BEACH NOURISHMENT COMBINED WITH SIC VERTICAL DRAIN IN MALAYSIA.

Claus Brøgger[1] and Poul Jakobsen[2]

The present paper presents measurements and results from a three year full scale Pilot Project with the SIC vertical drains system combined with beach nourishment. The SIC vertical drain system is used to prevent beach erosion by draining the beach and thus reducing water pressure in the beach. The site Teluk Chempedak a pocket bay on the East Coast of Malaysia near the town of Kuantan. The beach is located in front of Hyatt- and Sheraton Hotel and has a total length of 1000 metres. The beach was nourished with 177669 m^3 sand in June, July 2004. The sand was placed on the beach 1000 x 100 metres close to an equilibrium profile. The beach was drained with the SIC vertical drain system prior to and after beach nourishment. After three years the beach is stable with only a few percentages of sand loos. The Pilot Project ended July 2007.

1. Introduction

Teluk Cempedak on the East coast of Malaysia is one of the main tourist attractions in the Pahang State. This beach has a narrow and rather steep near-shore profile. There are hotels, roads and private properties located along the beachfront.

The beach has a history of erosion. This erosion has resulted in the narrowing of the beach area, which has affected adversely on the recreational and tourist activities in this area.

The average retreat rate is estimated to 0.8 m/year. If protective measures are not taken, the beach eventually will be eroded, and the ocean waves approach the land will endanger the properties and Infrastructure.

Conventional methods of using hard structures to arrest erosion are not suitable for this beach because these methods are costly and not environmentally friendly.

It was decided by the government to implement a pilot project to rehabilitate this beach by use of the SIC vertical drain system.

The objective of this project was to bring the beach back to a state where it can serve its purpose as a high standard tourist and recreational beach with good sand quality.

As part of the government requirements, MIKE 21 model was required to describe the hydrodynamic conditions (current and waves) and the sediment transport for the beach at Teluk Cempedak, where the beach over the last 20-30 years has been eroded with approximately 0.8 m/year.

A detailed dynamical model was setup for the beach area describing hydrographical conditions. The model includes water level, current, waves and

[1] SIC, Skagen Innovation Centre, Dr. Alexandrinesvej75, Skagen, DK-9990, Denmark
[2] SIC, Skagen Innovation Centre, Dr. Alexandrinesvej75, Skagen, DK-9990, Denmark

sediment transport. With use of this model the yearly average sediment transport has been calculated, the new beach profile optimized and sand nourishment needed estimated.

The model verification is based upon previous reports (Coastal Engineering Centre in the Department of Irrigation and Drainage DID, Malaysia), where it has been documented that shoreline erosion is approximately 0.8 m/year. This information comes from present and historical aerial photos. The amount of maintenance dredging in the navigation channel to Kuantan Port has been used to confirm the overall sedimentation in the area.

Teluk Cempedak beach is in a pocket bay located between two rocky headlands. The shoreline is orientated 355° according to north, which exposes the most of the beach for waves coming from the main direction of the northeast monsoon period (055°). The length of the beach is approximately 1000 m with a width above MHHW (Mean Higher High Water) of 0 – 20 m.

2. Construction Activities

July 2003: The beach in front of the Hyatt and Sheraton Hotel is pre-drained with the SIC vertical drain system.

May to July 2004: The beach is nourished with 177669 m^3 sand, see fig 2.

August 2004: The beach is drained again with the vertical drain System.

3. Drain filter set-up

SIC vertical drain filters were placed in rows forming a matrix along the coastline, see Fig. 1a . The drain system is designed in two sets as follows:

1. The first set is the basic SIC vertical drain system used to drain the existing beach and prepare for sand nourishment. Vertical 2m long drainpipes are located in a 100m x 10m matrix (9 columns and 5 rows) reaching from the surface of the beach face to the groundwater table. Total number of drainpipes is 55. The effect of the basic installation is to initially increase the drainage capacity of the active zone, and secondly transport silt away from the beach thus accelerating further the drainage capacity.
2. The second set is the off-set vertical drain system after sand nourishment. Vertical 2m long drainpipes are installed in a 100m x 10m matrix (9 columns and 5 rows), however, shifted 20m in the alongshore direction. Total number of drainpipes in this project is 110.

Each drainage pipe is made of PVC material, it has a length of 2.0 m and a diameter of 15 cm. see Fig. 1 .

