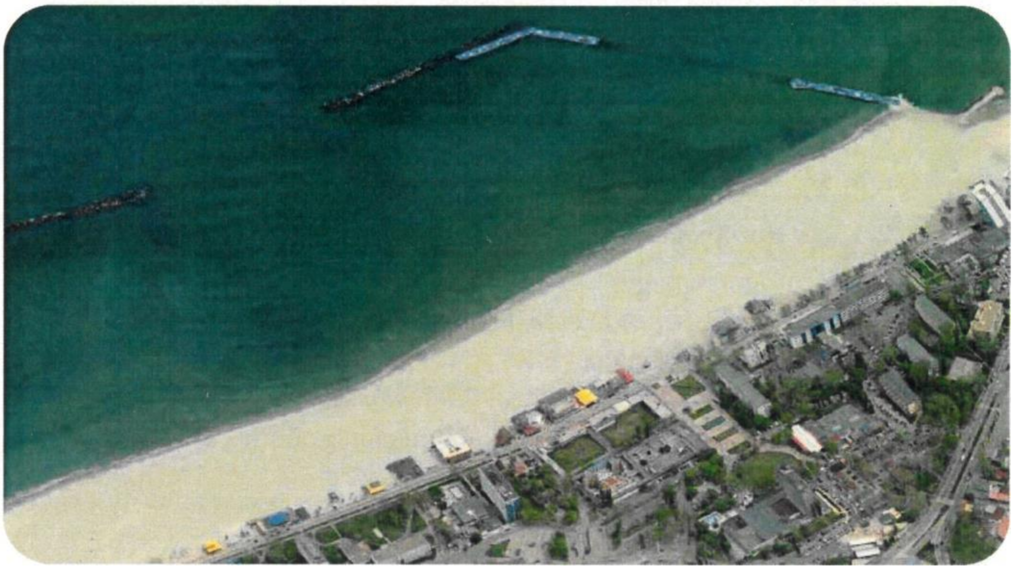
JOINT VENTURE
PORR BAU GmbH – FRANCO GIUSEPPE S.R.L. - DINAMICA S.R.L.

EXPLOITATION AND MAINTENANCE

MANUAL

"PROTECTION AND REHABILITATION OF THE SOUTHERN AREA OF THE ROMANIAN SEASIDE AT THE BLACK SEA IN THE AREA OF CONSTANTA MUNICIPALITY AND EFORIE NORD LOCALITY"



MAMAIA SUD

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REVISION INDICATOR

Document: Exploitation and maintenance manual

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REV O			Giuseppe Cutrupi Gheorghe Babu Antonino Sutera	2015-10-20

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SECTION I - INTRODUCTION

1 PREAMBLE

The document herein was drafted in accordance with the section 1.9.2.2 Exploitation and maintenance manuals in the ABADL Tender book, and includes:
• general description of the scope, the purpose, and work method for the Permanent Works; • general description of operational procedures and of periodical and preventive procedures; • instructions for the use and maintenance of installed equipment.
Concurrently, the elements required for monitoring and maintenance in accordance with CIRIA "Beach Management Manual" (C685) and/or GP 103-2004 “Design and execution guide with regards to carrying out and maintaining the artificial sand filling of the beaches” are also presented.
Throughout the entire duration of the designed life expectancy, the Permanent Works are subjected to degradation and deterioration. The Monitoring and Maintenance Program is fundamental to maintaining the efficiency of the project and its components. These activities are detailed in the document herein, the EXPLOITATION AND MAINTENANCE MANUAL (E&M Manual), which renders possible recognizing potential issues and describes the adequate actions to ensure the yield of the project throughout the entire designed life expectancy. The main component of the beach yield refers to the comparison between the data in the numeric modeling of the sediment transportation and the phenomenon recorded in the costal cell. The transportation of the sediments is the direct result of the hydrodynamic conditions. As such, monitoring these conditions is necessary. In the case of coastal protection structures, the yield refers to their stability in extreme conditions.
Moving forward, we present the structure of the E&M Manual, shortly describing each section contained within it.
The manual is divided in two sections:

Section I	presents general information about the project;
Section II	offers essential information about functioning and maintenance, necessary to ensure the desired project performance.

2 GENERAL INFORMATION

Objective denomination	Protection and rehabilitation of the southern area of the Romanian seaside at the Black Sea in the area of Constanta Municipality - Mamaia Sud (lot 1)
Placement	Lot 1 Mamaia Sud, Constanta, Romania
Investment holder	Administratia Nationala Apele Romane (Romanian Waters National Administration) Administrația Bazinală de Apa Dobrogea Litoral (Seaside - Dobrogea Water Basin Administration)
Investment beneficiary	Administratia Nationala Apele Romane (Romanian Waters National Administration) Administrația Bazinală de Apa Dobrogea Litoral (Seaside - Dobrogea Water Basin Administration)
Project elaborator	PORR Bau GmbH - Franco Giuseppe S.R.L. - Dinamica S.R.L. through GENERAL CONTRACTOR DINAMICA S.R.L.
Contractor	PORR BAU GmbH - FRANCO GIUSEPPE S.R.L. - DINAMICA S.R.L.

3 PLACEMENT

The Project site is located in the southern part of the seaside sector between the southern Midia Port breakwater in the north, and the L shaped breakwater (T9) to the south.

Fig. 3-1 - Mamaia Sud beach placement

The project area, in which the Works were carried out, has a length of 1,200 m along the shoreline (plus the links to the current shoreline, located to the north and south, obtained through sand filling, extended by 90.00 m, and 65.67 m respectively), starting from the z shaped groyne (MMI) located before Hotel Parc, under the administration of the Administrația Bazinală de Apa Dobrogea Litoral (Seaside - Dobrogea Water Basin Administration).

The causes of the erosion can be linked especially to:

- the development of the Constanta Port (southern part);
- the development of the Midia Port jetty (northern part), which have almost completely blocked the transportation of sediments from the Danube Delta along the shore;
- the modifications that occurred in the Danube's regime with regards to discharging sediments in the Black Sea, reducing the quantity of sand available for the entire seaside system.

The erosion rate in the Mamaia Sud area is variable depending on the localization and the presence of coastal protection structures. Certain works to protect against the erosion were carried out before 1990 (the wave-breaking structures at sea, parallel with the beach, the southern Z shaped groyne).

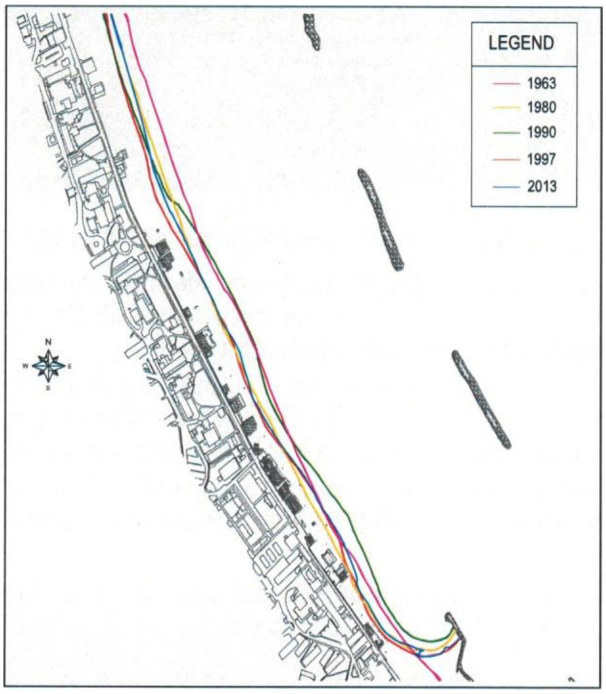

Fig. 3-2 - Historic evolution of the shoreline

3.1 Existing structures

In the interest area, there are protection structures to reduce erosion built before 1990. The situation before the beginning of the works is detailed in the current chapter.

3.1.1 Wave-breaking structures MM2 and MM3

The two wave-breaking structures MM2 and MM3, see Fig. 3-3 - The two existing wave-breaking structures placed at sea, almost parallel to the beach, measure 250 m each, with an interval between the adjacent heads of 250 m. The elevation at the structure's base is of about -5.0 m n.m.m. MN (mean value, with a maximum of -6.0 m n.m.m MN).

The structures are built from prefabricated simple concrete blocs - hollow blocs (Antifer) 41 kN/pcs (nucleus), and tetrapods of 200 kN/pcs for the heads and slopes from the sea, respectively 45 kN/pcs for the slope from dryland. The break-wave's structure's crown elevation is of +1.0 m n.m.m. MN (average value).

Figure 3-3 - The two existing break-wave structures

An inspection of the two break-wave structures performed by the design team on 26 September 2013 emphasized certain characteristics belonging to the structure. It seems that the two break-wave structures are sinking into the marine sublayer due to the foundation layer.

In the area of the two structures' heads (as well as along them), there is a large quantity of unsorted quarry rock, spread out up to -10 m from the break-wave structures' bases. On the dryland part of both structures, there are both tetrapods and hollowed blocs incorporated within the marine sublayer.

The marine sublayer around the break-wave structures is muddy in certain areas, however, a quick subsequent investigation indicated that there is clean sand under a recently deposited thin mud layer (several centimeters).

The main characteristics emphasized by the inspection are shown in the images below.

