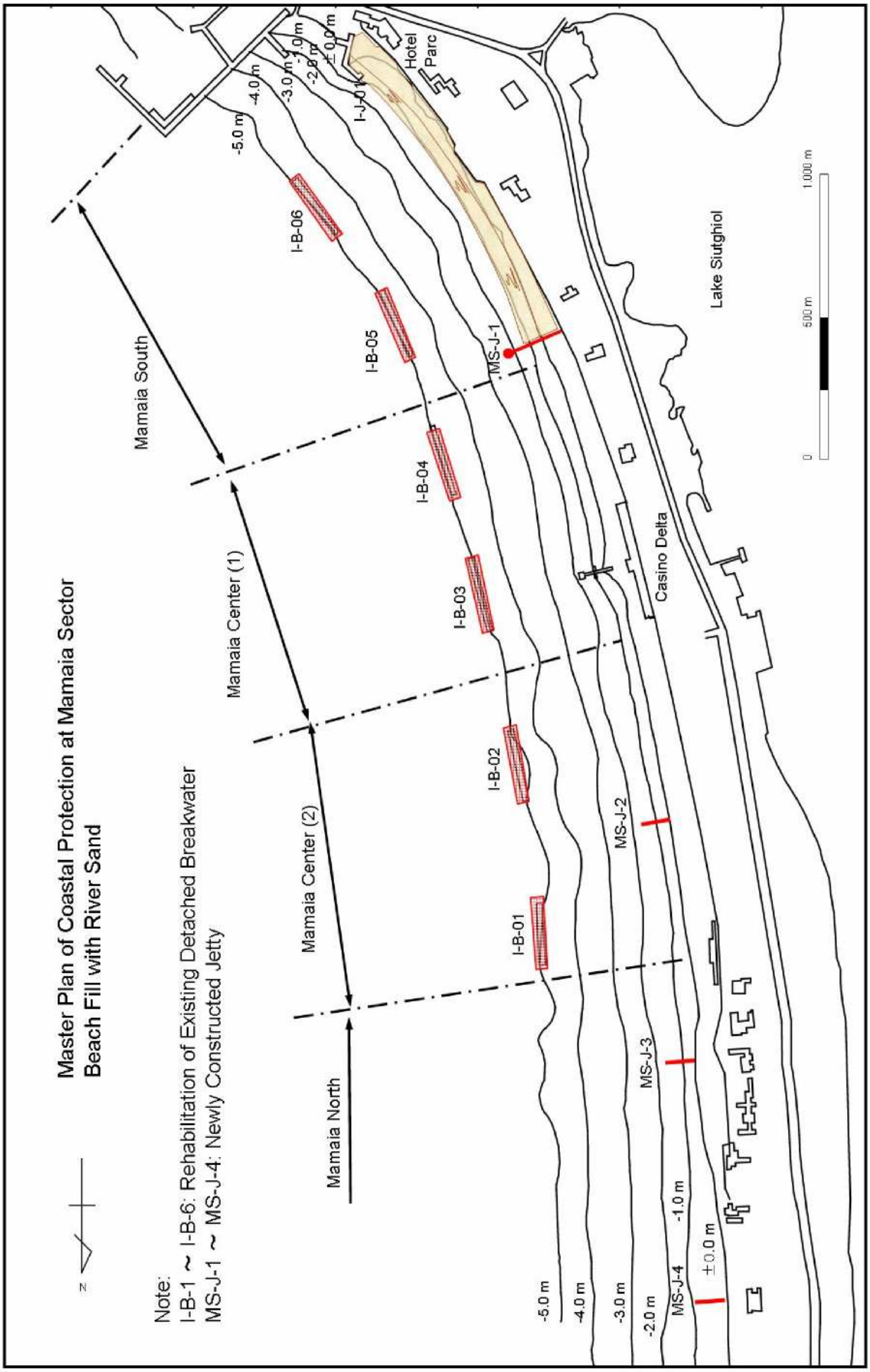


Fig. F.1.1(1): Master pan of coastal protection at Mamaia sub-sectors (beach bill with river sand)

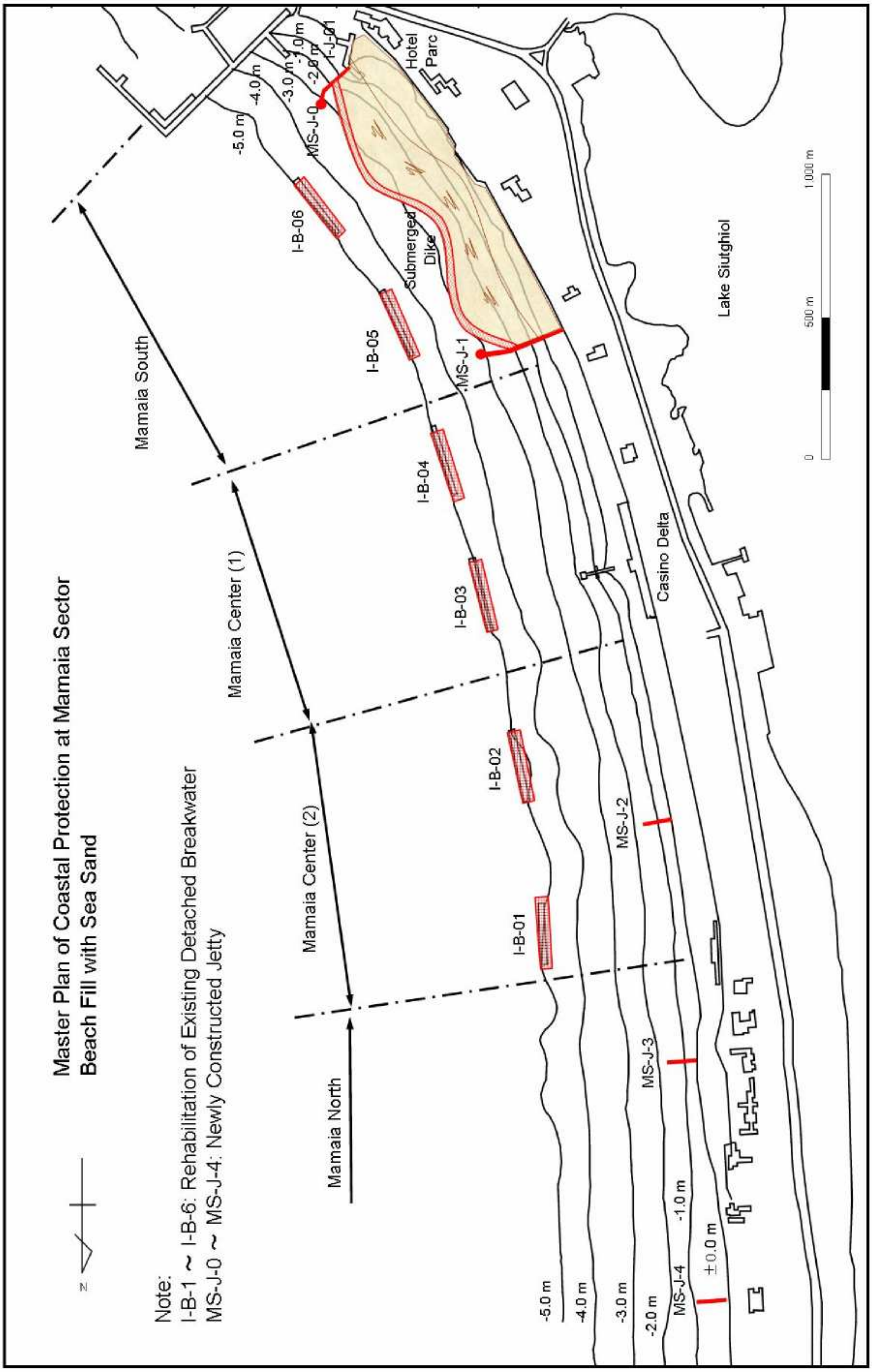


Fig. F.1.1(2): Master plan of coastal protection at Mamaia sub-sectors (beach fill with sea sand)

