Evaluation of the function of Vertical drains.

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ICS 2007
International Coastal Symposium.
Gold Coast, Australia

ABSTRACT

BRØGGER,C and JAKOBSEN,P., 2007. Evaluation of the function of Vertical drains. ICS2007 (Proceedings of the 9th International Coastal Symposium), Gold Coast, Australia.

The PEM system is used for beach erosion control and involves the principle of vertical draining.
Scientists generally agree that a well drained beach is robust and accrete, but beaches with a high water pressure will erode.
On this background a field test was performed on the Danish west coast with DIVER water level instruments.
The test with the Diver sensors was carried out over 2 weeks, where the PEM modules with sensors were placed between the wells with sensors in week nr. 2.
All the Divers in the wells and PEM modules were time locked and registered the water table for every 2 minutes.
The effect of the PEM modules corresponds to the theory from" (Glover and Todd, 1975)" about fresh water outflow in Coastal zones.

Additional index words: *Beach dewatering, SIC, PEM.*

INTRODUCTION

Scientists generally agree that a well drained beach is robust and will generally favour infiltration and onshore sediment transport.
The position of the water table in beaches is mostly controlled by tidal waves.
The effects of vertical drains on the water table in beaches are investigated in this report.
The drains are called Pressure Equalizing Modules (PEM). The vertical drains consist of a 1.0 m long screen drain on a 0.75m tube with a diameter of 0.06m. The functioning of the PEMs is that the effective permeability of the beach is increased. A two-week experiment was conducted at a beach near Holmsland on the west coast of Denmark in order to investigate the hydraulic functioning of the PEMs (Fig 1).
Two different experiments were meant to be investigated.
1.
A beach-scale experiment where tidal dynamics influence on the water table were monitored in rows with normal observation wells and PEMs.
2.
A close-in scale experiments, where the pressure distribution around a drain was continuously monitored.
The close-in test failed due to installation failure.

The experiment was divided into two periods.

Period one where all the wells were installed with pressure sensors DIVERs (fig 5)
Measurement every 2 minutes and.

Period two where PEMs were installed, also with pressure sensors.

Three rows were established.
One row with just wells and no PEMs, which then acted as a control site.
One row with both wells and PEMs.
One row with a few wells and mostly PEMS, which was designed primarily for the close-in-scale experiment.

The idea was to make a before-and-after comparison, where the tidal response in the wells during period two could be compared with the tidal response in period one.
Unfortunately due to a dramatic change in the weather conditions resulting in higher water level in week two compared with week one (Fig 2), we found the "before-after evaluation" not useful.
We then decided to use data only from week two and only from the center (C) row as it was found that the beach geology in the north (N) row differed to much.

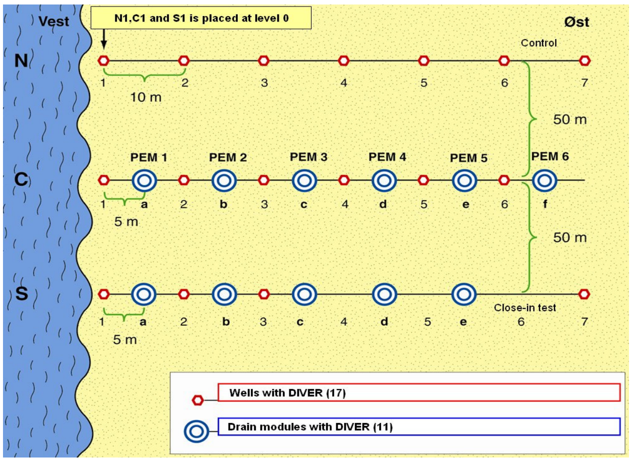

Figure 1. Test site

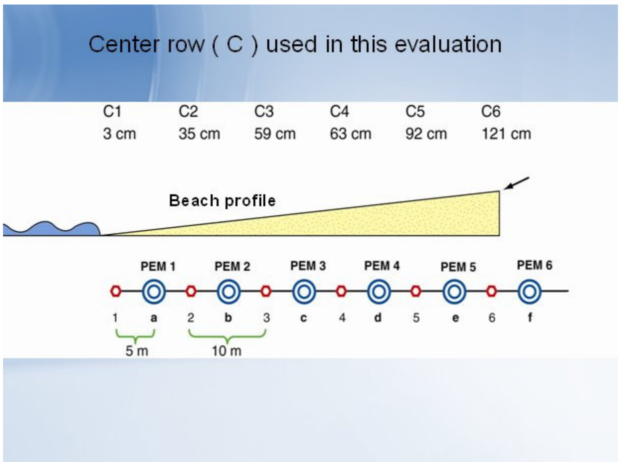

Figure 2. (C) Center row / Beach profile

Field site

The field site is located 5 km south of Hvide Sande on the West coast of Denmark, (Fig 3).
Figure1 show the location of the installed wells (small circle) all with DIVERs measuring the water level and the Pressure Equalizing Modules (big double circle) also with DIVERs.
The North row was meant as a control row, where no PEMs were installed.
The Center row includes wells, and with PEMs centrally located in between two wells (Fig 2).