Each drainpipe is perforated with horizontal slots arranged in sections vertically along the length of the pipe. Each section is 30 cm long and consists of horizontal arc slots cut into the pipe 1 mm apart with a width of 0.2 mm. First section of slots starts 75 cm below top of pipe.

The top of the drainpipe is closed with a plastic cap with a filter hole.

The top is covered with sand so they do not present obstacles to users of the beach; the bottom of the drainpipe is closed with a plastic cap.

The filters equalize the pressure of the ground water basin and an increased circulation of seawater in the coastal profile will take place. This will promote sedimentation of materials on the coastal profile.

The vertical filters increase the drop of the water level in the coastal profile in the period from high tide to low tide. Thus, the beach will be more effectively drained of water. When the water level is low on the coast during the period from low tide to high tide, the water circulation in the swash zone increases, which again increases the depositing of materials on the foreshore, thereby building up the beach from the sediments transported along the coast.

Over time the new materials in the coastal profile become increasingly coarse, due to a higher speed of the underlying water in the coastal profile. The result of deploying these vertical filters in a beach is a strong and wide equilibrium profile. (Brøgger and Jakobsen 2007).

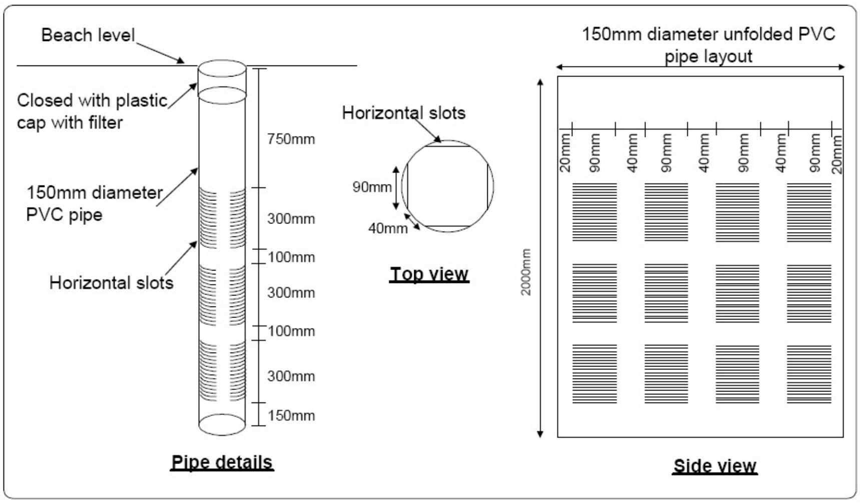


Figure 1. Vertical 2m long drainpipes are located in a 100m x 10m matrix.

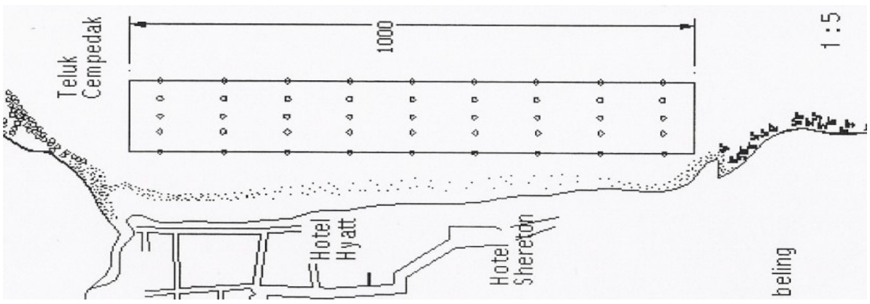


Figure 1a. SIC vertical drain pipe matrix on the beach, 9 columns and 5 rows

4. Nourishment Sand Area

The beach is 1000 meters long, and the sand was placed from the concrete wall and 100 meter out in the sea close to equilibrium profile, see figure 2.

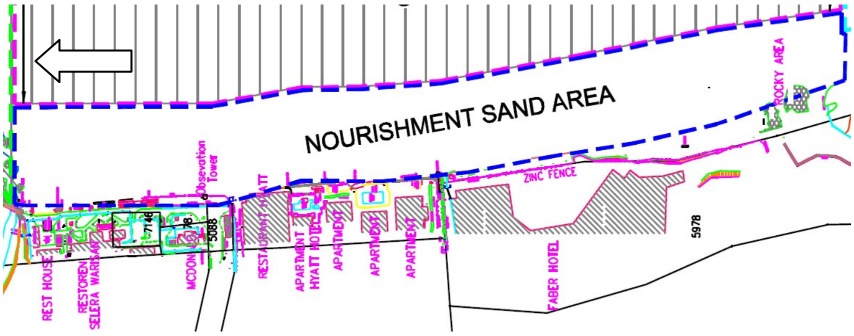


Figure 2. Nourishment sand area 1000 m long and 100 m wide.