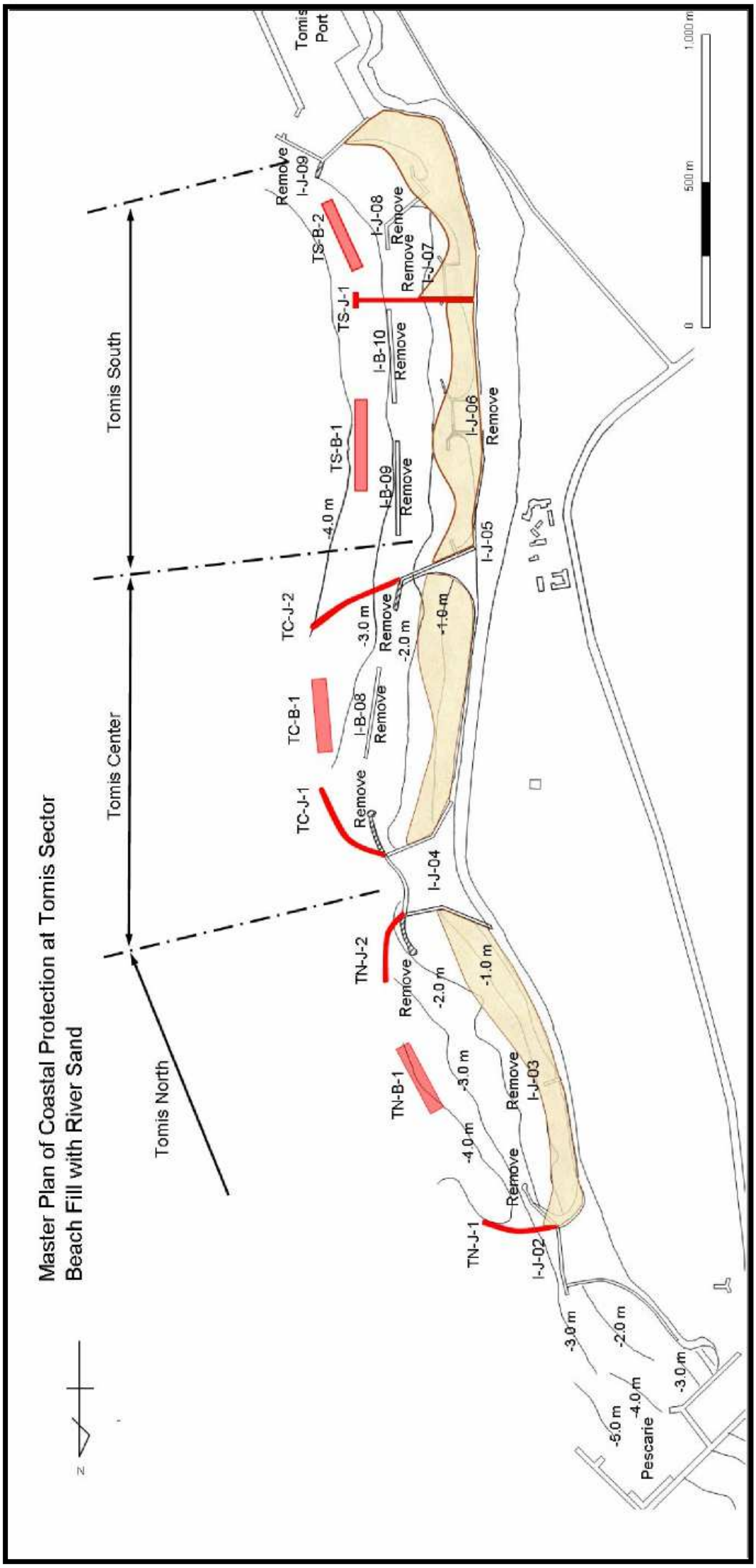


Fig. F.1.2: Master Plan of coastal protection at Tomis sub-sectors (Beach Fill with River Sand)

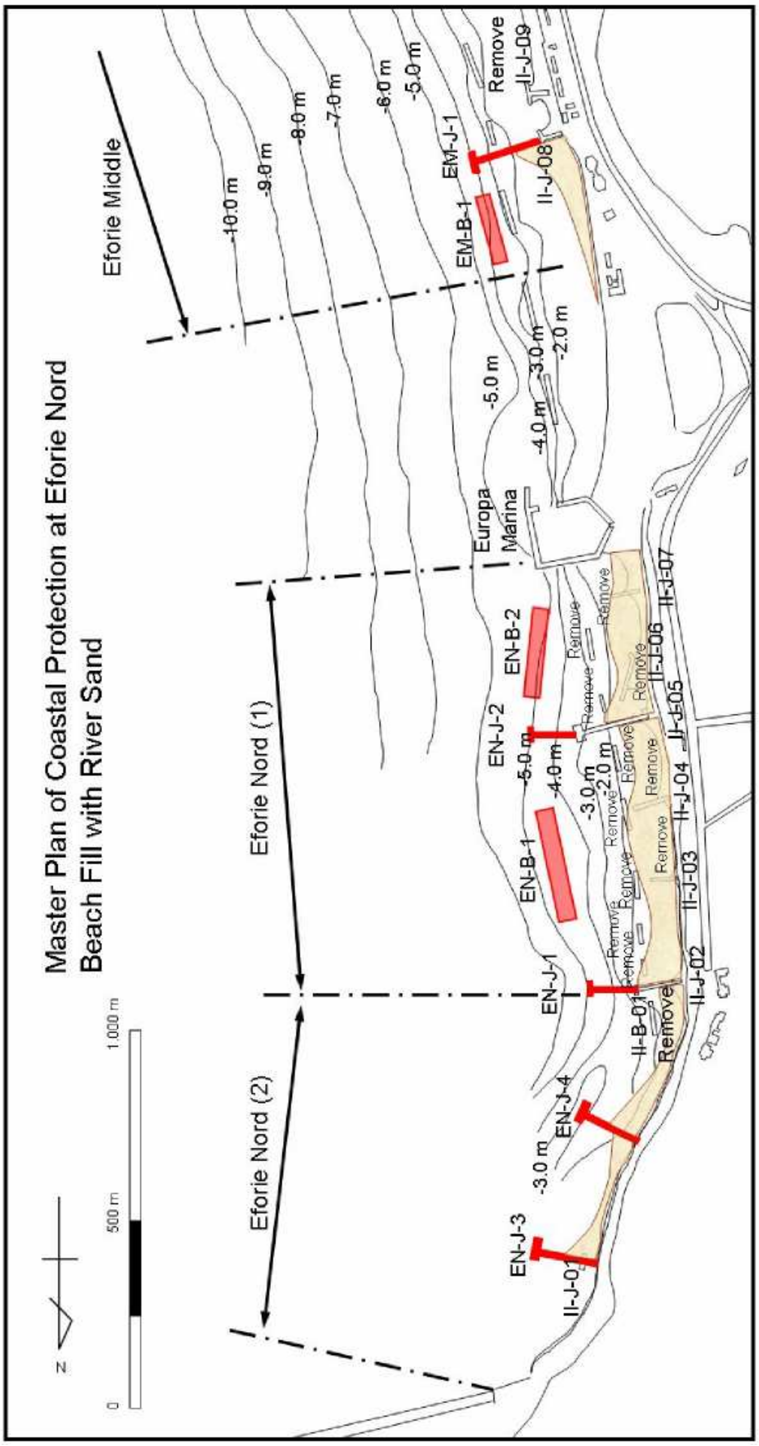


Fig. F.1.3 (1): Master Plan of coastal protection at Eforie Nord (beach fill with river sand)