Fig. 34 - The southern break-wave structure, inspection from 26.09.2013

Fig. 35 - The southern break-wave structure - inspection from 26.09.2013

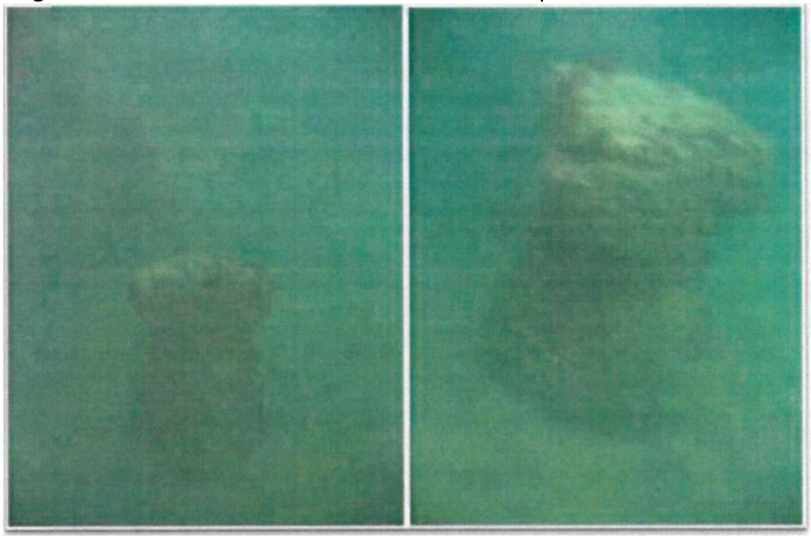

Fig. 36 - The northern break-wave structure: the heads of tetrapods sticking out of the marine sublayer (inspection from 26.09.2013)

3.1.2 The MM1 Groyne in the shape of a Z

At the southern limit of the project surface area, there is the Z-shaped MMI groyne located before Hotel Parc (see Fig. 3-7 - The MM1 Groyne in the shape of a Z)

Fig. 3-7 — The MM1 Groyne in the shape of a Z

This structure was built in 1978 and is composed of a nucleus of unsorted rock, a protection belt of hollowed blocks (Antifer) with a concrete slab over a horizontal berm.

Fig. 3-8 - The northern head of the MMI groyne

4 WORKS PERSPECTIVE

As provided in the Tender book, the Works imply ensuring a coastal protection system with the purpose of reducing the erosion risk (and possible associated floods). In the table below, we present the designed life expectancy, which can be revised annually based on the results obtained from monitoring:

Structure	Designed life expectancy
Dynamic remodeling structures	
Beach sand filling	50 years
Embankment structures made of stone, statically stable	
Emersed with a low ridge	50 years
Submersed with a low ridge	50 years

Table 4-1 - Designed life expectancy

5 RESPONSIBILITIES FOR IMPLEMENTATION OF MANAGEMENT PROCEDURES

Description	Responsible person
Monitoring Operational procedures Periodical and preventive maintenance procedures Other measures (for example, flood warnings, tourist safety)	ANAR / ABADL

Table 5-1 - Responsibilities for implementation of management procedures

The responsibility for the implementation of the procedures for the exploitation and maintenance of the Mamaia Sud costal cell belongs exclusively to the Administratia Nationala Apele Romane (Romanian Waters National Administration) and/or Administrația Bazinală de Apa Dobrogea Litoral (Seaside - Dobrogea Water Basin Administration).
It is essential to observe the monitoring program (see chapter 10 - Monitoring program) and the centralized recording of data resulted from monitoring.
The inspection, monitoring, and maintenance (periodical and preventive) activities shall be carried out in accordance with the provisions under the Manual herein (without being limited to this). If those responsible (ANAR / ABDL, designated authorities) for the implementation of the management procedures (inspection, monitoring, maintenance) do not observe their duties, the designed life expectancy cannot be guaranteed. In this case, the Contractor exonerated of any responsibility with regards to the performances and integrity of the structures, as well as with regards to any potential consequences.

6 BASIC INFORMATION

6.1 Geography and “Fetch” surfaces

The Mamaia Sud beach is exposed to storms from the north-eastern, the eastern, and south-eastern sectors.
The “fetch” surfaces (water surfaces above which the wind speed and direction are relatively constant) were calculated based on the position and exposure of the observation point.
The actual “fetch” surfaces were calculated using the method suggested in the “Coastal protection manual” (CERC, 1984). The actual “fetch” concept was introduced to reduce the “fetch” length with the purpose of measuring its width. The recommended method for determining “fetch” length is tracing nine radial lines until they intersect the shoreline for the first time; the length of each radial line is measured, and an arithmetic mean is performed. Fig. 6-2 shows an actual “fetch” obtained by using this method; the maximum “fetch” is on the east and south-east directions and are characterized by lengths of approximatively 560 km (300 naval miles).

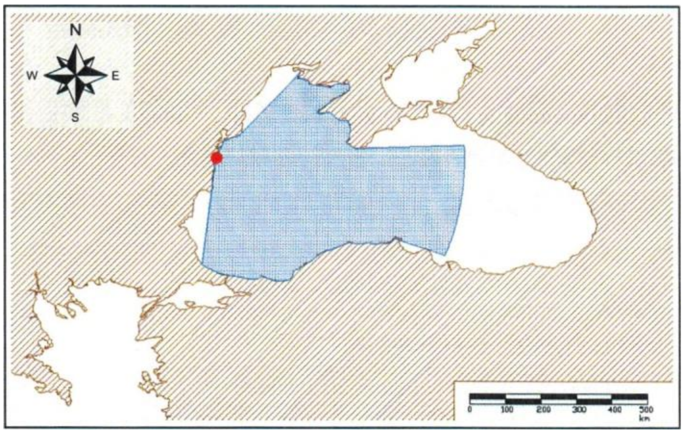

Fig. 6-1 Geographic fetch

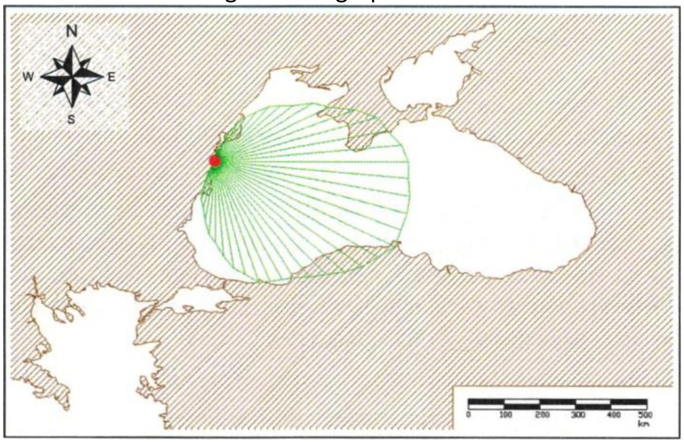

Fig. 6-2 Actual fetch

6.2 Climate

6.2.1 Water level

The water levels presented in the current document are relative to the Black Sea Average Water Level from 1975 (n.m.m. MN).

6.2.2 Modification of sea level

For the designed life expectancy of 50 years, an interval of 3.3 mm per year of sea level increase was taken into consideration (see Chapter 4.5 in the ABADL Tender Book). Between 1946 / 1985, the sea level increased by 2.7 mm/year, according to Bondar (Bondar, 2006). The estimation made by IPPC forwards a vast result range, however, the interval mentioned in the offer documents is within the IPPC limits and is considered correct for the project's purpose.
The apparent loss of sediments due to the increase in sea level was estimated according to Brunn's Rule (Brunn, 1962 and 1988), which appreciates that the transversal profile on shore does not change upon the sea level's increase. This hypothesis leads to a relation between the lowering of the sea sublayer in the active area and the situation in which the shoreline withdraws. Although deficient scientifically and not accepted in the scientist community (Cooper, 2004), this represents approximation accepted usually for estimating long-term erosion due to the increase in sea level. With regards to the Mamaia Sud shoreline sector, the analysis of the wave regime locates the closing depth at 5.6 m under the average sea level (that is, -5.87 n.m.m. MN), at sea compared to the line of the break-wave structures. The average width of the active area is of 500 m, and due to an average of 3.3 mm/year sea level increase, the adequate withdrawal of the shoreline is 0.2 m per year.

6.2.3 Extreme conditions of the water level

INCDM “Grigore Antipa” provided data regarding the water level, at one-hour intervals, for the Constanta Port, as part of the JICA study (2008). The data cover a period between January 1993 and December 2004 (see Chapter 2.5 from the ABADL Tender book). Sea level increase is also taken into account. This increase (+0.27 n.m.m. MN) is calculated as the sum of the water level averages between 2000-2004 (+0.233 n.m.m. MN, see the ABADL Tender book, Table 2.1., Chapter 2.5) and estimated RSLR of 3.3 mm/year during the last 10 years. Extreme water levels are presented in the table below.

The probability of occurrence in any given year [^{0}/0]	1 of X possibilities to occur in any given year	Water level (n.m.m. MN)
100 1	1 100	0.82

Tab. 6.1 - Extreme water level

6.2.4 Wind data

Data was obtained from the National Meteorology Service - Environmental Modelling Center in order to define the conditions of the wave climate at sea compared to the shore of Mamaia resort. The operational prognoses regarding the sea waves use the model WAVEWATCH III, which uses the operational product NCEP as entry data.

WAVEWATCH III ^{TM} (Tolman 1997, 1999a, 2009) is a product for wave modelling, pertaining to the third generation, created at NOAA/NCEP, similar to WAM (WAMDIG 1988, Komen et al. 1994). This represents an improved version of the WAVEWATCH model created by the Delft Technology University (Tolman, 1989, 1991a) and of WAVEWATCH II, created by NASA, the Goddard Space Flight Center, for ex. Tolman 1992). However, WAVEWATCH III ^{TM} is different from the previous versions with regards to various aspects, such as the equations on which it is based, the model’s structure, the numerical methods, and the physical parameterization. Furthermore, when the 3.14 version, WAVEWATCH III ^{TM} goes from a wave model to a wave modelling framework, which allows the easy introduction of additional physical and numerical approaches in wave modelling.

WAVEWATCH III ^{TM} resolves the spectral action density balance equation in random phase for the wave-direction number of spectrums. The implicit condition of this equation is that the environmental properties (the depth and current of the water), as well as the wave field, differs depending on time and space scales that are greater than the variation scales for a single wave. The 3.14 version includes certain options for the source terms regarding waters with extremely shallow waters (surf area), as well as the wetting and drying in grid points. The physical properties for the surf area, being rudimentary up to the present time, show that this wave model can be applied to any shallow waters,

The equations that represent the basis for WAVEWATCH III ^{TM} include the refraction and filtration of the wave field due to the temporal and spatial variations of the average water depth and the of the average current (waves, embankments etc.), when applicable. The parameterization of physical processes (source terms) include the increase and decrease of waves due to the action of the wind, the non-linear resonating interaction, dissipation (“foaming”), friction with the sublayer, embankment breaking (breaking caused by depth), and the spread due to the interaction between the waves and sublayer.

