OPTIONAL FIELDWORK
COASTAL ENGINEERING-2004
TECHNICAL REPORT

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1. PREFACE

Some students from the “Hydraulic structures” Faculty of “University of architecture, civil engineering and geodesy” in Sofia and another group of students coming from Hydraulic engineering section of Faculty of civil engineering of Technical university - Delft were combined for a special kind of joint fieldwork. The main point of combining of these two groups was to learn more about international relationships, how to work in a team, using also the skills that the others have. Another purpose of the practice was to learn more about the way of measuring without having any special equipment, using their brains and professional knowledge. The location of the “Field work” was on the Bulgarian seaside in resort “St.St.Konstatin and Elena” near by Varna. The students had the possibility to fight with driving wind and freeze seawater, to feel the sand in their shoes and the pain of the pointed stones of the groyne, but against that’s all, they have completed successfully their mission. There was the opportunity to travel all around the Blacksea Coast.

On the 8^{th} of October the Dutch students arrived in airport “Sofia” and together with the Bulgarian group have travelled to Blacksea. A day later, after a short discussion the students were divided into three completely mixed groups, each containing only one girl. The end of measuring and excursions was on the 17^{th} of October. The following pages are the report of this unforgettable experience.

SPECIAL ACKNOWLEDGMENTS:

The group of Bulgarian students would like to thank heartily affectionately Prof. Henk Jan Verhagen and eng. Boyan Savov, that after becoming the idea of such kind of students practice, they had worked hard to realize it. We appreciate your support, advices and perfect organisation.

Especially we express thanks to Prof. Kr.Daskalov , who gave us the opportunity to participate the practice, thank you for giving us an additional information by need and using your contacts to allow us using the laboratory of the university.

Also the support of Eskana SA and Royal Boskalis Westmister is appreciated. They gave us the opportunity to know more about problems on whole Bulgarian coast, visiting different parts of the seaside. We appreciate, that you like our sponsors made us easier taking part of this undertaking.

We are really thankful to “Black Sea Coastal Association” for support and providing our equipment.

We would like to thank dredging company “van Oord” for giving us the opportunity to be part of the crew of dragging ship “HAM 310” for some hours.

2. INTRODUCTION

From 8th till 17th October three well mixed groups of Dutch and Bulgerian students have worked for losing of problems, closely connected to Coastal Engineering.. For this short period of time they should collect in situ enough data of measurements and observations to give some ideas for possible solutions of projects. The fieldwork took place on the Bulgarian seaside, mainly close to Varna, in resort “St.St.Konstatin and Elena” , using as base point hotel “Admiral” and hotel “Flagman”. The beginning of this research has been founded in 2002 and collected data in the years was compared and the changes were read.

The second part of the work is the right interpretation of the data.

The main topics, that take part in the report are:

- beach measurements;
- wave measurements;
- quarry operations;
- bathymetric survey;
- groyne measurements;
- Tetrapods on Sunny day breakwater and the consolidation of the coasts;

Friday 8th Oct.	Arrival of the Dutch students with flight from Brussels at Airport Sofia. Introduction with Bulgarian students and the bus trip to St. Constantine.
Saturday 9th Oct.	Short excursion on the beach of St. Constantine and surroundings, leaded by eng.Boyan Savov.
Sunday 10th Oct.	Start of the fieldwork. Divided of the students into 3groups. Groyne measurement, defining of profiles and beach line registration, using GPS. Preparation works for the bathymetric survey and the artificial island.
Monday 11th Oct.	Each group works on its own task: Defining of profiles on the beach south of “Sirius”, Bathymetric survey with echo sounder and GPS (each group sailed and make measurements with the echo sounder), visual wave height measurement from the boat.
Tuesday 12thOct.	Excursion to theHarbour of Bourgas, observation of different kind of tetrapods, oktapods, hextapods and sailing on the board of the trailing suction hopper dredger HAM 310.
Wednesday 13thOct.	Visual wave height measurement, using theodolite and using computer with special program measuring of wave pressure, groyne measurement and converting of bathymetric survey data.
Thursday 14th Oct.	Excursion “Marziana” Quarry, choosing of samples and measuring of the stones. Afterwards a number of rockes will be additionally researched to determine their physical properties in the laboratory of our University, conclusions are shown in the following report. Visit “Sini Vir” Quarry, for extraction of material for different fractions of stones, used for concrete;
Friday 15th Oct.	Observation of landslide, a sloping building, Excursion to the White Lagoon, meeting with the owner of the hotel; visiting of oilfields and the most east part of Bulgaria, Cap Caliacra,.

Saturday 16th Oct. Observation and measuring of tetrapods on breakwater of the 'Sunny Day Marina' , short rest before departure on 17th .

Sunday 17th Oct. Departure to the Sofia and afterwards the Dutch group, flying to the Netherlands.

The used equipment was placed us at disposal mainly by "Blacksea Coastal Association". The accuracy of the measurements was enough for our purposes, although it wasn't very high.

The chapters in the report are divided according to the themes. Each of the three groups has made some measurements for each of the exercises, so every member of the fieldwork has the idea, what was going on.

Chapter I give us the idea about the state of the coastal appurtenances on the Bulgarian seaside, the way of distribution of tetrapods on the "Sunny day" breakwater, possible sizes, that have been used there, as well as some calculations and evaluation of the quality of the concrete, used
by this construction.

In chapter II it is described the way of working out on the beach measurements, having in mind the building of artificial island ca.100m in the sea, right in front of the blue hotel near by the "Sirius". Here could be found the results of the sieve analysis in lab in UACEG and the volume calculations, which have been made on Surfer 7.

Chapter III describes the steps of wave measuring on one side visual observation of the waves and determining on the wave high, on the other side, using measurements of the pressure, called into being the driving wind.

In chapter IV is collected the data of groyne measurements, having in mind the data of last years. There are made some conclusions about the changes of the groyne in the years.

In chapter V is described the visit in "Marziana" and in "Sini Vir" quarries. There is given the data, collected by stones measuring and is made analysis, if the material mined there is appropriate for consolidation of coastal appurtenances.

Chapter VI ranges Bathymetric survey. There is a description of echo sounder measurements, the results of the data collected by sailing with small boat in the region in front of the same beach, where are made the beach measurements. The data is used to represent the relief of the sea bottom.
the years.

LET'S START WRITING!!!

I. TETRAPODS ON SUNNY DAY BREAKWATER

Written by: Martin Andonov

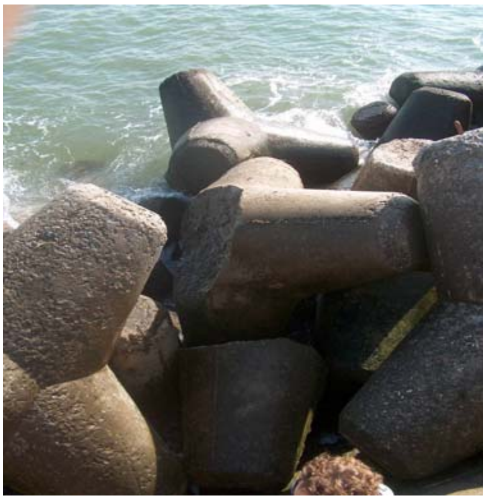
The breakwater is build with caissons around witch are placed tetrapods. Some of the tetrapods are damaged. The visual inspection shows that their quality is under the standards. The breakwater was built in 1984, and it has been exposed to storm waves for a large number of years.
In the south-west site of the breakwater is made a parapet structure, witch consist of prefabricated elements. Over these elements a cap has been made with in situ concrete. In some places (especially in the middle of the parapet) the in situ concrete is broken and the reinforcement is visible. There are three main reasons for that:

- in this site the form of the breakwater structure is trapezoidal. When a wave propagates to the smaller site of the trapeze it is going to be higher and more energy should be dissipated witch happens with maximum power in the middle of the parapet;
- with the propagation of the wave to the smaller site the depths are going to be smaller and consequently the high of the wave is going to be bigger ;
- and the third reason is that from the another two sites of the breakwater are coming, reflected waves witch superposes with the central wave witch is going to be higher.

Another reason can be the lower quality used for the fabrication of the cap. Obviously the quality of the execution was also not satisfying.

Figure 1The in situ cap

2 Tetrapods made in two days



1. Answers of the assignments:

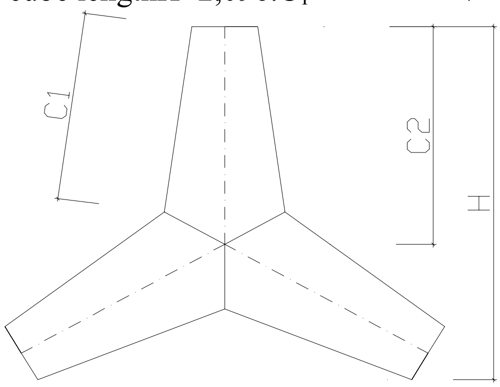
The following sizes if tetrapods are measured: C_1=110;115;120;122;125;130cm , where C_1 is the length of the tetrapods leg with respective C_2=130;130;140;140;145;150cm , where C_2 is the length of the tetrapods leg to the center of the tetrapod. Hence we have measured 5 different tetrapods. A reason for the different sizes can be that not all of them are composed in the mentioned year (1984). Another reason can be that a special formula that requires tetrapods with different sizes is used for calculating the breakwater.

2. Calculating the mass of the tetrapods:

Table 1Tetrapods characteristics

	C_1	C_2	H	V	M	Dn
-	cm	cm	cm	M^3	t	m
1	110	130	231	3.43	7.9	1.50
2	115	130	241	3.92	9.0	1.57
3	120	140	252	4.46	10.2	1.64
4	122	140	256	4.68	10.8	1.66
5	125	145	262	5.04	11.6	1.70
6	130	150	272	5.66	13.0	1.77

V – is the volume of the tetrapod
M – is the mass of the tetrapod for ρ=2.3t/m^3
Dn – equivalent cube lengthH=2,096.C_1 V=0,280.H^3



Dn=0,65.H

1. Calculating the design wave:

a) Hudsun:

$Hs = \sqrt[3]{K_d.\cot\alpha.\Delta.D}$,where

Hs – significant wave high

Kd – represents different influences (shape of the blocks, damage level, and others)

Cot α=1,5 – slope of the breakwater

$\Delta=(\rho_s-\rho_w)/\rho_w=1,26$

$\rho_s = 2,3t/m^3$ - concrete density

$\rho_w = 1,02t/m^3$

Dn – equivalent cube length

Table 2, Kd - values for tetrapods

Kd - values	Breaking waves	Non breaking waves
Trunk	7	8
Head	5	6

Table 3, Significant wave hight according to Hudson`s formula

Location	Wave	H [m]	Kd	Hs [m]
Trunk	Breaking	2,31	7	4,3
Head	Breaking	2,31	5	3,8
Trunk	Non breaking	2,31	8	4,5
Head	Non breaking	2,31	6	4,1
Trunk	Breaking	2,41	7	4,5
Head	Breaking	2,41	5	4,0
Trunk	Non breaking	2,41	8	4,7
Head	Non breaking	2,41	6	4,2
Trunk	Breaking	2,52	7	4,7
Head	Breaking	2,52	5	4,2
Trunk	Non breaking	2,52	8	4,9
Head	Non breaking	2,52	6	4,4
Trunk	Breaking	2,56	7	4,7
Head	Breaking	2,56	5	4,2
Trunk	Non breaking	2,56	8	4,9
Head	Non breaking	2,56	6	4,5
Trunk	Breaking	2,62	7	4,8
Head	Breaking	2,62	5	4,3
Trunk	Non breaking	2,62	8	5,1
Head	Non breaking	2,62	6	4,6
Trunk	Breaking	2,72	7	5,0
Head	Breaking	2,72	5	4,5
Trunk	Non breaking	2,72	8	5,3
Head	Non breaking	2,72	6	4,8

Significant waves were calculated for each tetrapod sizes because they were placed everywhere.

b) Van der Meer:

$$H_s = \left(3{,}75.\left(\frac{N_{od}^{0,5}}{N^{0,25}}\right) + 0{,}85\right).\Delta.D_n.s_{om}^{-0,2} \quad \text{,where}$$

$N_{od}^{0,5}$ =1 - breakage due to movements of the block

N=5000 – number of waves

S_{om}=Hs/Lo=0,06 – wave steepness

D_n – equivalent cube length

Δ – the same like in the Hudson formula

Table 4, Significant wave high according to Van der Meer`s formula

Location	Wave	H [m]	Dn	Hs [m]
Trunk	Breaking	2,31	1,50	4,3
Trunk	Breaking	2,41	1,57	4,5
Trunk	Breaking	2,52	1,64	4,7
Trunk	Breaking	2,56	1,66	4,8
Trunk	Breaking	2,62	1,70	4,9
Trunk	Breaking	2,72	1,77	5,1

c) Hanzawa:

$$H_s = \left(2{,}32.\left(\frac{N_{od}}{N^{0,5}} \right)^{0,2} + 1{,}33 \right).\Delta.D_n \text{ ,where}$$

the variables are the same like in the Van der Meer`s formula

Table 5Significant wave high according to the Nanzawa`s formula

Location	Wave	H [m]	Dn	Hs [m]
Trunk	Breaking	2,31	1,50	4,4
Trunk	Breaking	2,41	1,57	4,6
Trunk	Breaking	2,52	1,64	4,8
Trunk	Breaking	2,56	1,66	4,9
Trunk	Breaking	2,62	1,70	5,0
Trunk	Breaking	2,72	1,77	5,2

d) СНиП -02.06.04-82* (Russian standard):

$$H_s = \sqrt[3]{\frac{\Delta.M.\sqrt{1+\cot^3\alpha}}{3{,}16.K_{fr}.\rho_s.\sqrt{\frac{L_{om}}{H_s}}}} \quad , \qquad \text{where}$$

M – mass of the tetrapod

K_{fr}=0,008 – roughness coeffitiet

L_{om} – mean wave lenght

L_{om}/H_s=15 – wave steepness

the others variables are the same like in the previous formulas

Table 6Significant wave high according to the Russian standards

Location	H [m]	M [t]	Hs [m]
Trunk	2,31	7,9	4,5
Trunk	2,41	9,0	4,7
Trunk	2,52	10,2	4,9
Trunk	2,56	10,8	5,0
Trunk	2,62	11,6	5,1
Trunk	2,72	13,0	5,3

e) Iribaren(1965):

$$H_s = \frac{\Delta.D_n.(\mu.\cos\alpha + \sin\alpha)}{\sqrt[3]{N}} \text{ ,where}$$

μ=3,47 – friction coefficient

cosα=0,831; sinα=0,554 for cotgα=1,5
N_i – shape factor derived by experiments

Table 7Significant high accordng to the Iribaren`s formila

Location	H [m]	Dn	Hs [m]
Trunk	2,31	1,50	5,4
Trunk	2,41	1,57	5,7
Trunk	2,52	1,64	5,9
Trunk	2,56	1,66	6,0
Trunk	2,62	1,70	6,1
Trunk	2,72	1,77	6,4

The values for H_s calculated with the Iribaren`s formula are not reliable because the values of the coefficients N_i and μ witch are included in the formula are derived by experiments and they are not enough to say that μ and N_i are true. That is why these highs are not included in the comparison of the formulas.

Comparison with conclusions:

Table 8Significant waves comparison between the different formulas

Location	Wave	H [m]	Hudson	Van der Meer	Hanzawa	СНиП
Trunk	Breaking	2,31	4,3	4,3	4,4	4,5
Trunk	Breaking	2,41	4,5	4,5	4,6	4,7
Trunk	Breaking	2,52	4,7	4,7	4,8	4,9
Trunk	Breaking	2,56	4,7	4,8	4,9	5,0
Trunk	Breaking	2,62	4,8	4,9	5,0	5,1
Trunk	Breaking	2,72	5,0	5,1	5,2	5,3

The choice of a value for the different coefficients has a leading importance for the results. That is why we have differences from round 30 cm in the results. This is much more visible for the bigger tetrapods. We can claim that the formulas from Hudsun and Van der Meer are better for use because they are giving results with bigger safety.

3. Calculating the maximum dept-limited wave:
The theoretical maximum dept limited high is $H_s \approx 0{,}78.d$ (d is the water dept). In the nature the actual value is $H_s \approx 0{,}5.d$. If we assume water dept 8m and wave setup 0.5m we become H_s=4,5m witch leads to the conclusion that the breakwater "is doing his job well".
4. Calculating of the wave transmission:

It is assumed $T_{1/3}$=8s.

$$b_e = \frac{b_0 + b_b}{2} = 6{,}5m$$

b_o=3m – crest width
b_b=10m – Base width
R_c=2 – crest high above see level
H_s=4,5m

$$L_o = \frac{g.T^2}{2.\pi} = \frac{9{,}81.8^2}{2.\pi} = 100m$$

$\frac{h}{L_0} = \frac{8}{100} = 0{,}08$ $\frac{h}{L} = 0{,}127$ $L_{1/3} = 68m$

$\frac{b_e}{L_{1/3}} = \frac{6{,}5}{68} = 0{,}096$ $\frac{R_c}{H_c} = \frac{2}{4{,}5} = 0{,}44$ $C_T = 0{,}06$

$H_T = C_T.H_s = 0{,}06.4{,}5 = 0{,}27m$

H_T – transmitted wave high

5. Calculating of the expected breakage:

The Burcharth`s formula is used.

$B = C_o.M^{C_1}.f_t^{C_2}.H_s^{C_3}$,where

B – relative breakage in %

M – armor unit mass in tons

f_t=2Mpa – concrete static tensile strength

H_s – significant wave high in meters

C_0=0,00393, C_1= -0,79, C_2= -2,73, C_3=3,84 - constants derived by experiments

Table 9Percentage of units breakage

Location	H [m]	M [t]	Hs [m]	B [%]
Trunk	2,31	7,9	4,5	3,8
Trunk	2,41	9,0	4,7	4,1
Trunk	2,52	10,2	4,9	4,3
Trunk	2,56	10,8	5,0	4,4
Trunk	2,62	11,6	5,1	4,6
Trunk	2,72	13,0	5,3	4,9

The results of the count are quite the same.

6. Number of broken tetrapods:

We have count 175 tetrapods placed everywhere of the breakwater and 8 from them were broken. This makes 4,6%. This percentage has no influence of the function of the breakwater.

II. BEACH MEASUREMENTS

Written by: Liliya Traykova

Date of measuring: 10th Oct , 11th .Oct and 13th Oct.2004
Beach: South of the Sirius
Purpose: The owner of the hotel, south of "Sirius" wants to know the changes of the sand volume on the beach, the variation of the beach profiles should be defined
Characteristics: partly artificial beach; it has been expanded after the construction of the hotel
Tools: theodolite, tape-measure, double pentahedral prism, hub, stones

II.1. PREFACE

Beach: The zone of unconsolidated material that extends landward from the water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. The beach includes foreshore and backshore.

Sea beaches are permanent under series of influences and as a result of them they change themselves dynamically. These variations could be specified as seasonal (state of dynamic stability), erosion (the carrying away of beach materials by wave action, littoral currents, or wind) or accumulation (steady in the time shift of the beach line into the sea). To determine them we should monitor the beach relief and define the variations for a fixed time period. The bad weather didn't disturb us to collect the necessary information, which allowed us to calculate the changes of the beach.

The chosen section is marked by implementation of stabilization of the existing gore shape in 2002-2004 and decreasing of the seasonal fluctuations on the contiguous beaches. The measurements are made on the already defined control profiles, which have been laid out from stabilized base points. The profile measurements have been made using the method of T-graphic staff, as well as leveling. The position of the beach line has been determined with the help of GPS and DGPS. The results have been compared to evaluate of the achieved accuracy.

The first step before beginning the measurements was an observation of the beach, choosing a right number and kinds of tools and getting the idea of way of working and sort of the beach. Our measurements should start in 2002, but because of a communication error has been measured one beach more south. So, the start year for observation of this beach was 2003. The defined beach profiles (the intersection of the ground surface with a vertical plane; may extend from the top of the bluff or dune line to the seaward limit of sand transport) will be observed annually to monitor the variations in the beach location.

II.2. EXERCISE DESCRIPTION

In this project is made a juxtaposition of the data from years 2003 and 2004.

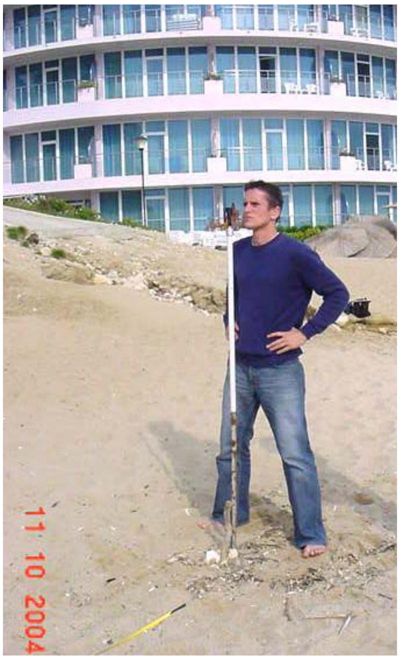
The measuring should be started as soon as possible and the exercise was made without using any sophisticated instruments, but it was extremely important to have sufficient beach data. For short time period the beach could change itself under a variety of conditions, for example storms and this should be avoided.

At first the baseline for profiles has been defined, determining its reference points. Also there were made some GPS and DGPS measurements and the accuracies were compared. Some conclusions were taken out of them.

Perpendicular to the baseline have been made some beach profiles almost at every 25th meter. The beach volume was calculated using a special computer program “Surfer 7”. Finally from the observed beach were taken six sand samples, which have been used for sieve analysis and to define the dependence of the diameter of the sand on the location of the sample on the beach.

II.3.WAY OF MEASUREMENTS

II.3.1. ESTABLISHMENT OF THE BASELINE



We have known with the basic equipment, which we have and start thinking of possible way to lose the problems. The first step was defining of baseline. The existing data from the last years can’t be used, because the measurements are usually from different locations. We have defined general fixed baseline, which should be never changed during the years of the measuring. It was located as straight as possible and the both endpoints were located near by the locations from the last year. It’s very important fixing of the reference pints and making possible finding them back in the next year. Using pictures, that were made in 2003, we have located it on the dry beachside.

The left reference point coincidences with the “Zero point” of the relative coordinate system. It is situated nearby the stairs of the blue hotel, as it’s shown on the figure below. The right one is on the stonewall nearly to the stone stairs on the opposite side of the beach. After discussing the appropriate points, the locations of these reference points have been determined by GPS.

FIGURE I.1. Left reference point – nearby the stairs of the blue

FIGURE 1.2. Right reference point – on the stonewall nearly to a stone bending stairway leading up to the road

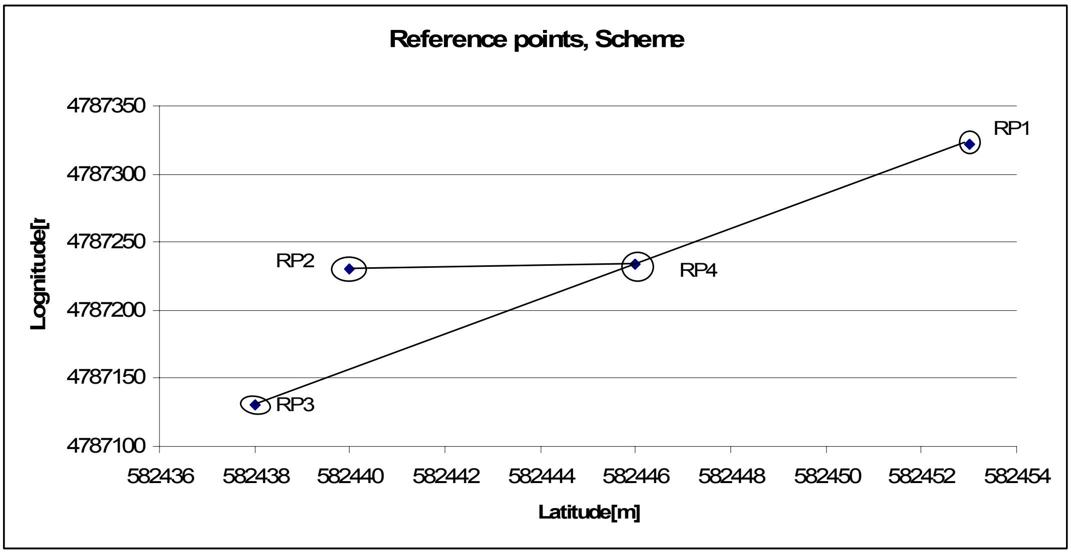


Figure 1.3. SCHEME OF THE REFERENCE POINTS-EXCEL

Number of the reference point	Coordinates	
	X	Y
Reference point on the blue hotel RP1	582453	4787322
Reference point on the yellow building RP2	582440	4787230
Reference point on the wall nearby the stone stairs RP3	582438	4787131
Reference point in the middle of the baseline RP4	582446	4787234

Table 1.1.Coordinates of reference points taken with GPS

To establish the baseline we should define it at first in the field. Having the baseline we can find nearby the locations of the profiles on almost every 25m, using the tape-measure and double pentahedral prism. It is obvious that it's impossible placement of monuments on a beach like this. That's the reason why we have made a map, using coordinates of the points (from GPS) and pictures. So, the group after us can find back the reference points and profiles comparatively easy. As a reference point (RP2) was used also the yellow building on the beach. It should be mentioned that in 2003 the same building had the blue colour. Reference point 1(RP1) is the hotel nearby the "Sirius", is the main point, which has also been used for the reference height. The corner of this plate was the reference in horizontal direction. In vertical direction the reference height was measured from the top of the plate. RP3 is on the stonewall nearly to the stone stairs. As RP4 is marked the middle of the baseline. The coordinates of the four reference points have been measured by the GPS system. Table I.1 shows the coordinates of the four reference points we used.

I.3.2. WATER LINE / BEACH LINE

The measuring of the beach line (water line) has been done using handhold GPS and the DGPS. The both lines have been plotted in one and the same figure to compare the results. The accuracy could be defined as good enough for our purposes. On a stationary GPS without a differential correction signal, you should see a 20m average radius "random walk" pattern. On the same receiver with DGPS corrections and a good view of the sky, the error should be reduced to approximately 2m average radius.

The tidal variation of the Black Sea was negligible and didn’t cause shoreline differences.