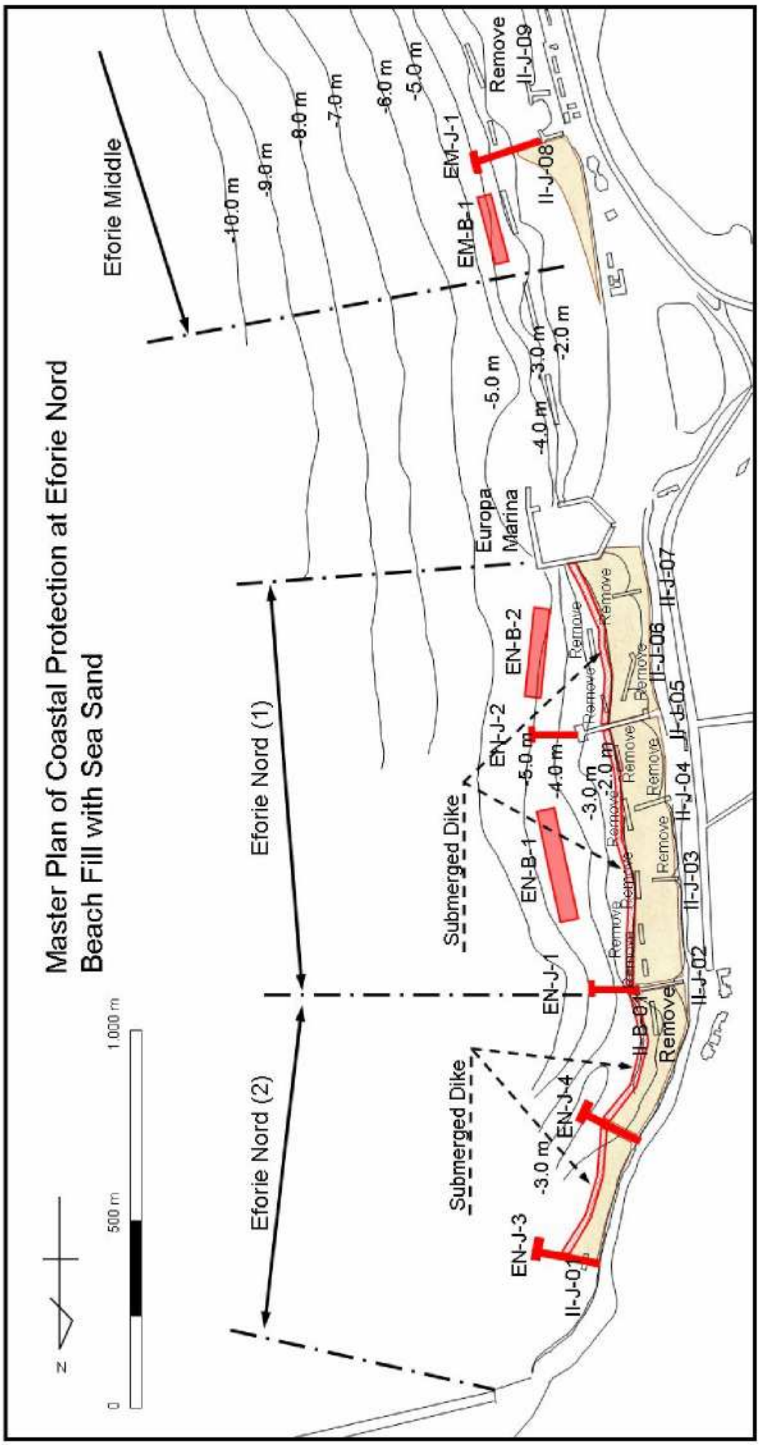


Fig. F.1.3(2): Master plan of coastal protection at Eforie Nord (beach fill with sea sand)

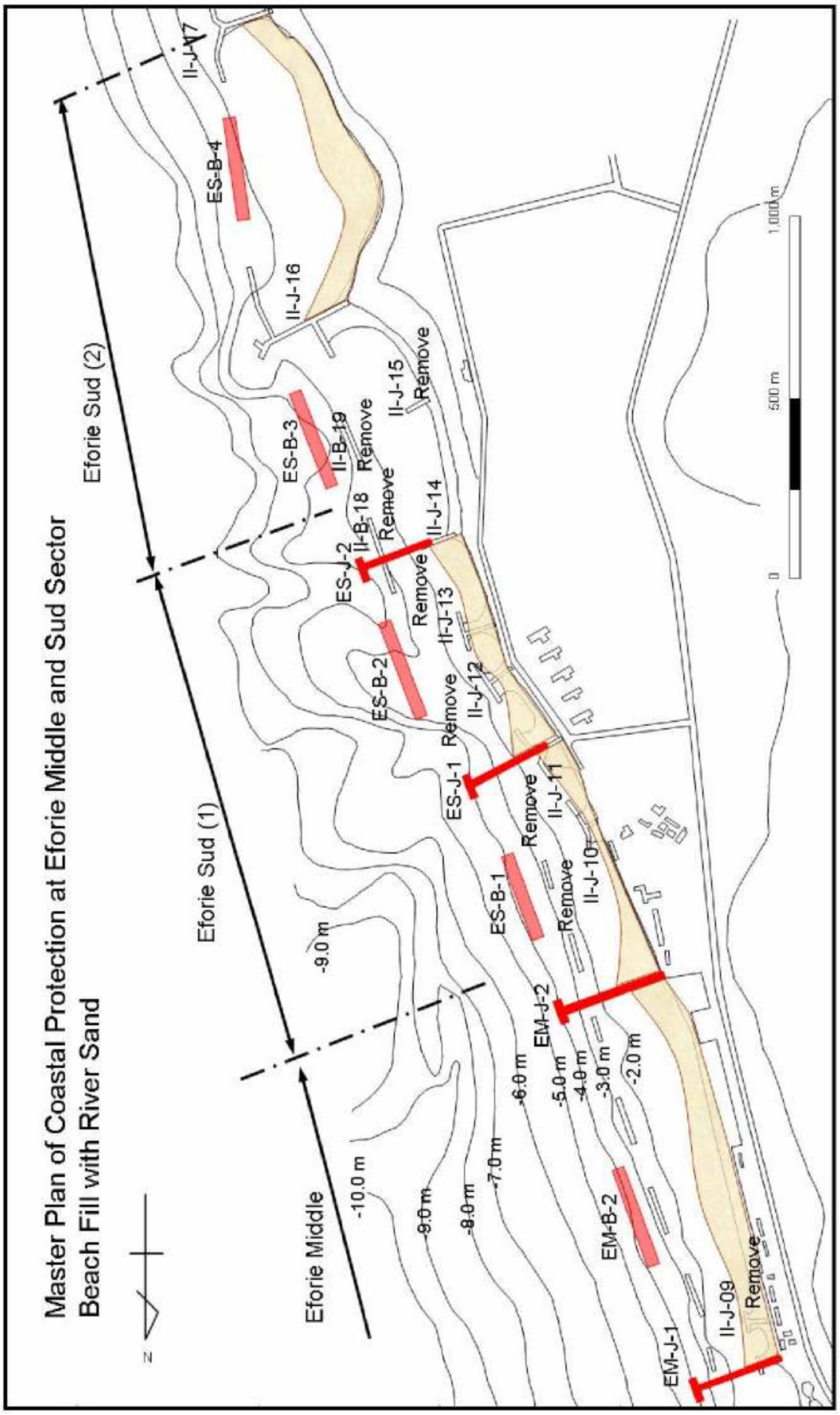


Fig. F.1.4: Master Plan of coastal protection at Eforie Middle and Sud Sector (beach fill with river sand)