The propagation of the waves is considered linear, in such a way that the non-linear effects, such as resonating interactions, are included in the source terms (physical).

The data about the wind used in the model are provided by the National Center of Environmental Prognosis (NCEP), Climate Forecast System Reanalysis (CFSR). CFSR was designed and created as a global high-resolution system which includes atmosphere, marine environment, dryland, and ice on the surface of the sea, in order to obtain the best estimation of these conjugate fields, for that respective period of time. In the future, the current CFSR shall be extended as a real-time operational product.

CFSR relative to most, if not all the elements above includes:

- conjugating atmospheric models with marine ones while generating the 6-hour prognosis field;
- an interactive sea-ice model;

- assimilation of radiants from the satellite to the static interpolation scheme in the grid points for the entire period.

The CFSR products for the atmosphere, the sea surface, and the dryland surface are available at a resolution of one hour in time and 0.5^0 horizontal resolution. This reanalysis shall be used with several purposes, including providing the basic data for most climate operational products belonging to NCEP Climate Forecast Centers, by defining the average states of the atmosphere, marine surface, dry land and marine ice for the climate of the following 30 years (1981-2010), providing initial conditions for historical prognoses needed to calibrate the NCEP operational prognoses on climate (between two weeks and nine months), and providing estimations and diagnoses for the global climate state, at period level of satellite data, with the purpose of researching climate at the level of communities.

The spatial resolution of the data set included in the global grid (the distance between the grid points available for the model) is of 0.5 x 0.5 degrees latitude and longitude. This global model includes various sub-fields that contain data at higher spatial resolutions, of 1/6 and 1/15 degrees on latitude and longitude - these surfaces covered by such secondary grids include the eastern area and the western area of the United States (including Hawaii and Puerto Rico), the western area of the Indian Ocean, Australia, several islands in the South Pacific, the Mediterranean Sea, North Sea, Red Sea, Persian Gulf, Cortez Sea, Black Sea, and the Baltic Sea.

The information provided by the National Meteorology Service - Environmental Modelling Center was organized by temporal series which include significant height values (Hs), period values (Tp), and average directions of waves (DIR). The reconstituted data cover the period January 1979 - December 2009, at 3-hour intervals.

Defining the climate of these waves at the point of the coordinates (29.354^0 E, 43.944^0 N), located in front of the Mamaia resort beach sector, was possible by processing the data regarding the waves at sea.

The at-sea wave rose is presented under Fig. 6-3, Fig. 6-4, and Fig. 6-5; especially, Fig. 6-3 indicated the wave rose for total values, Fig. 6-4 represents the wave energy rose, and, finally, Fig. 6-5 presents the rose of the waves' maximum heights.

Extreme storms originating from the north-east and east (30^0 +120^0 N) are characterized by means of significant wave height values of approximatively 5.5 m.

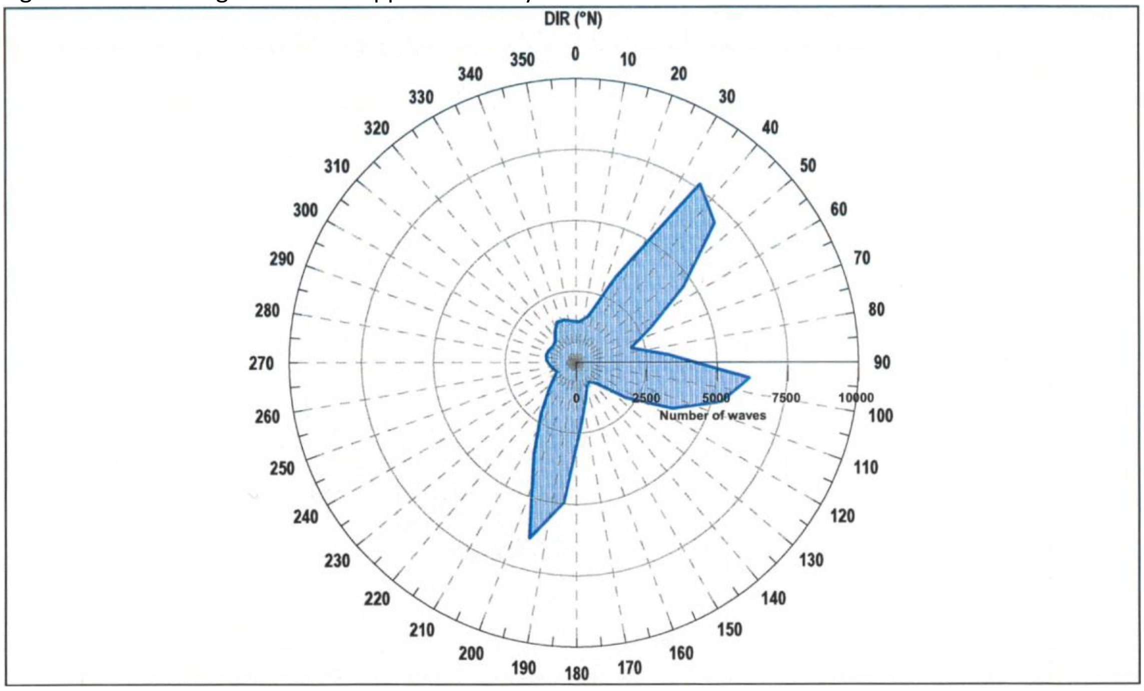

Fig. 6-3 - The at-sea wave rose: wave recordings (reanalysis of a period of 30 years - from 1979 until 2009)

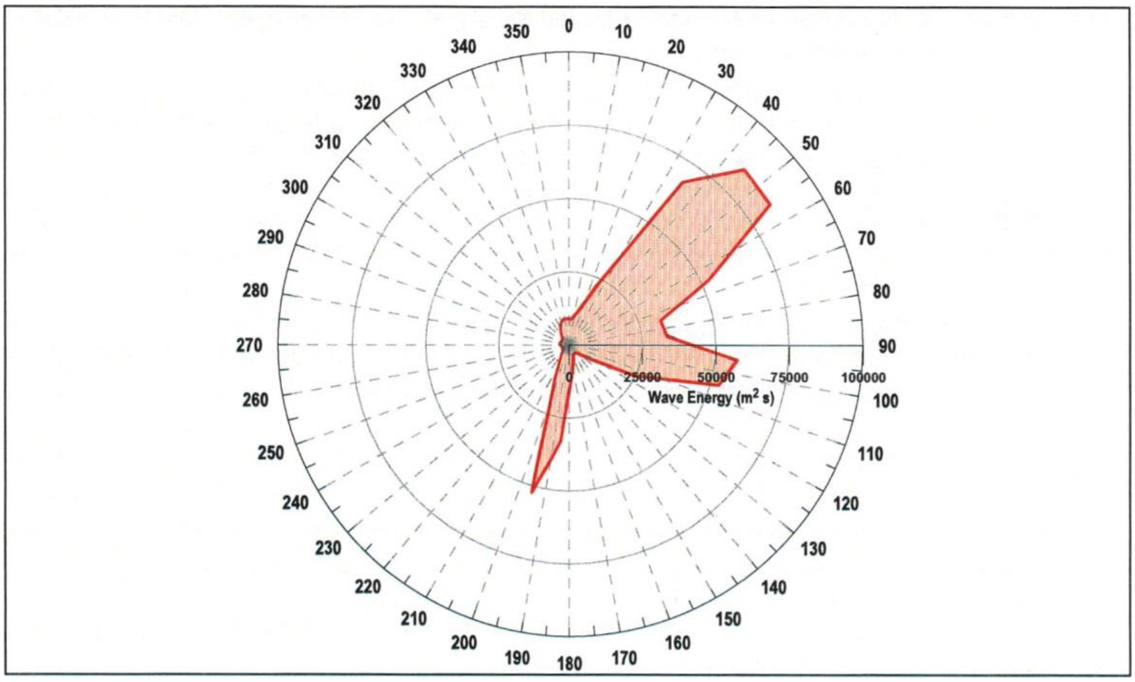

Fig. 6-4 - The at-sea wave rose: wave energy (reanalysis of a period of 30 years - from 1979 until 2009)

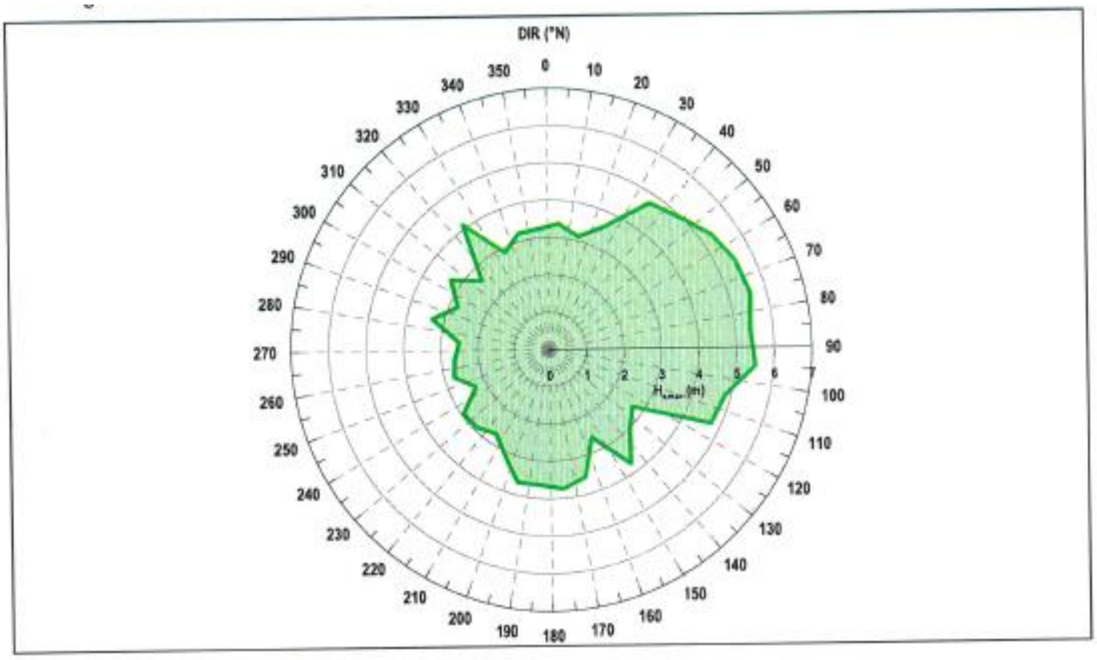

Fig. 6-5 - The at-sea wave rose: maximum wave height (reanalysis of a period of 30 years - from 1979 until 2009)

6.2.5 Extreme conditions of the waves at sea

An extreme waves statistic was carried using the data regarding waves at-sea (reanalysis of a period of 30 years, from 1979 until 2009)

Taking into account the geographic configuration of Romania's coastal area, which is exposed to the I and II quadrants directly, the extreme wave statistic was carried out with regards to the waves originating in the 30^0 120^0 N sector (directions of the at-sea waves).