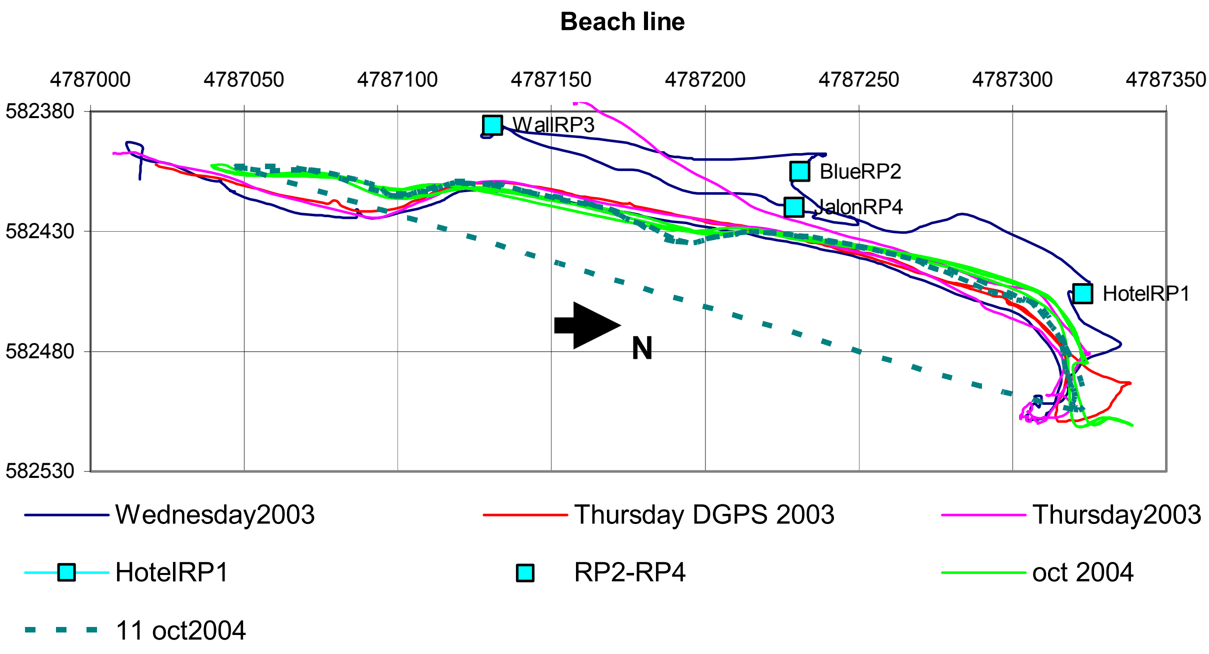


FIGURE I.4. COMPARISON OF WATER LINE, DETERMING WITH GPS AND DGPS, WITH THE LAST YEAR RESULTS

II.3.3. PROFILES

To measure the profiles was using a visual sighting and the horizon with help of theodolite or leveling instrument.

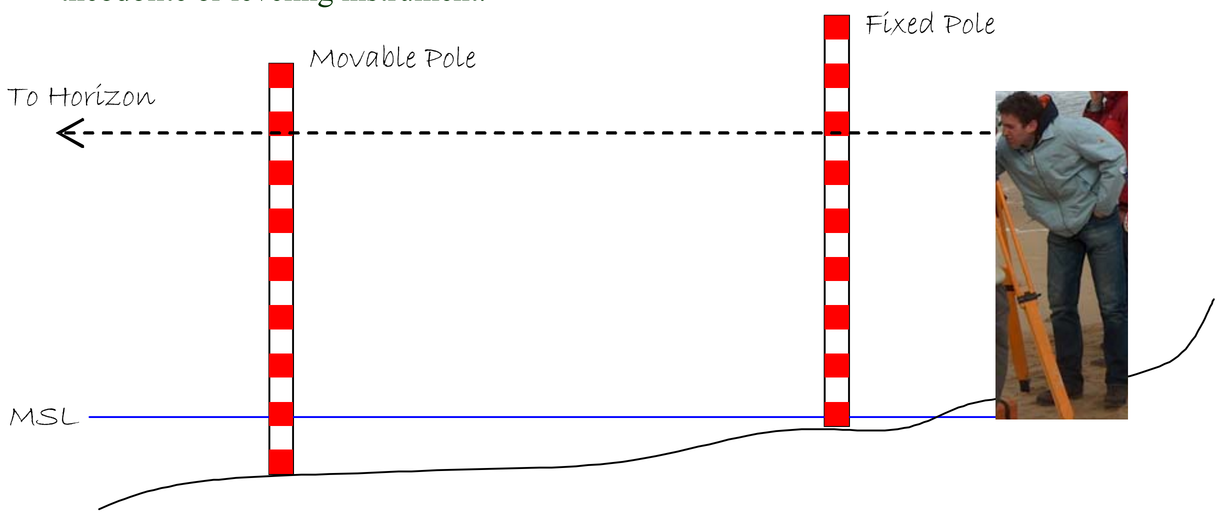


Figure 1.5. Measuring the beach with movable and fixed pole

As it was stated before the beach profile was measured by using lines, which are perpendicular to the baseline and at fixed distances from the zero point. There are several ways to get a view on the beach profile.

- When sophisticated equipment is not available it is possible to use simple tools.One way of measuring has been done by using the horizon as reference level. Every 5m the height of a point on a determined virtual beach line perpendicular to the baseline was defined. Using a theodolite for a clear and sharp view on the poles the relative height compared to the fixed pole and the horizon was measured. At the point on the fixed pole where the horizon met the pole, the value on the movable pole in a straight line to the horizon had to be estimated. The next figure gives an idea of this way of measuring the beach profile.

- When sophisticated equipment can be used there is a better way of measuring the profiles, as has been said before, by using a fixed baseline. On this baseline a fixed height is determined. For this fixed height we used the concrete plate at the hotel (RP1). At all other measured altitudes the height was read by using a theodolite. These points have been related to the height of the concrete plate. In this way it was possible to get a beach profile related to one reference point. As said before different profiles of rays perpendicular to the baseline have been measured.

The data of the each profiles have been visualized in the following figures. Using a double pentahedral prism was determine the direction of the profile, perpendicularly to the baseline. The zero of the profiles lies on the baseline, defined by the reference points.

FIGURE 1.6. Measuring of "Zero"profile

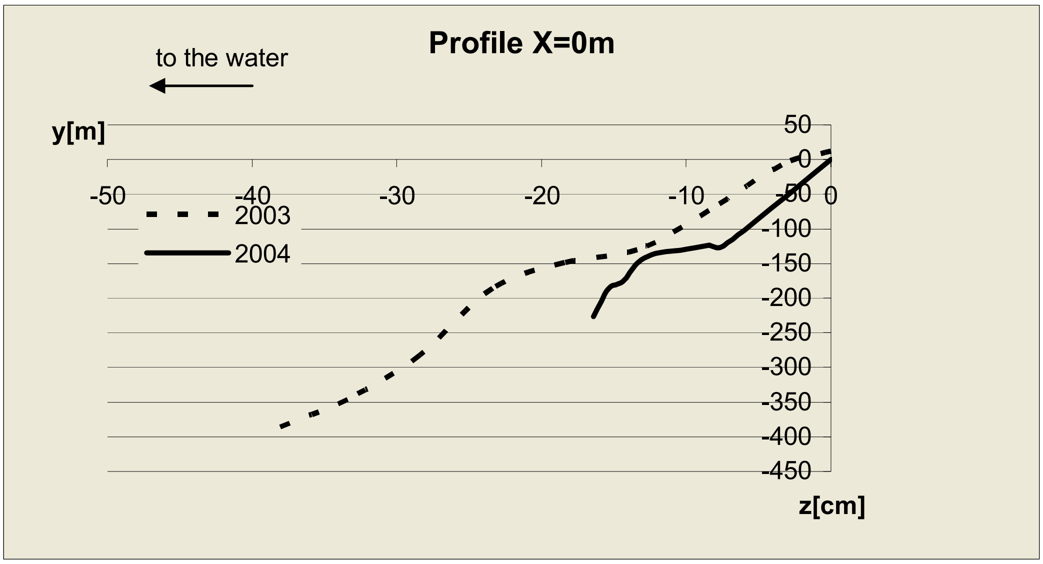


FIGURE 1.7. Profile X=0m: The excel file from the last year was changed,

FIGURE 1.7. Profile X=0m: The excel file from the last year was changed, because the point 0 is the Reference point 1 and its coordinates are 0. This makes impossible the data, represented last year.

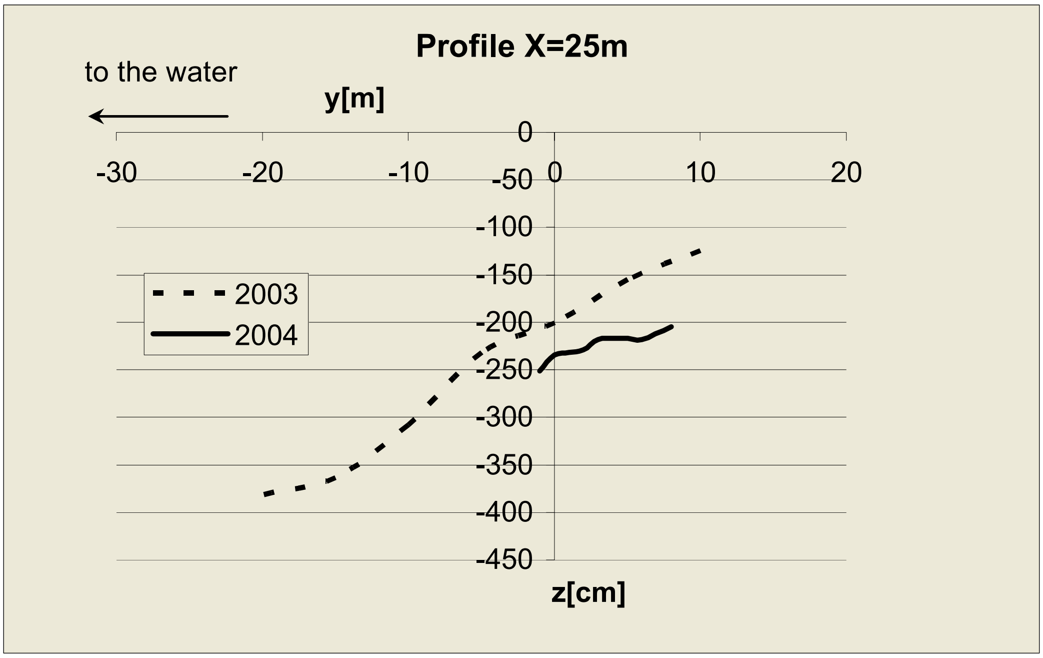


FIGURE 1.8. Profile X=25m: There is ca.40cm erosion, but the data from 2003 is again assumption, otherwise the erosion would be even greater.

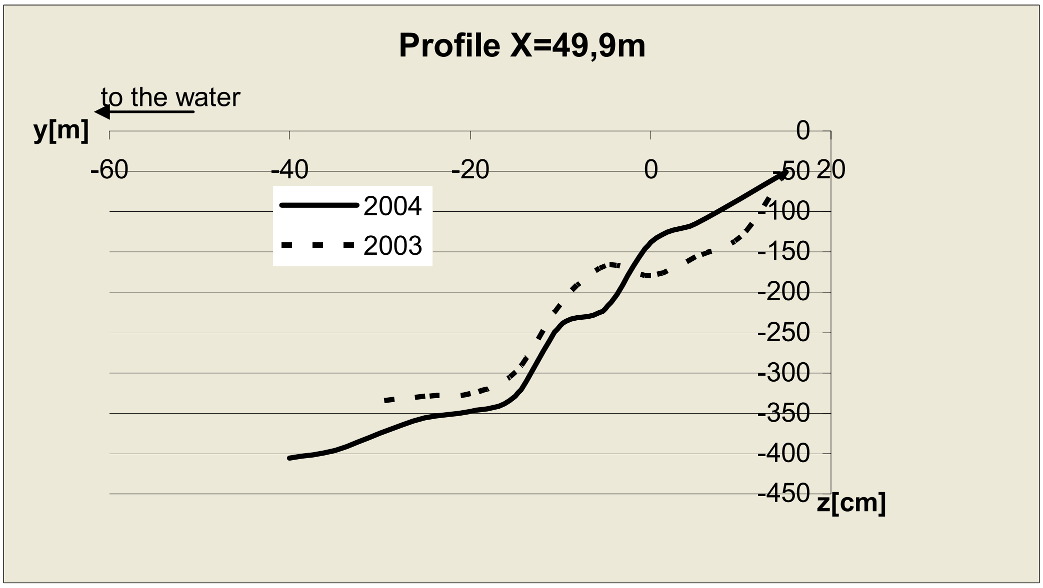


FIGURE 1.9. Profile X=49.9m: Nearly to the water we can assume that there is erosion, but on the dry side there is accretion. There wasn't found any mistake and was used the original data.

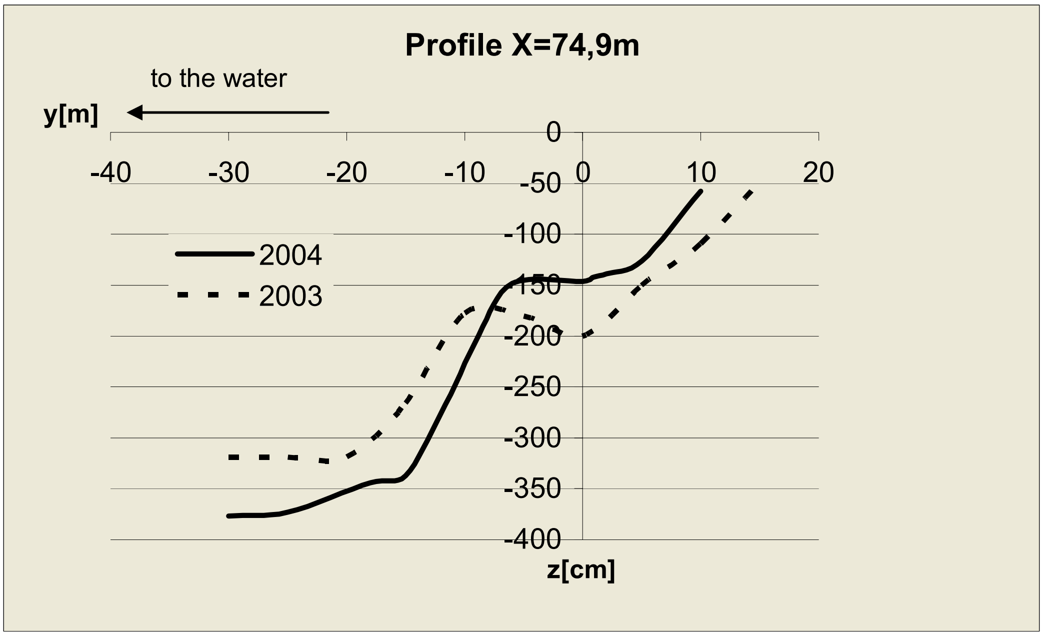


FIGURE 1.10. Profile X=74.9: Here we used again the original values, we think that another point is used as reference.Otherwise the all of values from last year would have been lower and, consequently the conclusion should be an accretion of the beach comparing on last year

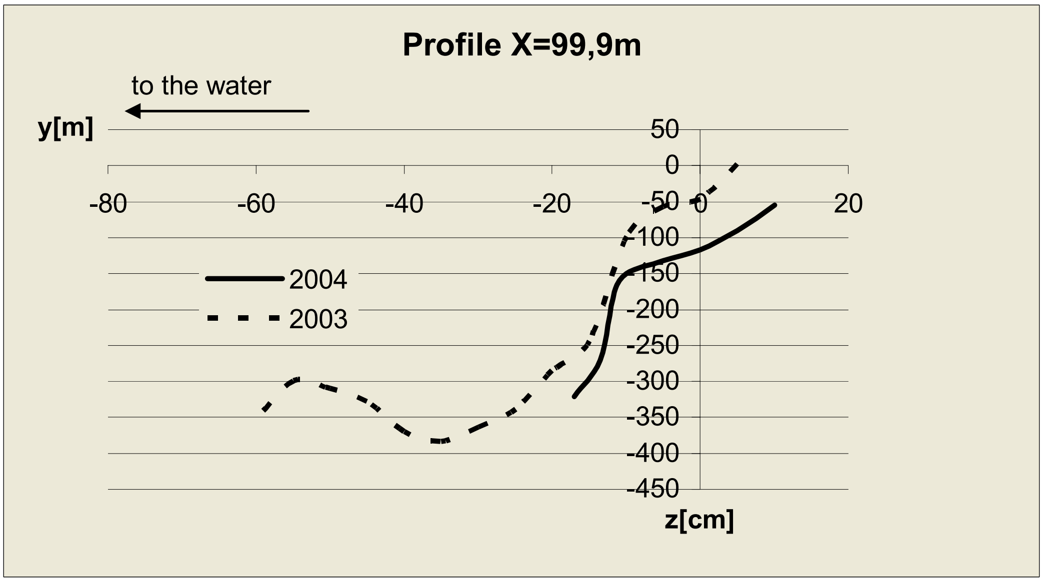


FIGURE 1.11. Profile X=99,9m: For this profile are used the adapted values, because otherwise there would be an extra difference between the data from last year and this year of 58 cm. The mistake in data from 2003 is may be by using wrong cell in excel.

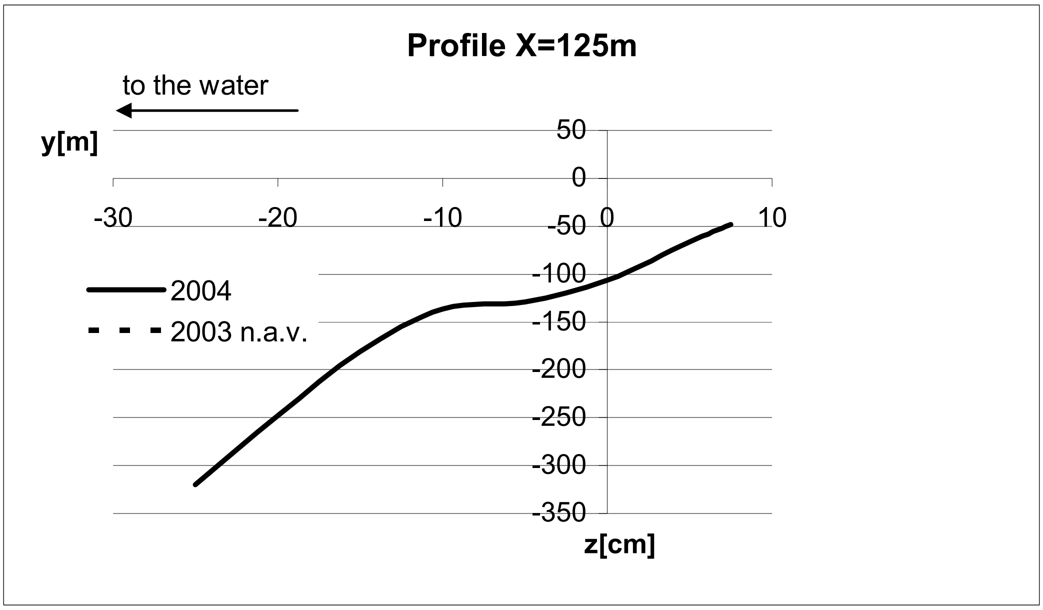


FIGURE 1.12. Profile X=125m: There is no available data for this profile from last year, so it isn't possible any comparison.

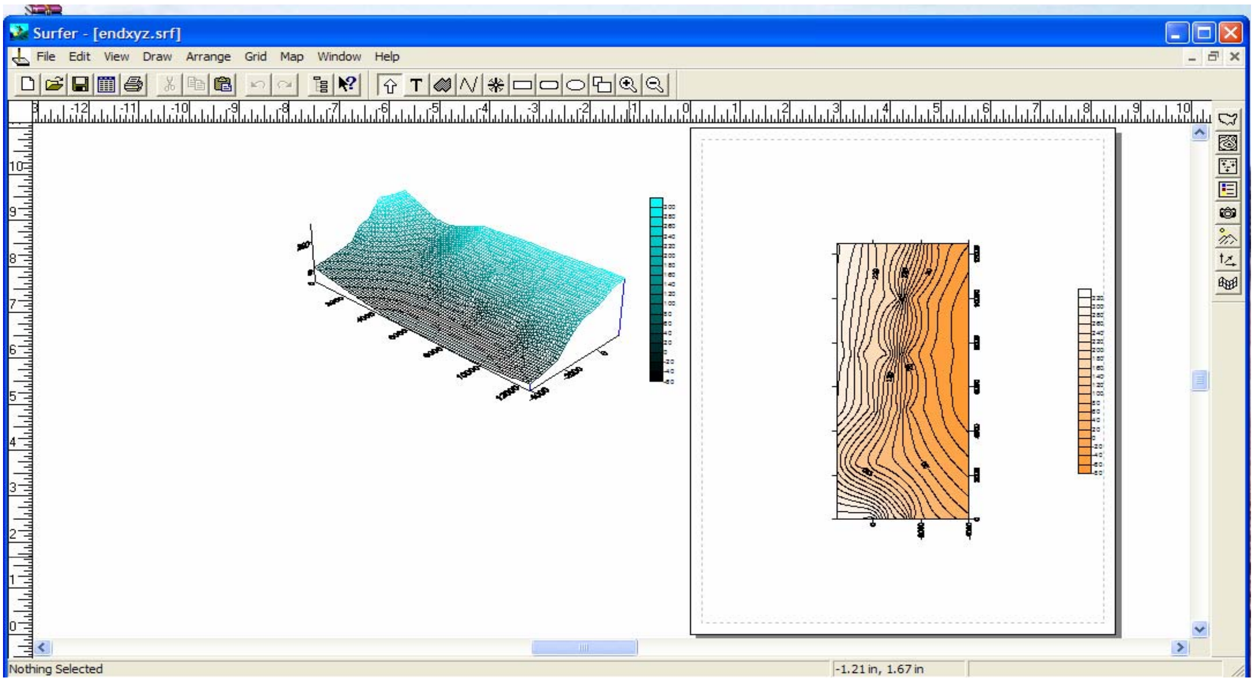
To bring this part of the chapter to its end we should compare the data first of all of all three beach lines, becoming from GPS, DGPS and Profiles data and then we should compare the data from the last year and now. It was quite difficult, because of some calculation errors by last year group, we have become some impossible conclusions (it seemed like had been supplied additional quantity of sand, without having information about it. The formulas were linked incorrectly to an incorrect reference. For some profiles the mistakes were over a meter. This made us to recalculate some of their profiles and so we became the results, shown on the graphs over. But we can't be sure that the comparing results are completely correct. We have tried to make our profiles as correctly as possible is or at least without to repeat the mistakes of 2003.

All of the data of our profile computation is selected in an excel file, which could be used by further analysis.

11.4. SAND VOLUME ON THE BEACH

Calculations of beach volume are made, using Program "Surfer 7". The author wish to appreciate the selfless help of Yasen Grigorov to learn me how to work with this program. The main purpose is to determine the sand losses on the beach, and comparing with the data from the last year to make some conclusions if there is any need of nourishment.

Last year (2003) the volume of the beach was calculated over the area where beach measurements were done. The area, measured in 2004, is completely different. This is the reason why the comparing of the data is not very good idea. The results from the Bulgarian report since 2003 are:



Approximated Volume by:

Trapezoidal rule: 180118

Simpson's rule: 180108

Simpson's 3/8 rule: 180099

Cut & Fill volume

Positive (cut) volume: 180120 m^3

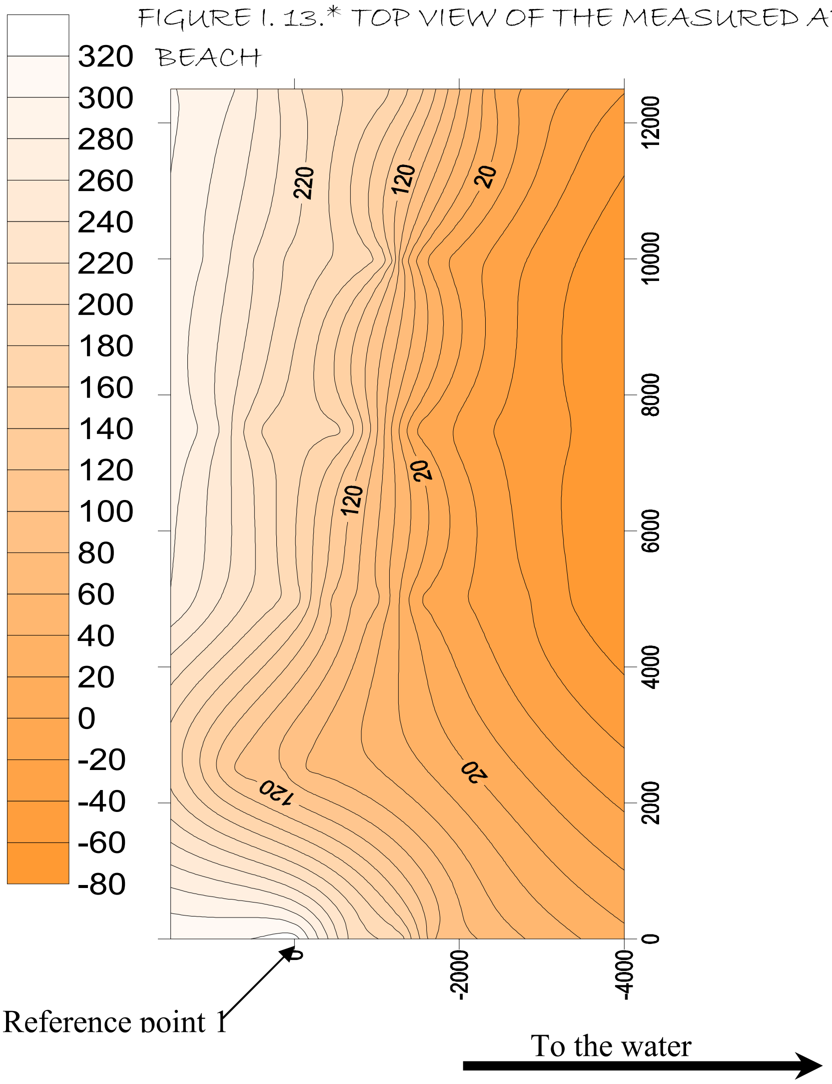
Negative (fill) volume: 0 m^3

Cut minus Fill: 180120 m^3

The results from this year are presented in areas of every 25 meters, starting from the Sirius hotel. For every part the volume of sand was taken that was in the observed area to a depth of 3.3m below the reference point. It's sure that this point is under the water level, the author personally brought the hub to its location on the water side of the beach. By using of Surfer 7 is a possibility to choose kind of method of interpolation. Each of the area is calculate with 4 methods: Kriging, Polynomial regression, Minimum curvanture and Triangulation with linear interpolation. By each method there is a deviation from the other results, because of the different interpolation between the points and the different kind of form of the grid, therefore of the plain. As a final result is taken the average value. It's not correct, but only to have any idea of the whole volume, the sum of sand volumes from all areas is: ≈5317m^3 . So the results of the both years could be correct, because the area measured in 2004 is smaller.