There are 5o meters between the rows and 10 meters between the wells. Between the wells and PEMs there are 5 meters.

The South row has only four wells, three nearest to the sea, and one at the other end, and five PEMs.
All wells were installed starting on 8:00, March 20, 2006. The PEMs were installed on March 26, 2006
The test ended on April 02 2006.
The MSL are shown on Figure 7.

The center row (C) (fig 2) only is used in this evaluation.

Fig 3 Test site location (Skodbjerge)

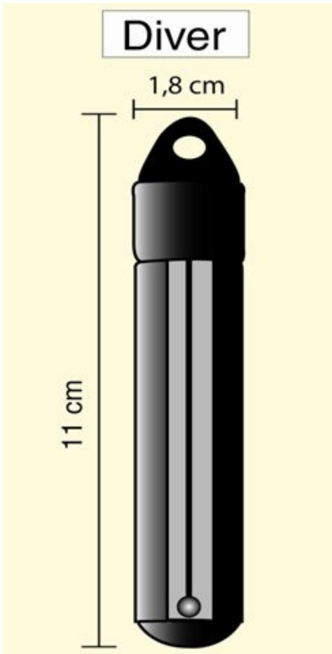

Fig 4 DIVER sensor

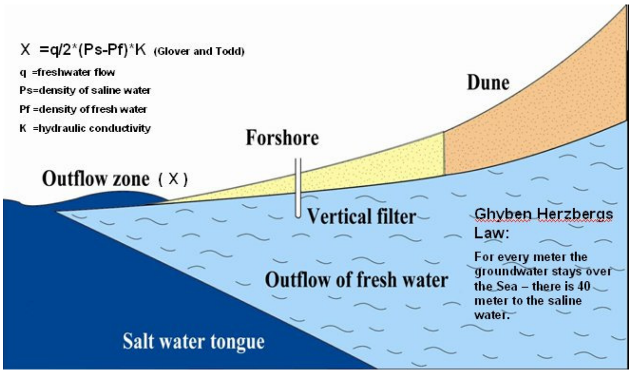

Fig 5

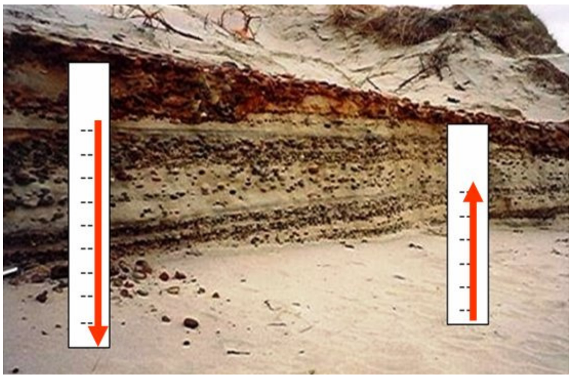

Fig 6

Conditions

Fig 5 illustrates the water pressure at the beach and outflow zone. According to "(GHYBEN HERZBERG)" we know that for every meter the groundwater stays over the sea – there is 40 meters down to the saline water.
However this is not the case in the outflow zone where according to "(CLOVER and TODD D.K)" the conditions are stated in the equation:

$$X=q/2(Ps-Pf)K$$

Where X= outflow zone in meter
q = freshwater flow pr. meter
Ps = density of saline water
Pf = density of fresh water
K = hydraulic conductivity

The outflow zone (X) moves with the tide and is an important factor in the function of the drains as the positive change of the hydraulic conductivity in the beach will broaden the area of outflow and increase the outflow thereby lower the water pressure in the beach.

Weather

During the first period the wind was easterly with small wave activity.
At the start of the second period the weather shifted to westerly wind with wind speeds between 14 and 19 m/sec, which resulted in a water level rise of 0.40 meter (Figure 7).

Vertical drains

Vertical drains connect different permeable layers in the beach and increase the outflow. The water may move up or down in the tubes depending on the water pressure in the beach and the swash zone (figure 6).
The pressure drop in the beach will increase the saline water circulation and accretion will take place creating a sand groin which catches the long shore sediment transport (fig 8).
The vertical drains acts like a starter that keeps the process going. When more or less impermeable layers has been penetrated or/and when several permeable layers has been connected by the drain, the draining process starts washing out fine material and in that way becomes more and more effective.

