Schleswig-Holsteinischer Landtag
Umdruck 16/3609

Ministerium für Landwirtschaft, Umwelt und ländliche Räume
des Landes Schleswig-Holstein

An die Geschäftsführerin
des Umwelt- und Agrarausschusses
des Schleswig-Holsteinischen Landtages
Frau Petra Tschanter
Landeshaus

-per Mail- 27.10.2008

Sehr geehrte Frau Tschanter,
in seiner 48. Sitzung beschloss der Umwelt- und Agrarausschuss einstimmig, den Antrag der Abgeordneten des SSW zu **'Alternative und ergänzende Küstenschutzmaßnahmen', Drs. 16/79**, für erledigt zu erklären und dies dem Landtag zu empfehlen.
In der Beratung zu diesem Antrag erklärte sich Herr Minister Dr. Christian von Boetticher bereit, die Zusammenfassungen der Untersuchungsberichte der Herren Prof. Burchardt und Fredsoe sowie die dänische und deutsche Zusammenfassung der Untersuchungsergebnisse zu Vertikalen Stranddrainagen dem Ausschuss zur Verfügung zu stellen.
Bitte entnehmen Sie diese der Anlage.

Mit freundlichen Grüßen
B. Hielscher

Ministerium für Landwirtschaft, Umwelt
und ländliche Räume
des Landes Schleswig-Holstein
Ministerbüro
Burkhard Hielscher -MB 6-
Postfach 50 09
24062 Kiel
Telefon: 0431 988-7207 oder 0151 17407521
Fax: 0431 988-7158
Mail: Burkhard.Hielscher@mlur.landsh.de

Coastal protection performance of the SIC Pressure Equalizing Modules.

Results of the three years field test at the southern Holmsland Barrier on the Danish North Sea Coast

by
Hans F. Burcharth
Prof. dr. techn, dr. h.c.

Department of Civil Engineering
Aalborg University
Denmark

27 May 2008

11.10 Summary and interpretation of survey results

The most important parameters for detecting the effect of the PEMs are the MBL, the beach width and the changes in volumes of dune and beach. The analyses revealed that over the three years there seems to be only a very weak (if any) correlation between the performance of the beach in terms of the variation of the parameters and the presence or not of the PEMs. On the other hand there seems to be a rather clear correlation between the beach performance and the presence of outer bars in the sense that coastal erosion took place mainly where the coast is badly protected against severe wave action because of holes in the outer bar. The eroded stretches were weak from the start of the project due to these holes, the positions of which did not change significantly during the project. Outer bars along the test site existed before the bar nourishment, but natural variability in the position of the holes prevented long-term erosion of a single stretch from taking place. Actually Ref. II which is the most eroded stretch in the test period was protected by a high outer bar few years before the start of the bar nourishment.

12. Overall conclusions

The objective of the three years field test was to verify the performance of the PEM system as a method for protection of sandy coasts against erosion. The investigations contained the following main activities:

a) Comparison of the performance of stretches with and without PEMs in terms of erosion/accretion, based on quarterly surveying per 100 metre of the coastal profiles.

b) Physical analyses of the function of PEMs.

c) Local field investigations of the function of the PEMs in terms of ground water pressure measurements in the beach in a row with and without PEMs.

d) Numerical simulations of the influence of the PEMs on the groundwater flow.

ad. a. The results of activity a) as presented in Chapter 11 showed no good correlation between stretches with and without PEMs with respect to erosion and accretion. Significant erosion took place both in some parts of stretches with and without PEMs. The largest erosion occurred where the beaches from the start of the study were low and narrow, most probably because of holes in the outer bar at these locations. During the three years study it seems that the spatial distribution of the significantly eroded parts of the beach remained correlated with the positions of the holes in the outer bar. If this is not the explanation of the significant erosion in Ref. II and southern part of Rør I then the only explanation must be a significant leeside erosion effect caused by the middle part of Rør I, i.e. a very negative effect of the PEM-system.