As a conclusion we can say that the beach is visually decreased compared with 2003 (as well as we estimate looking the pictures from last year), the possible reason is an erosion and it's really possible to be needed some sand nourishment. The results (in cm^3) are collected in the tables below:

FIGURE I. 13.* TOP VIEW OF THE MEASURED AREA OF THE BEACH



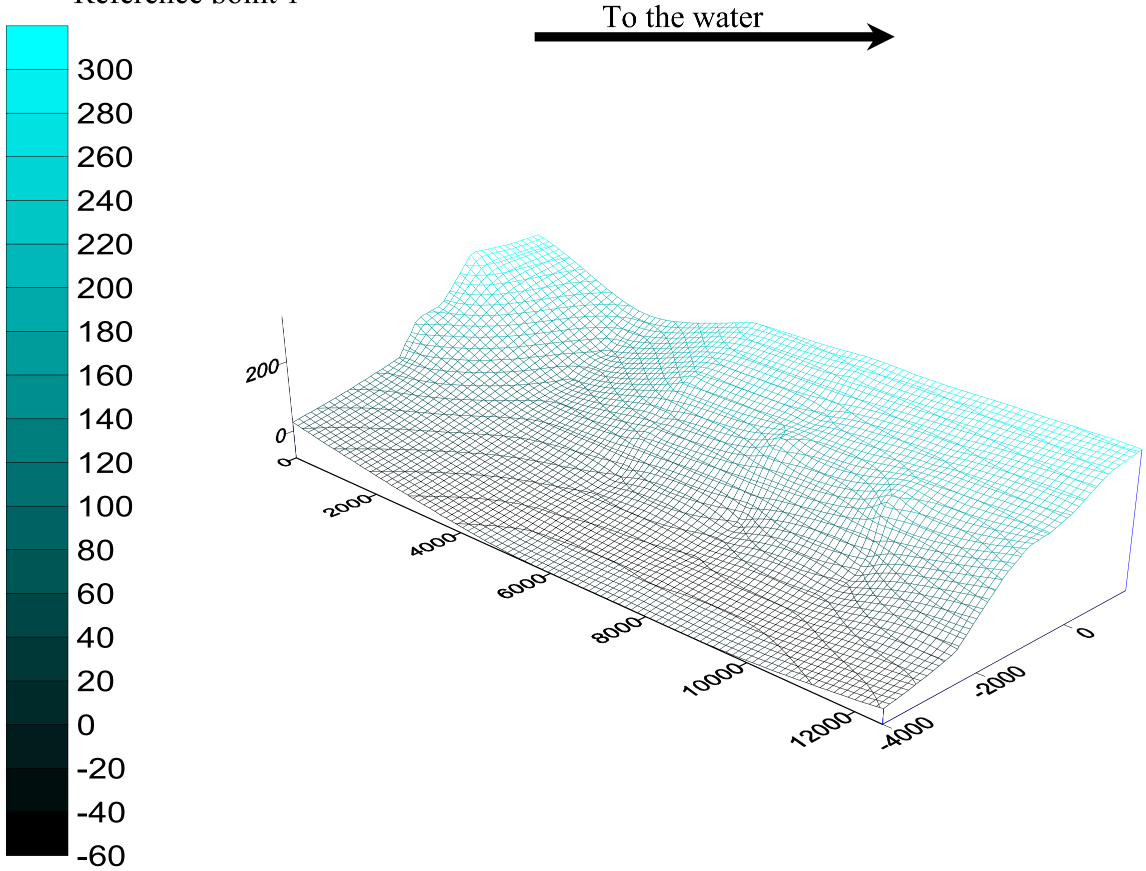


FIGURE I.14.* 3-D VIEW OF THE BEACH

*The author wants to excuse herself for the mirror view of the FIGURE I.13. and FIGURE I.14., but if you pay attention signs, there is know problem to read them.

To get more clear view of the positions of the profiles the data has also been interpreted in a 3D model. In order to monitor the variation of the beach during the years it is not only important to have a 3D view of the beach. It's more important thing to calculate the difference in beach volume. In the following tables are given the volume calculations.

	METHOD	
	Polynomial regression	Min.curvanture
Profile 0 to 25		
Grid File:	C:\Documents and Settings\Lilia Traykova\ Desktop\Beach_measurements2004lilly\0_25xyz.grd	C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\MIN0_25xyz.grd
Grid size:	100 cols by 98 rows	100 cols by 98 rows
Delta X:	25,25252525	25,25252525
Delta Y:	25,15463918	25,15463918
X-Range:	0 to 2500	0 to 2500
Y-Range:	-1640 to 800	-1640 to 800
Z-Range:	-87,3745236619 to 378,273005582	17,1577781273 to 635,002570041
VOLUMES		
Trapezoidal rule	887240369,9	1019379083,1
Simpson's rule	887240369,9	1019339285,6
Simpson's 3/8 rule	887240369,9	1019339123,6
CUT&FILL VOLUMES:		
positiva(cut):	899766405,6	1019404187,2
negative(fill):	12526035,7	0

cut-fill=	**887240369,9**	**1019404187,2**
Profile 25 to 50		
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\25_50regxyz.grd**	the method is not suitable for the data that we have in this region
Grid size:	**45 cols by 100 rows**	
Delta X:	**56,59090909**	
Delta Y:	**55,55555556**	
X-Range:	**2500 to 4990**	
Y-Range:	**-4000 to 1500**	
Z-Range:	**-86,1310340245 to 302,099735206**	
VOLUMES		
Trapezoidal rule	**1133934522,7**	
Simpson's rule	**1133954033,8**	
Simpson's 3/8 rule	**1133953521,7**	
CUT&FILL VOLUMES:		
positiva(cut):	**1178185411,9**	
negative(fill):	**44323812,8**	
cut-fill=	**1133861599,1**	

Table 1.2. Computation of the sand volume

	METHOD		
	Kriging	Triangul.w/Lin.Interplation	average volume
Profile 0 to 25			
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\krig20_25xyz.grd**	the method is not suitable for the data that we have in this region	
Grid size:	**100 cols by 98 rows**		
Delta X:	**25,25252525**		
Delta Y:	**25,15463918**		
X-Range:	**0 to 2500**		
Y-Range:	**-1640 to 800**		
Z-Range:	**67,82385 to 329,25245**		
VOLUMES			
Trapezoidal rule	**1024012029,8**		**976877160,9**
Simpson's rule	**1024018832,2**		**976866162,5**
Simpson's 3/8 rule	**1024018579,7**		**976866024,4**
CUT&FILL VOLUMES:			
positiva(cut):	**1024019684,1**		**981063425,6**

negative(fill):	**0**		**4175345,243**
cut-fill=	**1024019684,1**		**976888080,4**
Profile 25 to 50			
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\krig225_50xyz.grd**	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\tri25_50xyz.grd**	
Grid size:	**45 cols by 100 rows**	**45 cols by 100 rows**	
Delta X:	**56,59090909**	**56,59090909**	
Delta Y:	**55,55555556**	**55,55555556**	
X-Range:	**2500 to 4990**	**2500 to 4990**	
Y-Range:	**-4000 to 1500**	**-4000 to 1500**	
Z-Range:	**-76 to 279**	**-76 to 279**	
VOLUMES			
Trapezoidal rule	**757484726,8**	**692219126,7**	**861212792,0**
Simpson's rule	**757459538,8**	**691745055,6**	**861052876,0**
Simpson's 3/8 rule	**757463208,3**	**692222485,4**	**861213071,8**
CUT&FILL VOLUMES:			
positiva(cut):	**958525977,2**	**731877072,6**	**956196153,9**
negative(fill):	**201078560,5**	**39750954,1**	**95051109,1**
cut-fill=	**757447416,7**	**692126118,5**	**861145044,7**

Table 1.2. Computation of the sand volume

	METHOD	
	Polynomial regression	Min.curvanture
Profile 50 to 75		
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\5075regxyz.grd**	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\min5075xyz.grd**
Grid size:	**45 cols by 100 rows**	**45 cols by 100 rows**
Delta X:	**56,81818182**	**56,81818182**
Delta Y:	**55,55555556**	**55,55555556**
X-Range:	**4990 to 7490**	**4990 to 7490**
Y-Range:	**-4000 to 1500**	**-4000 to 1500**
Z-Range:	**-134,764968199 to 283,989925641**	**-76 to 395,089353999**
VOLUMES		
Trapezoidal rule	**1025921582,4**	**1075410510,1**
Simpson's rule	**1025921582,4**	**1075243651,1**
Simpson's 3/8 rule	**1025921582,4**	**1075243182,5**
CUT&FILL VOLUMES:		
positiva(cut):	**1322931759,3**	**1296647192,0**
negative(fill):	**297010176,9**	**221237607,8**
cut-fill=	**1025921582,4**	**1075409584,3**

Profile 75 to 100		
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\reg75100XYZ.grd**	the method is not suitable for the data that we have in this region
Grid size:	**63 cols by 100 rows**	
Delta X:	**40,32258065**	
Delta Y:	**40,4040404**	
X-Range:	**7490 to 9990**	
Y-Range:	**-3000 to 1000**	
Z-Range:	**-82,7050977936 to 298,645806082**	
VOLUMES		
Trapezoidal rule	**1079703541,4**	
Simpson's rule	**1079703541,4**	
Simpson's 3/8 rule	**1079703541,4**	
CUT&FILL VOLUMES:		
positiva(cut):	**1143430465,7**	
negative(fill):	**63726924,2**	
cut-fill=	**1079703541,4**	

Table 1.2. Computation of the sand volume

	METHOD		
	Kriging	Triangul.w/Lin.Interplation	average volume
Profile 50 to 75			
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\krig5075xyz.grd**	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\TRI5075xyz.grd**	
Grid size:	**45 cols by 100 rows**	**45 cols by 100 rows**	
Delta X:	**56,81818182**	**56,81818182**	
Delta Y:	**55,55555556**	**55,55555556**	
X-Range:	**4990 to 7490**	**4990 to 7490**	
Y-Range:	**-4000 to 1500**	**-4000 to 1500**	
Z-Range:	**-76,7881454141 to 283,848357522**	**-76 to 279**	
VOLUMES			
Trapezoidal rule	**1043170571,2**	**943534493,2**	**1022009289**
Simpson's rule	**1043140813,3**	**943618634,3**	**1021981170**
Simpson's 3/8 rule	**1043151355,9**	**943296855,7**	**1021903244**
CUT&FILL VOLUMES:			
positiva(cut):	**1299131488,7**	**1113808152,6**	**1258129648**
negative(fill):	**255958678,3**	**170180277,7**	**236096685,1**

cut-fill=	**1043172810,4**	**943627874,9**	**1022032963**
Profile 75 to 100			
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\krig75100XYZ.grd**	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\Tri75100XYZ.grd**	
Grid size:	**63 cols by 100 rows**	**63 cols by 100 rows**	
Delta X:	**40,32258065**	**40,32258065**	
Delta Y:	**40,4040404**	**40,4040404**	
X-Range:	**7490 to 9990**	**7490 to 9990**	
Y-Range:	**-3000 to 1000**	**-3000 to 1000**	
Z-Range:	**-48,9794693359 to 275,000133725**	**-47 to 275**	
VOLUMES			
Trapezoidal rule	**1061552221,3**	**1091860647,3**	**1077705470,0**
Simpson's rule	**1061537762,1**	**1091787942,2**	**1077676415,2**
Simpson's 3/8 rule	**1061539250,2**	**1091787090,0**	**1077676627,2**
CUT&FILL VOLUMES:			
positiva(cut):	**1131395025,1**	**1124679687,2**	**1133168392,7**
negative(fill):	**69840771,0**	**32813066,1**	**55460253,8**
cut-fill=	**1061554254,1**	**1091866621,1**	**1077708138,9**

Table 1.2. Computation of the sand volume

	METHOD	
	Polynomial regression	Min.curvanture
Profile 100 to 125		
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\reg100125xyz.grd**	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\min100125xyz.grd**
Grid size:	**72 cols by 100 rows**	**72 cols by 100 rows**
Delta X:	**35,35211268**	**35,35211268**
Delta Y:	**35,35353535**	**35,35353535**
X-Range:	**9990 to 12500**	**9990 to 12500**
Y-Range:	**-2500 to 1000**	**-2500 to 1000**
Z-Range:	**8,78671080574 to 317,630264156**	**-315,634499344 to 291,865942197**
VOLUMES		
Trapezoidal rule	**1433786562,5**	**1340911185,2**
Simpson's rule	**1433786562,5**	**1341001749,1**
Simpson's 3/8 rule	**1433786562,5**	**1341002200,6**
CUT&FILL VOLUMES:		
positiva(cut):	**1433786562,5**	**1400031724,1**
negative(fill):	**0**	**59088239,4**
cut-fill=	**1433786562,5**	**1340943484,7**
	METHOD	

	Kriging	Triangul.w/Lin.Interplation	
Profile 100 to 125			
Grid File:	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\krig100125xyz.grd**	**C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\tri100125xyz.grd**	
Grid size:	**72 cols by 100 rows**	**72 cols by 100 rows**	
Delta X:	**35,35211268**	**35,35211268**	
Delta Y:	**35,35353535**	**35,35353535**	
X-Range:	**9990 to 12500**	**9990 to 12500**	
Y-Range:	**-2500 to 1000**	**-2500 to 1000**	
Z-Range:	**-8,76034332884 to 286,669901619**	**9,07323943662 to 281,831697254**	
VOLUMES			AVERAGE
Trapezoidal rule	**1422009728,8**	**1319884266,2**	**1379147935,7**
Simpson's rule	**1422015317,0**	**1319506227,8**	**1379077464,1**
Simpson's 3/8 rule	**1422018065,1**	**1320387837,1**	**1379298666,3**
CUT&FILL VOLUMES:			
positiva(cut):	**1422486301,9**	**1319913949,5**	**1394054634,5**
negative(fill):	**475811,6**	**0**	**14891012,8**
cut-fill=	**1422010490,2**	**1319913949,5**	**1379163621,7**

Table 1.2. Computation of the sand volume

It is also possible to calculate the total volume of the beach with the grid files of all the areas combined, but this is not correct to be done, because the areas have not been measured over the same width of the beach. "Surfer 7" will fill in the blanks and calculate some places like full with sand, but actually there isn't. The accuracy is under doubt!

VOLUME COMPUTATIONS

UPPER SURFACE

Grid File: C:\Documents and Settings\Lilia Traykova\Desktop\Beach_measurements2004lilly\endxyz.grd
Grid size as read: 100 cols by 44 rows
Delta X: 126.262626263
Delta Y: 127.906976744
X-Range: 0 to 12500
Y-Range: -4000 to 1500
Z-Range: -79.9229824085 to 327.810810634

LOWER SURFACE
Level Surface defined by Z = 0

VOLUMES
Approximated Volume by
Trapezoidal Rule: 6312753612.27
Simpson's Rule: 6311954710.58
Simpson's 3/8 Rule: 6312053128.28

CUT & FILL VOLUMES
Positive Volume [Cut]: 7108227789.45
Negative Volume [Fill]: 795543078.675
Cut minus Fill: 6312684710.78

AREAS

Positive Planar Area	
(Upper above Lower):	**48335070.0317**
Negative Planar Area	
(Lower above Upper):	**20414929.9683**
Blanked Planar Area:	**0**
Total Planar Area:	**68750000**
Positive Surface Area	
(Upper above Lower):	**48518567.7306**
Negative Surface Area	
(Lower above Upper):	**20430623.3036**

II.5. SAND SAMPLES

From the observed beach were taken six different sand samples. As many samples we have as better view we have for the distribution of the sand on the beach and dependence on the distance to the sea. The places of the sand samples were chosen, so that after an analysis in the labor to become entire information about the sand distribution on the beach and sediment transport by wave motion. The placement of the samples is shown on the figure I.15. Their positions have been located with the help of GPS.

Samples	Coordinates	
	X	Y
Sample 5(on the beach,near to the water)	0582421	4787224
Sample 7(in the middle of the beach,btw samples 5&11)	0582412	4787223
Sample 8(wall-end of the beach)	0582388	4787133
Sample 10(in the middle of the beach,in the water)	0582425	4787218
Sample 11(in front of the yellow building)	0582399	4787227
Sample 12(in front of the blue Hotel)	0582454	4787318

Table I.3. Sand samples, coordinates

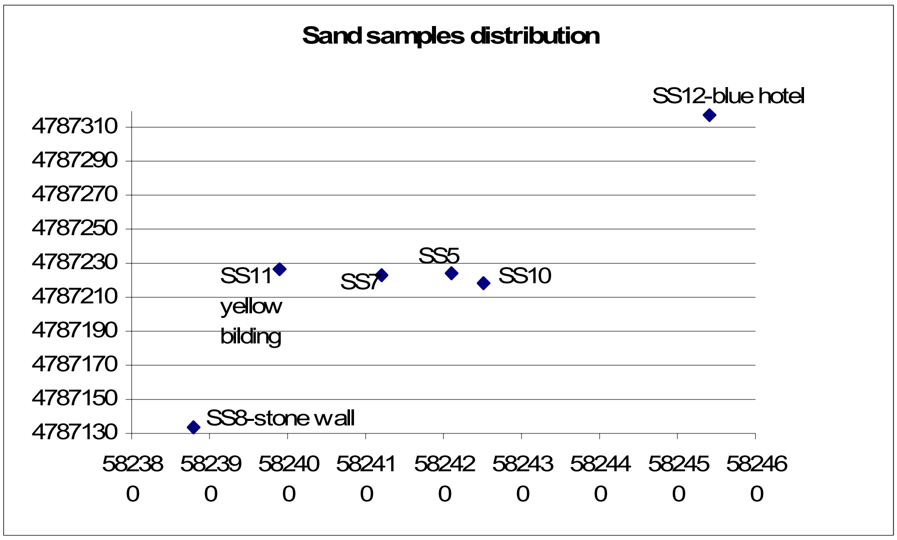
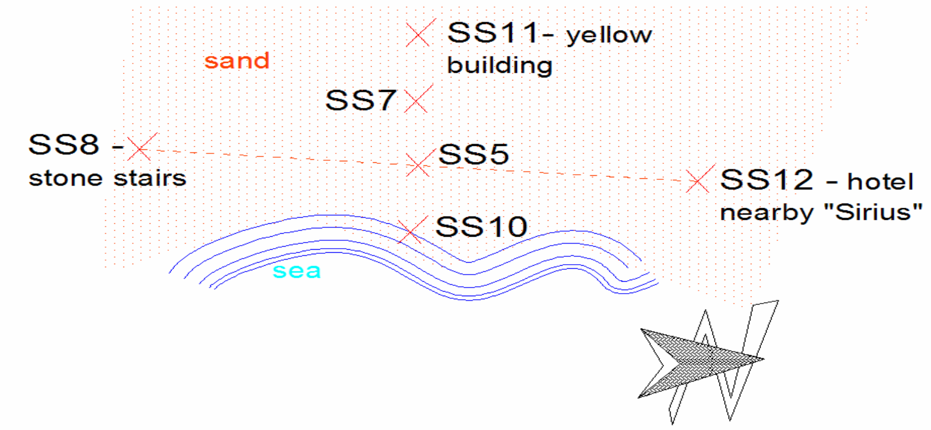


FIGURE I.15. SAND SAMPLES DISTRIBUTION ON THE BEACH



To decrease the possibility that only fine particles transported by the wind were collected, the samples were taken a few decimeters below surface. The samples were numbered in a random order and each was divided into two parts for the both groups

The samples have been brought at the University of architecture, civil engineering and geodesy in Sofia, where I have executed sieve analysis. The results are shown on the following figures and tables. As main characteristics of the samples is taken D_{50}. For each sample was executed only one sieve measurement. For our purposes, quantifying sediment transport, accuracy rates are of that small order and only one measurement satisfies. Calculations are given on the tables below.

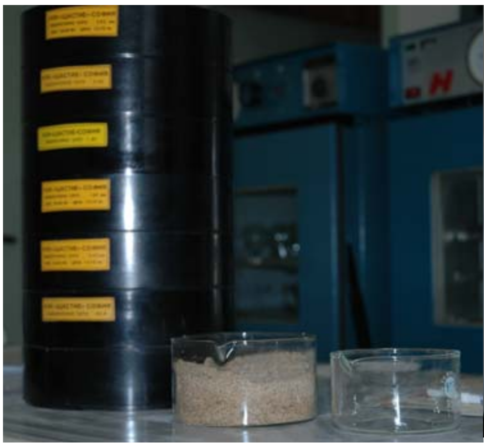
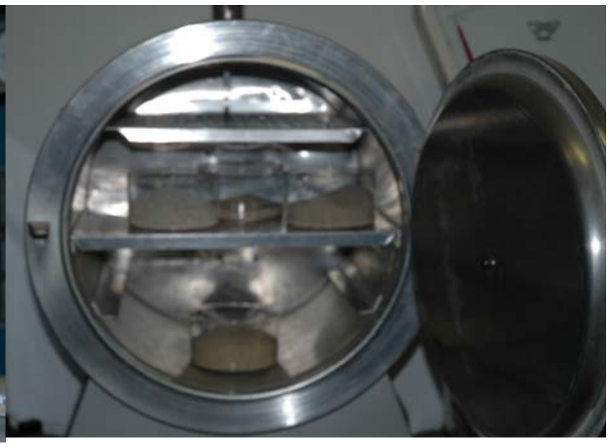


FIGURE I.16. SAND SAMPLES IN THE LAB - SIEVES DECREASING DIAMETER OF THE HOLES, DRYING CELL WITH THE SAMPLES

The analysis was started with drying of the samples in a drying cell. After it every sample was weighted on an electric scale. Then I started sieving on the sieves, which were ordered in decreasing order depending on the diameters of their holes as follow:
2,5mm; 2,0mm; 1,6mm; 1.0mm; 0.5mm; 0.09mm;

Each part of the sand rested on every sieve was weighed again and the sum of them should be the same like at the beginning.

FIGURE I.17. Electr. weighter in lab, visually estimation of D_{50}

The results are represented in log – scale (Figure I.16) and compared with the result from the last year. The horizontal axis of the graph is the diameter of the sieves and on the ordinate is the percentage of the sample, which is passed through the sieve.

By well graded sand this results in form of S-shaped curve. D_{50} is the value become by y=50%. This value represents the grain size which is exceeded by 50% of the sample. D_{50} is practically the same as the median grain size (D_m).

Another way to plot data from sieve analysis is using a log-gauss scale. For well-graded samples the result should be approximately a straight line.

Sample	10	5	11	7	12	8
D_{50} (mm)	0.23	0.29	0.43	0.44	0.57	0.58

TABLE I.4.: D_{50} VALUES

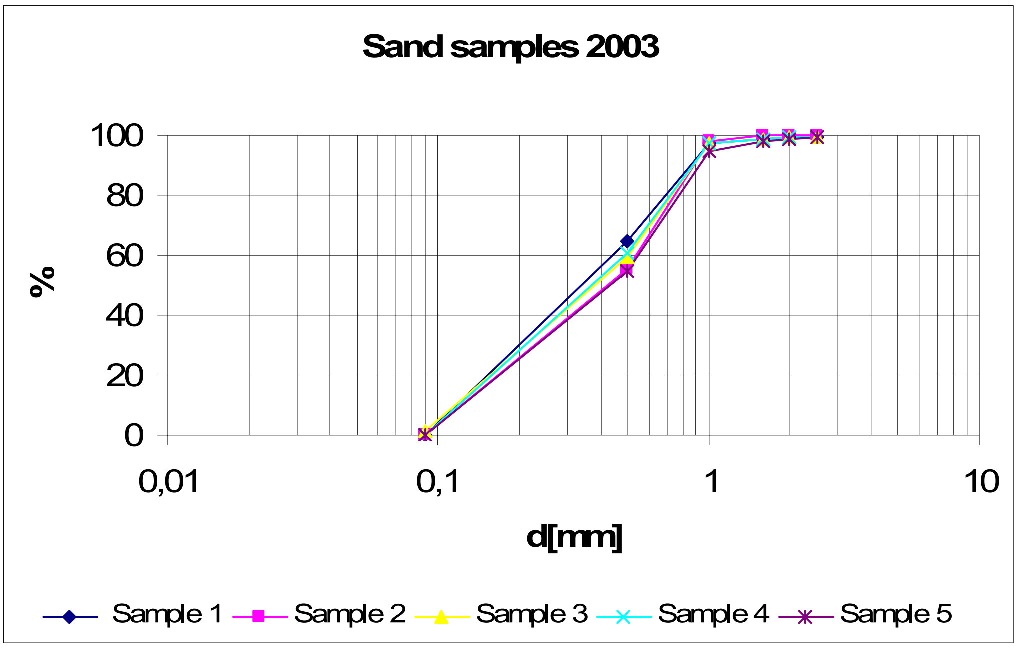
The table I.4. shows approximatly the expected results, that as nearer to the water is the sand sample, as finer is the grain size. The coarsest sand is near by the both end reference points. So, the dynamic character of the water movement near the shoreline can explain this. Finer sands show of the dynamic influence on this part of the beach. Sample 5, which is nearly to the beach line, has almost the same characteristic as the sand sample 10. The samples with the greatest parameter were taken near by the hotel and the wall, where the wind doesn't influent so hard over the grain particles. In contrast to the samples taken from the middle of the beach, where may have occurred some aeolic processes.