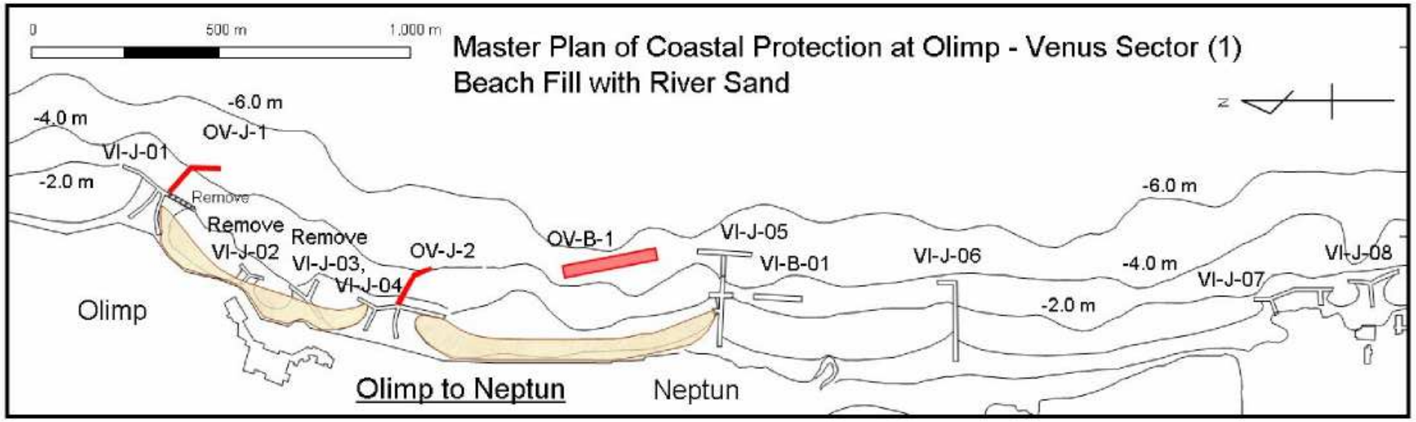


Fig. F.1.5: Master plan of coastal protection at Olimp-Venus sub-sectors (1)

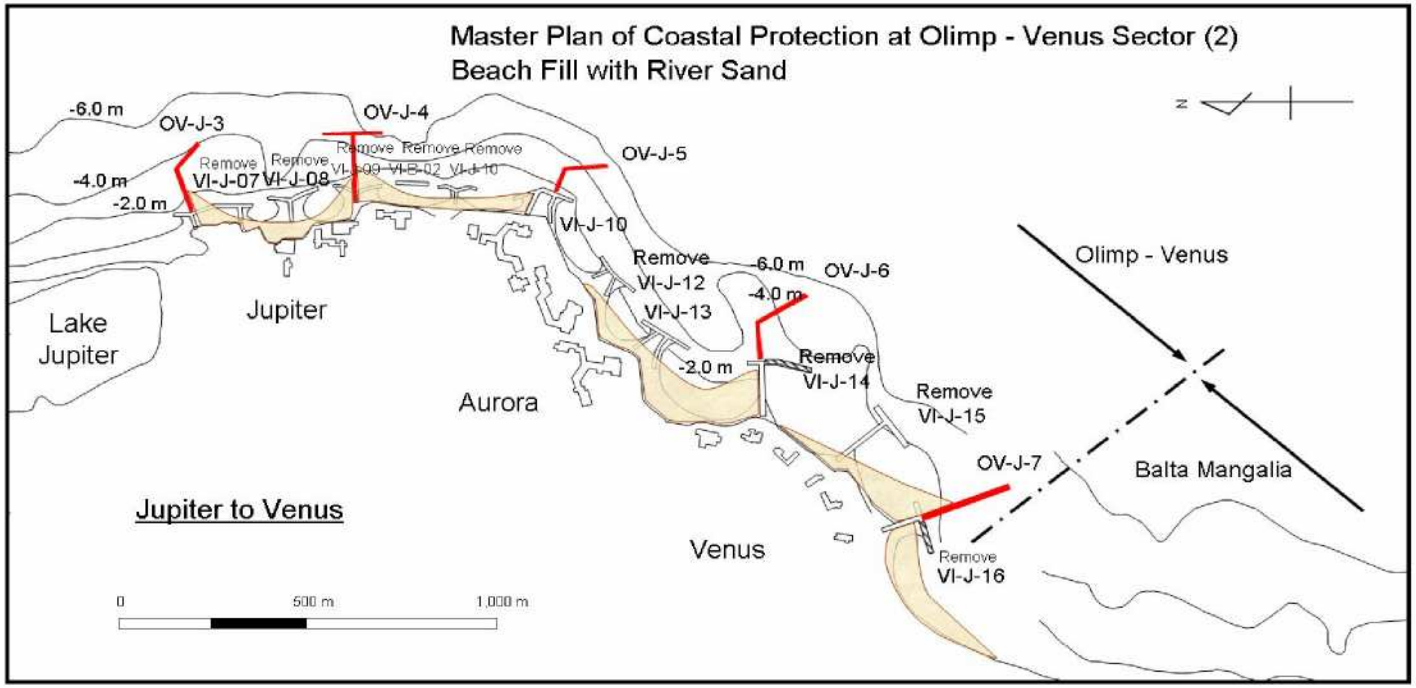


Fig. F.1.6: Master plan of coastal protection at Olimp-Venus sub-sectors (2)