The most significant accretion of sand took place in Ref. III, i.e. a stretch without PEMs. SIC explains this as downstream natural sedimentation behind the sand spit formed in Rør II. The problem with this explanation is that such accretion is not seen in other stretches downstream of even more pronounced sand spits, see Figs. 45-47. Also the beach width in Ref. III increased even after the beach width in Rør II decreased to a size smaller than in Ref. III so this can hardly be due to downstream sedimentation. Moreover, there is no physical explanation of such a phenomenon, which – if true – should also benefit the eroded Ref. II and southern part of Rør I.

The conclusion of activity a) is that it could not be demonstrated that the PEMs had a significant effect on the coastal morphodynamics. The observed changes can be explained by other phenomena.

ad. b. The physical analyses as presented in Chapter 9 show that the PEMs can under certain conditions have a drain effect which might be positive in terms of increasing the accretion. However, the effect – even under the certain conditions – will be marginal. Natural variations in the coastal morphodynamics are very much larger than any influence of the PEMs.

ad. c. The recording of the ground water pressure variations in the beach as presented in Section 6.5 could not and was not meant to quantify the draining effect of the PEMs, but could only demonstrate if the presence of PEMs would change the ground water pressure variation. An analysis of Peter Engesgaard (2006) showed that the PEMs did not change the pressure variation, as the observed variations could be explained by the expected natural variation. SIC compared the pressure variations in a row of PEMs with pressures in neighbour wells and found small differences from an assumed linear variation of pressures between the wells. This assumption together with some uncertainty on the levels of the pressure transducers in the PEMs and the wells (which is comparable in size to some of the pressure differences) makes it difficult to be conclusive about the measurements. Anyway, the measurements cannot show anything about the effective draining effect in terms of more persistent lowering of the ground water table in the beach.

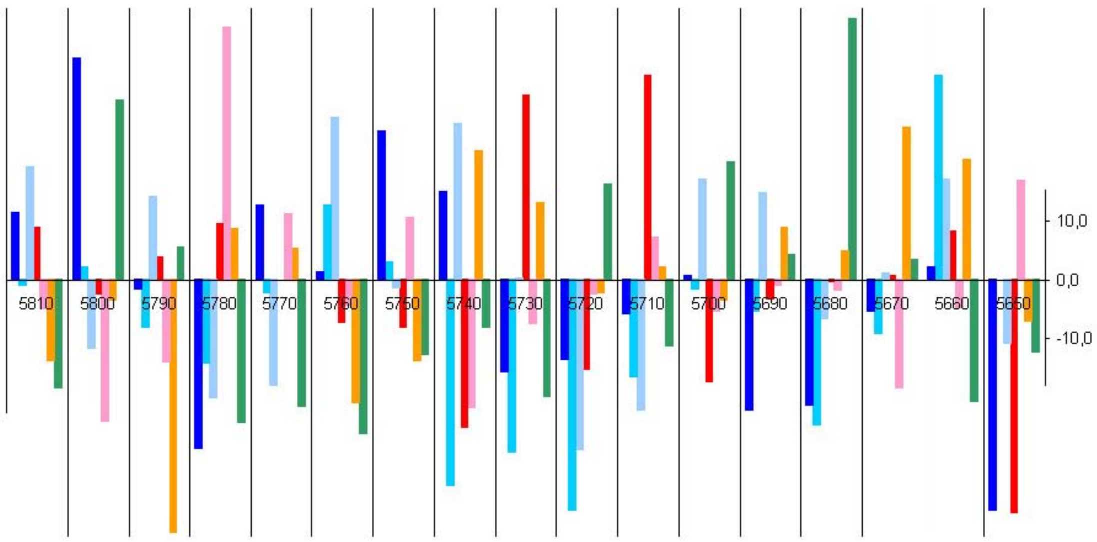
ad. d. The numerical simulations of the ground water flow as presented in Chapter 7 showed that the PEMs under certain conditions can have a draining effect, but this effect will be marginal.

In summary, the PEMs will under certain conditions have a positive effect in terms of increased drainage and perhaps related accretion of sand, but the effect will be marginal and almost impossible to detect on the background of the very large natural morphological changes of a beach like the actual one.