	Tara	m [gr]	m [gr]	m [gr]	m [gr]	m [gr]	m [gr]	m [gr]	M[gr]
Sample	[gr]	d>2,5mm	d=2,0-2,5mm	d=1,6-2,0mm	d=1,0-1,6mm	d=0,5-1,0mm	d=0,09-0,5mm	d<0,09mm	Σ
5	97,297	0,400	0,066	0,237	3,300	123,280	358,727	0,184	486,194
7	97,298	0,824	0,638	1,635	16,537	199,702	253,300	0,594	473,230
8	97,282	1,578	0,653	1,777	22,905	147,151	110,789	0,238	285,091
10	97,310	0,000	0,000	0,000	0,873	33,896	404,433	0,102	439,304
11	97,299	1,203	0,739	2,115	14,618	150,663	204,068	1,059	374,465
12	97,297	6,876	1,957	2,878	28,112	204,965	170,887	2,352	418,027

	Tara	m [%]	m [%]	m [%]	m [%]	m [%]	m [%]	m [%]	M[%]
Sample	[gr]	d>2,5mm	d=2,0-2,5mm	d=1,6-2,0mm	d=1,0-1,6mm	d=0,5-1,0mm	d=0,09-0,5mm	d<0,09mm	Σ
5	97,297	0,082	0,014	0,049	0,679	25,356	73,783	0,038	100,000
7	97,298	0,174	0,135	0,345	3,494	42,200	53,526	0,126	100,000
8	97,282	0,554	0,229	0,623	8,034	51,615	38,861	0,083	100,000
10	97,310	0,000	0,000	0,000	0,199	7,716	92,062	0,023	100,000
11	97,299	0,321	0,197	0,565	3,904	40,234	54,496	0,283	100,000
12	97,297	1,645	0,468	0,688	6,725	49,032	40,879	0,563	100,000

	Tara		m [%]	m [%]	m [%]	m [%]	m [%]	m [%]	M[%]
Sample	[gr]		d<0,09mm	d<0,50mm	d<1,00mm	d<1,60mm	d<2,00mm	d<2,50mm	Σ
5	97,297		0,038	73,821	99,177	99,855	99,904	99,918	100,000
7	97,298		0,126	53,651	95,851	99,346	99,691	99,826	100,000
8	97,282		0,083	38,944	90,560	98,594	99,217	99,446	100,000
10	97,310		0,023	92,085	99,801	100,000	100,000	100,000	100,000
11	97,299		0,283	54,779	95,013	98,917	99,481	99,679	100,000

Table 1.5. RESULTS OF THE SIEVE ANALYSIS



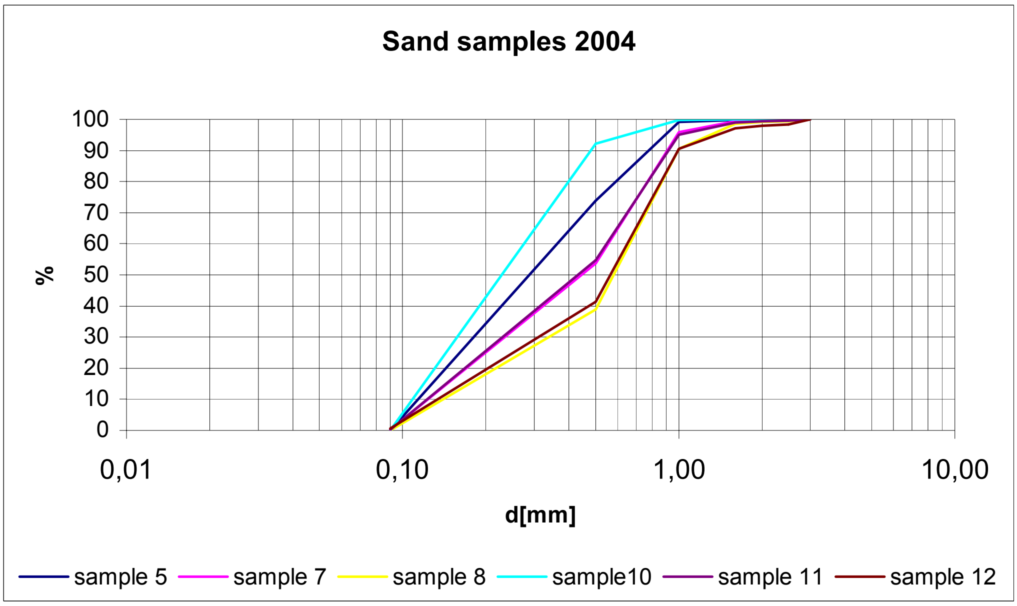
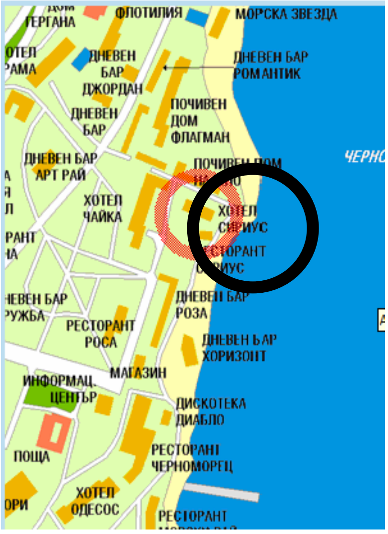


FIGURE I.18. DATA FROM THE SIEVE ANALYSIS IN LOG-SCALE, COMPARISON OF THE RESULTS OF LAST TWO YEARS

Sand samples were taken by windy and rainy weather, when also greater grains are moved to other places and the water line hardly ever moves under normal circumstances.

By the comparing of the data of last two years, using the representative values of D_{50}, we could say the sand in 2004 is finer than in 2003. This means that there were more dynamic processes during 2004 compared with 2003 and the sand volume could easier decrease by the wave motion, aeorolic processes etc. in the next years. The volume calculation shows the same result. It may be need of nourishment in next year.

II.6. PROJECT ISLAND IN SEA



The owner of the hotel near by the "Sirius" built on the beach resort "St. St. Konstantin and Helena" has the idea to create an artificial island in front of his hotel, placed in 100m in the Black sea. He would like to know, if there are any constructive reasons, which make the idea impossible. He would like to build another hotel, a bar or a restaurant on the island and to attract tourists' attention.

FIGURE I.19. THE ZONE IN FRONT OF "SIRIUS", WHERE SHOULD BE LOCATED THE ARTIFICIAL ISLAND

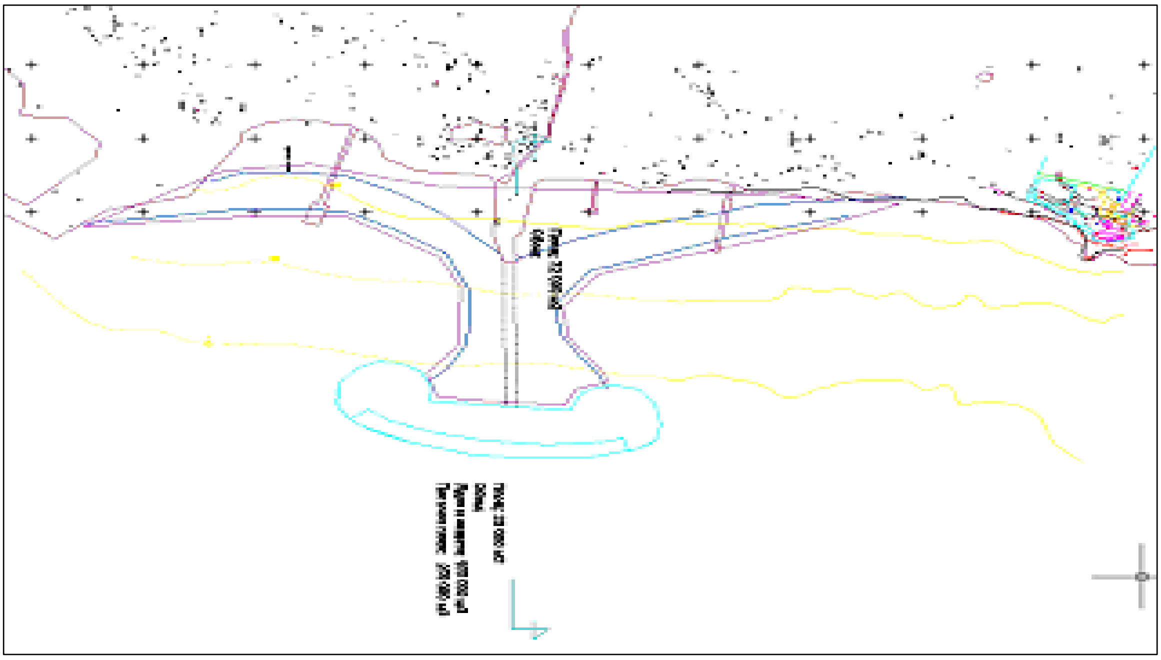


FIGURE I.120. PROJECT OF THE ARTIFICIAL ISLAND

In front of the hotel there is a part of a breakwater, this was constructed due to coastline regression. Compared with the last year the size of the breakwater decreased vastly.

The beach in front of Sirius is partly artificial and it has been expanded after the construction of the hotel. This is the beach, which we have measured.

The hotel owner is also the owner of a quarry and he prefers to use the sand, mined from his quarry for beach nourishment and for construction of the island. For the main body, cover and consolidation are needed 450 000m^3 , and for the sand beach on the island 250 000 m^3. The area, which is covered from the island is 25 000m^2.

By executing of the project it should be paid attention to some problems and the influences over the appurtenance. The waves and the sea flows in the region have to be measured and have to be taken the necessary precautions to consolidate the island, depending on the conditions. To know the conditions in the sea, it's good idea to have some information about the weather conditions in the region some years ago. The wind intensity should be watched closely for significant changes. It's certain to define the significant wave high using wave measurements similar to chapter II.

It should be proved that the material from the quarries of the owner is with sufficient quality. The quality of the materials, used by building the island must response to the conditions. It's obligatory to have enough available information for the soil conditions.

It's important to be researched the influence of an artificial island over the environment and over the beaches in the surround. It has to be paid attention to the changes in the water flows and the animal world has not to be disturbed. The possible damages should be minimized. The changes in the environment must be as less as possible.

IV. Wave Measurement

Written by: Ivo Petrov

Waves - disturbances of water - are a constant presence in the Black sea. Because waves travel all across the sea, transmitting vast amounts of energy, understanding their motions and characteristics is essential. The forces generated by waves are the main factor impacting the geometry of beaches, the transport of sand and other sediments in the nearshore region, and the stresses and strains on coastal structures. When waves are large, they can also pose a significant threat to commercial shipping, recreational boaters, and the beachgoing public. Thus for ensuring sound coastal planning and public safety, wave measurement and analysis is of great importance.

1. Wave Generation

Waves are generated by forces that disturb a body of water. They can result from a wide range of forces - the gravitational pull of the sun and the moon, underwater earthquakes and landslides, the movements of boats and swimmers. The vast majority of sea waves, however, are generated by wind.

Out in the sea, as the wind blows across a smooth water surface, air molecules push against the water. This friction between the air and water pushes up tiny ridges or ripples on the sea surface. As the wind continues to blow, these ripples increase in size, eventually growing into waves that may reach many meters in height.

Three factors determine how large wind-generated waves can become. The first factor is wind speed, and the second factor is wind duration, or the length of time the wind blows. The final factor is the fetch, the distance over which the wind blows without a change in direction. The faster the wind, the longer it blows, and the larger the fetch, the bigger the waves that will result. But the growth of wind-generated ocean waves is not indefinite. After a certain point, the energy imparted to the waters by a steady wind is dissipated by wave breaking (often in the form of whitecaps). When this occurs and the waves can no longer grow, the sea state is said to be a 'fully developed'.

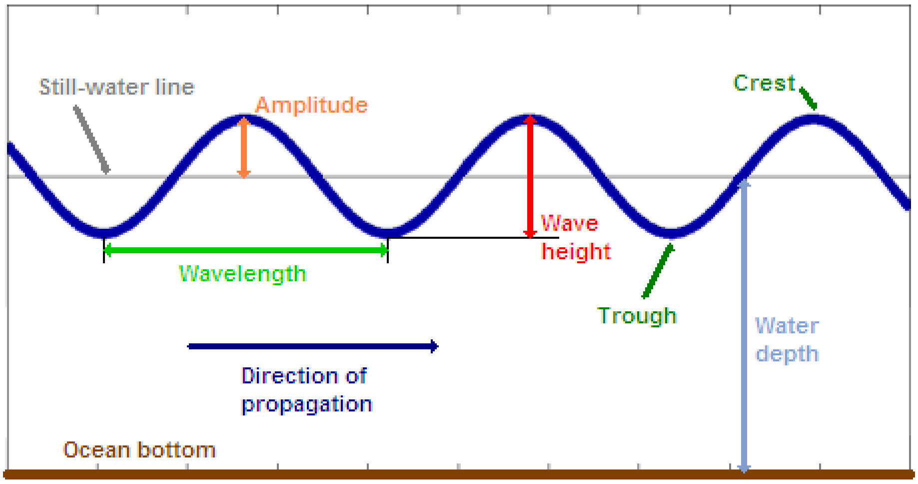
When waves are being generated by strong winds in a storm, the sea surface generally looks very chaotic, with lots of short, steep waves of varying heights. In calm areas far from strong winds, ocean waves often have quite a different aspect, forming long, rolling peaks of uniform shape. For this reason, physical oceanographers differentiate between two types of surface waves: seas and swells. Seas refer to short-period waves that are still being created by winds or are very close to the area in which they were generated. Swells refer to waves that have moved out of the generating area, far from the influence of the winds that made them.

In general, seas are short-crested and irregular, and their surface appears much more disturbed than for swells. Swells, on the other hand, have smooth, well-defined crests and relatively long periods. Swell is more uniform and regular than seas because wave energy becomes more organized as it travel longs distances. Longer period waves move faster than short period waves, and reach distant sites first. In addition, wave energy is dissipated as waves travel (from friction, turbulence, etc.), and short-period wave components lose their energy more readily than long-period components. As a consequence of these processes, swells form longer, smoother, more uniform waves than seas.

2. *Wave Dynamics*

Looking out at the water, an ocean wave in deep water may appear to be a massive moving object - a wall of water traveling across the sea surface. But in fact the water is not moving along with the wave. The surface of the water - and anything floating atop it, like a boat or buoy - simply bobs up and down, moving in a circular, rise-and-fall pattern. In a wave, it is the disturbance and its associated energy that travel from place to place, not the ocean water. An ocean wave is therefore a flow of energy, travelling from its source to its eventual break-up. This break up may occur out in the middle of the ocean, or near the coast in the surfzone.

In order to understand the motion and beahvior of waves, it helps to consider simple waves: waves that can be described in simple mathematical terms. Sinusoidal or monochromatic waves are examples of simple waves, since their surface profile can be described by a single sine or cosine function. Simple waves like these are readily measured and analyzed, since all of their basic characteristics remain constant.



A simple, monochromatic wave.

Because of their uniformity, simple waves can be readily studied.

Wave Anatomy:

- **Still-Water Line** - The level of the sea surface if it were perfectly calm and flat.
- **Crest** - The highest point on the wave above the still-water line.
- **Trough** - The lowest point on the wave below the still-water line.
- **Wave Height** - The vertical distance between crest and trough.
- **Wavelength** - The horizontal distance between successive crests or troughs.
- **Wave Period** - The time it takes for one complete wave to pass a particular point.
- **Wave Frequency** - The number of waves that pass a particular point in a given time period.
- **Amplitude** - One-half the wave height or the distance from either the crest or the trough to the still-water line.
- **Depth** - the distance from the ocean bottom to the still-water line.
- **Direction of Propagation** - the direction in which a wave is travelling.

The motion and behavior of simple sinusoidal waves can be fully described when the wavelength (L), height (H), period (T), and depth (d) are known. For instance, in deep water - when the depth is greater than one-half the wavelength - wave speed can be determined from the wave size. In shallow water, on the other hand, wave speed depends primarily on water depth.

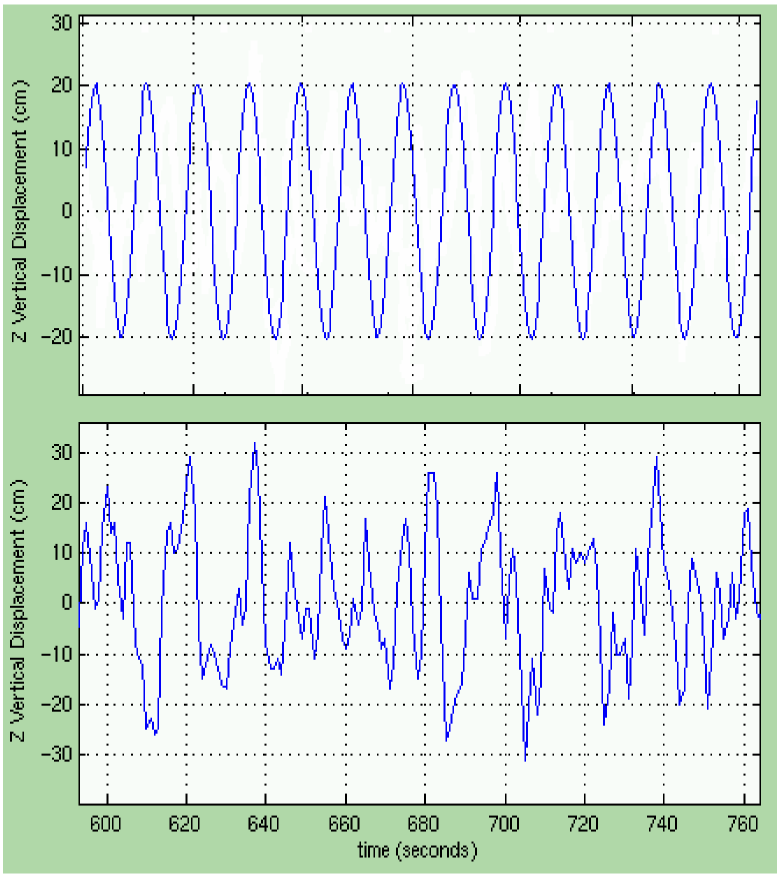
Similarly, wave height is limited by both depth and wavelength. For a given water depth and wave period, there is a maximum height limit above which a wave becomes unstable and breaks. In deep water this upper limit of wave height - called breaking wave height - is a function of the wavelength. In shallow water, however, it is a function of both depth and wavelength.

(Studies suggest the limiting wave steepness to be H/L = 0.141 in deep water and H/d = 0.83 for solitary waves in shallow water.)

3. Irregular Waves

Although simple waves are readily analyzed, in their perfect regularity they do not accurately depict the variability of ocean waves. Looking out at the sea, one never sees a constant progression of identical waves. Instead, the sea surface is composed of waves of varying heights and periods moving in differing directions. When the wind is blowing and the waves are growing in response, the seas tend to be confused: a wide range of heights and periods is observed. Swell is more regular, but it too is fundamentally irregular in nature, with some variablility in height and period. In fact, highly regular waves can be generated in the laboratory but are rare in nature.

Once we recognize the fundamental variability of the sea surface, it becomes necessary to treat the characteristics of the sea surface in statistical terms. The ocean surface is often a combination of many wave components. These individual components were generated by the wind in different regions of the ocean and have propagated to the point of observation, forming complex waves.



The waves seen in actual sea surface measurements, bottom, are much more irregular than simple waves, top.

If a recorder were to measure waves at a fixed location on the ocean, a the wave surface record would be rather irregular and random. Although individual waves can be identified, there is significant variability in height and period from wave to wave. Consequently, definitions of wave characteristics - height, period, etc. - must be statistical or probabilistic, indicating the severity of wave conditions.

By analyzing time-series meaurements of a natural sea state, some statistical estimates of simple parameters can be produced. The most important of these parameters is the significant wave height, Hs. Hs (or H 1/3) is the mean of the largest 1/3 (33%) of waves recorded during the sampling period. This statistical measure was designed to correspond to the wave height estimates made by experienced observers. (Observers do not notice all of the small waves that pass by; instead they focus on the larger, more salient peaks.)

Since ocean conditions are constantly changing, measures like significant wave height are short-term statistics, calculated for sample periods that are generally one hour or less. (The majority of CDIP's parameters are calculated for periods from 26 to 30 minutes.) Moreover, it is important to remember that the significant wave height is a statistical measure, and it is not intended to correspond to any specific wave. During the sampling period there will be many waves smaller than the Hs, and some that are larger. Statistically, the largest wave in a 1000-wave sample is likely to be nearly two times (1.86x) the significant wave height!

A number of other wave parameters - like Ta, the average period - are measured to describe natural sea states. Yet even taken together, the basic wave parameters give very limited information about wave characteristics and behavior. A single Hs value may correspond to a wide range of conditions, combining waves from any number of different swells. For this reason, phyical oceanographers have developed analyses that give more detailed, complete meaures of ocean waves.

4. Wave spectra and statistics

A wave spectrum is the distribution of wave energy as a function of frequency. It describes the total energy transmitted by a wave-field at a given time. Formally -

$$S(\omega) = 4\int_0^{\infty} R(\tau)\cos 2\pi\omega\tau d\tau \qquad (1)$$

where ω is the frequency of the waves (defined previously) and R(τ) is the autocorrelation function of the water-surface time
series –

$$R(\tau) = E[x(t)x(t+\tau)] \qquad (2)$$

where τ is the time lag between samples.
Wave spectra are strongly influenced by the wave-producing wind and its statistical/spatial characteristics. The spatial variability is primarily encapsulated into the fetch. Fetch is the length over which the wind blows to generate the waves. Virtually all models assume a constant wind speed over the fetch. Unfortunately, this is rarely the case.

Stochastic wave distributions

Another way to assess wave conditions is to describe the water depth (or the perturbation from the mean water level, η) at one

point for all time. To do so, the mathematics of probability density functions becomes important.
The most common distribution used is the Rayleigh distribution:

$$p(\eta) = \frac{\eta}{\sigma^2}\exp\left(\frac{\eta^2}{\sigma^2}\right) \qquad (3)$$

where η is the perturbation from the mean water surface and σ is the standard deviation of water surface. The standard deviation is defined by

$$\sigma^2 = \int_{-\infty}^{\infty} \eta^2 p(\eta) d\eta \qquad (4)$$

Another popular model is the Weibull distribution. The Weibull distribution was developed primarily to describe water flow (and stage) in rivers. It is

$$p(\eta) = \alpha\beta\eta^{\beta-1}\exp\left(-\alpha\eta^{\beta}\right) \tag{5}$$

where α and β are constants to be determined. Massel uses a = 0.75 and β = 0.75 for shallow-water situations.
Occasionally, a log-normal distribution is also assumed.

Common wave-field descriptors

To describe the intensity of the wave-field, it is useful to define moments. Moments are defined slightly differently in wave analysis than for turbulent flows. In this case,

$$m_n = \int_0^{\infty} \omega^n S(\omega) d\omega \tag{6}$$

For instance, you can show that the standard deviation of the water surface $\sigma = \sqrt{m_0}$.

There are several quantities used to describe the strength of a wave field. The most common is the significant wave height Hs. Hs is the average height of the largest 1/3 of the waves. However, it occasionally given the definition

$$H_{m_0} = 4\sqrt{m_0} \tag{7}$$

The other common wave-field descriptor is the root-mean-square wave height Hrms. Since the root-mean-square is equivalent to the standard deviation (of a zero-mean process),

$$H_{rms} = 2\sqrt{2m_0} \tag{8}$$

Typical statistical quantities can also be expressed in terms of the zero-moment, if we assume a Rayleigh distribution…..

Mean $H = \overline{H} = \sqrt{2\pi m_0}$, Median $H = \sqrt{2\pi m_0}$, Mode $H = 2\sqrt{m_0}$

Of particular interest to sedimentologists is the maximum wave height Hmax for a given $\overline{H}$.

The problem is that the Rayleigh distribution is 'flat'.
Assuming a Rayleigh distribution (from Massel) –

$$H_{0.1} = 5.09\sqrt{m_0}, \qquad H_{0.01} = 6.67\sqrt{m_0}$$

To counteract this problem, Glukhovskiy (1966) extended the Rayleigh distribution to shallow water and cast the pdf described in (3) to an exceedence pdf. His formulation is

$$P\left(H/\overline{H}\right) = \exp\left[-\frac{\pi}{4}\left(\frac{\varsigma^{2/(1-\varsigma)}}{1+\varsigma/\sqrt{2\pi}}\right)\right] \qquad (9)$$

where $\varsigma = \overline{H}/h$.

Statistics of wave period

The temporal structure of waves (i.e., the period) is more difficult to characterize. There are three different definitions, which have three different results. They are:

Average period between increasing zero-crossings

$$\overline{T_z} = 2\pi\sqrt{m_0/m_2}$$

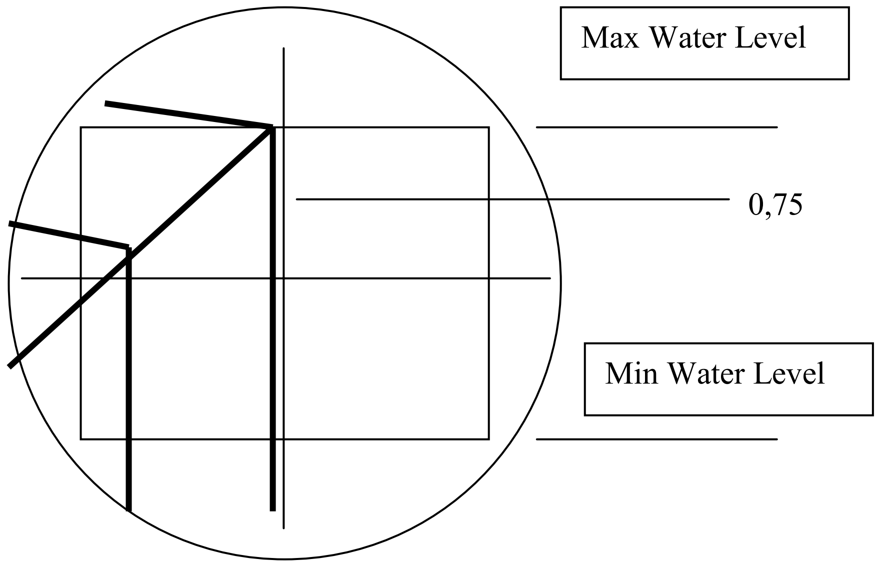
Average wave period

$$\overline{T} = 2\pi m_0/m_1$$

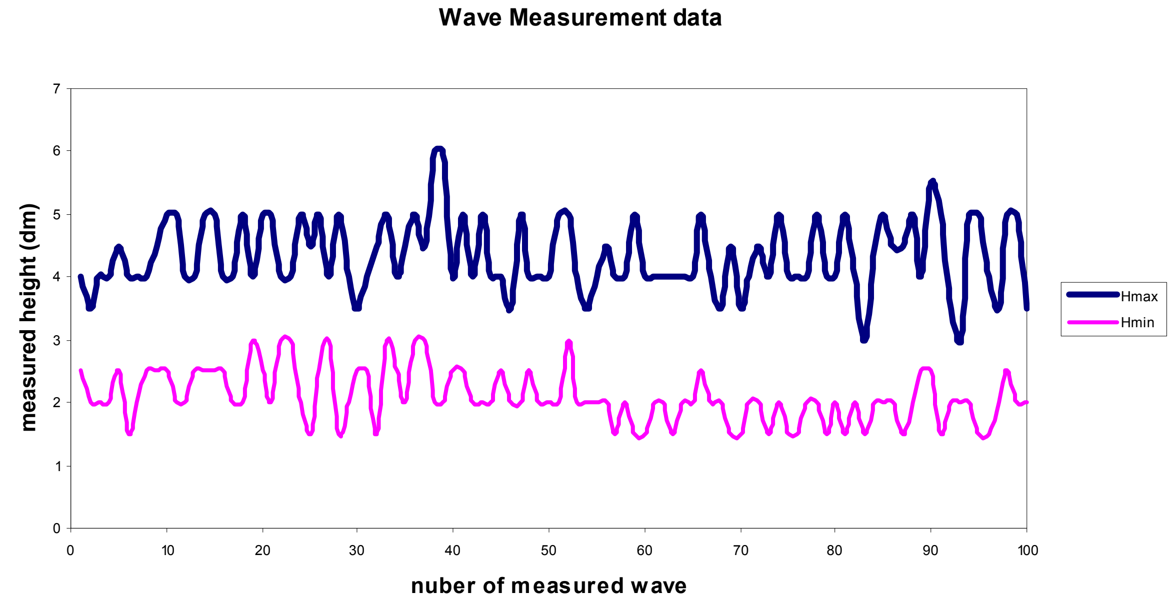
Average period between crests

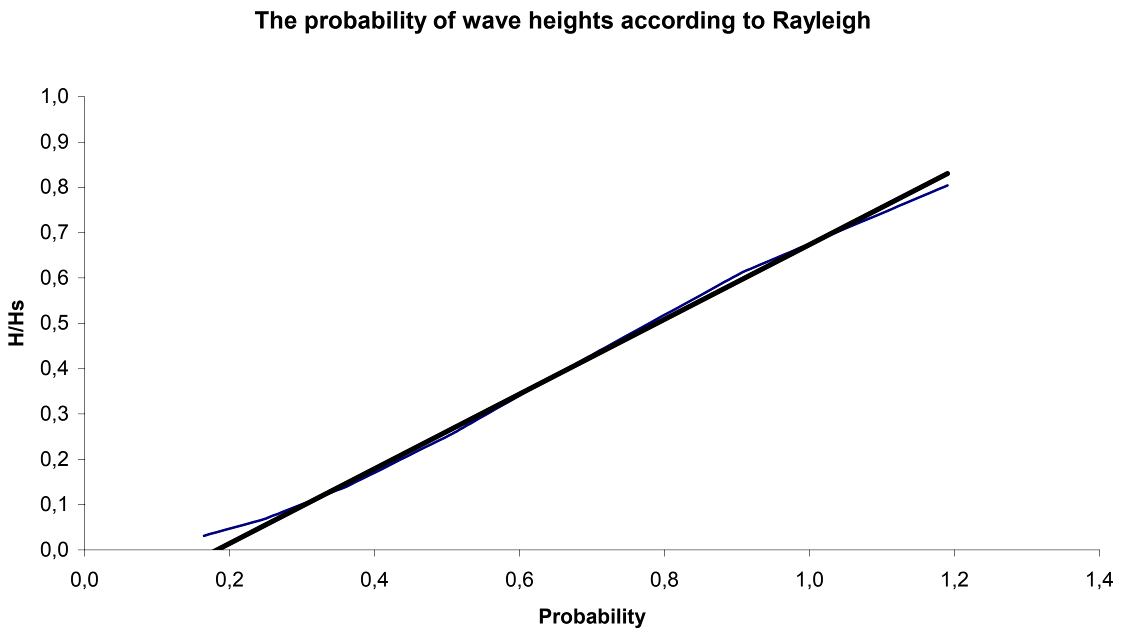
$$\overline{T_z} = 2\pi\sqrt{m_2/m_4}$$

The wave measurements made at groin near the Hotel proved that the Rayleigh distribution is very proper for analysing sea waves. There were made 3 observfation series of 100 waves for about 30 minutes. Only the clearly visible crests and Troughs were measured. The first day the measurements were made using a scaled lat. The next day the weather conditions were very bad, it was cold and windy and the waves were very high and dangerous for the students to stay at the edge of the groin. So we found another solution using a theodlite from a distance. The needed distance which can guarantee that the maximal amplitude is visible, is proportional to the height of the waves. The theodolite was positioned in a way that the minimal and the maximal water level at the end of the groin can be seen. This difference we have accepted for 100%. This was made beacause we were not able at that moment to determine the real dimensions of the last groin pile which was observed as lat and it is easier to to determine a particular water level as percentage from the distance between the upper and the lower line on visor.