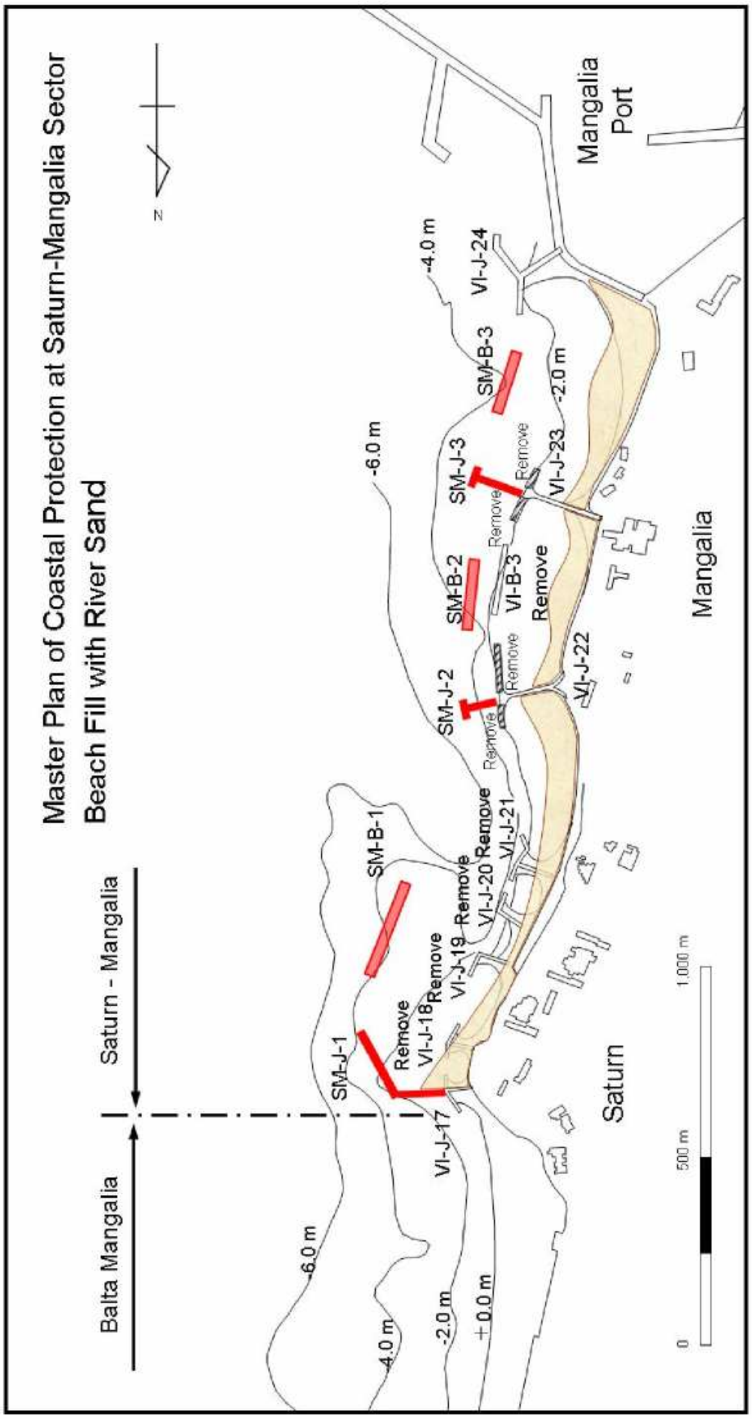


Fig. F.1.7: Master plan of coastal protection at Saturn to Mangalia

Most of existing groins are paved on their crowns with cast-in-place concrete of 20 to 30 cm thick and 3 to 4 m wide, upon which people can walk. However, the majority has been damaged with breakage, cracking, and/or scouring of foundation rubble stones. Therefore, pavement will be made with 1.0 m thick concrete to the isobath of about –2.0 m.

One reason of the damage of existing facilities by wave actions is an insufficient armoring of the slopes of rubble mound structures. Stabilopods are mostly placed in one layer and not exercising their interlocking functions. In the structural designs of proposed facilities, armor blocks are placed in two layers. For rubble armored structures, a gentle slope of 1 on 2 is adopted so that relatively small rubble stones can withstand the wave actions.

Standard cross sections of the proposed facilities based on the above design principles are shown in Figs. F.2.1 to F.2.12. In the following sub-sections, brief description is given for each structure.

(2) Rehabilitation of detached breakwater at Mamaia (Fig. F.2.1)

The breakwater was originally built as a mound type of breakwater made of concrete cube blocks with its seaward slope armored by 20-ton stabilopods. The crest elevation was +2.0 m above the datum level, but presently the crest is composed of a few legs of stabilopods exposed above the water, probably because of the general settlement or rolling down of stabilopods. Thus, the wave attenuation function of the breakwater is greatly reduced.

The most economical method for the rehabilitation of the breakwater will be to provide a mound of rubble stones behind the present deteriorated structure and to place 4.5-ton stabilopods in two-layer on top of it. Because incident waves will break on the seaward slope of the existing breakwater, waves attacking the newly placed 4.5-ton stabilopods will lose its energy and exercise less force on them. The stability number of stabilopods expressed in the K_D value of the Hudson formula is said to be 18. The significant wave height in the water of 5 m deep is estimated as $H_{1/3}$ ˜ 4 m, and the calculation based on the Hudson formula indicates the stability of 4.5-ton stabilopods at this water depth.

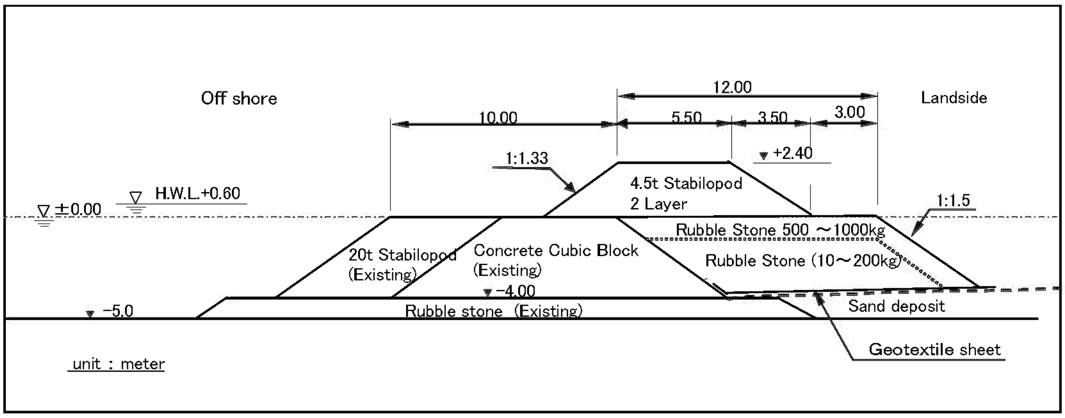


Fig. F.2.1: Cross section of rehabilitation of detached breakwater at Mamaia

(3) Sand-retaining groin at Mamaia South, MS-J-1 (Figs. F.2.2 and F.2.3)

The cross section shown in Fig. F.2.2 is applied for the section between the head of groin and the onshore distance of 100 m from the head. The side slopes are armored with two-layered rubble stones of 500 kg in weight, but the head itself is proposed to be armored with 4.5-ton stabilopods because of intensive wave actions there. The core section of rubble mound is designed with the crest elevation of +1.0 m to enable easy construction works with power shovels and other construction equipment. The gradient of side slopes is set at 1 on 2 for stability of armor stones and easy access of people to water. The side slopes are provided with underwater aprons of 5 m wide for foot protection against scouring. A walkway of 3 m wide is provided on the crown section, which will be built by cast-in-place concrete of 1.0 m thick.

For the trunk section between the shore and the point of 100 m from the groin head, the width of the foot protection apron is reduced to 2.0 m, because of weaker wave actions there, as shown in Fig. F.2.3.

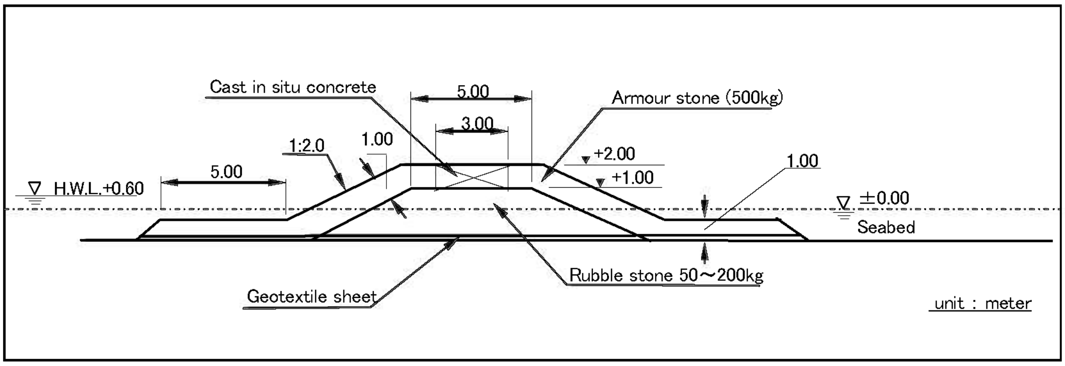


Fig. F.2.2: Cross section of sand-retaining groin at Mamaia South, MS-J-1 (1)
(offshore section of the length 100 m from the groin head)