This point of view is supported by the fact that even a system like the BMS, see Section 7.2, based on active lowering of the beach ground water table by pumping, can only create accumulation of a very limited amount of sand which for sure is insufficient as a means against coastal erosion on exposed coasts.

Firnally, it is the opinion of the author that the effect of vertical drainage can be improved by using drains which are active over a larger depth instead of the lower 1 metre of the 2 metre pipes. Moreover, the drains should have a much larger surface than the 6 cm pipes and should be much more densily spaced. It is not clear why pipes are needed. Instead one could for example dig holes of two metre width and depth per every 100 m^2 and fill the holes with cobble stones surrounded by filter stones. The drainage capacity would be much larger than that of the PEM system. Still, the coastal protection capacity will be small.

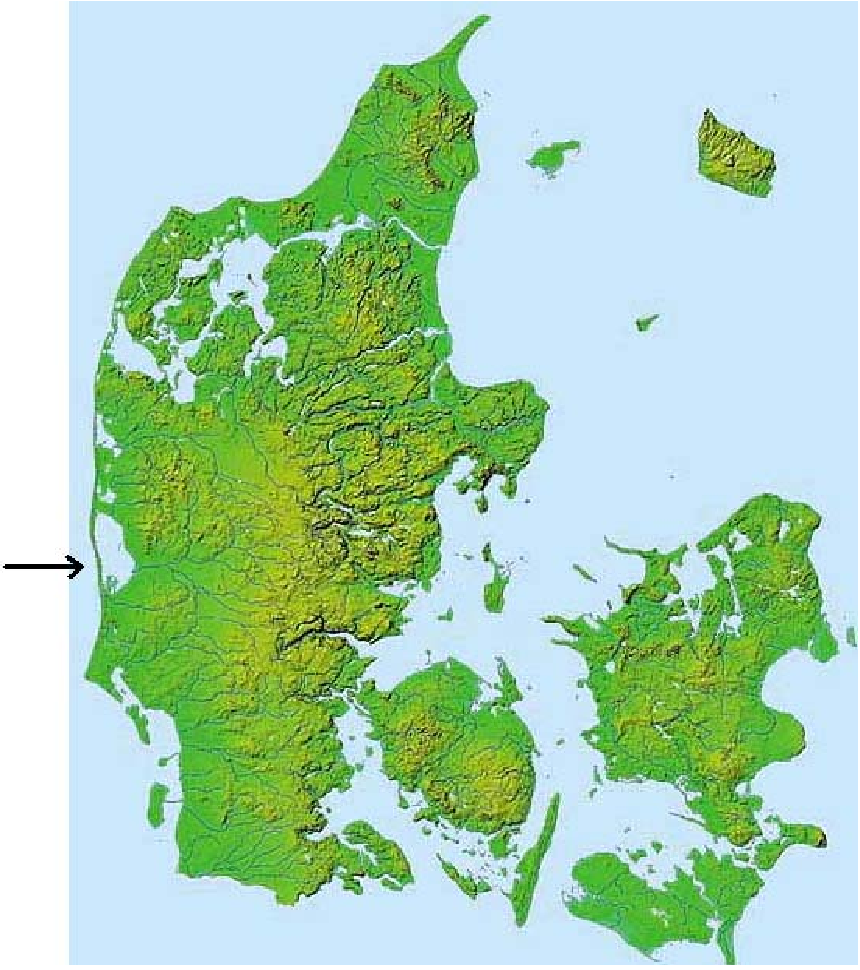
Report on field tests with the PEM-system at the West Coast of Jutland 2005-2008.



Jørgen Fredsøe, Department of Mechanical Engineering, DTU May 2008

Chapter 12 English Summary and Conclusions.

A large field test has been performed at an exposed location at the Danish West coast,



which is located in front of the North Sea.

The purpose was to investigate whether the PEM system (Pressure Equalization System) developed by the company SIC (Skagen Innovation Center) would protect the coast.

The system consists of vertical tubes (around two meter in height, inner diameter 5-6 centimeters) with small slots (0.2 mm) put in a row perpendicular to the coast with a mutual distance of ten meters. There is one hundred meters between each row along the beach. The top of the tubes is initially about 30 centimeter below the local beach surface.