The analysis of the wave statistic was carried out using the Gumbel-Weibull distribution, taking into consideration the maximum height of waves for each year (from 1979 until 2009); the maximum annual height values for each sector are presented under Fig. 6-6.

Fig. 6-7 presents the overlapping of data regarding the waves on the Gumbel distribution; the upper axis scale presents the return period in years. The results are also presented under Tab. 6.2, depending on the return period and the reduced variation (a characteristic parameter of static distribution).

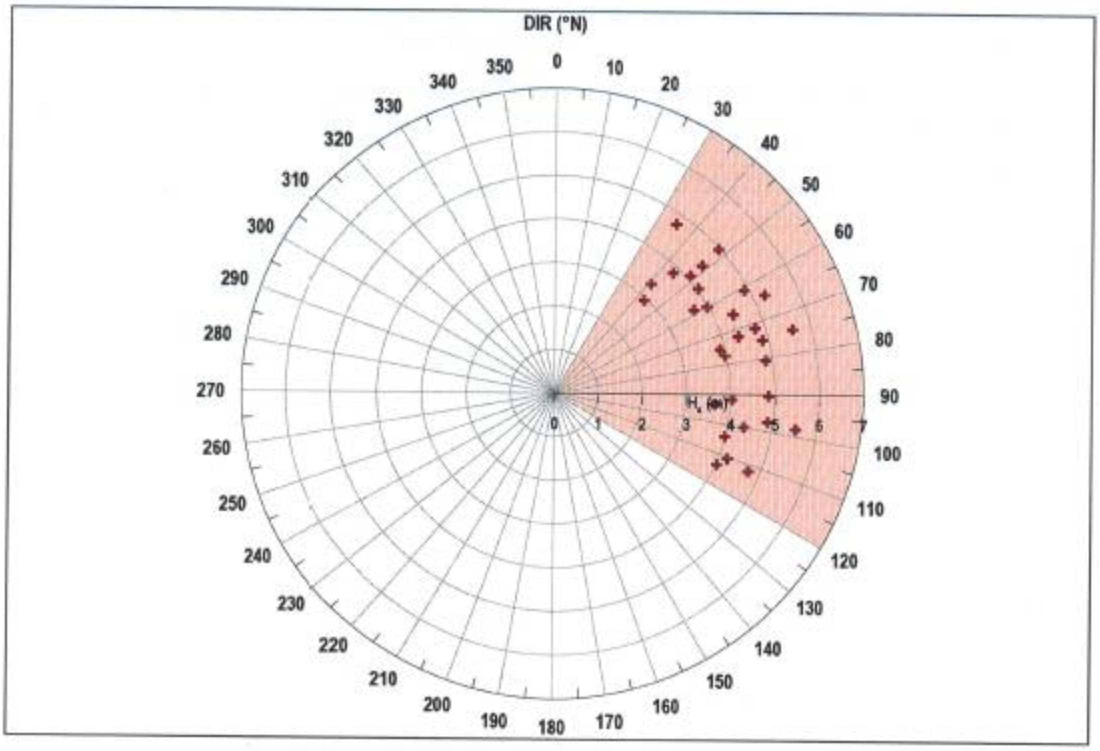

Fig. 6-6 - Wave rose for maximum annual heights

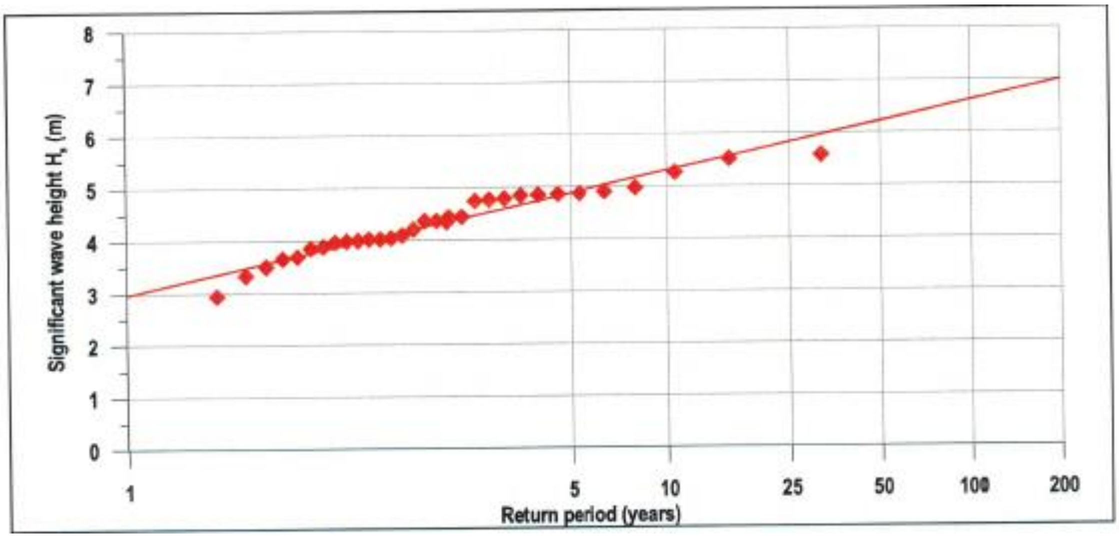

Fig. 6-7 - Overlapping of data regarding extreme waves on the Gumbel distribution

Recurrence period RP (years)	Y	Significant wave height Hs (m)
1		2.97
2	0.37	4.25
10	2.25	5.30
25	3.20	5.82
50	3.90	6.21
100	4.60	6.60
200	5.30	6.99

Tab. 6.2 - Extreme wave height obtained from the Gumbel distribution, with regards to the return period and reduced variation

6.2.6 Data regarding the wind

The at sea wave climate was defined by the use of data from the National Meteorology Service Environmental Modelling Center (see chapter 6.2.4). The data cover the period of time between January 1979 and December 2009 (reanalysis of a period of 30 years). The information was organized by temporal series which include speed (vel) and average wind direction (DIR). This is valid for the wind (wind fields) that generates at sea waves (see paragraph 6.2.4).

Fig. 6-8 and Fig. 6-9 present wind roses; especially, Fig. 6-8 presents wind rose for total recordings, and Fig. 6-9 presents the wind rose for average speeds. The dominating winds (characterized by speeds exceeding 20 m/s) are from the north-west, west, and north-east, while the most frequent winds are from the north and south-south-west.

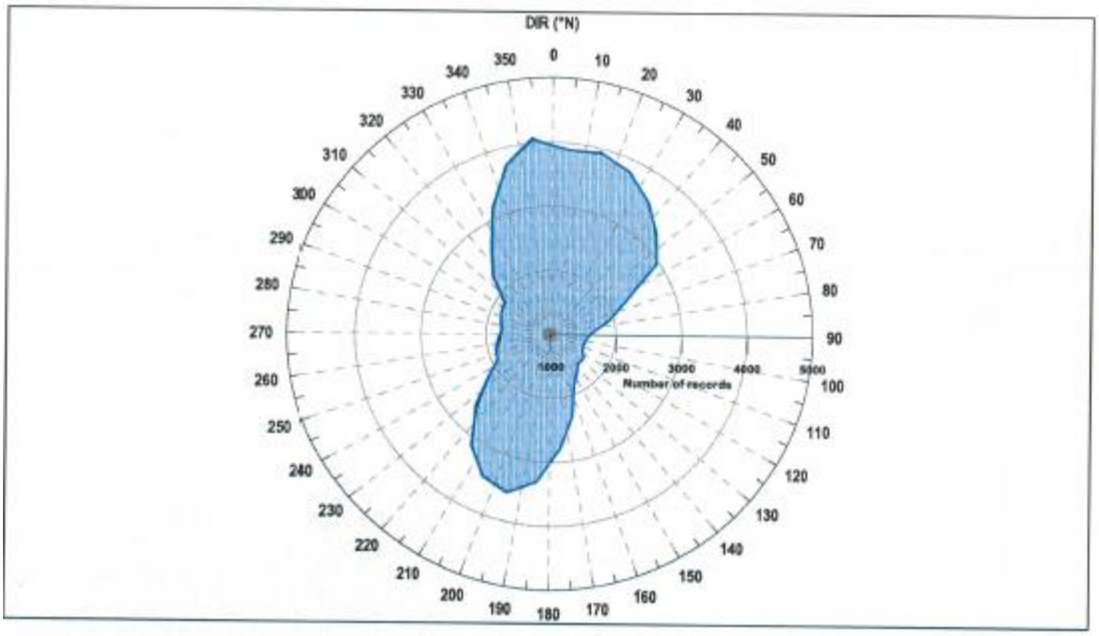

Fig. 6-8 - The at-sea wave rose: wave recordings (from 1979 until 2009)