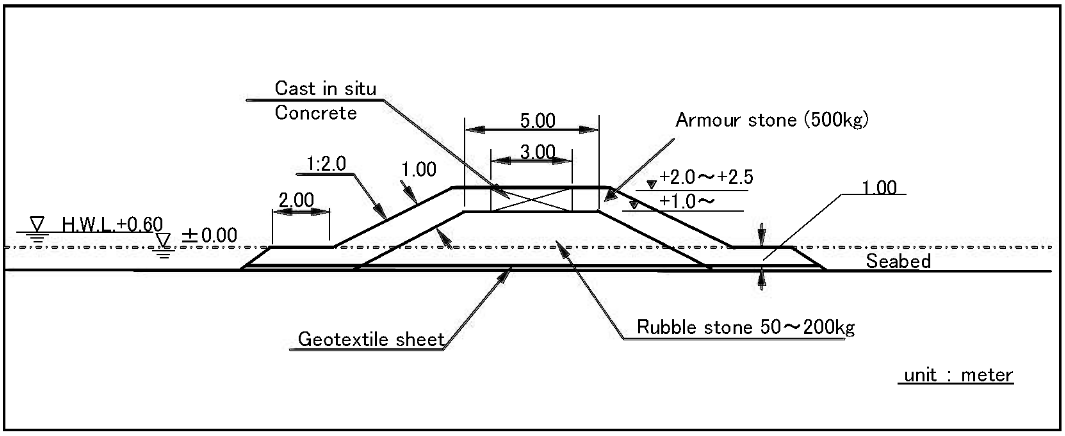
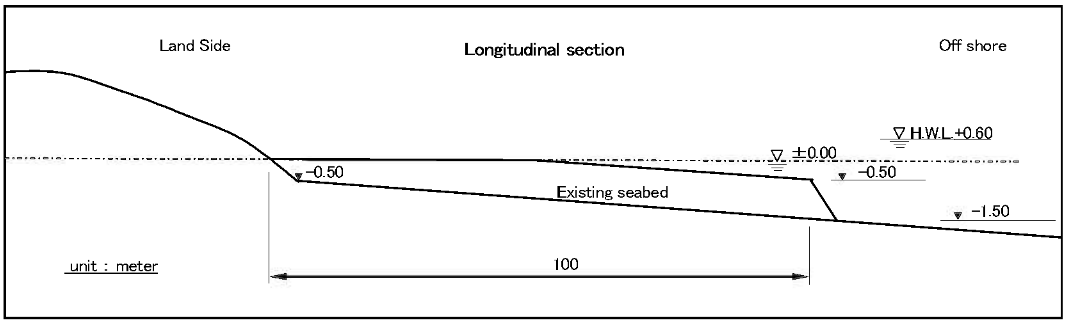


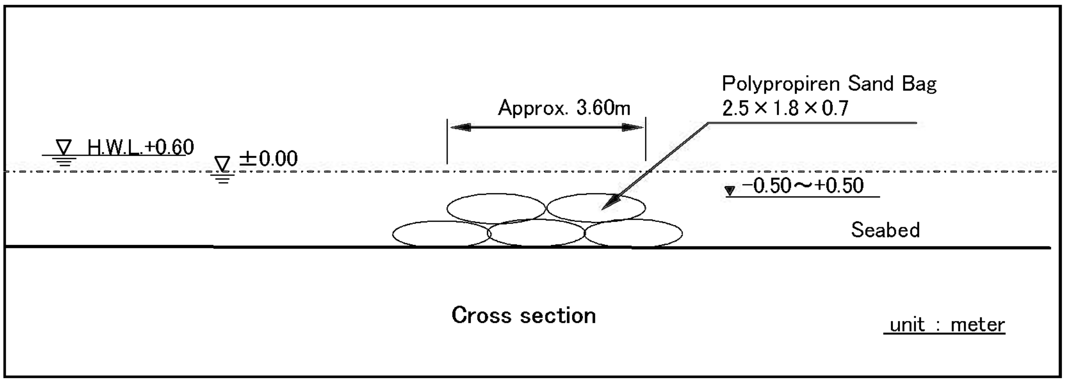
Fig. F.2.3: Cross section of sand-retaining groin at Mamaia South, MS-J-1 (2)
(trunk section between the shore and the point of 100 m from the groin head)

(4) Submerged groins at Mamaia, MS-J-2 to J-4 (Fig. F.2.4)

These groins are given the objectives of reducing the speed of longshore currents, which are the major factor responsible for alongshore sediment transport and beach deformation, either erosion or accretion. Because the net sediment transport in Mamaia Beach is toward the north as shown in Fig. 4.5.4, the sub-section of Mamaia Center is expected to experience intensive erosion by stopping of sediment supply from the south by the sand-retaining groin MS-J-1. By installing three submerged groins of MS-J-2 to J-4, the rate of the northward sediment transport will be reduced. The groins can be of simple structure because they are not intended to fully stop longhsore currents. Thus two layers of polypropiren sand bags filled with sand is selected as a structural type, and its crest is set at –0.5 to ±0.0 m. The length of these groins is planned to be 100 m.



(a) longitudinal section



(b) cross section

Fig. F.2.4: Groin MS-J-2, 3, and 4 at Mamaia

(5) Jetty type A (Fig. F.2.5)

This type of structure is applied for jetties at the head portion and the trunk section in relatively large water depth. The surface is armored with two-layered 4.5-ton stabilopods. The gradient of the slope is determined from the stability consideration, but the gradient of 1 on 1.33 is often employed for stabilopods.

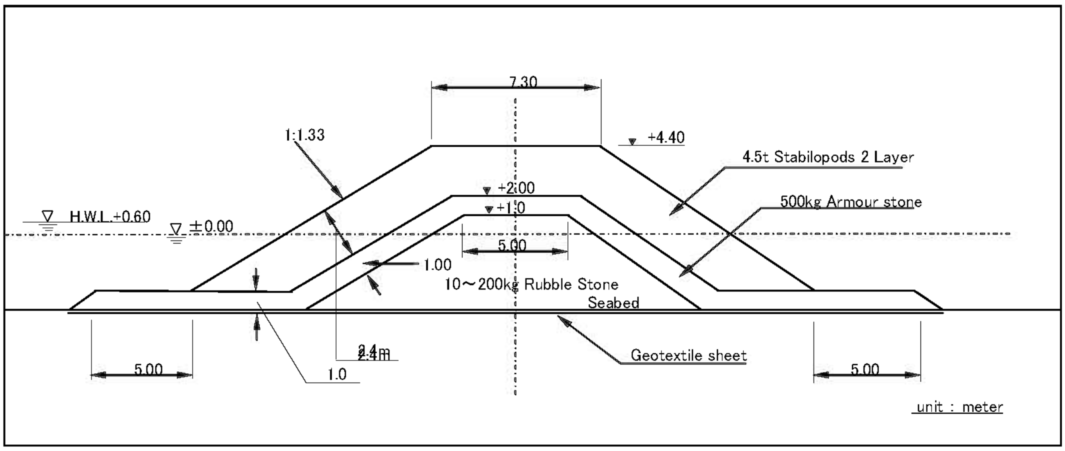


Fig. F.2.5: Cross section of jetty type A

(6) Jetty type B (Fig. F.2.6)

This type of structure is used for the portion of jetties that is located at the inner side of the curved section and not exposed to direct wave attacks. The seaward slope is armored with two-layered 4.5-ton stabilopods, but the landward slope is armored with rubble stones of 1 to 3 tons in weight against the impact of overtopped water and/or waves diffracted by the head of jetty.