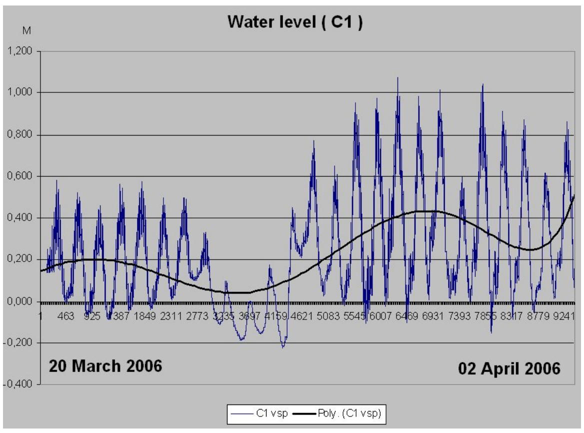

Fig 7

Fig 8

Fig 9

Fig 10

Impermeable layers

The presence of more or less impermeable layers in a beach is well known.
They may consist of very fine material.
The material could be particles of clay or organic material coming from rivers and municipality sewers (Fig 10).
These layers we also found at the test site (fig 6, fig 9) where the drain pipes penetrates the impermeable layers and connects the permeable layers.

Pressure sensors

This field test use DIVERs as pressure sensors in the beach.
This model was chosen because it is robust and accurate, it has no external wires. The measurements are easily transferred to a PC via a docking station.
The DIVER (Fig 4) measures the groundwater level with an accurate pressure sensor.
The weight of the water Colum above is the determining factor.
The DIVER sensors were submerged in the wells / drains and their X Y Z coordinates were logged with GPS.
All DIVERs were synchronized in time and the logging intervals were set to 2 minutes.

(fig 12 , fig 13)The data from the DIVERs shows that in PEM 1 and PEM 2 the water level is well above the calculated average value (C1+C2)/2, (C2+C3)/2. Indicating an upward draining flow as expected in the outflow zone.

Method

The draining effect is illustrated by comparing the water level inside the drains with the water level in the beach as recorded of the sensors inside the wells (C1+C2)/2, (C2+C3)/2, (C3+C4)/2, (C4+C5)/2, (C5+C6)/2.

C1 and C2 water pressure

The difference in C1 and C2 is reduced to 5-6 cm after draining in period two.
Without draining the level difference is between 4 and 19 cm indicating the drains has equalized the pressure (fig 11).