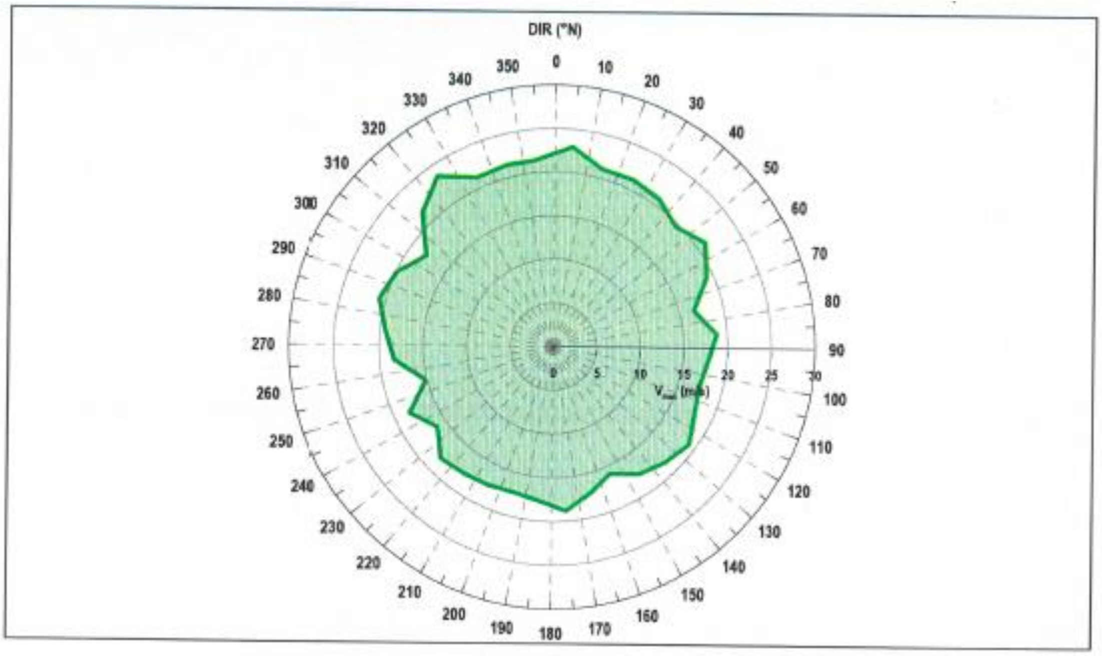

Fig. 6-9 - The at-sea wave rose: maximum speed (from 1979 until 2009)

6.2.7 Data regarding currents

The marine currents follow a dominant direction from the north to the south, which generally characterizes the water's circulation in the western sub-basin.

The water circulation system in the Black Sea consists of large closed cyclonic cells that form within the current of the Black Sea (Fig. 6-10).

Large scale circulation is, of course, of a reduced importance for the shallow water dynamic, it is determining the evolution of the shoreline; taking into account the fact that the shoreline between the Danube's mouth and Constanta is supplied by the sediments carried out the river, the sand sediments mechanism depend on the waves and the currents generated by them. These currents are described in detail in the hydrodynamic modelling report.

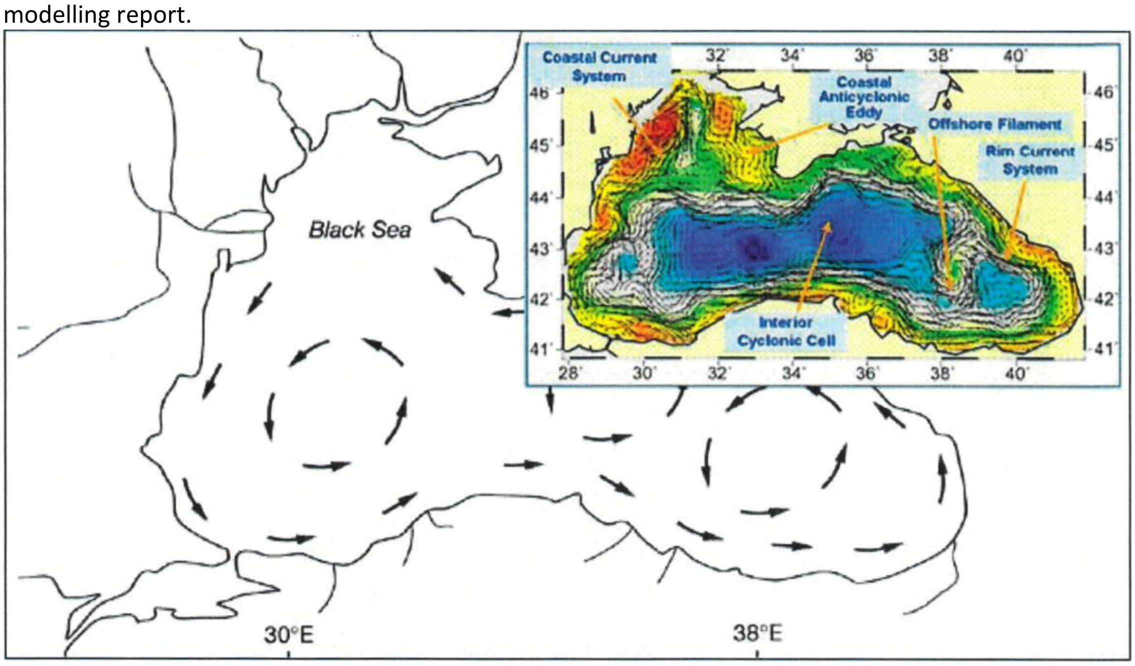

Fig. 6-10 - Large scale water circulation in the Black Sea (Mandych et al., 1995)

7 EXECUTED WORKS

The purpose of the project was that of enlarging the beach's width, as well as improving the efficiency of the coastal protection structures. The coastal protection structures within the project works are divided into two categories:

- beach sand filling to rehabilitate it, and protection against erosion;
- "statically stable" structures of various types, such as:
  - the rehabilitated break-wave structures "MM2" and "MM3"; another link structure "CSI" (between "MM2" and "MMI"); a new groyne of stone tied to the shore "RJI"; new groynes made of geotubes filled with sand, bound to the shore, buried into the sand.

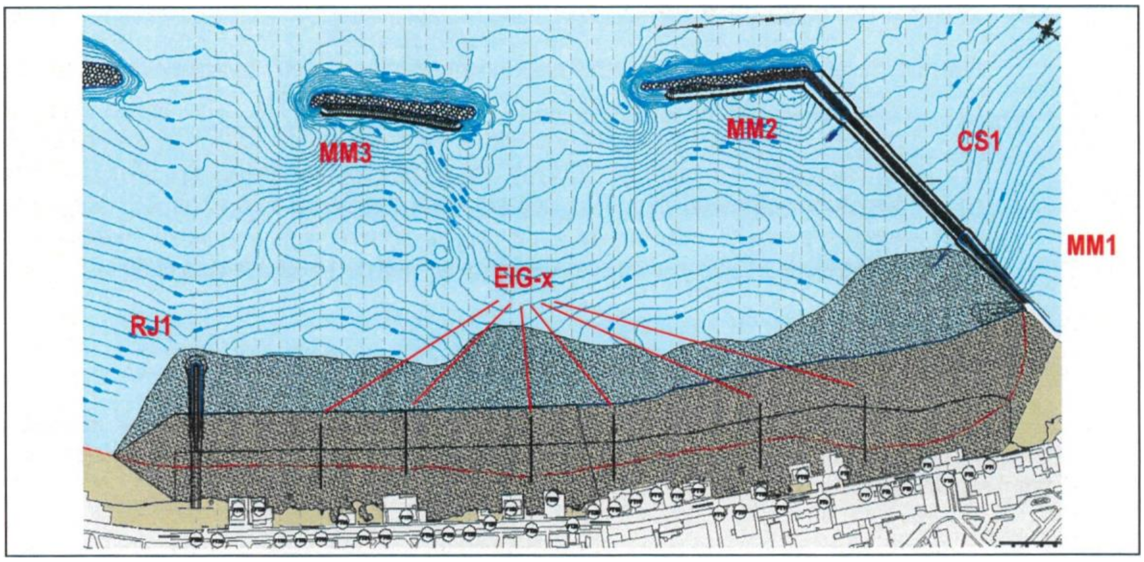

Fig. 7-1 - Project surface and placement plan

7.1 Beach sand filling

Sand filling the beach improved its stability by enhancing the dissipation of the wave energy along the submersed and the emersed profile transversal onto the shore (see Fig. 7-2). The beach sand filling was performed over a length of 1200.00 m, to which we add the adjustment sand filling at the existing shoreline, extended by 90 m to the north and approximatively 65 m to the south (see Fig. 7-1).

7.2 Break-wave structures MM2 and MM3, detached, rehabilitated

The break-wave structures "MM2" and "MM3" had a length of 250 m and were separated by an interval of 250 m. these structures built from gross stone embankment with a non-enforced, pre-made concrete bloc belt, respectively 41 kN/pcs. (nucleus) Antifer blocs, and tetrapods (200 kN for the heads and slopes from the sea, 45 kN/pcs. on the ridge's slope from the shore). As such, the level of the structures' crown was at +1.0 m (average value).

The rehabilitation works modified the structures as follows:

- The rehabilitated MM2 break-wave structure has a total length of 295.00 m; the southern part of the structure, including the expansion towards the shore (Fig. 7-3 and Fig. 7-4) has a total length of 184.68 m; the crown elevation is at +1.00 m; the northern and central part of the structure, measuring 110.32 m, was rehabilitated by a submersive expansion of the structure towards the shore (the belt elevation in the submersed rehabilitation area is of -0.50 m).
- The rehabilitated MM3 break-water structure (Fig. 7-6): the rehabilitation length is of 205.00 m, including the central part of the existing structure; the rehabilitation consists in the enlargement of

the structure on the side from the shore (the elevation of the belt in the submersed rehabilitation area is of -0.50 m).

7.3 CSI link structure

The link structure (between MMI - that is the groyne in the shape of a Z - and MM2) consist of two parts, respectively: • The expansion of the Z-shaped groyne (emersed structure, Fig. 7-7): this is an emersed embankment structure built with gross stone, making up the part from the shore of the new CSI structure. This part, measuring 129.00 m, has a crown width of 4.00 m at +1.50 m.

• The submersed link (Fig. 7-8): this submersed part of the CSI structure ties the emersed expansion of the Z-shaped groyne to the head from the shore of the rehabilitated MM2 structure; it has a length of 212.00 m and a crown with a width of 10.00 m at a -0.50 m elevation.

7.4 Sand retaining groyne RJ-I (MM12)

The sand retaining groyne RJ-I (Fig. 7-9) (perpendicular on the beach) is placed near the northern limit of the beach sand filling area. The groyne length is of 200.00 m, of which 86.23 m (the sector from the shore) is buried in the sanded beach sand.