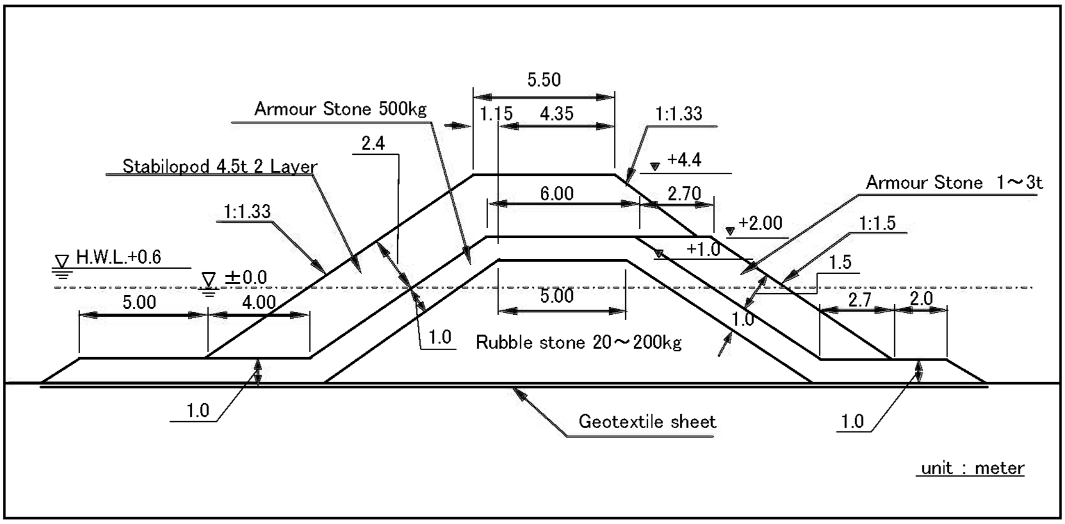


Fig. F.2.6: Cross section of jetty type B

(7) Jetty type C-1 (Fig. F.2.7)

This type of structure is used for the head section of jetties in the area where wave actions are relatively weak. The rubble stones of 1 to 3 tons in weight are placed in two layers for armoring. Actual size of rubble stones is to be determined by considering the degree of wave deformation based on detailed bathymetric surveys.

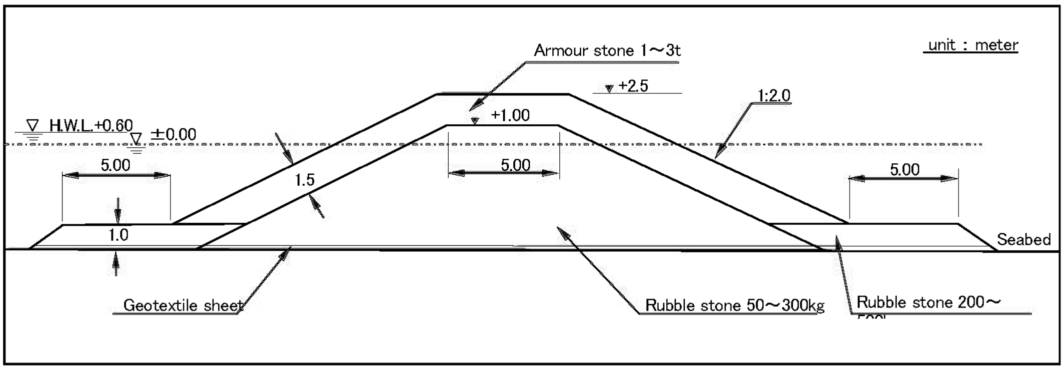


Fig. F.2.7: Cross section of jetty type C-1

(8) Jetty type C-2 (Figs. F.2.8)

This is the structure to be employed for the trunk sections of jetties in shallow water, where wave actions become weak. In the cost estimation of the proposed facilities of the coastal protection plan, this type of structure is used for the portion of jetties in water shallower than 2 m. As seen in Fig. F.2.8, a walkway is provided with thick concrete, but such a walkway is not provided in the jetty type C-1, because the wave actions are too strong for the walkway to maintain its integrity.

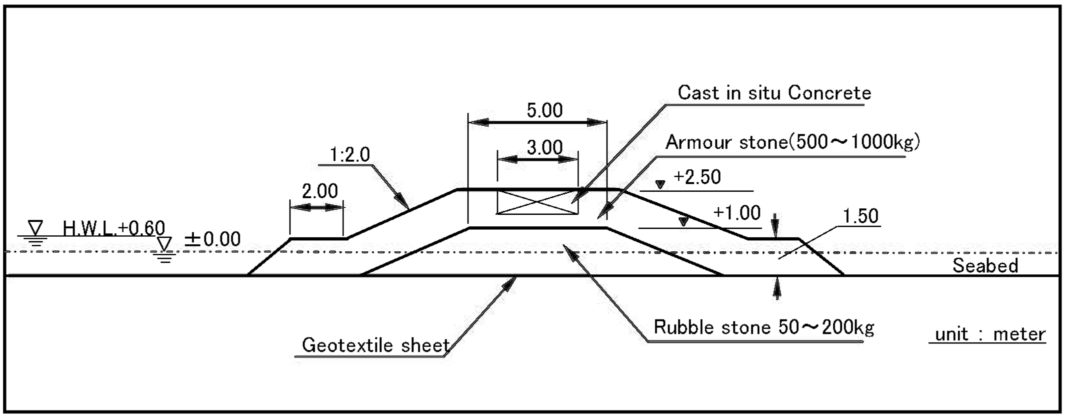


Fig. F.2.8: Cross section of jetty type C-2

(9) Jetty type E for rehabilitation of Jetty II-J-02 and Jetty II-J-05 (Fig. F.2.9)

The existing jetties II-J-02 and II-J-05 in Eforie Nord are preserved for the length of 100 m as the trunk sections of the new jetties EN-J-1 and EN-J-2, but they are in the deteriorated state, which require rehabilitation. The jetties II-J-02 and II-J-05 are made of rubble mound with concrete pavement of 0.3 m thick. The present damaged pavement is to be removed and a new walkway will be built with cast-in-place concrete of 1.0 m thick.

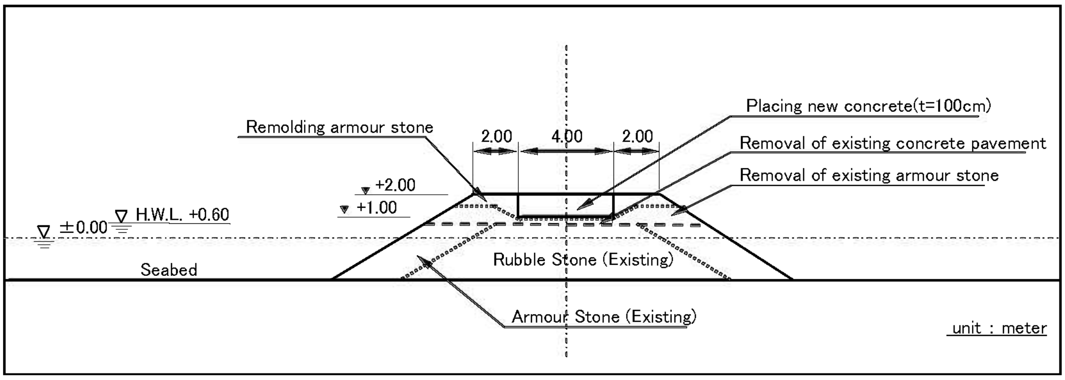


Fig. F.2.9: Cross section of type E [rehabilitation of jetty II-J-02(100 m), II-J-05(100 m)]

(10) Jetty type F for rehabilitation of Jetty II-J-05 (Figs. F.2.10)

The offshore portion of the existing jetty II-J-05 was built with concrete blocks and thin concrete pavement (0.3 m). However, the concrete pavement has been deteriorated by cracking, breakage, and washed-away. The crest elevation is about +1.0 m above the datum level, which is too low and allows wave overtopping and overflow. Thus, it is proposed to remove the whole deteriorated pavement and to cast fresh concrete directly on top of existing concrete blocks to the thickness of 0.8 m. The crest elevation will become +1.5 m, which is the same as the present wing section at the jetty head. Furthermore, mounds of rubble stones will be placed in the both sides of the existing concrete blocks for protection against scouring.