5. Sand Nourishment

The design of the sand nourishment (length, width and slope) starts with the design requirement of the SIC vertical drain system. The design of sand nourishment is mainly based on the following two manuals:

1. Shore Protection Manual by Coastal engineering Research Center of US Army Corps of Engineers, 1984.
2. The Beach Nourishment Manual by the Delft Hydraulics, 1986.

The SIC vertical drain system requirement is that a minimum 30 m wide beach to be extended in front of the upper berm boundary above the mean high water. Accordingly the drainpipes in the drain system shall also cover the range from the mean higher high water (MHHW) till the mean lower low water (MLLW). The design requirement of the SIC vertical drain system requires that the sand nourishment should be pre-spread out in a profile close to the equilibrium. The designed profile should also cover the range from MHHW to MLLW instead of the conventional method of placing sand on bulk above the mean high tide and allow the waves and tides to takes their course in shaping the equilibrium profile. The nourished sand was consequently placed from the concrete wall on the beach and 100 meter seaward.

Sand volume

The volume computed from the results of the Interim (Pre-Construction) topographic and bathymetric survey (surveyed on 06/03/2004 to 13/03/2004) and the designed sand nourishment level utilising the Terramodel version 9.8., was 167488 Cubic metres.

Actual nourished sand = 177669 Cubic metres.

Sand grain size

The sand on the beach, before sand nourishment, had a grain size between 0.3 – 0.5 mm (the finest sand in the northern part of the beach).

The nourishment sand grain size is approximately 0.5 mm.

Beach slope

The average beach slope before nourishment was 1 in 60, the designed slope was 1 in 45 (equilibrium profile).

6.0 Weather

Wind

In the two monsoon periods the dominating wind directions are N/NE in the NE monsoon. December is the month with the highest wind speed and the longest period with wind speed higher than 8 m/s, max 10-14 m/s, see table 1.

	North			North-East			East			South-East			South			South-West			West			North-West		
Month	Mean	Max	Dir [%]	Mean	Max	Dir [%]	Mean	Max	Dir [%]	Mean	Max	Dir [%]	Mean	Max	Dir [%]	Mean	Max	Dir [%]	Mean	Max	Dir [%]	Mean	Max	Dir [%]
Jan	5	8	1.6	6	11	6.5	3	7	0.2	1	2	0.1	0	0	0.0	0	0	0.0	1	1	0.0	3	5	0.0
Feb	6	10	1.6	5	11	5.3	3	9	0.6	2	4	0.2	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Marts	2	5	0.5	4	9	4.9	3	7	2.2	2	4	0.5	2	4	0.2	1	3	0.1	1	1	0.0	1	1	0.0
April	2	6	0.3	4	10	2.1	3	5	1.9	2	6	1.9	3	6	1.4	3	8	0.3	2	3	0.1	2	4	0.1
May	1	1	0.1	3	6	0.8	3	5	1.6	3	6	1.7	3	7	2.8	3	6	1.4	1	2	0.1	2	2	0.1
June	2	3	0.1	3	4	0.1	2	4	0.3	3	6	1.3	4	8	4.5	4	7	1.9	1	1	0.0	0	0	0.0
July	1	2	0.1	1	1	0.0	3	5	0.4	3	7	0.7	5	10	4.9	4	10	2.1	2	3	0.2	2	2	0.1
Aug	1	1	0.0	1	2	0.0	1	2	0.1	3	5	0.4	5	10	5.3	5	9	2.4	1	2	0.1	1	2	0.1
Sep	2	2	0.1	2	3	0.1	1	3	0.2	3	7	0.8	4	10	4.6	4	8	2.3	2	4	0.1	1	2	0.1
Oct	2	6	0.8	2	7	0.9	2	5	0.9	2	4	0.9	3	6	1.8	3	6	1.4	3	6	1.0	3	6	0.8
Nov	4	9	2.5	5	10	3.1	2	4	0.5	2	3	0.3	2	3	0.1	1	4	0.3	2	4	0.7	2	5	0.8
Dec	7	14	3.1	7	13	3.9	4	9	0.5	3	4	0.2	6	7	0.1	5	5	0.0	4	6	0.1	5	8	0.5

Table 1. Offshore wind in knots east coast of Malaysia 1991-08-01 to 1992-07-31,1998 and 1999

Rainfall

The rainfall in Kuantan is approx. 2.5 metre yearly. The rainfall can be up to 1.11 metre over a 5 day period in the monsoon time.