7.5 Geotubes filled with sand (6 buried groynes - EIG)

Six 85.00-meter groynes (Fig. 7-9) are built as sand buried retaining elements; this groynes are made of geotubes filled with sand, buried in the sanded beach between the Z-shaped groyne and the RJ-I groyne.

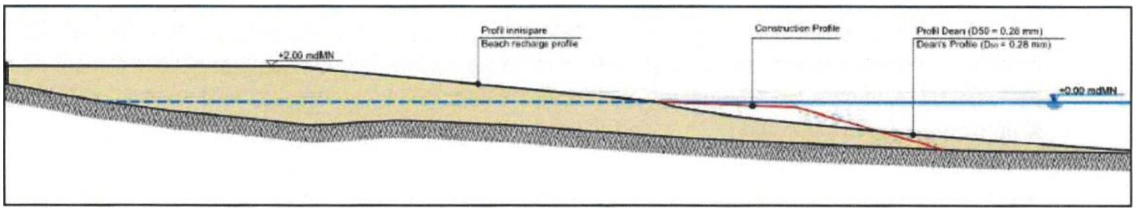

Fig. 7-2 - Transversal section through the sanded beach (adapted scale)

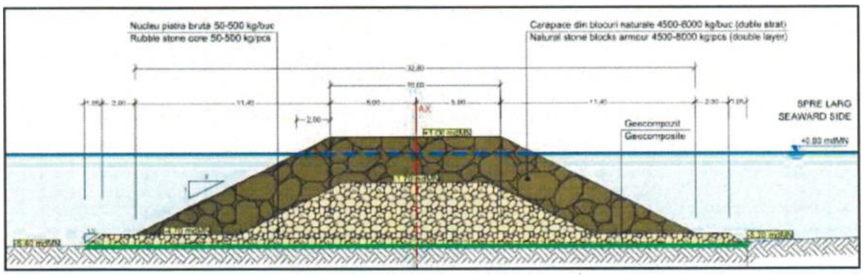

Fig. 7-3 - Typological section through the MM2 expansion

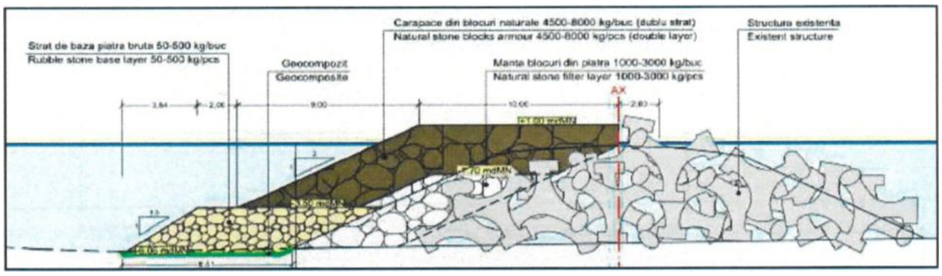

Fig. 7-4 - Rehabilitation of the emersed part of the MM2 structure

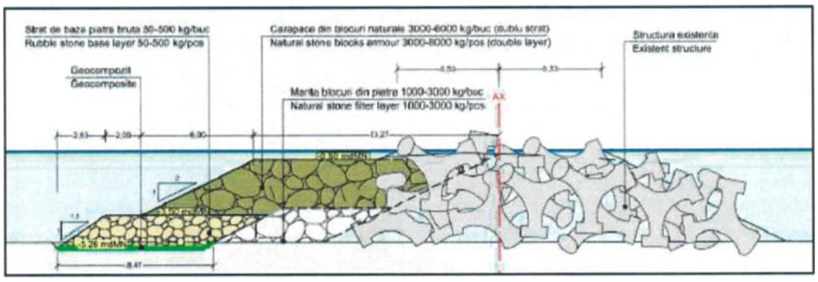

Fig. 7-5 - Rehabilitation of the submersed part of the MM2 structure

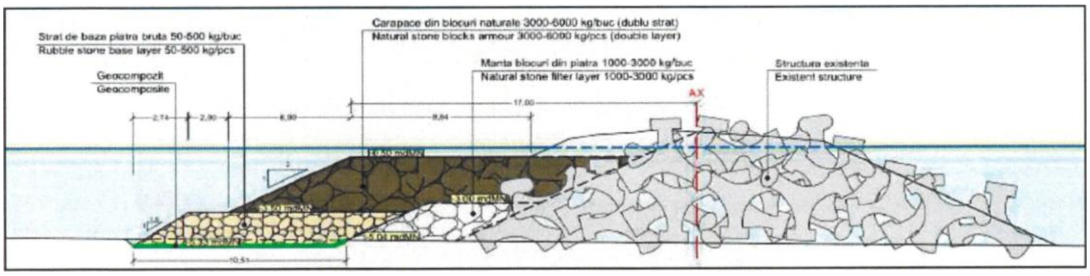

Fig. 7-6 - Section through the rehabilitation of the MM3 structure

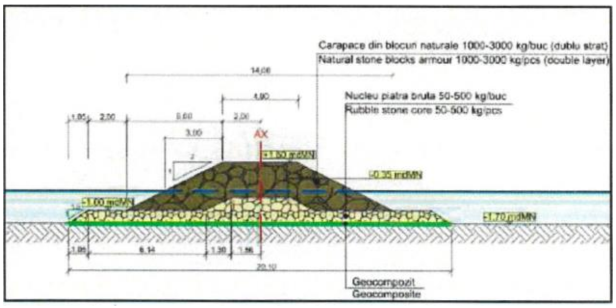

Fig. 7-7 — Section through the expansion of the Z-shaped groyne (CSI)

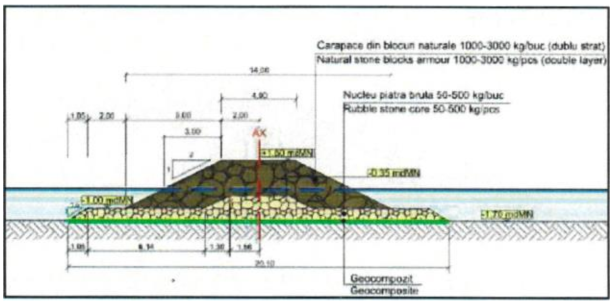

Fig. 7-8 - Section through the submersed link structure (CSI)

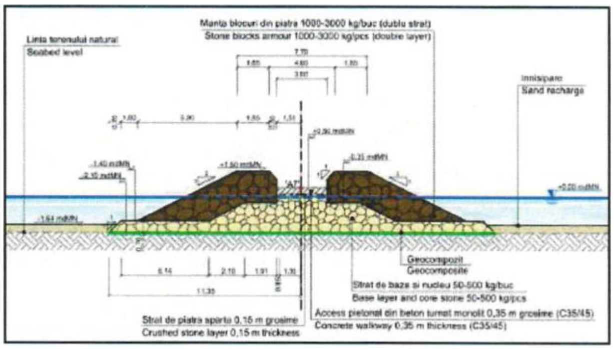

Fig. 7-9 - RJ-I - Type section in the middle area (RJI)

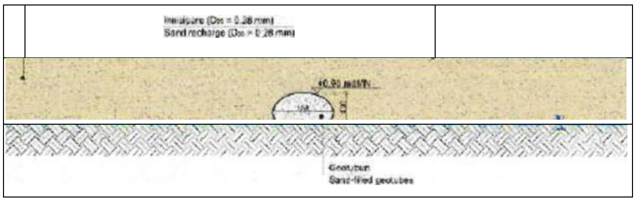

Fig. 7-10 - Geotubes filled with sand EIG - Type transversal section

8 GENERALITIES

This part of the E&M Manual presents information about the necessary procedures to ensure long-term project performance through adequate monitoring and maintenance.

The performance of each structure throughout the entire designed life expectancy is associated to an adequate monitoring and maintenance protocol.

Inspections must be carried out at regular intervals: daily for navigation signals and annually for local erosion, the crown level, displacement of blocs from the belt, the integrity of the concrete slab, the integrity of geotubes filed with sand. Additional inspections are recommended after severe events (for example, significant heights for waves at sea of over 3 m - to check for potential displacements of the belt blocs), in accordance with the Stone structure manual (Chapter 10.3.3); mandatory extended additional inspections shall be carried out in all situations in which the height of storm waves in the NE-ESE sector exceed 75% of the SLS conditions (designed value), that is 4.95 m.

Lower, we present the list of public websites (we recommend carefully reading the legal terms and the conditions for each data source) which may be used as a reference for the wave data prognosis and diagnosis sources:

Source	Web address	Comments
Turkey State Meteorological Service	http://www.mam.gov.tr/en-us/marine-metu3-wave.aspx	
University of Athens	http://forecast.uoa.gr/wamindx.php	
Greek Marine Research Center	http://www.poseidon.hcmr.gr/waves forecast.php?area id=bsea	
Buoyweather inc.	http://www.buoyweather.com/wxnav6.isp?region=black sea&prog ram=Maps	
Oceanweather inc.	http://www.oceanweather.com/data/index.html	Virtual Buoy available upon request

Table 8-1 - Web data sources for the prognosis / diagnosis of waves

9 REFERENCES

A comprehensive, coherent, and compatible set of standards was used, corresponding to the construction shape and the environment. Under Table 9-1 - List of standards, standards, design codes, and good practice standards are presented.