The measured relative heights were wrirren down and transformed to real heights. With the help of this data was proven, using some of the obve mentioned formulas, that the probability of the sea waves can be described according to the Rayleigh distribution.

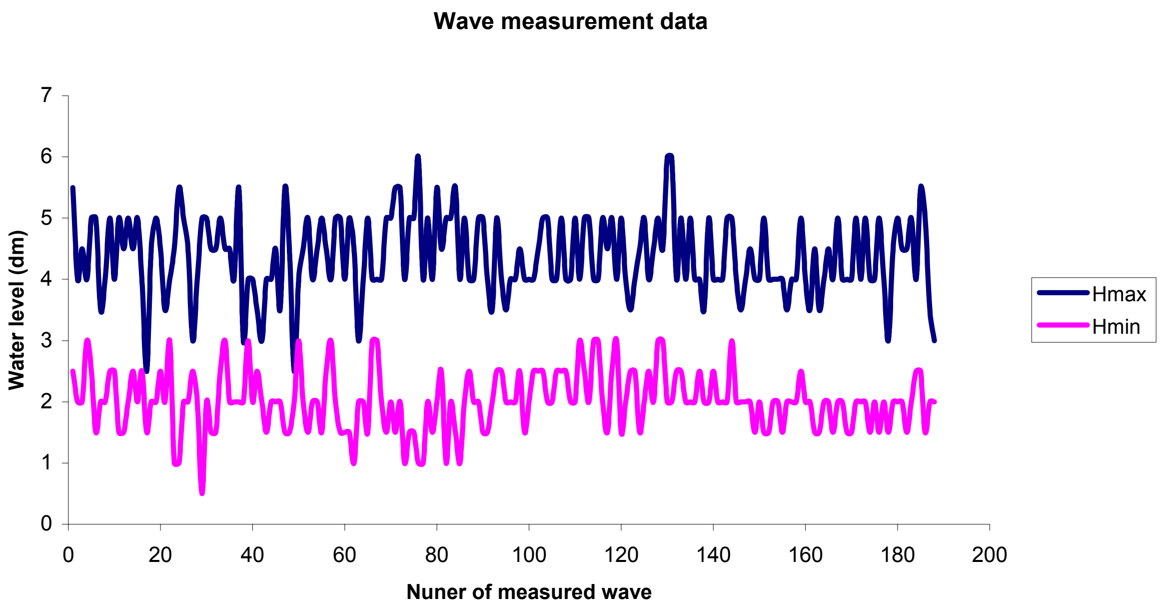


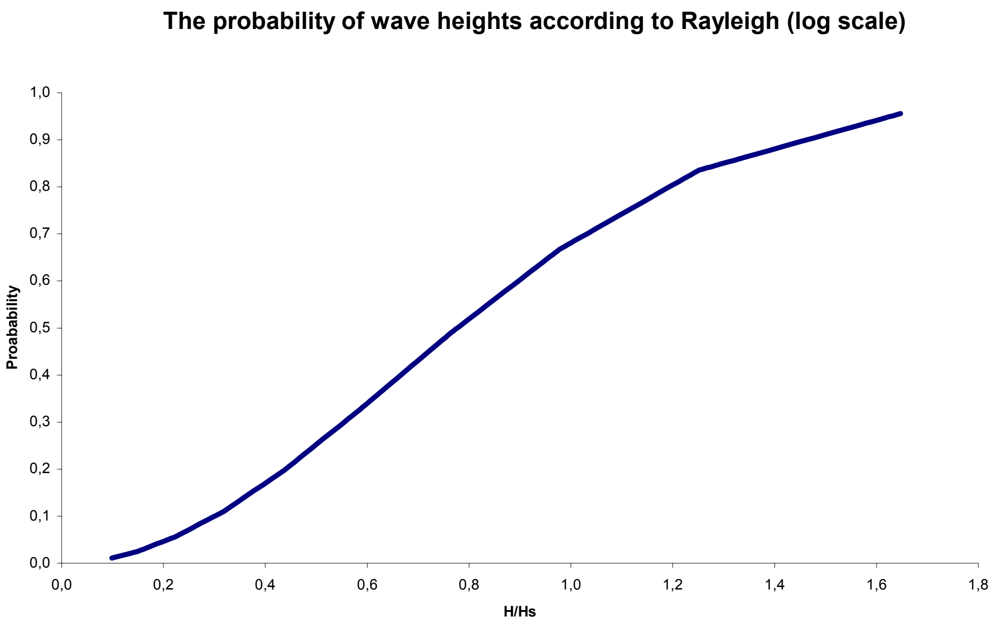


Hs = 0,3 m

The Probability function H/H_S is transformed in a special scale that dislpays the logarythmic curve as a straight line. The fact that this function is thispayed nearly as a line proves that the wave heights are distributed according to Rayleigh.

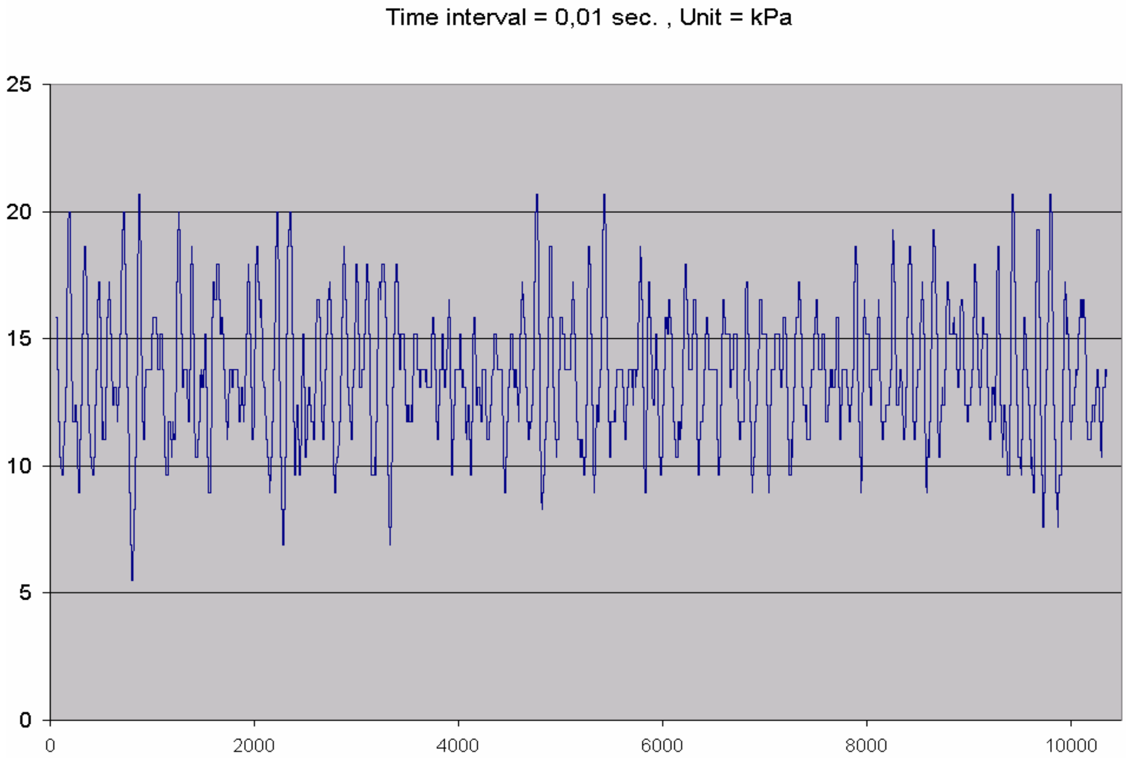
In this case the measured waves are 100 (visual)

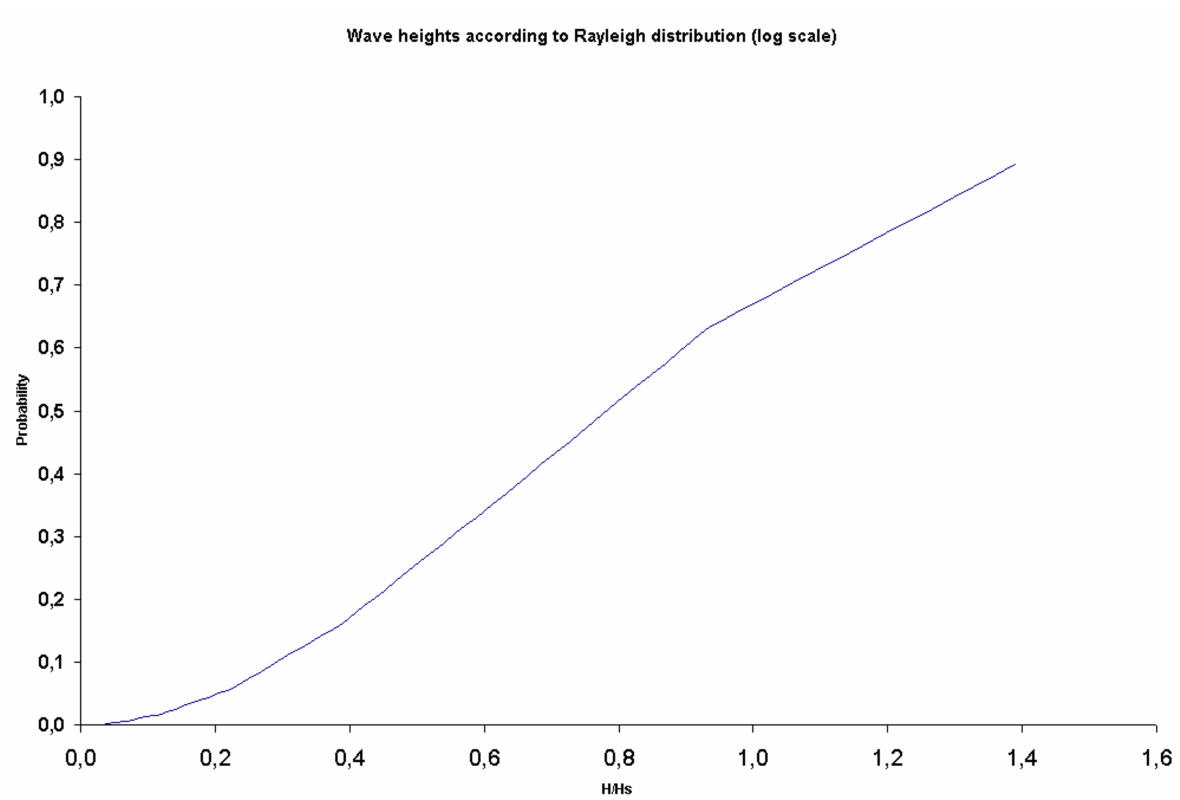

Wave measurement data
Water level (dm)
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
Nuner of measured wave
Hmax
Hmin


The probability of wave heights according to Rayleigh (log scale)
Proabability
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
0,0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
1,6
1,8
H/Hs

Hs=0,33 m

It was also used a electonic measuring device made at the Institute of Oceanology Varna.It measures the pressure at defined depth. The pressure is measured in kPa , and the depth is measure according to predefined time interval. The pressure measuring unit is mounted to a plastic pipe, it comunicates with a mobile computer using serial cable. There is a special software developed to make the measurement. It is possible to define time interval and the duration of the measurement. The program stores the data into a text file. The measuring unit does not require separate power supply it is using power only from the serial port of the computer. In our case the time interval is 0,01 sec , which means that every second 10 measurements are recorded. This accuracy is not important , but the results prove one more time that the wave height probability is distributed according to Rayleigh.





13 Oct
Maximal wind speed 10,7 m/s

i. **Hs=0,81 dm**

IV. Groin measurements

Written by: Ivelina Ivanova

IV.1 Introduction

Groyne is a protective structure of stone or concrete extends from shore into the water to prevent a beach from washing away. In this exercise the profile of a groyne has been measured.

By comparing the results with the results of 2002 and 2003 the changes can be observed and indicates damage of the groyne.

Written by Burgers, Joppe Jort :

The resulting damage can be compared with the theoretical damage that is calculated using the method “van der Meer” suggests (not sufficient data to calculate in this exercise).

Van der Meer

Although van der Meer is not applied in this exercise, the calculation method is briefly explained (“introduction bank, bed and shore protection”, Schiereck 2001).

$$\frac{H_{sc}}{\Delta d_{n50}} = 6.2\,P^{0.18}\left(\frac{S}{\sqrt{N}}\right)^{0.2} \xi^{-0.5} \quad \text{(plunging breakers)}$$

$$\frac{H_{sc}}{\Delta d_{n50}} = 1.0\,P^{-0.13}\left(\frac{S}{\sqrt{N}}\right)^{0.2} \xi^{P}\sqrt{\cot\alpha} \quad \text{(surging breakers)}$$

$$\xi = \frac{\tan\alpha}{\sqrt{H/L_0}}$$

P is a measure for the structure’s permeability.
S is a measure for the damage
N is the number of waves
ξ is the Irribarren number

$$\xi_{\text{transition}} = \left[6.2\,P^{0.31}\sqrt{\tan\alpha}\right]^{\left(\frac{1}{P+0.5}\right)}$$

The expression for plunging breakers is used when $\xi < \xi$transition.
The expression for surging breakers is used when $\xi > \xi$transiti

IV.2.Position of measurements

The same profiles are measured as the groups took last two years. So the measurements are comparable. The coordinate system is explained in Figure4.1

At the end of the breakwater we searched for a fixed point that was easy to recognize and would not move or disappear in future. We chose for the right side of the breakwater and outlet channel (see photograph and drawing) seen from the shoreline on. As a starting point for the measurements we ignored the bended piece of the breakwater. We noticed that in the last horizontal concrete plate (the one before the slope, as indicated on the drawing) a little corner was missing (see detail drawing). We took this corner as a reference point of the line we stipulated along the breakwater (x = 0, x-axis along the breakwater). The starting point of the line is set 1,5 m perpendicular to this corner. Every 5 meters we marked a point, and we decided to measure a cross-profile every 10 meters perpendicular to this line, starting at L = 5 m (see drawing), ending at L = 55 m.

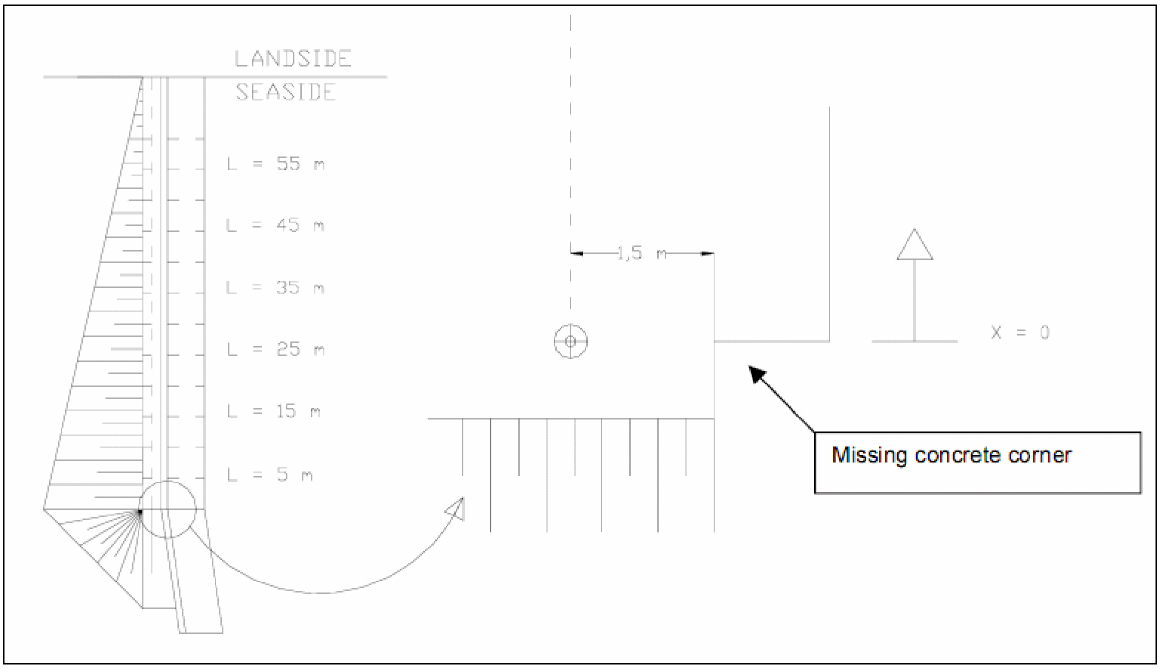


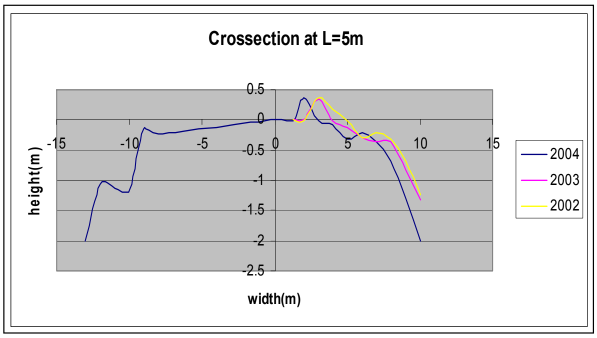
Figure4.1: Top view of groin

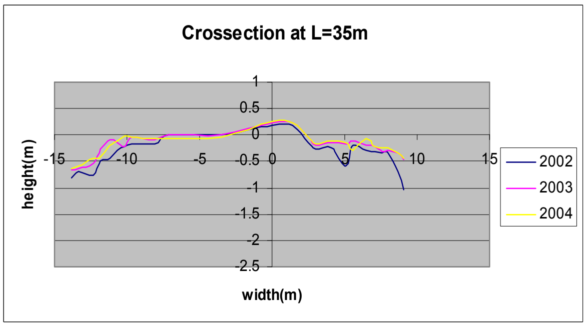
IV.3. Method

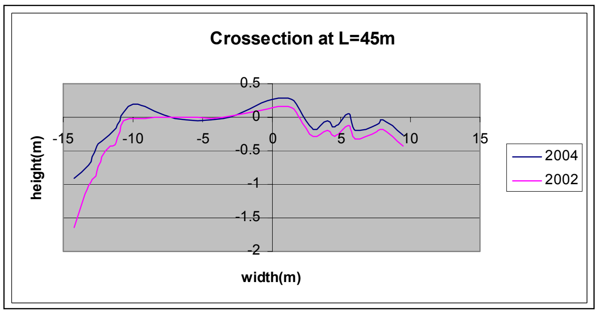
Two different teams in two different days have made the measurements. The both groups used the same equipment. The axis were determined as follows:x-axis-positive in southern direction and the y-axis-positive in landwards direction. On the cross-sections perpendicular to the x-axis the relative height is measured using a theodolite. The theodolite was placed on a stable location from where every part of the groin could be seen. The relative height could be read from a hub fixed on a hemisphere. A hemisphere is used to level out the influence of individual blocks. The size of the hemisphere should be approximately $d_{hemisphere}$ = ½* d50.
For the measurements two hemispheres are available. One with diameter 0.25m and other with diameter 0.75m. The hemisphere with diameter of 0.75m was used by the measurements.
The groin is with nearly horizontal concrete crest, which profile is not included. The measurement on the non horizontal parts of the groyne have made approximately every

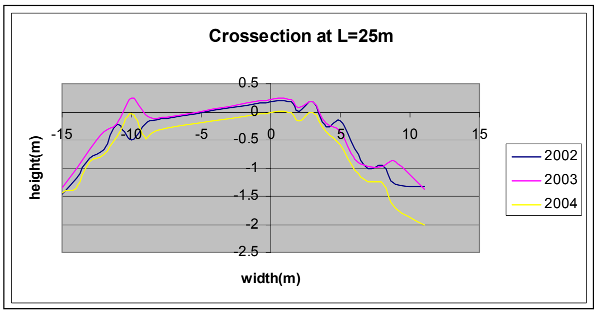
1.0 meter on the x-axis. The previous years are measured this parts every 0.5 meter. All results are worked and compared. So the inconsistency is eliminated.
The measurements were implemented every 10 meters. The first measured point is at L = 5m. A five cross-section were received (L = 5m;L=15m;L = 25m;L = 35m;L = 45m and L = 55m).
The first group begun at the fixed point and the second group- at L = 65m.The difference were by reason of the badly weather. The profiles are re-covered.

IV.4.Graphs









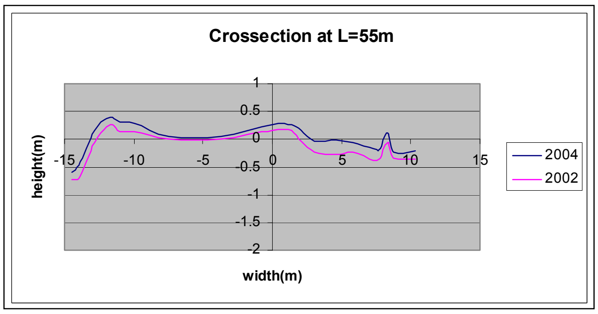


Figure:4.2.

IV.5.Analysis of the measured profiles

In the graphs are plotted the heights for all cross-sections. In 2002 and 2004 are measured 6 different profiles. In 2003 the cross-sections at L = 45m and at L = 55m were not included.
By the drawing of the profiles all data are revised to make a good comparing.
So the appropriation of the changes in volume of the groyne and the displacement of rocks on the groyne is already possible.
In 2002 was used a hemisphere with diameter of 0.25m.
In cross-section at L = 5m the difference between 2002 and 2003 is small. In 2002 is used a small hemisphere and this difference is negligible. The 2004 profiles is nearly the same as the others. Weakly displacement in left can be seen.
In cross-section at L = 15m the difference in profiles is larger. Two bigger peaks at the southern part around x = 3.0m and x = 7.0m can be seen. This material has disappeared. A part of the northern side appeared a peak, which is measured this year(x = -11m).Probably the material is displaced by a violently weather.
In cross-section at L = 25 m the three graphs are almost re-covered. In 2004 is measured approximately 0.25m lower. Here the material is washed away.
The next profiles are measured for the second group.
In cross-section at L = 35m the graphs overlap well. The small differences in 2002 are owing to the smaller hemisphere.
Cross-section at L = 45m and at L = 55m are not measured in 2003.The measured profiles in 2002 and 2004 are almost the same. The existing incongruities due to the different hemispheres. It is possible this material has been washed away.
Further investigation will be recommend for the changed parts of the groyne.

IV.6.Change of the volume

The volume of the groyne is calculated for all cross-sections. The comparing is made for 2002 and 2004.The changes are insignificant and comparing with 2003 is pointless. The used program is surfer 7 with the method Kriging. As boundary the water level can not be chosen, because it is very variable.
The changes in volume are not large. The individual blocks can move down or aside. This movement set the pattern for changing in the volume of the cross-section.
This profiles are measured every year.

The difference is 57.8 m^3 Figure5.3. show the measurements of 2004 and figure5.4.-2002.
From the both figures can be made a conclusion for the points in danger.

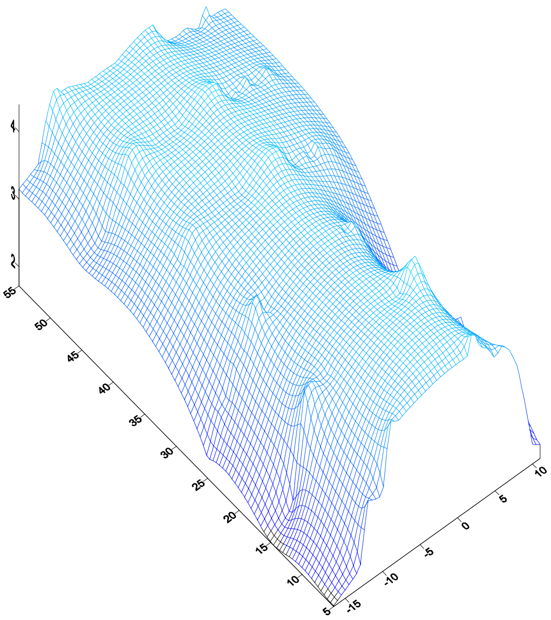


Fig.4.3.Groyne 2004

CUT & FILL VOLUMES

Positive Volume [Cut]:	**4954.16477815**
Negative Volume [Fill]:	**0**

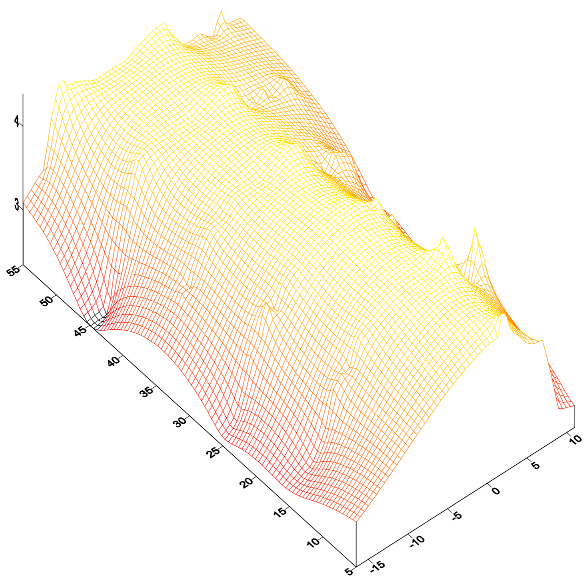


Fig.4.4.Groyne 2002

CUT & FILL VOLUMES

Positive Volume [Cut]:	**5011.97831694**
Negative Volume [Fill]:	**0**

IV.7.Remarks

IV.7.1 Accuracy and different water level

Two different groups made the measurements on two different days. The first day the weather was good with any wind. The second day the weather was worse with strong wind. The first group started the measurements on the fixed point; the second group-at L = 65m.All results are worked to make a comparison.