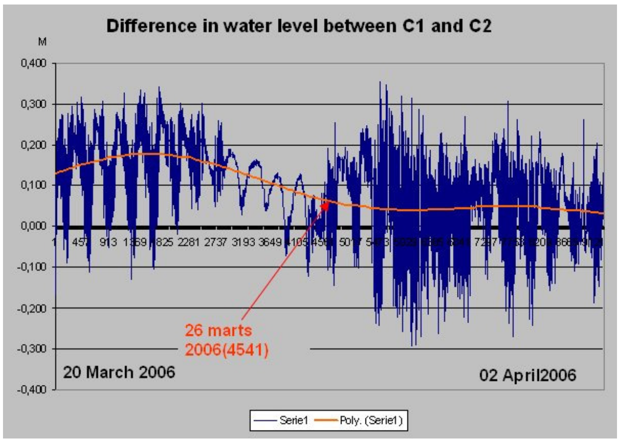

Fig 11

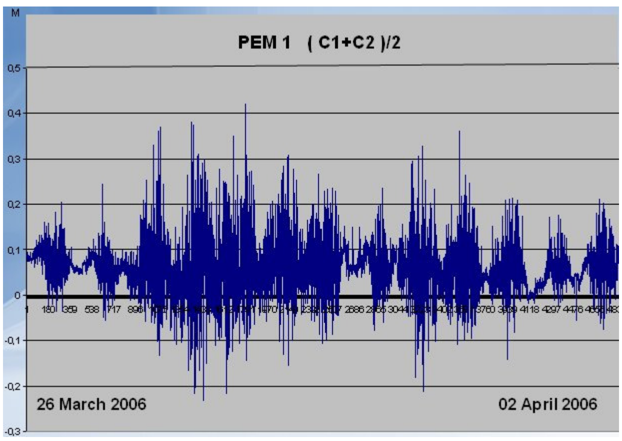

Fig 12

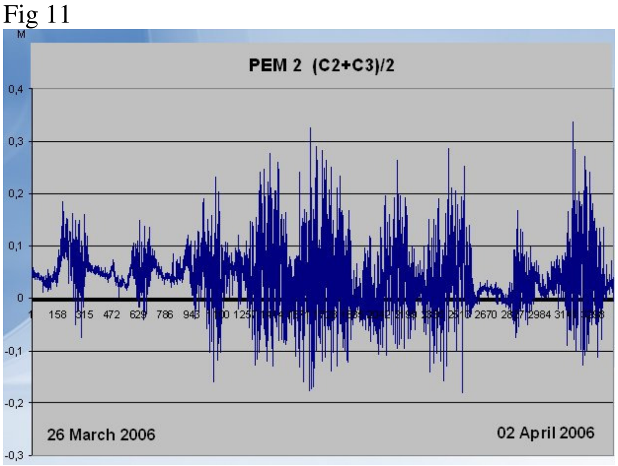

Fig 13

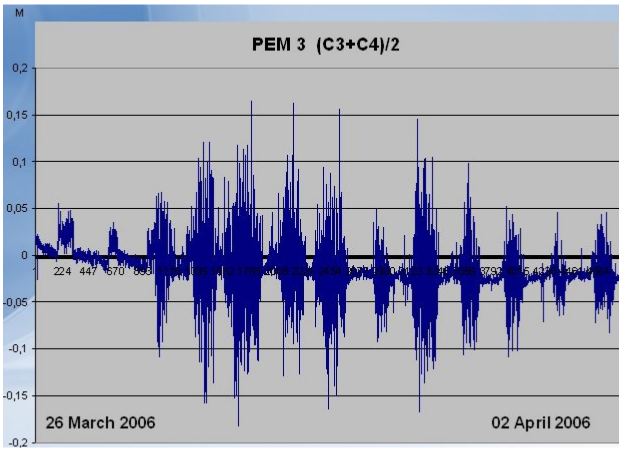

Fig 14

(fig 14 , fig 15, fig. 16) PEM 3, PEM 4 and PEM 5 data shows, that the water level is below the calculated value (C3+C4)/2, (C4+C5)/2 (C5+C6)/2 indicating an downward draining flow as expected in the dry zone.

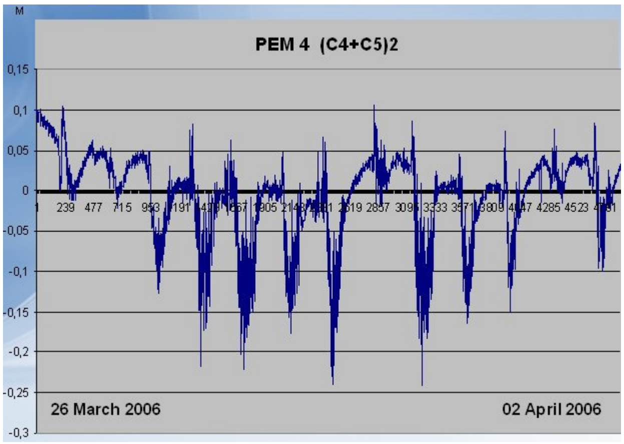

Fig 15

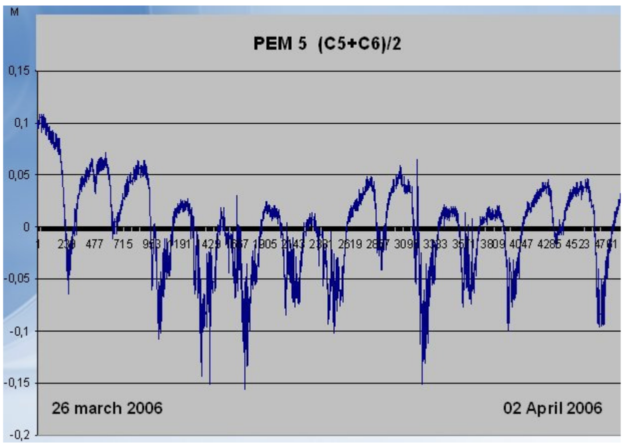

Fig 16

Conclusion

The hydraulic effect of installing pressure equalizing modules (PEM) was investigated.

The test showed that on a dry beach the water level inside the PEM was significant lower than in the neighboring wells, indicating effective downward draining of the beach.

PEM modules in the swash zones that were submerged due to high tide, showed a higher water level than in the neighboring wells. This indicates that the outflow of water is increased by the drain.

The effect of the drains acts as trigger starting the process and thereafter the system is self sustained.

Effective draining of a beach will increase the beach's capacity to absorb water from the incoming waves. The sediment they contain will be deposited on the shore. Gradually a sand groin will develop picking up the long shore sediment adding sand to the beach.

References.

Jakobsen, P. Pressure Equalisation Modules For Environ-mentally Friendly Coastal Protection.Conference Yamba 2000

Jakobsen, P. SIC- systemet løsningen på den globale vandstands-stigning. Geologisk Nyt. AarhusUuniversity 1/07 page 4 - 8.

Jakobsen P. Trykudligningsmoduler skaber brede ligevægt-sprofiler. Geologisk Nyt. Aarhus University 1/07 page 10 -17.

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