Reference	Title	Year
CIRIA; CUR; CETMEF, CIRIA C683 The Rock Manual (Manual of rock structures)	The Use of Rock in Hydraulic Engineering	2007
ER 1110-2-2902	Prescribed Procedures for the Maintenance And Operation Of Shore Protection Works	1989
EM 1110-2-3301	Design of Beach Fills	1995
USACE (2002), EM 1110-2-1100 updated as webpage	Coastal Engineering Manual (CEM) http://chl.erdc.usace.armv.mil/chl.aspx?p=s&a=artides:104	2002
HR Wallingford	Construction health and safety in coastal and maritime engineering	2005
CIRIA	Beach Management Manual	2010
GP 103-2004	Design and execution guide with regards to carrying out and maintaining the artificial sand filling of the beaches	2004

Table 9-1 - List of relevant standards

10 MONITORING PROGRAM

As specified in CIRIA - The Rock Manual, a clear management strategy is based on a monitoring program; this program shall aim for the following aspects:

- Knowing the past: without the detailed recording of changes that occurred, it is difficult to find out the causes of the changes and to predict future modifications;
- Identifying current issues: monitoring modifications offers the possibility of assessing the stability of the structures;
- Scheduling management operations: monitoring is useful to establish the calendar for interventions. Operations such as sand filling can be scheduled with great precision and efficiently if the beach is carefully monitored. The monitoring of the structures shall include periodic inspections and the ones performed in case of severe events. If it is necessary, the inspection protocol shall be updated throughout the designed life expectancy, with the purpose of adapting to the real needs and/or to the specific aspects observed during the designed life expectancy.

10.1 Structure list

The full list of elements that need to be monitored is presented below. With the purpose of facilitating monitoring, each element is defined through an alpha-numeric code, a type, and a synthetic description:

Reference	Element type	Element description
MM2	Break-wave structure	Rockfill embankment with low ridge
MM3	Break-wave structure	Rockfill embankment with low ridge
CSI	Link structure	Rockfill embankment with low ridge
RJI	Groyne	Rockfill groyne embankment
EIGI	Groyne	Geotubes filled with sand buried into the beach
ElG2	Groyne	Geotubes filled with sand buried into the beach
ElG3	Groyne	Geotubes filled with sand buried into the beach
ElG4	Groyne	Geotubes filled with sand buried into the beach
ElG5	Groyne	Geotubes filled with sand buried into the beach
ElG6	Groyne	Geotubes filled with sand buried into the beach
PMS	Mamaia Sud Beach - beach that underwent sand filling	Artificially sand filled beach

Table 10-1 - List of designed elements

10.2 Beach monitoring

The beach monitoring plan is based on the following components:

- Monitoring beach profiles;
- Measuring waves and water levels;
- Aerial photography of the shoreline.

10.2.1 Periodical monitoring strategy

10.2.1.1 Beach profile monitoring

The beach profile consists of the section line perpendicular on the shoreline or on a baseline previously established. The profiles (sections) are used to quantitatively establish the reaction of the beach to storm events, the extent to which the beach recovers, the long-term volumetric changes, surfaces subjected to the risk of possible floods or erosions, and the possible covering of the profile transversal on the shore. To the extent to which the beach profiles are combined with the monitoring of the bathymetry in the area near the shore, the morphological modifications can be assessed over the entire area under the influence of the waves.

The densities of the lines must be sufficient to offer an adequate representative cover of the beach. The profile step must be of at most 30 m. The overlap with the profile resulted from previous profile monitoring actions is mandatory. The profiles (sections) for strategic level monitoring must not be considered immediately next to the structures as a separation of approximatively 5 m from the structure is sufficient.

Frequency of measurements: annually - before the summer season (at most 1 May) and after the summer season (at most 1 November).

10.2.1.2 Topographic measurements specifications

<u>Horizontal data:</u>

The method to establish a control in horizontal plane shall be in accordance with European standards. All coordinates shall be reported to the Stereographic Projection 1970. Each topographic plan shall comprise information with regards to the used network. The main assessment network’s primary points shall be established, being carried out with FINO topographical landmarks of at least 600 mm in length, and those placed on the hard elevation elements shall be 100 mm metallic pickets secured through drilling and gluing with epoxy raisin.

<u>Vertical data:</u>

All level-metric data shall be determined in the Black Sea 1975 reference system. All landmarks used must have a closing on elevation of at most 10 mm. The maximum error between the network points shall not exceed the relative error of 1/20,000 over distances greater than 200 m. For shorter distances, the maximum error shall not exceed ± 10 mm expressed as mean square error. The precision of details in plane shall be such so that the position in plane of any well-defined details point is correct within the limits of a standard deviation of 0.3 m at plane scale upon verification in relation with the nearest control station.

10.2.1.3 Bathymetric measurements

<u>Horizontal data</u>

All measurements shall be performed according to the 1H0 Standards to Hydrographic Measurements SP44 IHO. All coordinates shall be reported to the Stereographic Projection 1970.

<u>Vertical data</u>

All level-metric data shall be determined in the Black Sea 1975 reference system. All reference points established during measurements shall have a levelling closing of at most 10 mm. A navigation system shall be installed on the vessels destined for measurement in order to allow directing them precisely on a predefined course or maintained on previously determined positions. The precision of all equipment shall be assessed before the beginning and end of the measurement activities, using an independent system.

<u>Data regarding the fixed position</u>

At least the following data shall be recorded at each measurement point:

- The sole number of the positioning point;
- The date and time;
- The gross positioning data;

- The calculated X and Y coordinates;
- The deviation from the preestablished route or point.
- Sonar / echoprobe
- An ultrasound probe (sonar) is necessary in order to perform the bathymetric measurements. The probe shall have the following minimal specifications:
- Depth resolution

Sampling speed	5 surveys per second
Measuring unit	meters
Double frequency	220 kHz high frequency / 30 kHz low frequency
Sound speed value	Adjustable
Transducer current value	Adjustable
Even marking	Manual, external action
Automated placement markings	At each placement

The data shall be continuously recorded and archived at each placement. The ultrasound measurements shall have a 0.1 m precision. The measurement operations shall be performed in sea and favorable weather conditions. The measurements shall be repeated in the areas in which the recording quality is inadequate.

10.2.1.4 Measurement report

A report shall be drafted after each topographic and bathymetric measurement, which shall contain the following elements:

- description of the used measurement methods and equipment, of the precision degrees achieved, of the employed personnel that performed the measurements, and any issues that were experienced, supported with photographs;
    - The details in the equipment calibration certificate issued by the manufacturer / provider or their authorized representative;
- The support network adjustment reports;
- Data in digital format: topographic and bathymetric data, processed and corrected, shall be attached to the Measurement Report in ASCII format as follows: X axis (east direction of the measuring grid), Y axis (north direction of the measuring grid), Z axis (elevation in relation to the Black Sea 1975 reference system).
- The plans shall be attached to the Report in hardcopy and digital forms (with layouts ready for printing) as follows:
- The plan elevation at 1:500 scale with the indication of altimetric elevations, at a maximum distance of 10 m; A plan presenting level curves and bathymetric contours at 0.2 m intervals and the projected beach level, throughout the entire investigated area (bathymetric and topographic), based on the combined information in the DTM model. The information shall be organized in distinct layers.

10.2.1.5 Visual Inspection

- Frequency: Annually

10.2.1.5.1 Modifying the beach in comparison with the baseline

- the level of the beach against the concrete bulwark, groynes, or other fixed elements on the beach;
- the proof of erosion on the dune surfaces or of abrupt slopes on the beach berm;
- losing sand and exposure of buried groynes (geotubes).
- Comments:
- The persons that carry out the inspection shall require information from measuring the baseline, as well as from previous inspections, in order to ensure that the modifications are accurately rendered. It is necessary that reference be made to photographs from previous inspections.

10.2.1.5.2 Beach texture

- deposit or loss of sand that covers a part of the upper beach • deposit or loss of mud on the inferior beach's surface
- proof of waves passing over the beach ridge

10.2.1.5.3 Photographs

Photographing the aspects from pre-determined fixed points (compared to the baseline) may offer valuable information regarding performance. These data are regularly collected so as to inform and find out the long-term and seasonal evolution. The photographs must be taken from the same standpoint, in the same direction and with the same focal distance, in order to cover the same visual field as the previous photographs. The photographs taken during the inspections shall be archived and managed for all subsequent beach management activities.

10.2.1.5.4 Report

We recommend the use of at least the Inspection Form found under APPENDIX 1 to record changes. Details regarding report drafting can be found under Chapter 13.

10.2.2 After storm monitoring

The beach's reaction to storm conditions can have both long-term and short-term consequences, and as such, measurements need to be carried out after storms or whenever such events are recorded.

After an event that is over 75% SLS (Hs > 4.95 m)	After an event that is over OLS (Hs > 3.00 m)
Measurements of the shoreline, measuring the emersed beach	Measurements of the shoreline, measuring the emersed beach

The requirements formulated under Chapter 10.2.1 shall be observed.

10.3 Structure monitoring

The performance of a structure is assessed by comparing the measurements associated to its state and performance in a number of points, in time.

The major deteriorations that have occurred as a result of storms are easily identified. Without monitoring, the small changes can pass undetected and can finally lead to major deteriorations.

Monitoring the structures consists of the following events:

- periodic monitoring (see 10.2.1);
- monitoring in case of events (see 10.2.2).

We recommend the use of at least the Inspection Form found under APPENDIX 2 to record changes. Details regarding report drafting can be found under Chapter 13.

10.3.1 Periodical monitoring strategy

The recommendations for the beach also apply to statically stable structures.