Height measurements are accurate on the millimeter, the horizontal distances of the cross-section less than a few centimeters thus the height accuracy is not useful. The accuracy in the volume calculations is lower.

IV.7.2.Rock displacement

In three follower years are measured almost one and the same profiles of the groyne. For the point with coordinate x = 0 is possible to make a correction in a relative height. The heights of this point measured in the year are equalized. By the first profile have not difference. By the other is as follows:

	2002	2003	2004
L = 15m	0	0	-0.1
L = 25m	0	0	-0.2
L = 35m	0	0.1	0.1
L = 45m	0	-	1.5
L = 55m	0	-	-2.4

The mentioned point is on the crest of the groyne. The crest is consider as not variable. But the measurements are indicative of disappearance of the material or mistake by the measurements. Causes for mistake can be rough surface in this moment(stones brought by wind) or badly laid instrument.

All graphs are based on the results without correction.
The calculation of the total volume to.

Table 4.5 Measured heights of the groyne profile

L=5m		L=15m		L=25m		L=35m		L=45m		L=55m	
x	z	x	z	x	z	x	z	x	z	x	z
10	-2	10	-2	11	-2	-13.8	-0.65	-14.2	-0.91	-14.5	-0.72
9	-1.304	9	-0.951	9	-1.71	-13.3	-0.58	-13.2	-0.72	-14	-0.71
8	-0.679	8	-0.971	8	-1.275	-12.3	-0.43	-12.7	-0.47	-12.8	-0.05
7	-0.359	7	-0.901	7	-1.255	-11.8	-0.41	-12.2	-0.36	-12	0.23
6	-0.209	6	-0.871	6	-1.025	-11.2	-0.18	-11.7	-0.26	-11.5	0.26
5	-0.319	5	-0.551	5	-0.575	-10.7	-0.12	-11.2	-0.16	-11	0.14
4	-0.089	4	-0.106	4	-0.35	-10.2	-0.02	-10.7	0.08	-10	0.14
3	-0.004	3	0.414	3	0	-9.65	-0.04	-9.6	0.2	-7.5	0
2	0.361	2	0.394	2	-0.16	-8.1	-0.06	-7	-0.01	-3.7	0
1.3	-0.004	1	0.01	1.45	-0.005	-7.1	-0.06	-3.5	-0.01	0	0.16
0	0	0	0	0	0	-3.5	-0.04	0	0.26	1.4	0.16
-8	-0.224	-8	-0.271	-8.15	-0.33	0	0.26	1.4	0.26	2.05	-0.04
-9	-0.134	-9	-0.431	-9	-0.48	1.4	0.24	2	0.1	3.05	-0.23
-10	-1.154	-10	-0.441	-10	-0.025	2.5	-0.04	3	-0.17	4.6	-0.27
-11	-1.134	-11	-0.341	-11	-0.43	3	-0.17	4	-0.06	5.8	-0.24
-12	-1.074	-12	-0.401	-12	-0.76	4.05	-0.12	4.5	-0.15	7.3	-0.39
-13	-2	-13.5	-2	-13	-0.89	5.1	-0.13	5.6	0.05	7.7	-0.35
				-14	-1.345	5.6	-0.3	6	-0.19	8.3	-0.05
				-15	-1.43	6.5	-0.07	7.6	-0.11	8.8	-0.33
				-16.5	-2	7.1	-0.22	8	-0.04	10.3	-0.35
						7.6	-0.24	9.5	-0.27		
						8	-0.25				
						8.7	-0.34				
						9.1	-0.43				

x-horizontal distance
z-relative height

Table 4.6. Measured heights of the groyne profiles in forgoing years

L = 5m			
2002		2003	
X	Z	X	Z
0,0	0,0	0,0	0,0
0,5	0,0	0,5	0,0
1,0	0,0	1,0	0,0
1,5	0,0	1,5	0,0
2,0	0,4	2,0	0,4
2,5	0,5	2,5	0,5
3,0	0,0	3,0	0,2
3,5	-0,3	3,5	-0,1
4,0	-0,1	4,0	0,0
4,5	-0,5	4,5	-0,3
5,0	-0,3	5,0	-0,3
5,5	-0,3	5,5	-0,3
6,0	-0,4	6,0	-0,2
6,5	-0,5	6,5	-0,3
7,0	-0,4	7,0	-0,3
7,5	-0,7	7,5	-0,6
8,0	-0,8	8,0	-0,7
8,5	-0,9	8,5	-0,8
9,0	-1,3	9,0	-1,2
9,5	-1,6	9,5	-1,5

L =15m			
2002		2003	
X	Z	X	Z
-16,5	-1,4	-16,0	-1,5
-16,0	-1,8	-15,5	-1,5
-15,5	-1,6	-15,0	-1,5
-15,0	-1,6	-14,5	-1,4
-14,5	-1,4	-14,0	-1,2
-14,0	-1,3	-13,5	-1,3
-13,5	-1,3	-13,0	-1,1
-13,0	-1,3	-12,5	-1,0
-12,5	-1,3	-12,0	-0,4
-12,0	-1,0	-11,5	-0,2
-11,5	-0,3	-11,0	-0,4
-11,0	-0,6	-10,5	-0,3
-10,5	-0,4	-10,0	-0,2
-10,0	-0,5	-9,5	-0,2
-9,5	-0,2	-9,0	-0,2
-9,0	-0,5	-8,5	-0,2
-8,5	-0,2	-8,0	-0,2
-8,0	-0,2	0,0	0,1
0,0	0,1	0,5	0,1
0,5	0,1	1,0	0,1
1,0	0,1	1,5	0,7
1,5	0,1	2,0	0,8
2,0	0,2	2,5	0,3
2,5	0,1	3,0	0,5
3,0	0,4	3,5	0,5
3,5	0,1	4,0	0,2
4,0	0,0	4,5	-0,1
4,5	-0,3	5,0	-0,2
5,0	-0,5	5,5	-0,5
5,5	-0,6	6,0	-0,7
6,0	-0,7	6,5	-0,5
6,5	-0,6	7,0	-0,5
7,0	0,3	7,5	-0,4
7,5	-0,2	8,0	-0,8
8,0	-0,3	8,5	-0,9
8,5	-0,9	9,0	-0,8
9,0	-1,0		
9,5	-0,8		
10,0	-1,1		
10,5	-1,4		
11,0	-2,1		

L=25m			
2002		2003	
X	Z	X	Z
-17,0	-1,8	-15,5	-1,7
-16,5	-1,6	-15,0	-1,4
-16,0	-1,7	-14,5	-1,2
-15,5	-1,9	-14,0	-1,1
-15,0	-1,5	-13,5	-0,8
-14,5	-1,5	-13,0	-0,7
-14,0	-1,2	-12,5	-0,8
-13,5	-1,1	-12,0	-0,4
-13,0	-0,8	-11,5	-0,4
-12,5	-0,7	-11,0	-0,3
-12,0	-0,7	-10,5	-0,3
-11,5	-0,6	-10,0	0,2
-11,0	-0,2	-9,5	0,1
-10,5	-0,3	-9,0	-0,1
-10,0	-0,5	-8,5	-0,3
-9,5	0,0	-8,0	-0,2
-9,0	-0,2	0,0	0,2
-8,5	-0,5	0,5	0,2
-8,0	-0,1	1,0	0,2
0,0	0,2	1,5	0,2
0,5	0,2	2,0	0,0
1,0	0,2	2,5	-0,1
1,5	0,2	3,0	0,1
2,0	0,0	3,5	0,0
2,5	-0,1	4,0	-0,2
3,0	0,2	4,5	-0,2
3,5	-0,1	5,0	-0,4
4,0	-0,3	5,5	-0,6
4,5	-0,3	6,0	-0,9
5,0	-0,2	6,5	-0,8
5,5	-0,3	7,0	-1,0
6,0	-0,6	7,5	-1,0
6,5	-0,5	8,0	-1,0
7,0	-1,0	8,5	-0,9
7,5	-0,9	9,0	-0,9
8,0	-1,0	9,5	-1,0
8,5	-1,1	10,0	-1,5
9,0	-1,3	10,5	-1,6
9,5	-0,9	11,0	-1,4
10,0	-0,9	11,5	-1,4
10,5	-1,1		
11,0	-1,3		
11,5	-1,4		

L=35m			
2002		2003	
X	Z	X	Z
-16,5	-1,8	-16,5	-1,2
-16,0	-1,2	-16,0	-1,1
-15,5	-1,2	-15,5	-1,1
-15,0	-1,2	-15,0	-1,0
-14,5	-1,1	-14,5	-0.9
-14,0	-0,8	-14,0	-0,7
-13,5	-0,8	-13,5	-0,6
-13,0	-0,7	-13,0	-0,6
-12,5	-0,8	-12,5	-0.5
-12,0	-0,6	-12,0	-0.4
-11,5	-0,5	-11,5	-0.3
-11,0	-0,4	-11,0	-0.1
-10,5	-0,3	-10,5	-0.1
-10,0	-0,2	-10,0	-0.2
-9,5	-0,2	-9,5	0
-9,0	-0,4	-9,0	-0.3
-8,5	0,1	-8,5	-0.2
-8,0	-0,2	-8,0	-0.1
0,0	0,2	0,0	0.3
0,5	0,2	0,5	0.3
1,0	0,2	1,0	0.3
1,5	0,2	1,5	0.3
2,0	0,0	2,0	0.1
2,5	-0,1	2,5	0
3,0	-0,3	3,0	-0.2
3,5	-0,4	3,5	-0.2
4,0	-0,2	4,0	-0.1
4,5	-0,4	4,5	-0.2
5,0	-0,6	5,0	-0.1
5,5	-0,2	5,5	-0.1
6,0	-0,7	6,0	-0.1
6,5	-0,3	6,5	-0.2
7,0	-0,3	7,0	-0.2
7,5	-0,3	7,5	-0.3
8,0	-0,4	8,0	-0.3
8,5	-0,7	8,5	-0.3
9,0	-1,0	9,0	-0.4
9,5	-1,0	9,5	-0.4
10,0	-1,1	10,0	-0.4
10,5	-1,2	10,5	-0.5
11,0	-0,5	11,0	-0.4
11,5	-0,8	11,5	-0.8
12,0	-1,4		
12,5	-1,2		

L = 45	
2002	
X	Z
15,0	-3,2
14,5	-3,0
14,0	-3,1
13,5	-3,0
13,0	-2,4
12,5	-2,3
12,0	-2,0
11,5	-1,9
11,0	-1,8
10,5	-1,5
10,0	-1,5
9,5	-1,4
9,0	-1,5
8,5	-1,5
8,0	-1,6
0,0	-1,3
-0,5	-1,3
-1,0	-1,3
-1,5	-1,3
-2,0	-1,5
-2,5	-1,6
-3,0	-1,7
-3,5	-1,9
-4,0	-1,6
-4,5	-1,7
-5,0	-1,7
-5,5	-1,6
-6,0	-1,8
-6,5	-1,8
-7,0	-1,9
-7,5	-1,7
-8,0	-1,6
-8,5	-1,8
-9,0	-1,9
-9,5	-1,9
-10,0	-2,1
-10,5	-2,0
-11,0	-2,3
-11,5	-2,0
-12,0	-2,5
-12,5	-2,3
-13,0	-1,4

L = 55	
2002	
X	Z
17,0	-2,9
16,5	-2,8
16,0	-2,7
15,5	-2,5
15,0	-2,4
14,5	-2,2
14,0	-2,1
13,5	-2,2
13,0	-1,5
12,5	-1,5
12,0	-1,2
11,5	-1,2
11,0	-1,3
10,5	-1,5
10,0	-1,3
9,5	-1,5
9,0	-1,5
8,5	2,9
8,0	2,8
0,0	2,7
-0,5	2,5
-1,0	2,4
-1,5	2,2
-2,0	2,1
-2,5	2,2
-3,0	1,5
-3,5	1,5
-4,0	1,2
-4,5	1,2
-5,0	1,3
-5,5	1,5
-6,0	1,3
-6,5	1,5
-7,0	1,5
-7,5	1,5
-8,0	1,5
-8,5	1,3
-9,0	1,3
-9,5	1,3
-10,0	1,3
-10,5	1,5
-11,0	1,6
-11,5	1,7
-12,0	1,7
-12,5	1,8

V. QUARRY

Written by: Sava Tachev

1.1 I. Introduction

On Thursday the 14th of October we visited two quarries of Eskana S.A. – Marciana and Sini vir.

Marciana quarry

Marciana quarry produces gravel for lower concrete brands, for road coverings and microproducts for fillers in the plastics and painting industries as well as admixtures for fodder mixtures. The produced fractions here are 5/30mm, 25/60mm, 60/150mm, 0/75mm.

Picture 1- Marciana quarry

1.1.1.1 Picture 2 – Sini vir quarry

Sini vir quarry

The fractions produced here are used for concrete, asphalt coverings and railway ballast. The produced fractions are 5/15mm, 5/25mm, 25/60mm.

rushing and Grading Installation

II. Problem description

The problem given was: determining the properties of a given pile of rock – the D_{n50}, elongation and blockiness. Solving the problem followed the steps below:

1. Selecting 23 rocks at Marciana quarry
2. Weighing them – each of the stones weighed between 10 and 50 kilograms
3. Measuring the three axial lengths – x, y, z
4. Calculating the dry mass, mass under water and the moist mass
5. Calculating the average density of the rocks

$$C = \frac{m_3 \cdot \rho_\omega}{m_2 - m_1}$$

where m_1 – mass with paraffin under water, m_2 – mass with paraffin, m_3 – dry mass

6. Determining the volume of the blocks mentioned in point 5 – in the laboratory at the UACEG - Sofia
7. Calculating the elongation

$$\frac{l}{d} = \frac{\text{longest - axial - length(x)}}{\text{shortest - axial - length(z)}}$$

8. Calculating the blockiness

$$BLc = \frac{\text{volume - of - the - rock - block}}{x \cdot y \cdot z}.100\%$$

9. Calculating the standard deviation of the blockiness - σBLc

10. Finally calculating the D_{n50}

$$D_n = \sqrt[3]{\frac{m}{\rho_s}}$$

11. Arranging the data from points 1 -10 in a table – see table 5
12. Repeating points 1-10 for 5 big rocks, the data can be seen in table 7
13. Further comes the actual design of a hydraulic structure, therefore the porosity n_v and the single layer thickness k_t have to be defined. This is done by substituting the values of the table underneath in the formula:

Parameter = A + B.BLc + C.$(l/d)_m$ + D.σ .(BLc)

Table1

Parameter	slope	A	B	C	D
Single layer porosity n_v	1:1.5	42.38	-0.2177	3.695	-0.4128
	1:2	42.9	-0.2204	3.740	-0.4179
	1:3	43.46	-0.2233	3.789	-0.4233
Layer thickness k_t	1:1.5	1.1375	-0.0026	-0.1588	-0.0003
	1:2	1.0736	-0.0024	-0.1499	-0.0003
	1:3	1.1038	-0.0025	-0.1541	-0.0003
Double layer porosity n_v	1:1.5	34.53	-0.2137	3.4460	0.1852
	1:2	35.94	-0.2224	3.5860	0.1928
	1:3	36.20	-0.2240	3.6130	0.1942

14. Reconstructing the design wave height and determining the corrections of the coefficients in the ‘Van der Meer – equations’ according to Stewart (2002)

$$\frac{H_s}{\Delta D_{n50}} = 6.2 \cdot p^{0.18} \left(\frac{S_d}{\sqrt{N}} \right)^{0.2} \zeta^{-0.5}$$

$$\frac{H_s}{\Delta D_{n50}} = 1.0 \cdot p^{-0.13} \left(\frac{S_d}{\sqrt{N}} \right)^{0.2} \zeta^{p \cdot \sqrt{\cot g \alpha}}$$

The two coefficients have to be changed in case of ‘non – standard’ blockiness and elongation, according to Stewart:

Table2

bl_C- range	l/d range	Armour porosity(%)	placement method	‘6.2’	‘1.0’
40%-50%	1.3-3.0	38.7	standard	7.09	-
40%-50%	1.3-3.0	36.1	dense	6.68	1.67
50%-60%	1.3-3.0	37.1	standard	6.44	1.51
50%-60%	1.3-3.0	35.2	dense	7.12	2.08
60%70%	1.3-3.0	35.5	standard	7.71	2.63

60%70%	1.3-3.0	34.4	dense	10.85	-
50%-60%	1.0-2.0	36.1	standard	8.50	1.45
50%-60%	1.0-2.0	34.6	dense	8.80	-

This is done for the other task given – to redesign the groyne at St. Konstantin with use of the rock from Marciana quarry.

1.1.2

1.1.3 III. RESULTS

After determining the densities of the small stones taken from Marciana quarry in the laboratory at the UACEG – Sofia the following values were calculated:

le 3

	Dry Mass [g]	Mass with Paraffin [g]	Mass under water [g]	$m_{paraffin}$ [g]	$V_{paraffin}$ cm^3	Volum cm^3	Density $[g/cm^3]$
1	11.059	12.800	6.146	1.741	1.945	4.709	2.349
2	24.959	32.421	13.303	7.462	8.337	10.781	2.315
3	14.519	18.832	7.701	4.313	4.819	6.312	2.300
4	11.129	15.448	5.745	4.319	4.826	4.877	2.282
5	16.372	20.859	8.802	4.487	5.013	7.044	2.324
6	24.528	30.269	13.098	5.741	6.415	10.756	2.280

AVERAGE: ρs = 2.308 g/cm3 – Marciana quarry

1.2 Sieve analysis

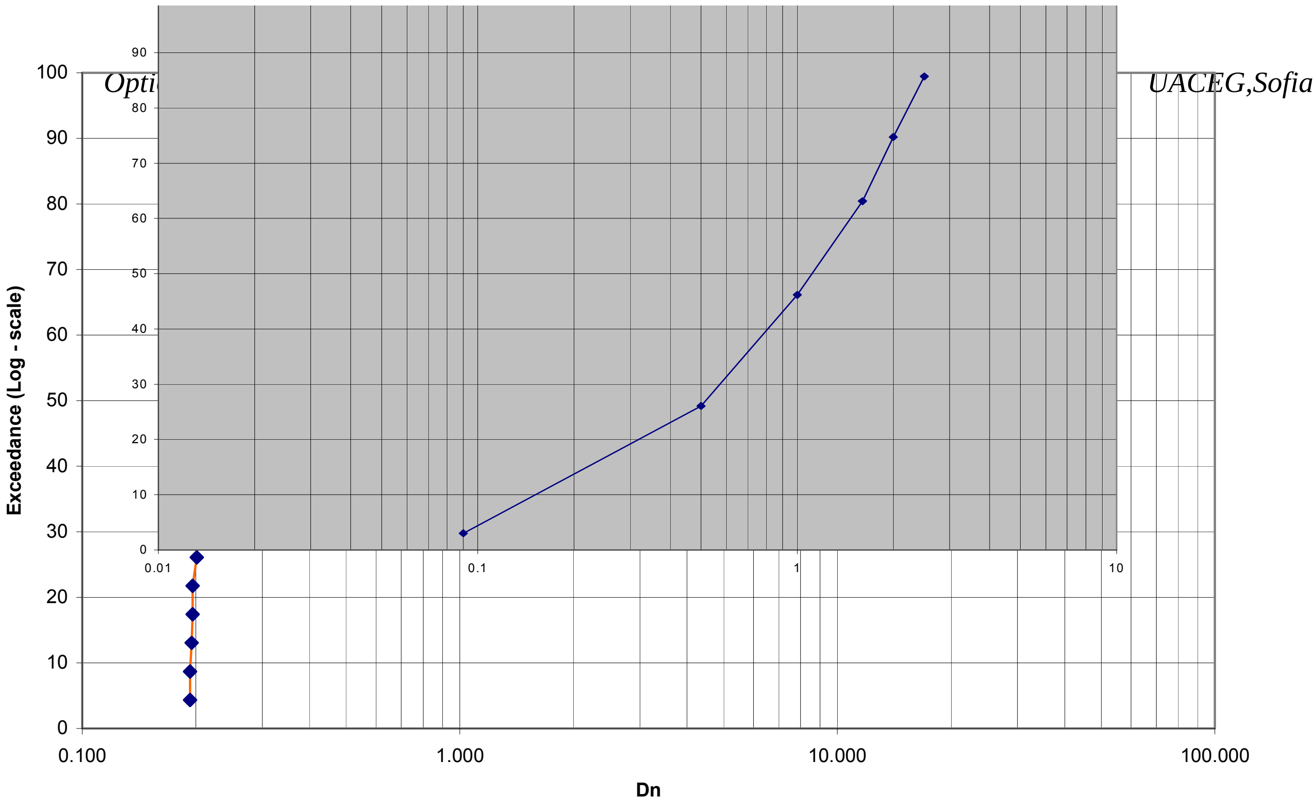
When working in Marciana quarry we also took a sample of the sand. At the hydraulic laboratory of University of Architecture, Civil Engineering and Geodesy – Sofia the sieve analysis was performed. We arranged the data in table 4.

Sand fractions

Analytical balance

Table 4

Sample No.	Total Mass (gr)	Mass (gr) of each fraction with Diameter from - to						
		<0.09 (mm)	0.09-0.50 (mm)	0.50-1.00 (mm)	1.00-1.60 (mm)	1.60-2.00 (mm)	2.00-2.50 (mm)	>2.50 (mm)
1	298.637	8.972	68.825	60.061	50.670	34.641	32.849	42.619
		Mass of fraction with Diameter less than:						
		0.09 mm	0.50 mm	1.00 mm	1.60 mm	2.00 mm	2.50 mm	
1	-	8.972	77.797	137.858	188.528	223.169	256.018	298.637
		Ratio of fraction as % of total mass						
		0.09 mm	0.50 mm	1.00 mm	1.60 mm	2.00 mm	2.50 mm	
1	-	3.004	26.051	46.162	63.129	74.729	85.729	100



Marciana Quarry measurements of a single rock block
Table 5

№	Mass [kg]	[X cm]	Y [cm]	Z [cm]	l/d	X*Y*Z [m^3]	Vol [m^3]	BLc [-]	Dn [m]	Dn [m]
1	19.800	33	28	20	1.65	0.018	0.0086	46.4	0.205	0.193
2	22.500	31	26	15	2.07	0.012	0.0097	80.6	0.214	0.193
3	42.500	45	35	17	2.65	0.027	0.0184	68.8	0.264	0.195
4	17.300	31	24	14	2.21	0.010	0.0075	72.0	0.196	0.196
5	24.400	36	28	19	1.89	0.019	0.0106	55.2	0.219	0.196
6	19.050	33	26	17	1.94	0.015	0.0083	56.6	0.202	0.201
7	26.100	39	31	23	1.70	0.028	0.0113	40.7	0.224	0.202
8	46.000	44	36	28	1.57	0.044	0.0199	44.9	0.271	0.205
9	18.800	35	29	22	1.59	0.022	0.0081	36.5	0.201	0.205
10	28.200	46	33	20	2.30	0.030	0.0122	40.2	0.230	0.214
11	47.150	46	38	29	1.59	0.051	0.0204	40.3	0.273	0.214
12	47.250	43	37	28	1.54	0.045	0.0205	46.0	0.274	0.219
13	17.050	25	21	16	1.56	0.008	0.0074	87.9	0.195	0.223
14	40.600	30	25	23	1.30	0.017	0.0176	102.0	0.260	0.224
15	16.650	22	19	14	1.57	0.006	0.0072	123.3	0.193	0.227
16	25.500	43	36	19	2.26	0.029	0.0110	37.6	0.223	0.230
17	28.100	46	33	19	2.42	0.029	0.0122	42.2	0.230	0.230
18	22.500	42	29	14	3.00	0.017	0.0097	57.2	0.214	0.260
19	16.650	35	29	20	1.75	0.020	0.0072	35.5	0.193	0.264
20	27.050	40	34	24	1.67	0.033	0.0117	35.9	0.227	0.271
21	17.300	33	28	22	1.50	0.020	0.0075	36.9	0.196	0.273
22	19.850	30	23	15	2.00	0.010	0.0086	83.1	0.205	0.274
23	48.000	43	35	30	1.43	0.045	0.0208	46.1	0.275	0.275

Figure 1

Some statistical values of this distribution are needed to calculate the void ratio and the layer

№	Mass [kg]	[X cm]	Y [cm]	Z [cm]	l/d	X*Y*Z [m^3]	Vol [m^3]	BLc [-]	Dn [m]	Dn [m]
1	576.400	185	150	120	1.54	3.330	0.2497	7.5	0.630	0.630
2	1077.400	285	180	140	2.04	7.182	0.4668	6.5	0.776	0.718
3	1364.200	305	190	120	2.54	6.954	0.5911	8.5	0.839	0.723
4	855.100	260	125	120	2.17	3.900	0.3705	9.5	0.718	0.776
5	871.450	240	155	145	1.66	5.394	0.3776	7.0	0.723	0.839

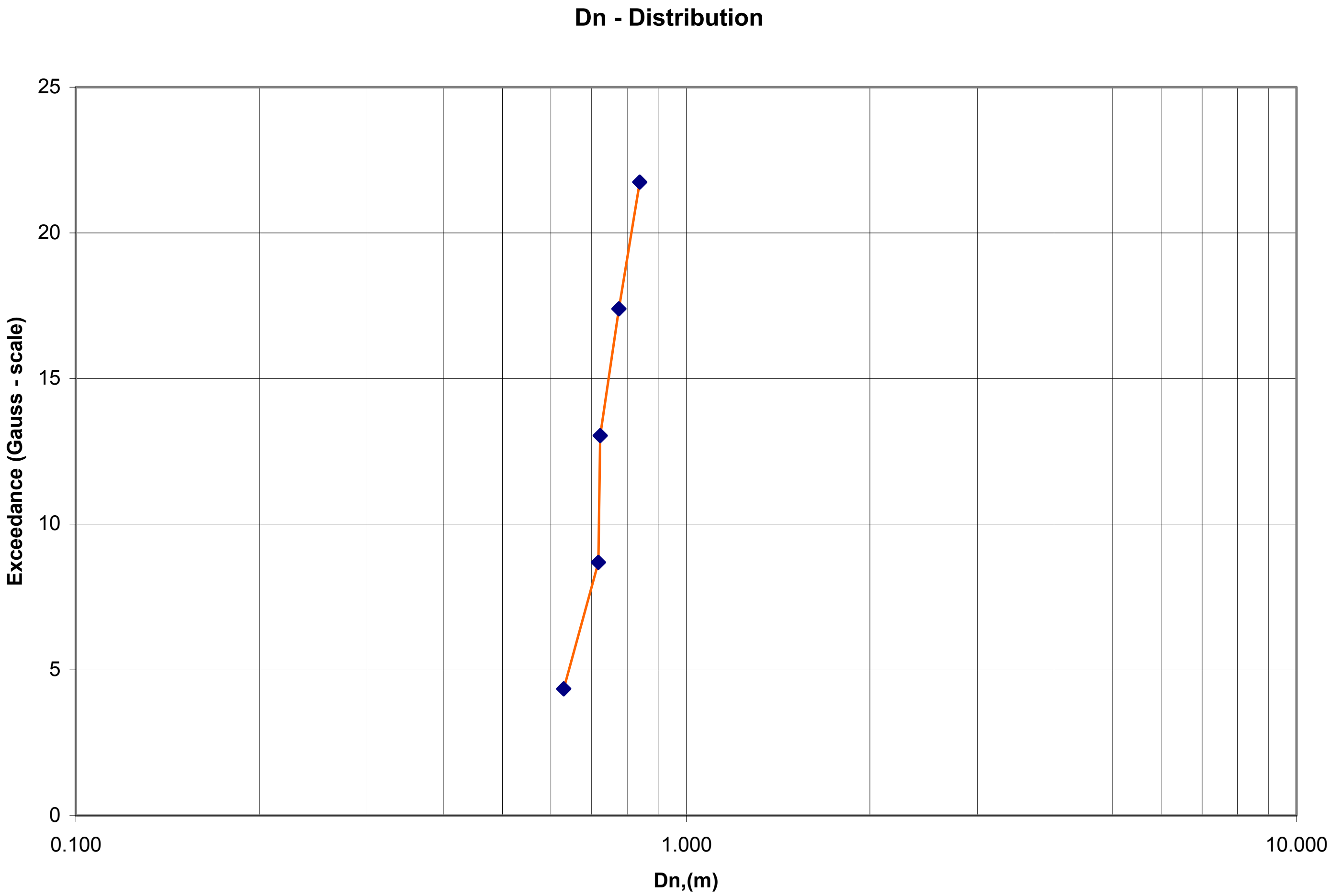
thickness by substituting the values of A, B, C and D from table 1 ; slope is 1:3. This way the coefficients in the Van der Meer equation become according to table 2, 7.09 (“6.2”) and 1.0 (“1.0”).