7.0 Hydrodynamic data (historical)

Current

Near shore current in the pocket bay in the monsoon time directs the sediment transport direction in the bay from north to south.

In the inter-monsoon time the sediment transport direction in the bay is from south to north.

Sediment

There is no sediment input from the sea into the pocket bay.

Tidal

Tidal data is from the nearby Kuantan Port. Analyzing data from period 1996-01-01 to 2000-08-31 indicates that there is a strong seasonal change in the mean water level with a difference between the NE and SW monsoon at approximately 0.4 m with the highest level in the NE monsoon (Nov-Feb) due to the metrological conditions, see figure 3.

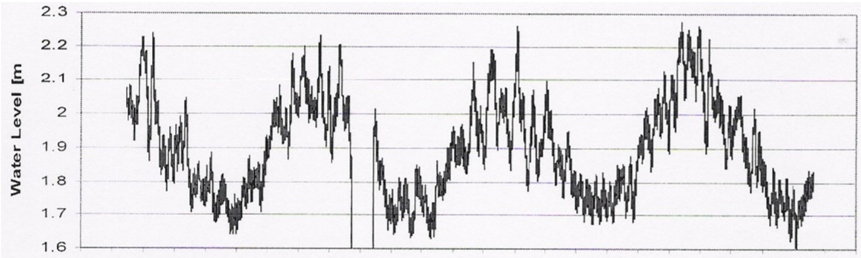


Figure 3. Tides at Kuantan Port over 4 years (X-axis), peaks are NE monsoon (Nov-Feb)

Difference between measured and predicted tide indicates that the NE monsoon period is much more turbulent, see Figure 4.

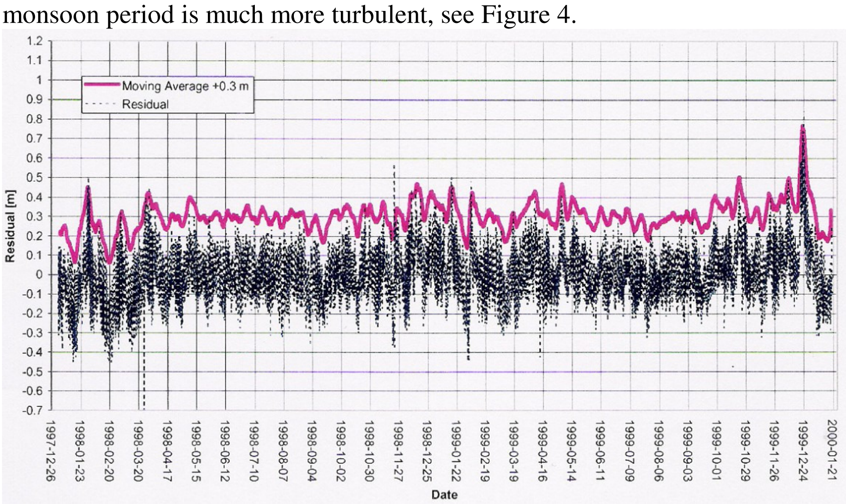


Figure 4. Difference between measured and predicted tide (residual). (Kuantan Port)

Waves

Waves are not a strong factor. As for the wind data the dominating wave direction is 055° (NE monsoon), the yearly average wave height is approximately 0.20 m, but during the NE monsoon the average wave height is 0.75 m.

Near shore current in the pocket bay during the monsoon time, directs the sediment transport in direction from north to south.

In the inter-monsoon time the sediment transport direction in the bay is from south to north.

8.0 Evaluation

The evaluation of the project is based on data from four areas, see figure 5:

1. Nourishment sand area from the concrete wall on the beach and 70 m out towards the sea. The evaluation is based on the average beach level (ABL) from the concrete wall in front of the hotels and 70 metres towards the shoreline and out into the sea.
2. Northern area, offshore.
3. Center area, offshore.
4. Southern area, offshore.

All areas are evaluated for every 25 m as shown in figure 5.

Bathymetric survey was done by DFS3200 Dual Frequency echo sounder (operated on single frequency mode).