Reference	Daily	Periodically (annually)
MM2	Signaling for navigation	Local erosion, crown level, displacement of blocs in the belt
MM3	Signaling for navigation	Local erosion, crown level, displacement of blocs in the belt
CSI	Signaling for navigation	Local erosion, crown level, displacement of blocs in the belt
RJI	Signaling for navigation	Local erosion, crown level, displacement of blocs in the belt, the integrity of the concrete slab
EIGI • ElG6		Local erosion, geotubes integrity (nothing if buried)

10.3.2 Monitoring after a storm

Structure reference	After an event that is over 75% SLS (Hs > 4.95 m)	After an event that is over OLS (Hs > 3.00 m)
MM2	Local erosion, crown level, displacement of blocs in the belt	displacement of blocs in the belt
MM3	Local erosion, crown level, displacement of blocs in the belt	displacement of blocs in the belt
CSI	Local erosion, crown level, displacement of blocs in the belt	displacement of blocs in the belt
RJI	Local erosion, crown level, displacement of blocs in the belt	displacement of blocs in the belt
EIG 1 – EIG 6		

11 MAINTENANCE PROTOCOL

The maintenance actions are mandatory in order to ensure the performance requested by the project throughout its entire designed life expectancy. These consist of (but are not limited to): maintaining the beach and the protection structures, monitoring the quality of the swimming water, placing, and maintaining the signaling systems for navigating and for the beach.
As a consequence of monitoring and the characteristics of the structures, specific actions shall be undertaken is the measured parameters exceed the threshold values specified in the following table:

Reference	Performance criterion	Reasons and decisions
MM2	The crown level is at 0.2 m under the designed elevation	Placement of stone blocs in a belt, according to project specifications
MM2	Local erosion of the structure, over 1 m compared to the designed depth	Filling holes with unsorted quarry stones, if the erosion is associated to the local deterioration of the structure slope
MM2	The integrity of the belt protection layer	Replacing the blocs displaced from the belt with new blocs, according to project specifications
MM3	The crown level is at 0.2 m under the designed elevation	Placement of stone blocs in a belt, according to project specifications
MM3	Local erosion of the structure, over 1.0 m compared to the designed depth	Filling holes with unsorted quarry stones, if the erosion is associated to the local deterioration of the structure slope
MM3	The integrity of the belt protection layer	Replacing the blocs displaced from the belt with new blocs, according to project specifications
CSI	The crown level is at 0.2 m under the designed elevation	Placement of stone blocs in a belt, according to project specifications
CSI	Local erosion of the structure, over 1 m compared to the designed depth	Filling holes with unsorted quarry stones, if the erosion is associated to the local deterioration of the structure slope
CSI	The integrity of the belt protection layer	Replacing the blocs displaced from the belt with new blocs, according to project specifications
RJI	The crown level is at 0.2 m under the designed elevation	Placement of stone blocs in a belt, according to project specifications
RJI	Local erosion of the structure, over 1 m compared to the designed depth	Filling holes with unsorted quarry stones, if the erosion is associated to the local deterioration of the structure slope
RJI	The integrity of the belt protection layer	Replacing the blocs displaced from the belt with new blocs, according to project specifications
EIG 1 – EIG 6	The upper elevation is at 0.5 m under the designed elevation	Refilling sandbags, according to project specifications
EIG 1 — EIG 6	Geotubes integrity	Replacing the geotubes or local repairs
PMS	The width of the horizontal berm +2 m < 60 m	Sand filling in accordance with project specifications

Table 11-1 - List of maintenance activities associated to performance

Performing all maintenance activities necessary for the Mamaia Sud protection cell (in their integrality) is the sole responsibility of ANAR/ABADL.

11.1 Beach maintenance

In order to maintain the beach in the long run, but also in order to maintain the beach in optimal conditions for tourism, certain beach maintenance works must be carried out. These maintenance works shall be carried out at least once per year before the summer season. The beach maintenance works consist of, but are not limited to the following activities, if necessary:

- Mechanic levelling of the beach with specific equipment (bulldozer, motor-grader etc.);
- Relocation of sand from the areas with excess sand to the eroded areas.

In the case in which, as a result of extreme conditions, the horizontal berm with an elevation of +2.00 m decreased under a width of 60.00 m, then filling shall be necessary using the project specifics.

11.1.1 Beach hygiene

The beach must be regularly cleaned, and the waste resulted from the tourist exploitation of the beach must be selectively collected and adequately removed (in accordance with the legislation in force). These activities must be planed at regular intervals.

11.2 Structure maintenance

If the structures' parameters are no longer within the performance criteria limits, then the measures in table 11-1 must be implemented. The observance of the performance parameters is monitored through the monitoring schedule described under chapter 10. Not adopting the respective measures can lead to severe consequences upon the stability of the beach, that is an accentuated erosion of the Mamaia Sud cell.

11.3 Water quality

Monthly measurements shall be carried out (weekly during the summer season) to verify swimming water quality (total coliform bacteria, fecal coliform bacteria, fecal streptococcus). This information shall not be included in the annual report.

1.1.4 Swimmer and navigational safety

The structures were provided with navigation signaling (day and night signaling) according to the project and the specifications received from the Romanian Naval Authority. The integrity of these signaling elements shall be constantly monitored in accordance with the monitoring schedule, and the signaling lamps must be permanently cleaned so as to allow the charging of the batteries by means of the incorporated photovoltaic cells.

The beach signaling buoys shall be placed in accordance with the project before each summer season and they shall be removed at the end of each summer season. Furthermore, the position of the buoys shall be monitored weekly throughout the summer season.

11.5 Other maintenance activities

Outside the summer season, rush fences should be mounted in order to avoid eolian erosion and sand deposit on the areas adjacent to the beach. As a result of the expansion of the berm and the beach surface, it is expected that a large quantity of sand will be engaged by the wind.

12 EXPLOITATION SAFETY

As is the case of structure performance, safety while exploiting them must be maintained throughout the entire duration of the project's life; a list of provided activities is presented below:

Reference	Performance criterion	Reasons and decisions
MM2	Integrity of navigation signals	Repair of replacement
MM3	Integrity of navigation signals	Repair of replacement
CSI	Integrity of navigation signals	Repair of replacement
RJI	Integrity of navigation signals	Repair of replacement
RJI	Integrity of concrete pedestrian walkway	Repair or placement of a new concrete layer, in accordance with the project specifications
RJI	Structure erosion	Placing adequate fences and explanatory panels in the area of the eroded surfaces and the execution of repair works
EIGI - EIG6	Structure erosion	Placing adequate fences and explanatory panels in the area of the eroded surfaces and the execution of repair works

Table 12-1 - List of maintenance activities associated to safety

In case of major events, the public must be informed and warned, and the coastal protection structures must be monitored from the perspective of safety during exploitation and public safety. The public must be warned through indicators placed on the access walkways indicating bad weather conditions and security risks. The access ways on these structures shall be closed for public access.

The responsibility for implementing the warning system, as well as for limiting the public's access, belongs solely to ANAR/ABADL.

13 REPORTING

Reporting shall be done annually. The annual report shall comprise the following information:

- General presentation of the indicated situation;
- Detailed description of the monitoring activity;
- Detailed description of the maintenance activity;
- Assessment of the Mamaia Sud costal cell (beach and costal protection structures).

The annual report shall also contain the Inspection forms, photographs, and the reports drafted during the reference year. The annual report shall include a chapter dedicated to the beach, as is described under Chapter 13.1. The responsibility of drafting the reports is exclusively that of ANAR / ABADL.

13.1 Reporting on the state of the beach

After having performed the inspection activities, the collected data shall be analyzed as follows:

- Generating a digital model of the land area (topographic and bathymetric measurements);
- Determining the actual position of the shoreline (that is, the average contour of the shoreline);
- Determining the average width of the horizontal berm found at a +2.00 m elevation;
- Assessing the beach's evolution from the perspective of sediment transportation;
- Potential modifications of inspection / monitoring / maintenance activities.

Due consideration must also be paid to the fact that the shoreline's long-term evolution is based on annual average values calculated over the entire designed life expectancy. It is thus possible that, depending on the meteorological conditions, differences might appear compared to the annual average values. Therefore, there will be years when there will be higher values of sediment loss (especially the first few years) and years during which the mean sediment loss values will be low. The beach is in a permanent dynamic balance under the action of various factors. The slope of each balance profile part depends on the characteristics and orientation of the swell, of the sand, currents etc.

Quarterly, as is defined under Chapter 10.2, the Beneficiary (ANAR / ABADL) must draft a report that will include the following information (but shall not be limited to it):

- Information regarding climate (see chapter 6.2);
- The beach's geometric characteristics (profile and volume);
- Inspection forms and photographs.

14 APPENDIXES

14.1. APPENDIX 1 - PMS inspection form (Mamaia Sud Beach)

14.2. APPENDIX 2 - Structural characteristics inspection form

14.3 APPENDIX 3 - SEALITE Manual

Inspection form MAMAIA SUD BEACH		APPENDIX 1	
Inspection date:	STRUCTURE CODE: PMS	COMMENTS	
INSPECTION TYPE: ROUTINE AFTER STORM EROSION? YES NO UNDER THE SECTION ____________ LA ____________ ____________ LA ____________ ESTIMATED VOLUME			
DEPOSIT? YES NO UNDER THE SECTION ____________ LA ____________ ____________ AT ____________ ESTIMATED VOLUME BERM OVERTOPPING? YES NO UNDER THE SECTION ____________ LA ____________ ____________ LA ____________ ESTIMATED VOLUME			
EXPLOITATION SAFETY? GOOD SUFFICIENT POOR ACCESS ON THE BEACH? GOOD SUFFICIENT POOR			
BEACH HYGIENE DEGREE? GOOD SUFFICIENT POOR OTHER DEFICITS? YES NO Shall be completed in detail on the right			
DRAFTED BY: ____________ Signature		APPROVED BY: ____________ Signature	

Inspection form STRUCTURAL CHARACTERISTICS		APPENDIX 2	Page 1 of 1
Inspection date:	STRUCTURE CODE:	COMMENTS	

INSPECTION TYPE: ROUTINE AFTER STORM

DETERIORATION OF THE MIDDLE SECTOR: YES NO
LEFT SIDE RIGHT SIDE
LENGTH [m] WIDTH [m]
HEIGHT [m]
DISPLACEMENT OF BLOCS IN THE BELT: YES NO
COMPRESSION YES NO
ABRUPT SURFACES YES NO
DETERIORATION OF STONE BLOCS YES NO
EXPOSURE OF NUCLEUS YES NO

DETERIORATION OF CROWN: YES NO
DISPLACEMENT OF BLOCS IN THE BELT: YES NO
ABRUPT SURFACES YES NO
DETERIORATION OF STONE BLOCS YES NO
EXPOSURE OF NUCLEUS YES NO
OTHERS (give details on the right) YES NO

HEAD DETERIORATION: YES NO
DISPLACEMENT OF BLOCS IN THE BELT: YES NO
COMPRESSION YES NO
ABRUPT SURFACES YES NO
DETERIORATION OF STONE BLOCS YES NO
EXPOSURE OF NUCLEUS YES NO
OTHERS (give details on the right) YES NO

GENERAL STATE:
GOOD SATISFACTORY POOR
GOOD MAINTENANCE: YES NO
STABLE STONE BLOCS IN NORMAL CONDITIONS? YES NO

DRAFTED BY: APPROVED BY:

Signature Signature