2 Table 6

Nominal diameter	d_{n50}	0.23
Mean elongation	l/dm	1.92
Mean blockiness (%)	BLc_m	41.4
S.D. Blockiness (%)	σ.BLc	8.31
Single layer porosity(%)	Nv	38.0
Layer thickness	Kt	0.7
Double layer porosity(%)	Nv	3.5

Marciana Quarry measurements of a single bigger rock block

3 Table 7



In order to answer the requirements from point 14 a Dn50 of 1.0m was calculated. We estimated Dn50 of 5 bigger stones, and eventually a density of 2308 kg/m^3 was determined in the laboratory at UACEG-Sofia.

So Hudson formula rewritten:

$$H_s = \sqrt[3]{\frac{M \cdot K \cdot \Delta^3 \cdot \text{cotg}\alpha}{\rho_s}}$$

where $$\Delta = \frac{\rho_s - \rho_\omega}{\rho_\omega} = \frac{2308 - 1000}{1000} = 1{,}308$$

K_D=3.5 for rough angular quarry stone, 2 layers

$$H_s = \sqrt[3]{\frac{2308 \cdot 3{,}5 \cdot (1{,}308)^3 \cdot 3}{2308}} = 2{,}864\ \text{m}$$

And applying Van der Meer equation:

It is accepted:

- Permeability P=0.1 - impermeable core; concrete
- Number of waves N=7500 - damage considered to have reached an equilibrium

- Damage level S=10 - failure of the structure

$$\zeta_{transition} = \left[6{,}2 \cdot p^{0{,}31} \cdot \sqrt{\tan\alpha}\right]^{\frac{1}{p+0{,}5}} = \left[6{,}2 \cdot 0{,}1^{0{,}31} \cdot \sqrt{\frac{1}{3}}\right]^{\frac{1}{0{,}1+0{,}5}} = 2{,}55$$

Calculation of presume assumption on the wave period Ts=8s, therefore
$L_0 = gT^2/2$ =102m

Wavelength in deep water would be:

$$\zeta = \frac{\tan\alpha}{\sqrt{\frac{H_s}{L_0}}} = 1{,}84 < \zeta_{transition} = 2{,}55$$

$$\frac{H_s}{\Delta D_{n50}} = 7{,}09 \cdot p^{0{,}18} \cdot \left(\frac{S_d}{\sqrt{N}}\right)^{0{,}2} \cdot \zeta^{-0{,}5} = 7{,}09 \cdot 0{,}1^{0{,}18} \cdot \left(\frac{10}{\sqrt{7500}}\right)^{0{,}2} \cdot 1{,}84^{-0{,}5} = 2{,}243$$

$$\Delta = \frac{\rho_s - \rho_\omega}{\rho_\omega} = \frac{2308 - 1000}{1000} = 1{,}308$$

And finally

$$D_{n50} = \frac{H_s}{2{,}243 \cdot \Delta} = \frac{2{,}864}{2{,}243 \cdot 1{,}308} = 0{,}976\,\text{m}$$

3.1.1

3.1.2 IV. Conclusions and Recommendations

The tests of the samples from Marciana quarry showed that the stones obtained there are easily erodable and have low density. That is why they are not appropriate for application in hydraulic engineering.

On calculating back from an existing groyne to the design wave height, and then redesigning this groyne with an armour layer of a different stone quality a certain number of assumptions were made – for the wave period of the design wave and the slope angle of the groyne. As a result a big inaccuracy in the equations occurred. It should be also pointed that it is not certain if the small stones blockiness is the same as that of the big ones.

VI. BATHYMETRIC MEASUREMENTS

Written by: Ivan Petrov

1. Introduction

The purpose of these measurements is to get insight in the beach morphology, as a basis for further coastal protection works. The beach is situated near the “Sirius” hotel in St. Constantine and Helena. The owner of the hotel wants to improve the beach width, because he wants to ensure the hotel guests more space to sunbathe.

Coastline alteration occur not only due to changes onshore – visual one, but also due to changes offshore, beneath the water level. To measure the water depths in the research area (0,72 км²) we use an echo-sounder connected with a GPS in order to determine the position of a certain water depth on the horizontal plane. GPS and the echo sounder were at present.

The collected data can be used to determine the sediment volume in the coastal area at the moment of survey. Within time this can be repeated to analyze the loss or fill of sediment in the cross section and conclusions for the current status and prediction for the future development of the beach morphology can be made.

2. Area

For calculations of beach stability, for the design of the coastal protection in front of the Sirius and for the design of the artificial island it is necessary to have some kind of depth information. Therefore a survey vessel is used to measure the underwater slope.

First the area to be surveyed has to be determined. The artificial island will be constructed in front of the beach halfway the Sirius hotel and the St Elias marina, see Figure.1. The original plan worked out by the three groups consisted of three vessel runs.

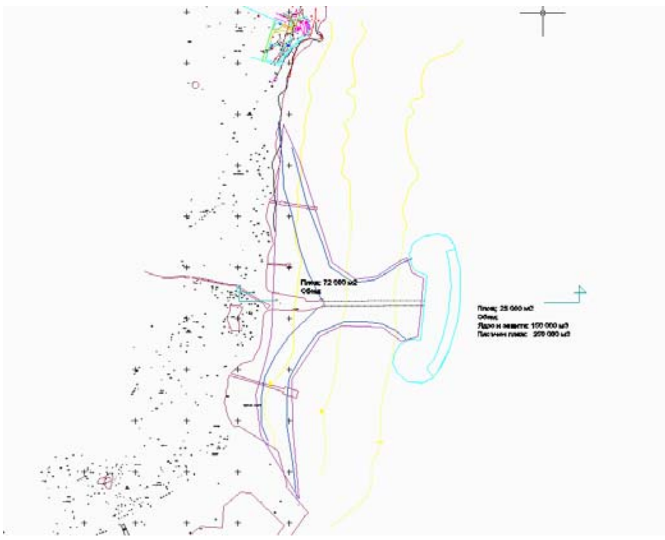


Figure 1: Artificial island

The first two groups would measure broadly respectively area one and two. The third group would measure the area where the island will be located more accurately. The area of the survey can be seen in Figure.2.

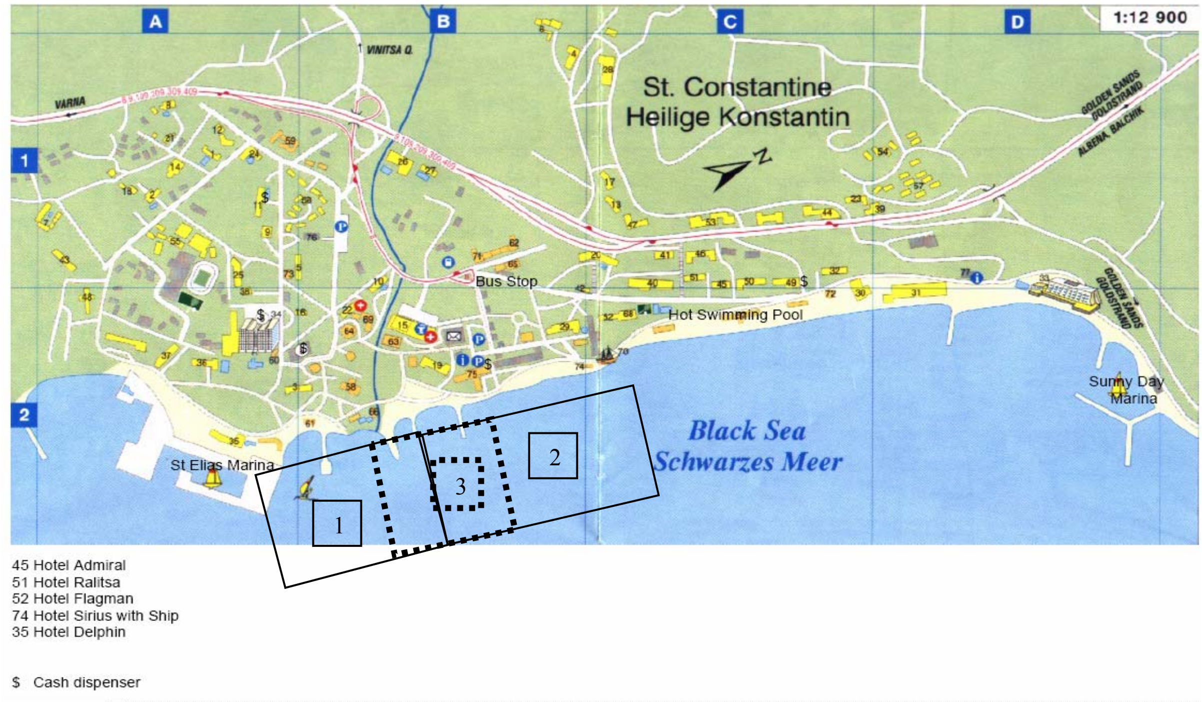


Figure 2: Survey area

3. Equipment

In order to carry out the measurement, we used a small boat, on which was fixed the echo-sounder conected with a GPS.

The echo-sounder is based on the principle that water is an in viscid medium for the transmission of sound waves and that a sound pulse will bounce off the bottom of the sea, returning to its source as an echo. The time interval between the initiation of a sound pulse and echo returned from the bottom can be used to determinate the water depth. An echo-sound system is made of a transmitter, a receiver that picks up the reflected echo, electronic timer and amplification equipment, an indicator or graphic recorder.

Figure .3.a. : GPS related to an Echo-sounder

The GPS was used to determine the exact position of the boat at a certain time by each of the measurements. The GPS cannot be as much accurate as the DGPS-device, which was used by the measurements in the previous year. A much higher accuracy can be achieved using the DGPS in respect to a normal GPS, which is quite accurate for certain objectives it self, but there wasn't at present. The position of the boat was determined using a handhold GPS onboard of the vessel (*Figure 3a, b.*).

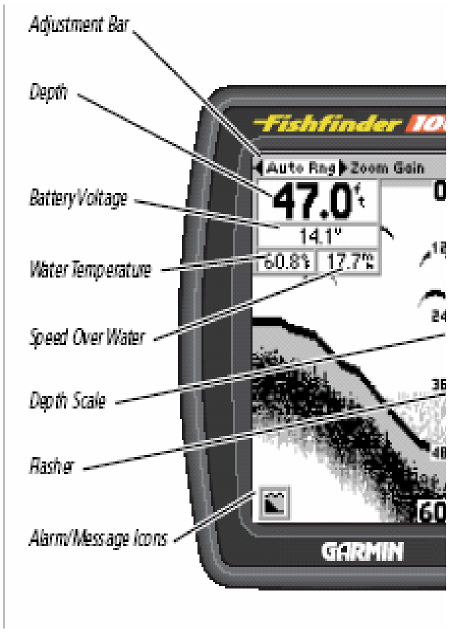


Figure 3.b.: GPS related to an Echo-sounder

4. Method

In order to get a reliable bathymetry along the beach, the boat has to sail in straight lines on top of imaginable cross sections perpendicular to the coastline. This was done visually, because of the lack of a DGPS.
The boat positioning than was linked to the measurement of the echo-sounder. This is possible as the time of the both devices were adjusted to each other. Consequently the water depth at an exact position is known.
Afterwards the results can be linked to the beach measurements in a way that the total sediment volume in the coastal zone can be calculated.
The boundary definition of the area is based on the principle of looking at a sediment cell in the coastal zone. By setting the boundaries at two intersections between which you want to quantify sediment volume changes, you can investigate the sediment flux in/out the area of interest. As we are looking at the “Sirius” beach this area is given by a groin in front of the hotel and by a jetty southwards. One usually takes the so called closure depth as the lower limit of the coastal profile. Depth changes seaward of these changes are not directly related to the shoreline dynamics. The closure depth is often the outer edge of the transport zone corresponding to the highest wave that may occur.

5. Depth

Beyond a certain depth the building of an artificial island is not feasible. So depths in excess of 20m are not interesting for this survey and therefore not measured. In 2003 the bathymetric survey was carried out emphasizing the quantification of the sediment volume changes. Therefore the seaward limit of the measured area was that of the closure depth. The closure depth is often the outer edge of the transport zone corresponding to the highest wave that may occur. The measured area in 2003 was up to a depth of MSL -11m. This was also done in 2004. Yet, this year a single run with the boat was made to a depth of MSL-16m in order to obtain more insight in the bottom relief in the specific area where the island would be made

6. Results

The measurements were made during a moderate wave climate in order to navigate the boat along straight, perpendicular to the coast, lines (*Figure 4.*). In fact there were a number of trips, which can be clearly seen on the figures from this and previous year measurements. The purpose was to increase the accuracy, and it has no meaning of splitting them from each other.

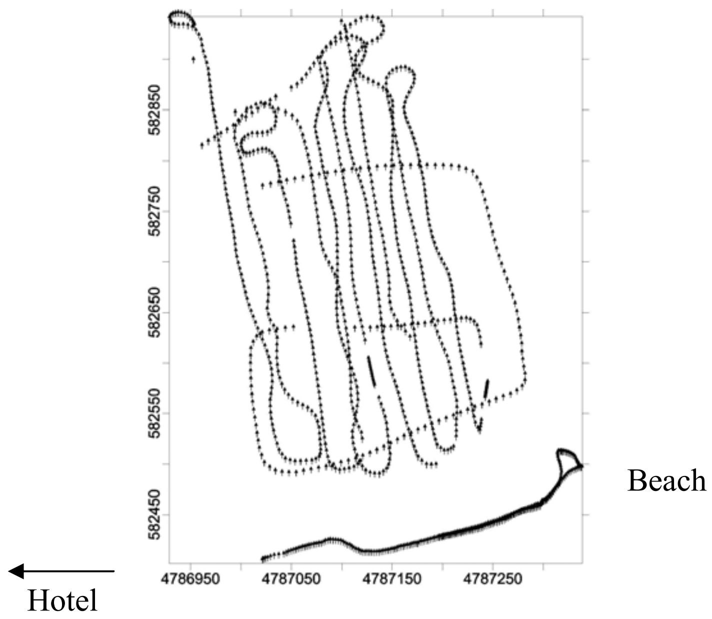


Figure 4a: Trajectories of the vessel during the measurements in October.2003.

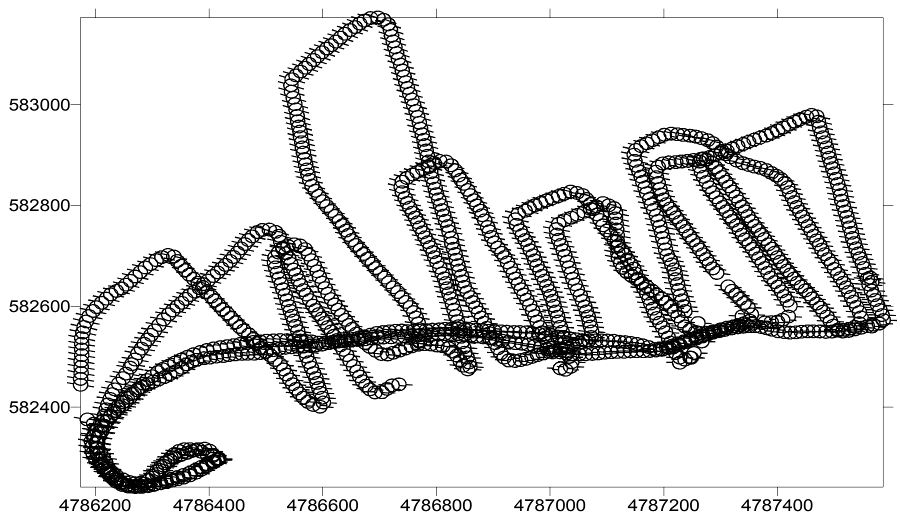


Figure 4 b: Trajectories of the boat during the measurements in year 2004

The results of these measurements are introduced into a profile-shaping computer program SURFER 7,0. It averages the single points of each data point to a line in between. This can be assumed realistic, as the distance of these points to each other are relatively small compared to the morphologic timescale considered within this problem, which is plausible. The bathymetry is shown in Figures 5a, b and 6a, b. Exact figures are not given in the report being waste of paper. This is added to the CDROM with the data.

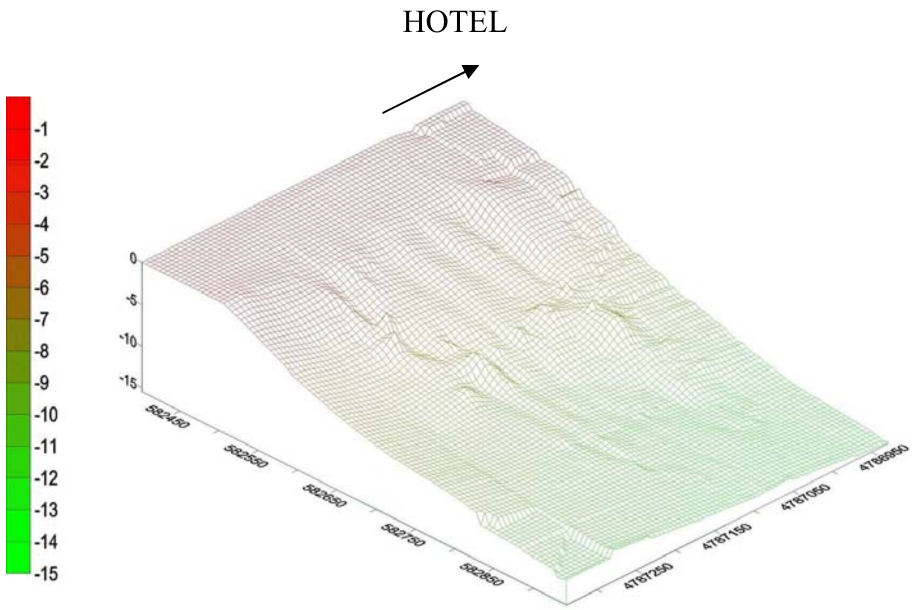


Figure 5a: Bathymetry according to the measurements in year 2003.

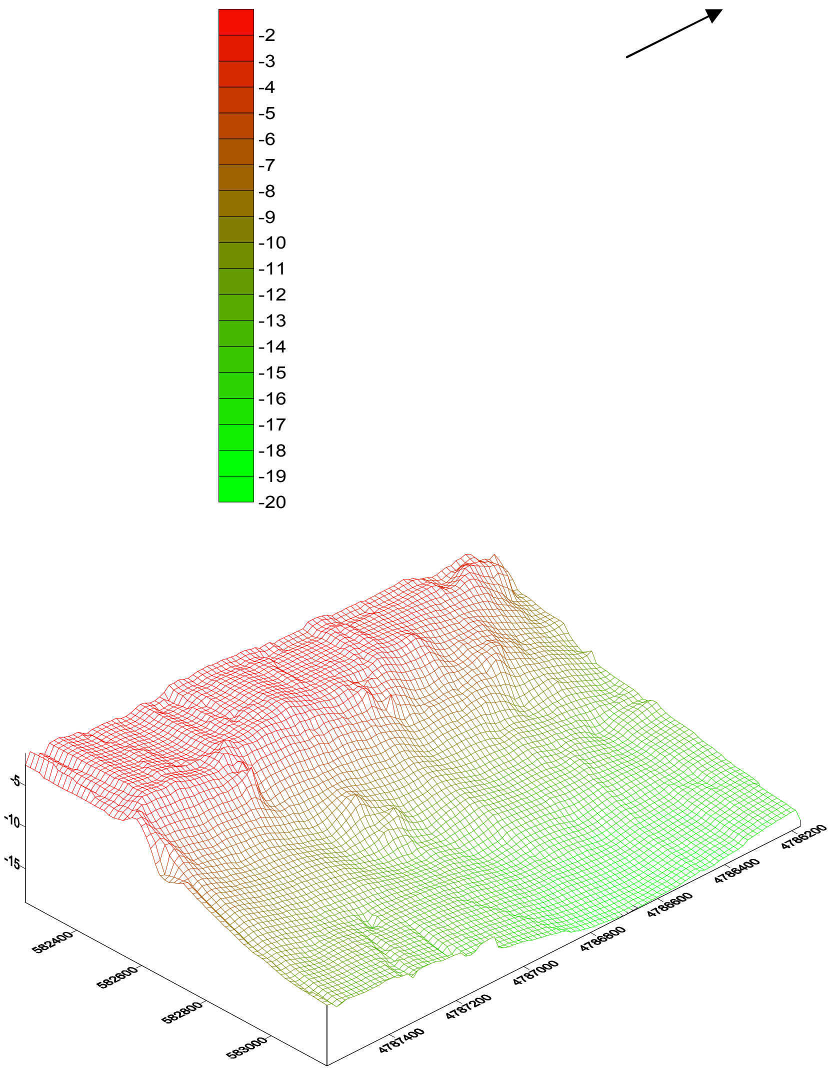


Figure 5b: Bathymetry according to the measurements in year 2004.

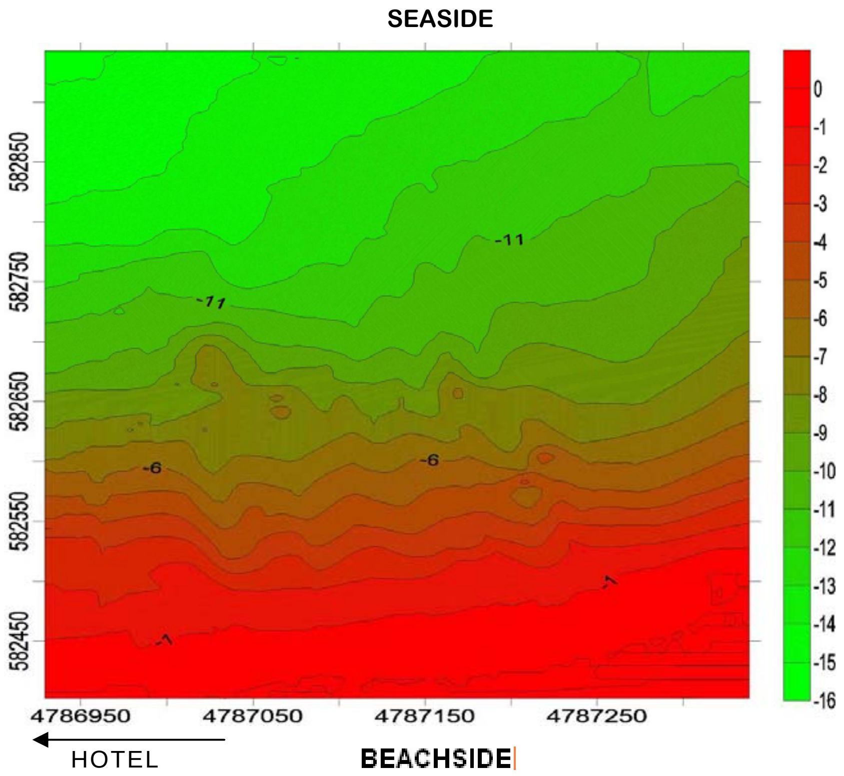


Figure 6a: Bathymetry according to the measurements in year 2003.