The details of the PEM system are given in chapter 4.

An 11 kilometer long stretch was allocated to the test, the details shown below: you have sections with tubes, which in Danish are “rør”, so rør1 means the northern 4500 meter long section covered by tubes, and rør 2 is another much shorter (900 meter) section also covered by tubes. Three Reference section, each 1800 meters long, are sections without tubes, for comparison. Unfortunately, because SIC would like a long uninterrupted section with tubes, the different sections do not have the same length.

Figure 2
Location of test stretches

Mål: 1:50000
Projekt: JJ/TL
Rev.: 05.10.2005
Godkendt: 11.05.2005
Tegn. nr.
Nr. 100
Gr. 103-859-2

1. **Detailed flow field and sand accumulation.**

The functioning of the system is not clear. SIC has a lot of explanations, which not all are discussed in this report, but is listed in the ending chapter, ch. 13 (in Danish). This expert can not find other explanations than a smaller (actually zero) flow resistance inside the tubes as compared to that in the sand outside the tube will lead to a local redistribution of the flow patterns. A small amount of water in a distance 2-3 times the tube diameter prefer to flow through the tubes rather than outside in the sand. This requires a vertical pressure gradient, which you for instance have in the case of a tidal flow, where you have a damped standing wave in the beach. In other words: the impact diameter of the tubes is less than 20 centimeters, leading to an improved drainage of the whole beach less than a tenth of one per thousand (less than 0.0001) of the tidal flow in and out of the beach. The flow velocity inside the tubes will in the most extreme cases not exceed 5-6 mm /second for common beach sand. We have never measured the flow velocity inside the tubes, but we all agreed in, that it would be too low to measure with an ordinary propeller. But this expert measured it in the lab, where it was confirmed that it was just as low as explained above. So you can conclude that *the drainage effect leading to a local depression in the water table in the beach is negligible.*

Another possible effect is to *reduce the upwards directed pressure gradient* in the sand. The upward directed gradients stem partly from a falling tide, and partly from freshwater supply from the hinterland. The upward directed gradient is estimated to be maximum 0.05 for the specific site, which is far away from mobilizing the sand (fluidization). The changes due to the PEM-system are again estimated to be negligible.

Numerical modeling of the flow with and without tubes in a real environment confirms our estimates, that the impact of the tubes seems very small. The numerical runs include tide, freshwater supply from land and inclusion of permeable/impermeable layers. Still the impact radius is always negligible (sometimes the impact of the tubes is, that you get more water flowing into the beach than out, causing a rise in the water table. This corresponds to the well-known rise in the MWL in a beach as compared to the Sea in a tidal environment). The numerical modeling is described in chapter 5 and appendix 4.

Visual observations in the beach face confirm the negligible drainage effect: the transition between the wet surface and the drained surface moves smoothly along the shore, and don't realize that you pass an array of tubes, If you have drainage, a local bend should be observed.

Water level measurements in the field. We studied the water level variation inside the tubes and compared with the water level outside the tubes. (Actually, you usually measure the water level variation in soil using a system of perforated slots in a tube very similar to the PEM-system; however the slots are in this case restricted to the very lower end of the tubes). We observed a water level difference up to about 15 centimetres, which agrees perfect with the numerical modeling, and do not demonstrate any significant drainage effect.

The description of the functioning of the tubes is given in chapter 5, and the field test is described in appendix 1 and 2.

Accumulation of sand.
Local accumulation of sand is not observed, neither around the individual tubes nor around each

array of tubes. You would expect a ridge of accumulated sand at least around each array, and a spit in front of the row. This is certainly a very strong indication that the impact of the tubes on the beach morphology at the most is very weak.

Conclusions regarding near tube observations.

- *The flow through the tubes is weak, we are talking about a few millimeters per second*
- *The drainage effect is usually less than half of one per thousand.*
- *No local sink can be observed in the beach face*
- *No local accumulation of sand is observed around individual tubes or array of tubes.*

2. Large scale control boxes.

Actually the intention of this test has from the very beginning been to look at larger control boxes containing the whole beach, the dune system and the offshore part. This expert also included the considerations above, because it is such a strong indication on, whether the tubes have any impact at all.