D-GPS reference station was established for navigation and positioning during the bathymetric survey utilizing Trimble 4000 RS Receiver.

Topographic and bathymetric profiling of the foreshore area was performed over a length of the shoreline of 1000 meters. The shoreline profiles were spaced at 25 meters interval and 10 meter interval along the profile. The landward limit of the shoreline profiles were 100 meters beyond the high water mark. The seaward limit was 1000 meters seawards of the high water mark.

Land survey system used was Geodimeter Electronic Total Survey Station.

The survey and data processing are done by licensed surveyor: Jurukur Perunding, Bandar Baru Seri Petaling, KL Malaysia.

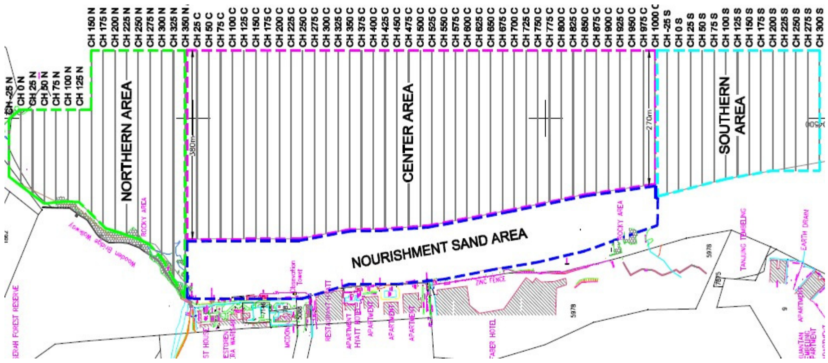


Figure 5. Evaluation areas.

Evaluation schedule

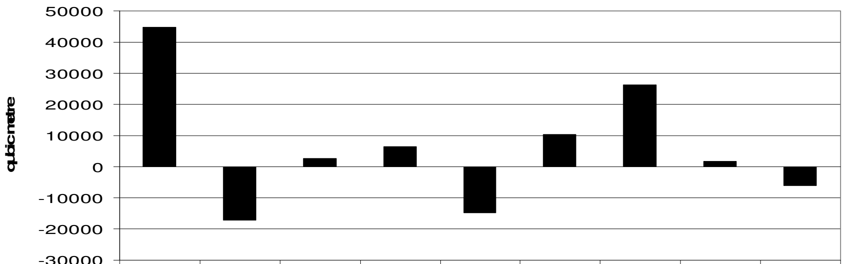
The project area was evaluated first time on March 2003, this was a pre-project evaluation.

Further evaluation:

March 2004,July 2004,October 2004,March 2005,July 2005,October 2005,March 2006,July 2006,Oktober 2006,March 2007,July 2007. (July 03 the beach was pre-drained with SIC vertical drain, May-July 04 the beach was nourished with 177669 m3 sand, August 04 the beach was drained again with SIC vertical drain).

Offshore North

Figure 6 data shows that after sand nourishment, 44835 m3 sand have moved into the offshore north area, and after the stabilizing period we register a normal fluctuation pattern.

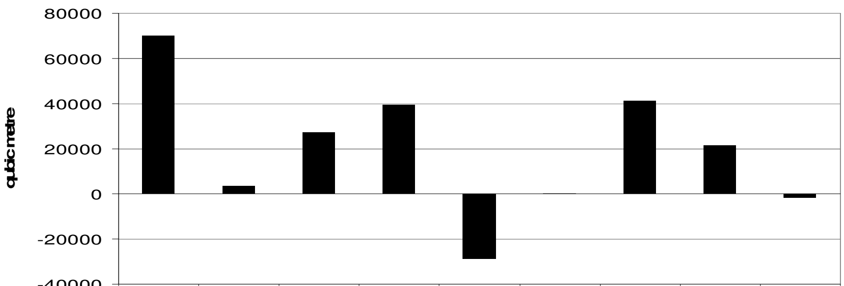


	Oct 2004	March 2005	july 2005	Oct 2005	March 2006	July 2006	Oct 2006	March 2007	July 2007
■ M3	44835	-17224	2633	6471	-14805	10308	26177	1777	-6141

Figure 6. Offshore North development CH -25N to CH 350N

Offshore Center area outside nourished area

Figure 7 shows that, just after sand nourishment, data indicate that 70167 m3 sand have moved into the center area outside the nourished area, after the stabilizing period we register a normal fluctuation, see figure 7.