(11) Artificial reef (Fig. F.2.11)

Artificial reefs or submerged, detached breakwaters are installed offshore for the purpose of wave attenuation through the process of wave breaking over their crests. Thus, less wave energy reaching to the shore, beaches will become more stable against wave-induced deformation process of erosion and accretion. Their crests are designed to be located underwater, and they are invisible from people strolling on the beaches. It is a preferable structure from the aesthetic viewpoint, but the crest must be wide enough to ensure the required degree of wave attenuation. In the present study, the crest elevation is set at –0.5 m below the datum level in consideration of the lowest recorded water level of –0.30 m (see **3.3**).

The core portion should be built with various sizes of stones, using small stones at the bottom layer next to the seabed and increasing the size toward the surface. The top of artificial reefs is to be covered with concrete blocks specially designed for artificial reefs. The required size of concrete blocks depends on the wave conditions and the individual shapes of blocks. Manufacturer's recommendation for the block size should be respected.

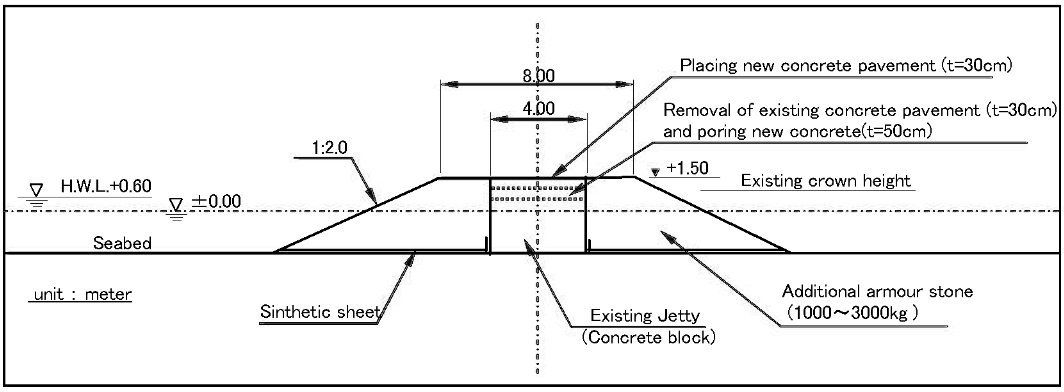


Fig. F.2.10: Cross section of type F [rehabilitation of jetty II-J-05 (100m)

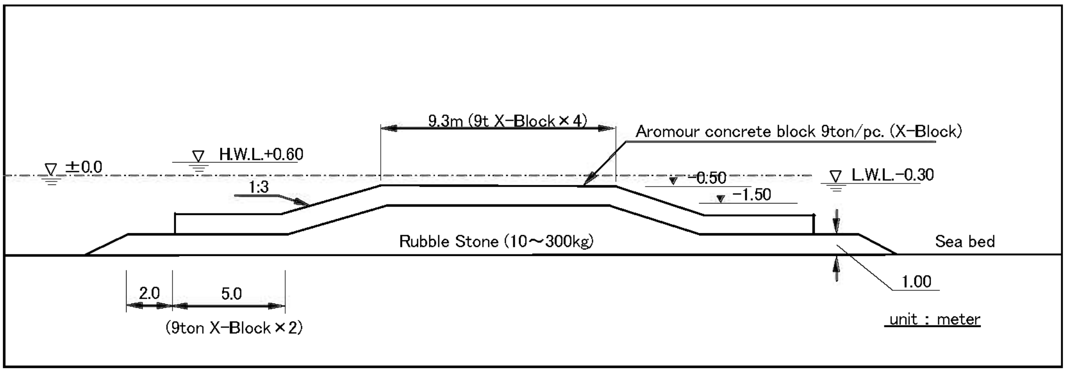


Fig. F.2.11: Cross section of submerged breakwater (artificial reef)

(12) Sand-retaining underwater dike (Fig. F.2.12)

This facility is employed when beach fill is carried out by using sea sand mined from the seabed off Midia Port or Sulina Channel, in case that authorization of river sand mining from the Danube is not issued before execution of the coastal protection projects at Mamaia South and Eforie Nord. Because the sea sand is of fine grain size and the beach profile with sea sand becomes very gentle, the filled beach section requires an underwater dike to retain sand within the beach area.

The location of dike installation and its crest elevation depend on the beach fill plan. The cross section shown in Fig. F.2.12 is a temporary one and will be modified during the feasibility study stage.

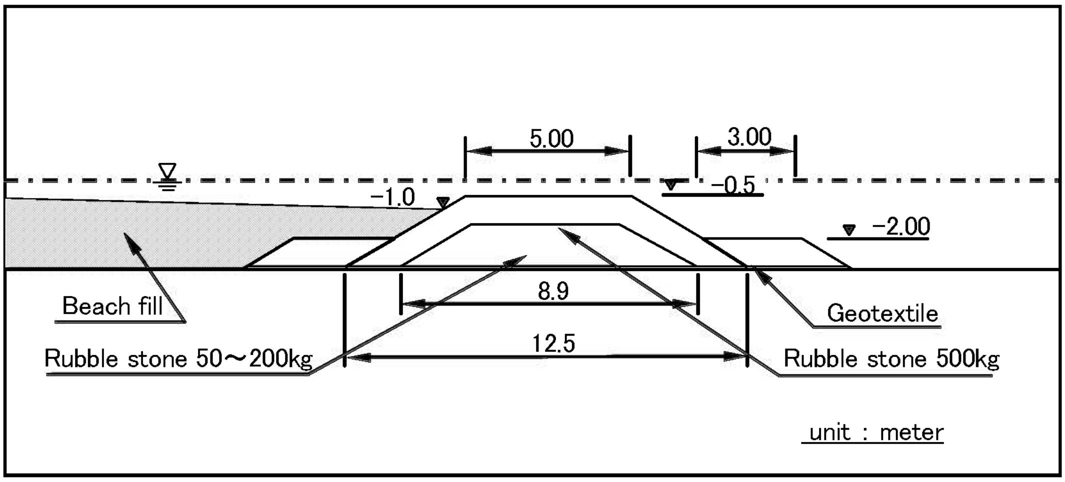


Fig. F.2.12: Cross section of underwater dike for beach fill

F.3 Conditions of Tentative Cost Estimate

The tentative estimate of construction cost listed in Table 5.8.1 has been made under the following conditions:

1) The prices of materials, labor cost, rental fees of construction equipment, etc. are based on quotations at the market price in 2005.

2) The cost of river sand is evaluated as delivered at the Basarabi wharf along the Danube – Black Sea Canal for the projects at Mamaia and Tomis, while river sand for the projects south of Eforie is thought to be delivered at Agigea (South Constanța Port). Sea sand is assumed to be dredged by a trailing suction hopper dredge at the eastern area off Midia Port, stored in her hopper, carried to the offshore of a beach fill site, and ejected to the fill area through floating pipelines activated by the dredge's pump.

3) The loss of nourished sand is estimated as 10% in ten years according to several cases in Japan, or 1% per year. This loss of nourished sand is to be re-supplied in each phase of coastal protection plan, and the cost of re-supplying sand is included in the maintenance cost.

4) The cost of operation and administration is estimated as 3% of the initial investment cost, according to several past examples.

5) The cost of removing present facilities is based on the available drawings of standard cross section collected during the Study, because the detailed survey of existing structures were not undertaken.

6) The cost of rehabilitation of the existing facilities in the Mangalia Sector from Olimp to Mangalia for those requiring rehabilitation is assumed to be one half of the jetty type B (Fig. F.2.6), which has some similarity with these existing facilities.

7) The construction cost includes the profit and expenses incurred, which are assumed to be 25% of the net cost.