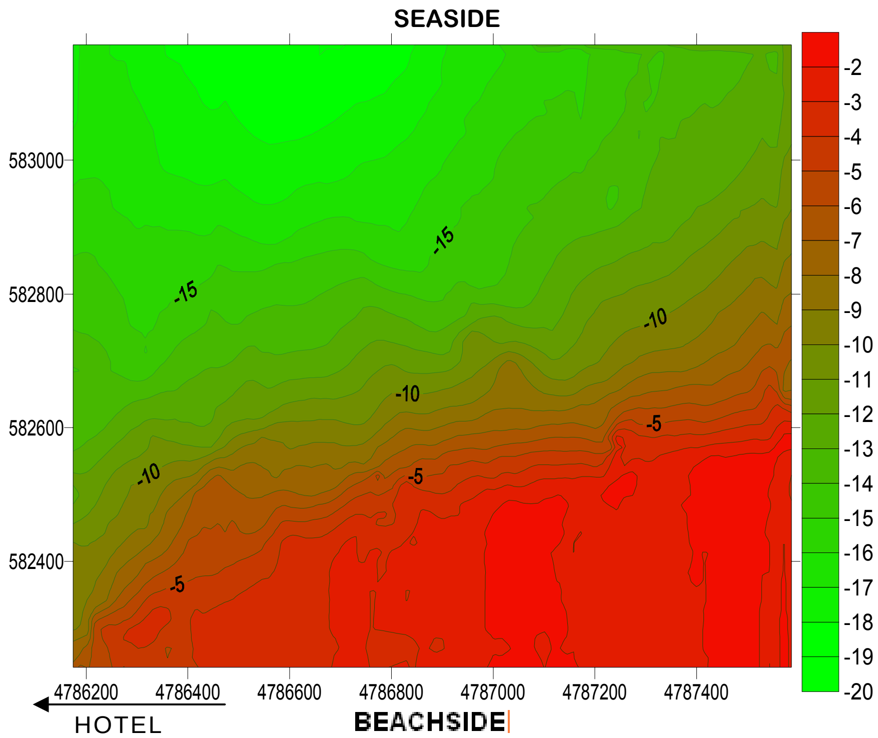


Figure 6b: Bathymetry according to the measurements in year 2004.

7. Discussion

After presentation of the results some discussion can be done on the results itself, and on the used methods. In other words, are the results realistic and are the applied methods of survey that accurate to draw conclusion from it?
In our case the GPS and the echo-sounder were based side by side on the boat so the difference between them, Δ X, can be assumed as equal to zero.
Then the difference between the measured depth and the actual depth - Δ*Xi*, *i*- slope of the sea bottom, is negligibly small. Using more trajectories and thus measuring multiple depths near one point, we may assume that the made measurements are accurate.

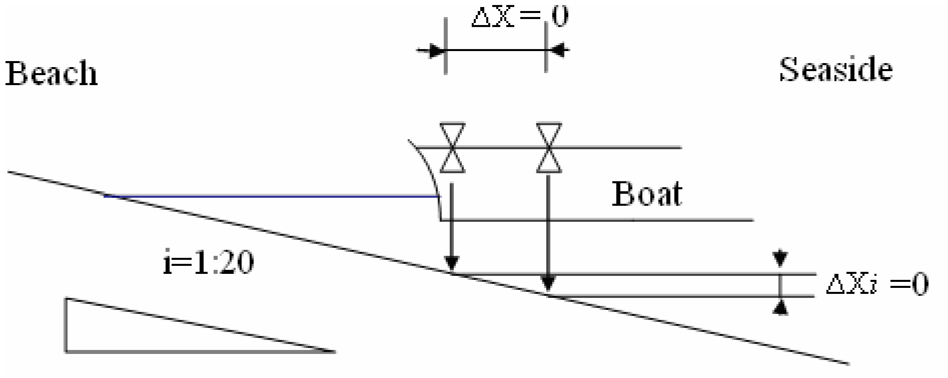


Figure 7. Error due to distance between GPS and echo-sounder

For the measurement's accuracy the influence of the elevation due to the waves can be assumed as negligible, because with a dense data grid and good interpolation this effect is minimized.

The influence of temperature and density on the traveling distance of an echo (and so on the calculated depths) is as a first approximation to be related as a function of the bulk modulus and the density. The relation is given as:

$$v = \sqrt{\frac{K}{\rho}}$$

$\rho = density$
$K = bulkmodulus$

$$\frac{\rho}{K} = \frac{d\rho}{dp}$$

$$K = 2.2 * 10^9 \, Pa$$

The density of the water itself isn't constant with variable temperature and density. Temperature of the seawater at the time of measuring was 18° C. Salinity was not measured but is approximately 2 %, which gives a density of the water in the order of 1020kg/m^3. If we make the assumption that the echo sounder was calibrated to the situation at the side at that

moment, thus taken the local water temperature and density into account, only gradients of temperature and salinity would be of interest. This is an empirical relation.
The velocity of the boat has no significant effect on the accuracy of the measurements, because compared to the traveling speed of sound (approximately 330 m/s), is negligibly small and the Doppler effect is of no meaning.

8. Influence of the used methods and instruments on the measurement's accuracy

Boat navigating with instruments

As stated earlier the position of the instruments on the boat will cause a negligible error on the measured depths. The inaccuracy engendered by the elevation variations due to wave action is expected to be canceled out in some extent over the whole area and in a denser data grid.

Navigating in straight line on GPS

To get a nice profile navigating on straight lines perpendicular to the coastline is preferable. This was executed by using the direction given by a GPS instead of using beacons. The results from this and last year's measurements is expected to be representative to the slope of the seabed, because of the used interpolation methods by the program Surfer 7,0. Changes in the slope are often quite smooth and small ridges are of no importance of the morphologic scale.

Echo-sounder

The inaccuracy of the echo-sounder itself is in the order of a few centimeters. The positioning of the echo-sounder and the GPS side by side, as stated earlier, cancels out the probability of exceedance of differences between the measured and the actual depths. For the calibration of the echo-sounder itself there was no information available at the present time. The influence of the temperature and density on the measurements are stated above.

Morphological changes

Severe erosion and accretion deals with a lot of sediment. As we look at the total volume of sediment in the area, you can expect significant changes to be of great magnitude as well. Small ridges are therefore of no importance to the big picture, but miscalculating depth over the whole area would introduce changes, much greater non-existing morphological changes. Time effects are not taken into account at all, because the measurement last only one day. It's really hard to tell if one measures structural erosion or incidental erosion due to a storm.

4 9. Conclusion

Looking at the plots of the profiles from this and previous year we can be satisfied as they give a realistic view compared to known depth profiles of that area. However, the purpose of the survey is not to quantify the volume of sediment itself, but to analyze morphological changes, being the sediment volume changes, within the given area. When we compare the results from the last two years in one and the same research area (coordinates: X=4786900 – 4787250; Y=582400 – 582900) it is obvious that there's a decrease of the soil stratum. It's also obvious that a sediment volume transport appears south of the researched area. However that can due to incidental erosion inflicted by a storm. Nevertheless the method that was used to quantify morphological changes is useful, but the results will be more accurate if the measurements are done regularly. Finally we must state that it is only a snapshot of the beach profile in the summer and to measure the bathymetry only one day a year is not sufficient to determine the type of erosion that we are dialing with - structural or incidental erosion.

VII. The White Laguna

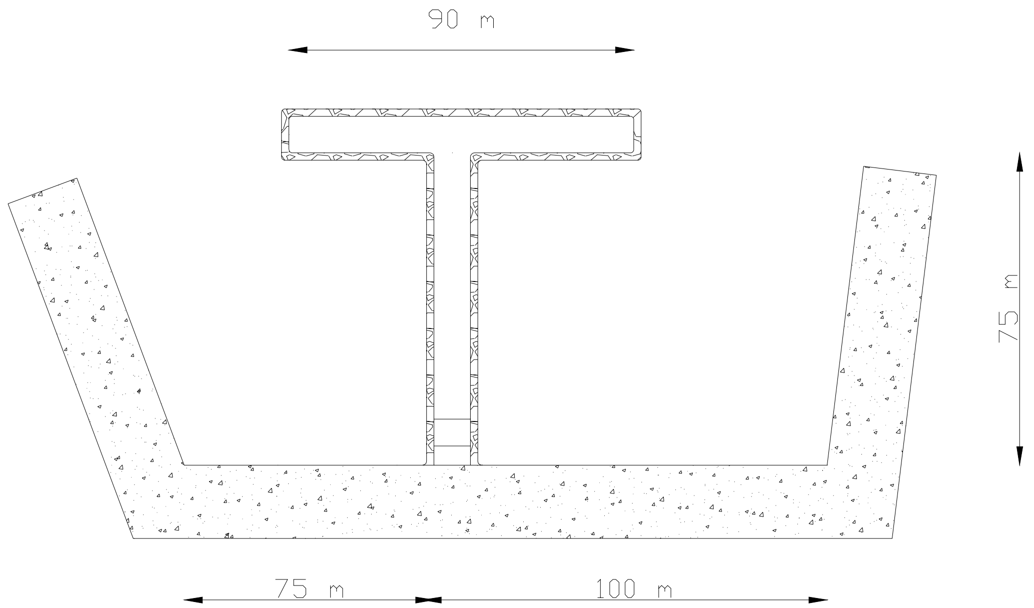
Written by: Ivo Petrov

Description of the problem

One of the explored places during the excursions around the Black Sea coast was the White Laguna. It is situated in the northern part of the coast between Albena and Kavarna and it is very close to the main road (which is along the coastline). It is a nice place for a vacation and real rest away from the noisy resorts. The guests of the complex can also enjoy the magic water of the three mineral springs. There are also intensions of building more hotels near the Laguna because of the rising international interest. But this beautiful place has a real problem, which can affect the tourism business. In the summer when the hotels are full with guest who wants to have a bath in the see or just to lay on the beach the seawater is full with algae which are also thrown out on the beach. The seaweeds are so intensive that there are also anaerobic processes in the water which cause unpleasant smells. The solution until now was to load these big amounts of dead or live seaweeds with baggers on a small truck every day during the tourist season! This is surely unpleasant for both the guests and the management. The task of this excursion day was to think about a solution with the methods of the coastal engineering, and we were kindly offered by the manager to have a drink in the café of the hotel. We used this time for the first steps in solving our task.

1. Geometrical specifications of the Laguna

(Note: All of this dimensions are not exact and are interpreted in situ, the idea is to be created a picture of the place)
The form of the Laguna can be accepted rectangular with dimensions 175 m length and 75 m width. A groyne divides the Laguna in two parts with lengths 75 m and 100 m. There is also another groyne about 90 meters which lies parallel to the beach and forms with the first groin a T. There is also a small opening near the beach which connects the both parts of the Laguna. The average depths at distance 75 m form the coast line are 2m for the left side and 3 m for the right side. The Volumes of the left and the right parts are calculated according to these estimated dimensions. The volume of the left part is about 5600 m^3 and for the right 22 500 m^3.



Picture 1.

2. Needed conditions for the growth of algae

Before we can continue with the engineering solutions we must take into account that the problem in this case is mainly biological. So we should determine the physical factors which are stimulating the growth of the algae's. The algae are first level producers of organic substance; this means they use CO2, H2O, sunlight and mineral substances. The process of photosynthesis needs also definite conditions such as temperature and pH. From all this conditions we now that the key-factor are the mineral substances such as phosphates and nitrates. But the quality of the Black Sea water is relatively good in the past five years, because the use of phosphate-containing washing powders in EU and Eastern Europe is reduced to minimum. So there can be another source for the mineral substances- for example the mineral springs.

3. Possible sources of mineral substances or growth stimulating factors.

1. Waste waters in the Laguna

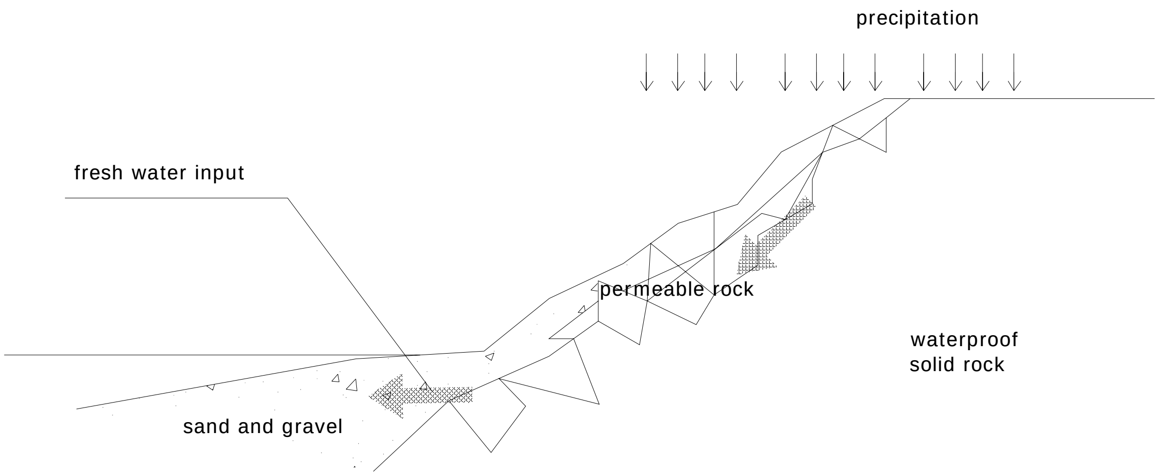
The manager of the complex assured us that the sewers system of the hotels is connected to the main sewers and is conveyed to a waste water treatment plant.

2. Mineral springs

There are tree mineral showers direct on the beach with sum discharge of about 25m³/d. We calculated the discharge with the help of a bottle and a stopwatch. This discharge will need about a year to replace the water in the left part and about 3 years to replace the whole volume of the Laguna. We know that many times during the year there strong storms, which cause ''water exchange'' in the Laguna so there is practically no influence of the mineral springs.

3.Groundwaterflow

The taste of the water in the Laguna was not the typical taste of the Black See water, the contents of salt was significantly lower. Excluding the discharge from the springs, we suppose that there is fresh groundwater input into the Laguna. This is possible because of the relief (see picture)



Picture 2. *Topographic profile, possible fresh water input mechanism*

4.High water temperature

The temperature is also in connection with the depth – the sunlight energy can only heat the upper layer of the water, because it is absorbed before it reaches the deeper layers. The shallow waters are warmer. The higher temperature activates the biological activity of the see algae. The time we were there the temperatures of the sea water were much under the summer levels and we couldn't notice extraordinary amounts of algae in the Laguna. The temperature of the water in the Laguna was definitely higher than the Black Sea water temperature at the moment.

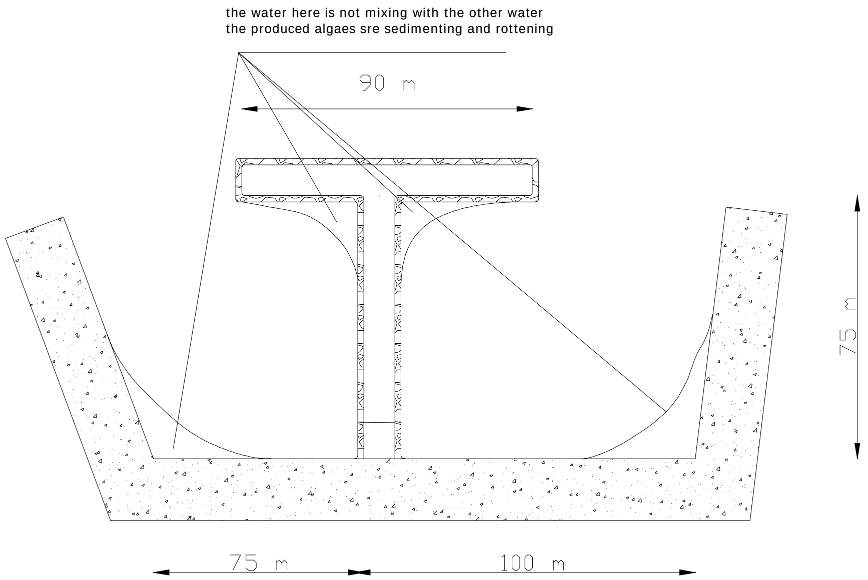
5.Agricultural land in the neighbourhood

There were no agricultural lands in the neighbourhood.

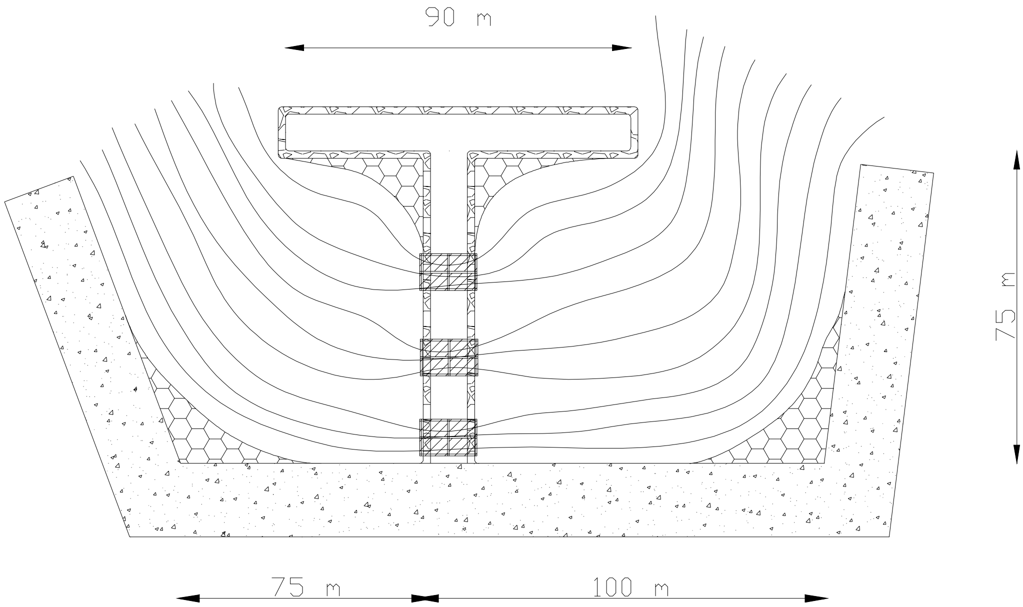
4. Bad flow conditions

All of the problems can be solved if the flow conditions in the Laguna are optimized, and a stream trough the Laguna is generated. This is possible if the angles in the form of the Laguna are made oval to exclude the possibility of dead zones where there is no water flow (the velocity is 0). We are sure that the there are now this type of zones while the stones there had a thin covering layer with black moss on the waterline, which is a sign for anaerobic processes. If in this a zone was a constant flow the new water from the sea could bring amounts of oxygen and there would not be possible for anaerobic processes to take place. The black colour on the stones comes from metals like Cu a Zn and this is typical for the anaerobic processes in contaminated water. The profile of the sea bed could also be artificial optimized for a better flow.

Picture 3. *White Laguna, oval shape could better the flow conditions*

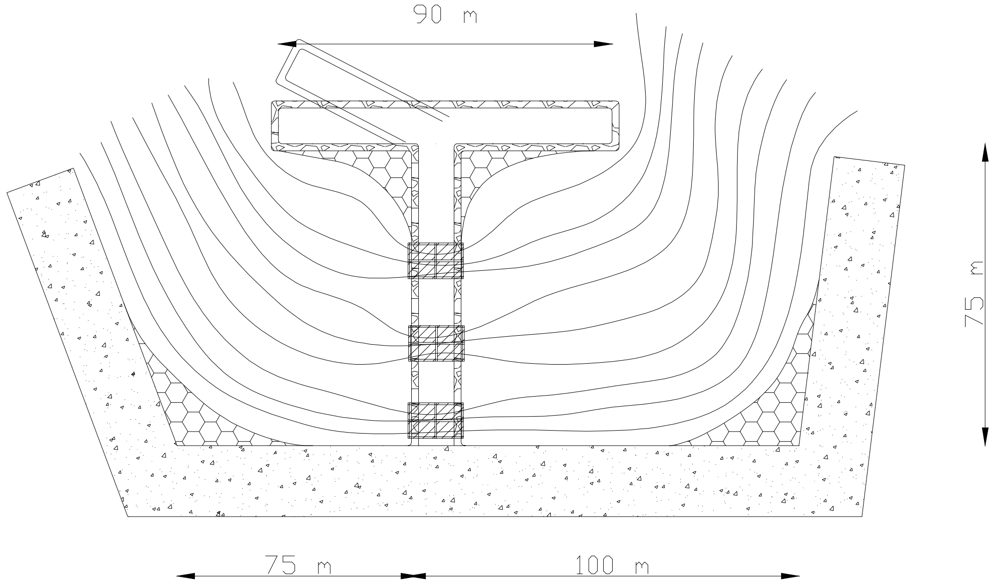


There can be made several bigger openings in the groyne for bettering the flow through the Laguna and ensuring regularly distributed flow. This method is used in the hydraulic structures when the flow comes from a small to bigger flow area.



Picture 4. *White Laguna ,several openings could better flow*

The depth in the left chamber is smaller than the depth in the right chamber, this difference can be due to different flow conditions and sediment transport capabilities of the waves affected by the parallel wavebraker. This Problem can be solved if we redesign the groins in such a way that they allow the waves indirectly to transport sea water. It is also possible to accelerate the flow speed in the Laguna if we incline the parallel groyne against the stream. But this can occur too expensive!



Picture 5. *White Laguna, redesigning wavebraker*

There is a opening in the groyne near the beach with a width about 3 m , the depth of the water there was about 0,7 m, the obvious velocity was about 0,2-0,3 m/s. So we can calculate discharge of about 0,5 m³/s which was flowing at the moment from the left chamber to the right chamber. This leads to the statement that there is an average input in the left chamber and an average output from the right chamber which are about 0,5 m³/s. This could be accepted if the salt content of the water was normal. So we suppose that there is input of fresh ground water. There are two possible ways of calculating it , based on the difference in the salt contents or assuming a flow speed trough the sand. We don't have exact or any data for the salt contents and the parameters of the ground water flow and in order to begin calculations wee need first exact data.

5. Needed information

1.Accurate topographic map of the region
2.Exact picture of the flow conditions (velocities , directions etc.)
3.Map of the sea streams in the region

4.Wave measurements
5.The sediment transport (the type of the sand on the bed and its changes during the year)
4.The contents of organics in the Laguna water
5.Temperature of the water in the Laguna and the sea
6.Data about the precipitations combined with the salt contents of the water in the Laguna

6. Conclusions

The Problem is very complex and can be solved with the help of simple but very expensive decisions:

1. Deepening the Laguna (dradging)
2. Artificially made oval shape of the corners
3. Bigger or more openings connecting the two sides of the Laguna
4. Reconstruction of the wavebraker.

The most effective and cheaper method can be determined with the help of computer model of the Laguna which is also expensive and needs time.

VISITS

Written by: Sava Tachev

During the fieldwork which took place between 9 and 16 October 2004 a few building sites, finished landslides and coastal protection structures were visited.

12 October 2004

We visited Bourgas harbor where we saw and examined the new east breakwater and the new quay. We got onto a jumbo trailing suction hopper dredger and looked at the working process.

14 October 2004

We visited the quarries Marciana and Sini vir owned by the company Eskana S.A.

On our way back to the hotel we stopped at the Institute of Oceanology situated in Varna and looked at the training submarine.

15 October 2004

The resort The White Lagoon was visited. We went to the most eastern point of Bulgaria – Cape Shabla. On traveling we paid attention to the Landslides near the road.

Picture 1

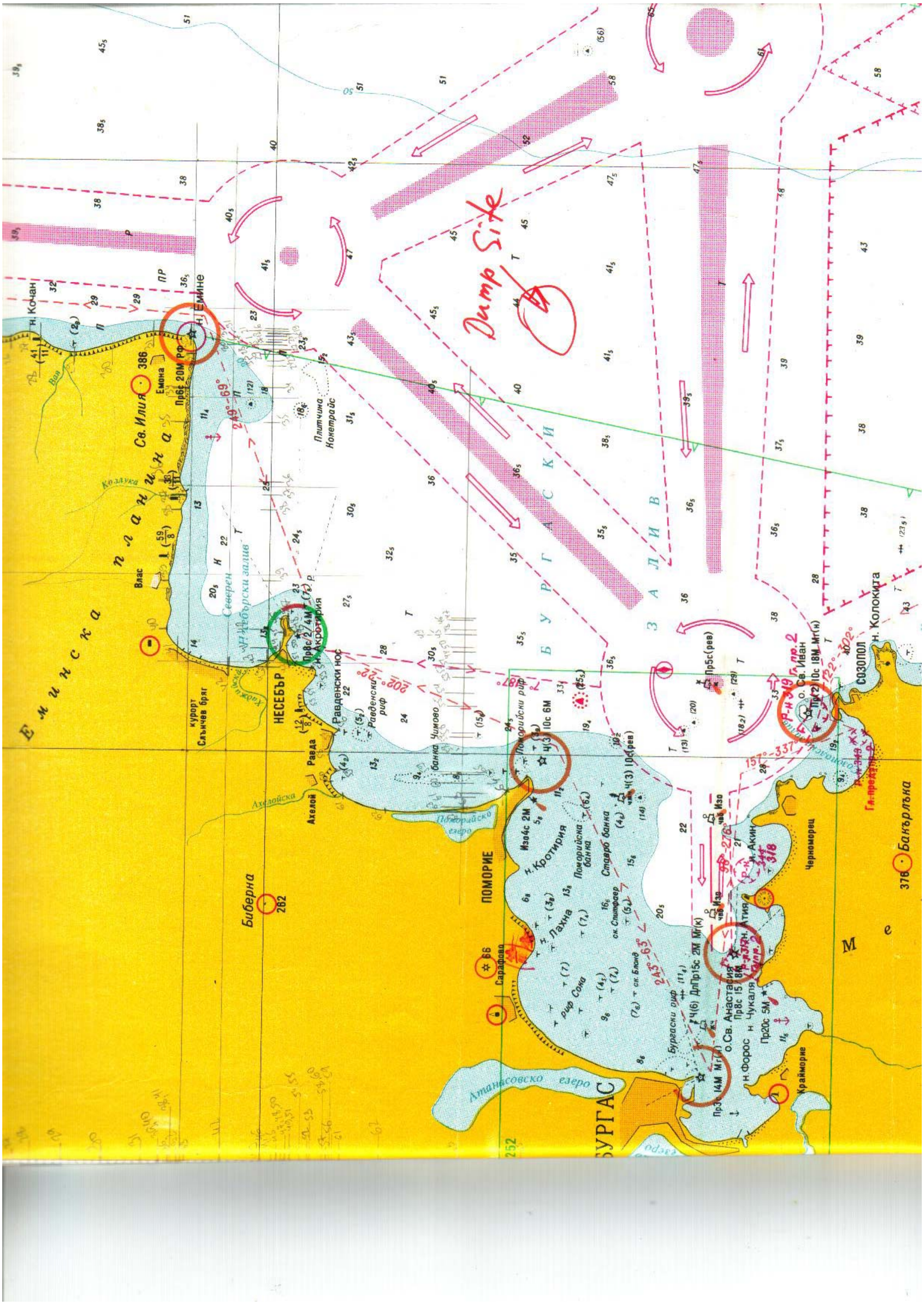
Bourgas Harbor – The new quay Terminal 1

Picture 2

Bourgas Harbor – The new breakwater

Picture 3

Bourgas Harbor – Construction of the new part of the harbor


Dump Site
НЕСЕБЪР
ПОМОРИЕ
БУРГАС
СОЗОПОЛ
Атанасовско езеро
Емине
Бибеерна

Picture 4

Bourgas harbor – The jumbo trailing suction hopper dredger

Picture 5

The White Lagoon resort

Picture 6

Landslide Kabakum-State before starting protection works

Picture 7

Landslide Kabakum - State after completing the protection works

Picture 8

Marciana quarry

Picture 9

Sini vir quarry – drilling machine