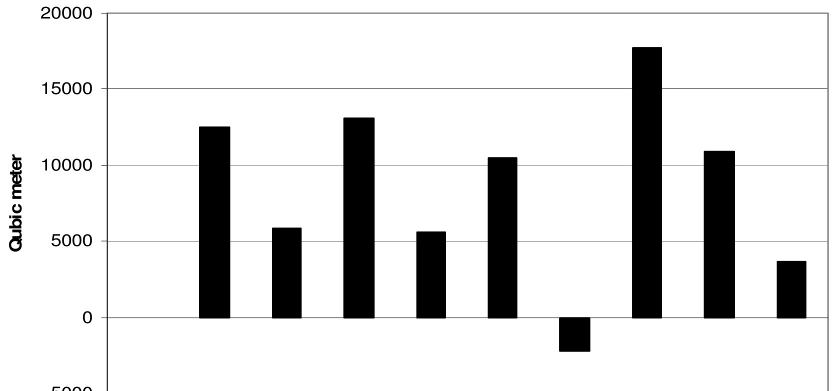


	oct 2004	march 2005	july 2005	oct 2005	march 2006	july 2006	oct 2006	march 2007	july 2007
■ M3	70167	3556	27201	39428	-28757	306	41382	21277	-1596

Figure 7. Offshore center development outside nourished area.

Offshore South

Figure 8 shows that, just after sand nourishment, the sand volume is fluctuating between 5000 and 13000 m3, which indicates a stable situation.

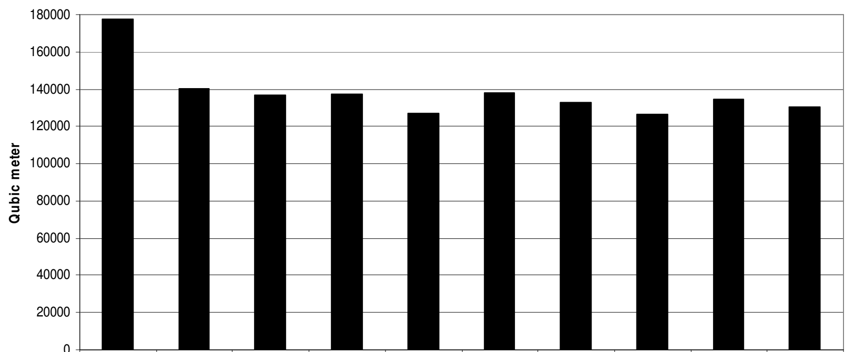


	July 2004	Oct 2004	March 2005	july 2005	Oct 2005	March 2006	July 2006	Oct 2006	March 2007	July 2007
■ M3	0	12542	5873	13097	5632	10463	-2182	17738	10876	3655

Figure 8. Offshore South development CH -25S to CH 300S.

Nourished area volume development

Figure 9 indicates that, after stabilizing and packing, the nourished sand has found a stable condition as a product of the SIC vertical drain system.

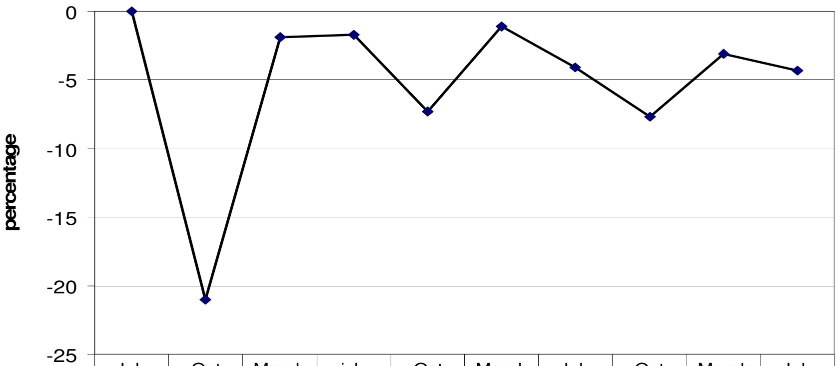


	July 2004	Oct 2004	March 2005	july 2005	Oct 2005	March 2006	July 2006	Oct 2006	March 2007	July 2007
Serie1	177669	140101	136896	137263	127139	138149	132834	126476	134755	130712

Figure 9. Nourished area volume development.

Sand loss percentage

Figure 10 shows that, after the 21% loss in the stabilizing and packing period, the loss of nourished sand is only a few percent. It is also clearly seen that the loss in the winter time (NE monsoon) is about 7%, while in the summer time the sand loss is less.



	July 2004	Oct 2004	March 2005	july 2005	Oct 2005	March 2006	July 2006	Oct 2006	March 2007	July 2007
%	0	-21	-1,9	-1,7	-7,3	-1,1	-4,1	-7,7	-3,1	-4,3

Figure 10. Sand loss in percentage.

The Average Beach Level (ABL)

ABL is a strong indicator of the beach resistance against erosion, (Jakobsen and Brøgger 2007). In figure 12 it is seen that the nourished sand, after the drainage of the beach, has found its equilibrium profile and is stable. Again it is seen that the ABL is slightly lower in the winter time, but the beach is able to regain in the summer period.

The design for a 70 meter wide beach at Teluk Cempedak is an ABL of 1.88 meter and a volume of 131 m3/m. After 3 years in this project the ABL is 2.25 m, and the average volume of sand in the profile is 156 m3/m .

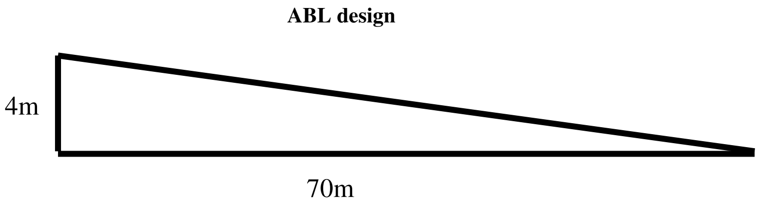
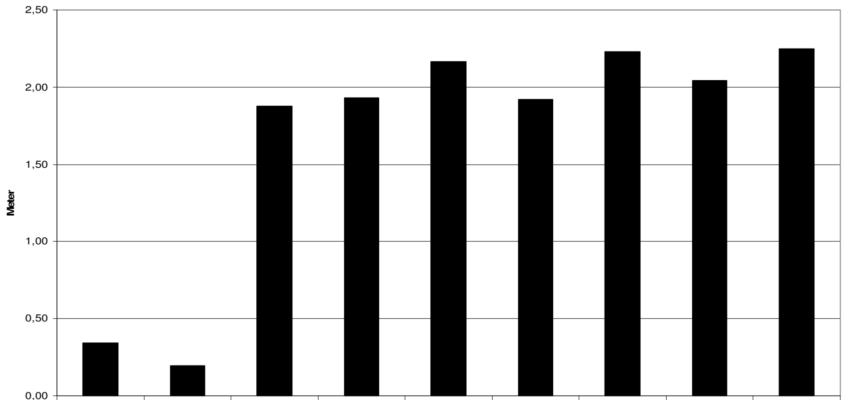


Figure 11. Average beach level calculation design, reference level is “official 0”.

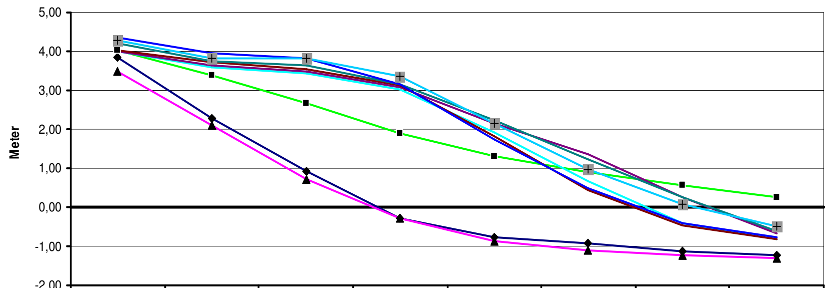


	March 03	March 04	July 04	March 05	July 05	March 06	July 06	March 07	July 07
M	0,34	0,20	1,88	1,93	2,17	1,92	2,23	2,04	2,25

Figure 12. Average Beach Level (ABL) from concrete wall and 70 meter towards sea.

Average beach profile

Figure 12 shows the average profile in the sand nourishment area from the concrete wall on the beach and 70 meter seawards. Before the beach was nourished and drained, the beach was concave. After nourishment and drainage, the beach is convex. The beach stays convex after three years. Figure 12 also shows that beach width is stable around 60 meter, compared to the 27 meter before nourishment and the SIC vertical drain system.



	0 m	10 m	20 m	30 m	40 m	50 m	60 m	70 m
March 03	3,83	2,29	0,93	-0,28	-0,78	-0,91	-1,12	-1,23
March 04	3,5	2,11	0,72	-0,28	-0,87	-1,1	-1,22	-1,3
Design	4,03	3,39	2,67	1,90	1,31	0,89	0,57	0,26
March 05	3,99	3,60	3,43	3,02	1,92	0,68	-0,40	-0,81
July 05	4	3,64	3,49	3,07	2,17	1,36	0,26	-0,66
March 06	4,02	3,71	3,53	3,13	1,82	0,44	-0,47	-0,82
July 2006	4,2	3,73	3,64	3,17	2,22	1,23	0,24	-0,61
March 07	4,36	3,96	3,81	3,16	1,74	0,50	-0,40	-0,78
July 07	4,29	3,81	3,81	3,37	2,14	0,97	0,08	-0,48

Figure 12. Average beach profile from concrete wall and 70 meter seawards.

Average beach volume development 70 meter

Fig 13 shows that the nourished sand on the beach (70 meter) has in three years increased 25900 m3, which is equal to 19,68%

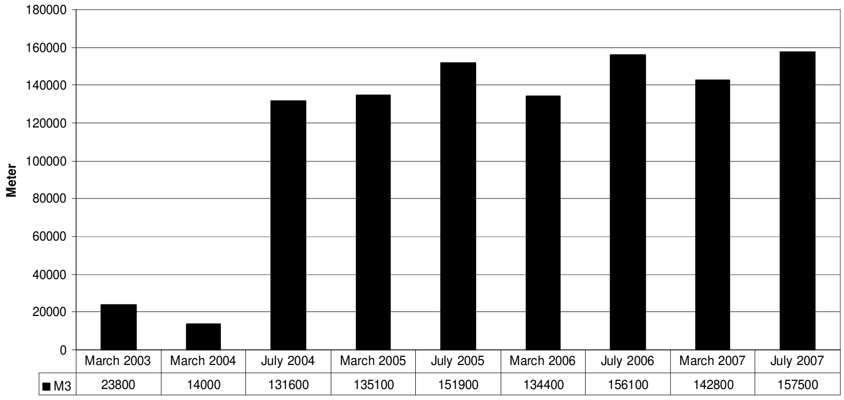


Figure 13.Average beach volume development 70 meter

9,0 Summary

- The objective of this three year pilot project was to produce a documentation of the efficiency of the SIC vertical drain system and the systems capability to stop or reduce the erosion on a sand nourishment beach with no natural sediment input. The nourished sand on this location normally has a lifetime from 3 to 5 years.
- Following a packing and stabilization period of 3-4 months during which the beach reached an equilibrium profile, the beach at Teluk Cempedak has remained stable, and the loss of sand offshore is after three years only a few percents.
- SIC is of the opinion that the project was over-nourished by some 30000 m3 sand.
- The volume of the sand in the nourished area was, after three years, reduced by 46957 m3 some of which, 17.700 m3 (10 %), was reduced in the packing process and 29200 m3 had moved out in the offshore profile in the pocket bay in the process of creating a equilibrium profile. It must be noted that of the nourished 46957 m3 loss after three years, the 37568 was lost after 3 month.
- Beach width is stable close to 60 meter after three years.
- The sand volume on the beach has gained 25900 m3 in three years.
- The SIC vertical drain system effectiveness has been proven and documented in this project.

REFERENCES

Brøgger C. and Jakobsen P. Evaluation of the function of Vertical drains, *Conference ICS 2007 Gold Coast Australia.*

Jakobsen P. Pressure Equalisation Modules For Environmentally Friendly Coastal Protection, *Yamba 2000 Australia*.

Jakobsen P. and Brøgger C. Coastal protection based on Pressure Equalization Modules (PEM), *Conference ICS 2007 Gold Coast Australia.*

Jakobsen P. and Brøgger C. Environmentally Friendly Coastal protection Based on vertical drains

,*Conference ICCE 2008 Hamburg Germany.*

KEYWORDS – ICCE 2008

PAPER TITLE : **BEACH NOURISHMENT COMBINED WITH SIC VERTICAL DRAIN IN MALAYSIA.**

Authors : Claus Brøgger and Poul Jakobsen
Abstract number : 1164

shore,beach,coast,coastal,erosion,skagen,SIC,vertical drain,swash zone,Equilibrium Profile,sand,environmentally friendly,PEM,pressure equalization module,