The large scale test is certainly difficult because of the large scale spatial and temporal variations in the coastal profile and the beach. We divided the profile up into four parts: the dunes was that part of the profile above 4 meter above MSL, the beach was the next 100 meter in the offshore direction, offshore 1 the next 300 meter and offshore 2 the next 300 meter again. The most relevant part is the beach box, where the tubes are implemented. However wind interaction between beach and dunes is also of importance to explain whether the interaction between tubes and beach occurs. Figure 3 shows the variation in accumulated sand in the “beach box” (rather than “beach” because the width always is 100 meters independent of the actual beach).

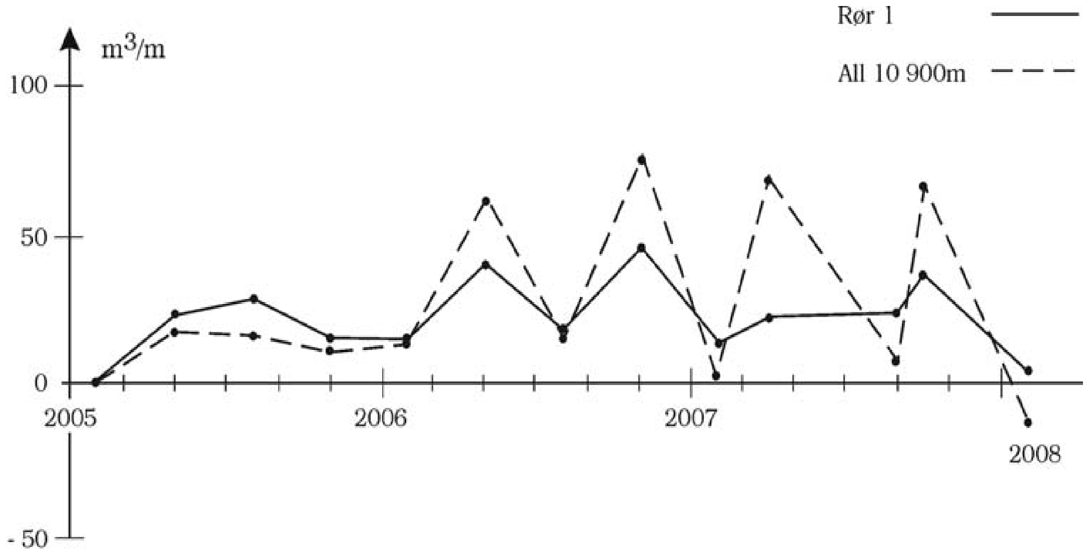


Figure 12.3: Temporal Variation in beach volume: The beach volume changes so much that the conclusion depends on the cut of the test.

The full drawn line shows the accumulated amount of sand per meter alongshore in the large tube covered section rør1, while the dashed shows the similar one averaged over all 11 kilometers. Before the test the coastline is an average stable due to heavy sand nourishment (in average 600.000 cbm a year since 1993). The figure demonstrates that the *natural fluctuations* in the coast are so large, that you can not identify the weak signal which might exist from the tubes. The values plotted are positive because the tubes were put into the beach just after a major storm occurring January 8th and 9th 2005, so we had a lot of backfilling to the beach from offshore after that occasion. Else the variation is as usual large temporal fluctuations, and because we stopped the experiment in January 2008, we got nearly zero total accumulation in the large tube-covered area during the whole test. If we instead had stopped just 4 month earlier, we would instead predict accumulation of 34 cubic meters per meter. Figure 3 demonstrates that in order to detect the possible signal from the tubes, you should run this test for 25 or maybe 100 years.

In reference 2 you have a large loss of sand from the dunes and the beach due to a developing wind breach. (SIC would like to attach the breach to the lack of tubes, but the position of the breach was the most likely place for it to occur: low and narrow beach and relative low dunes were present there *before* the test).

In reference 3 with no tubes installed you had the largest gain of sand at all.

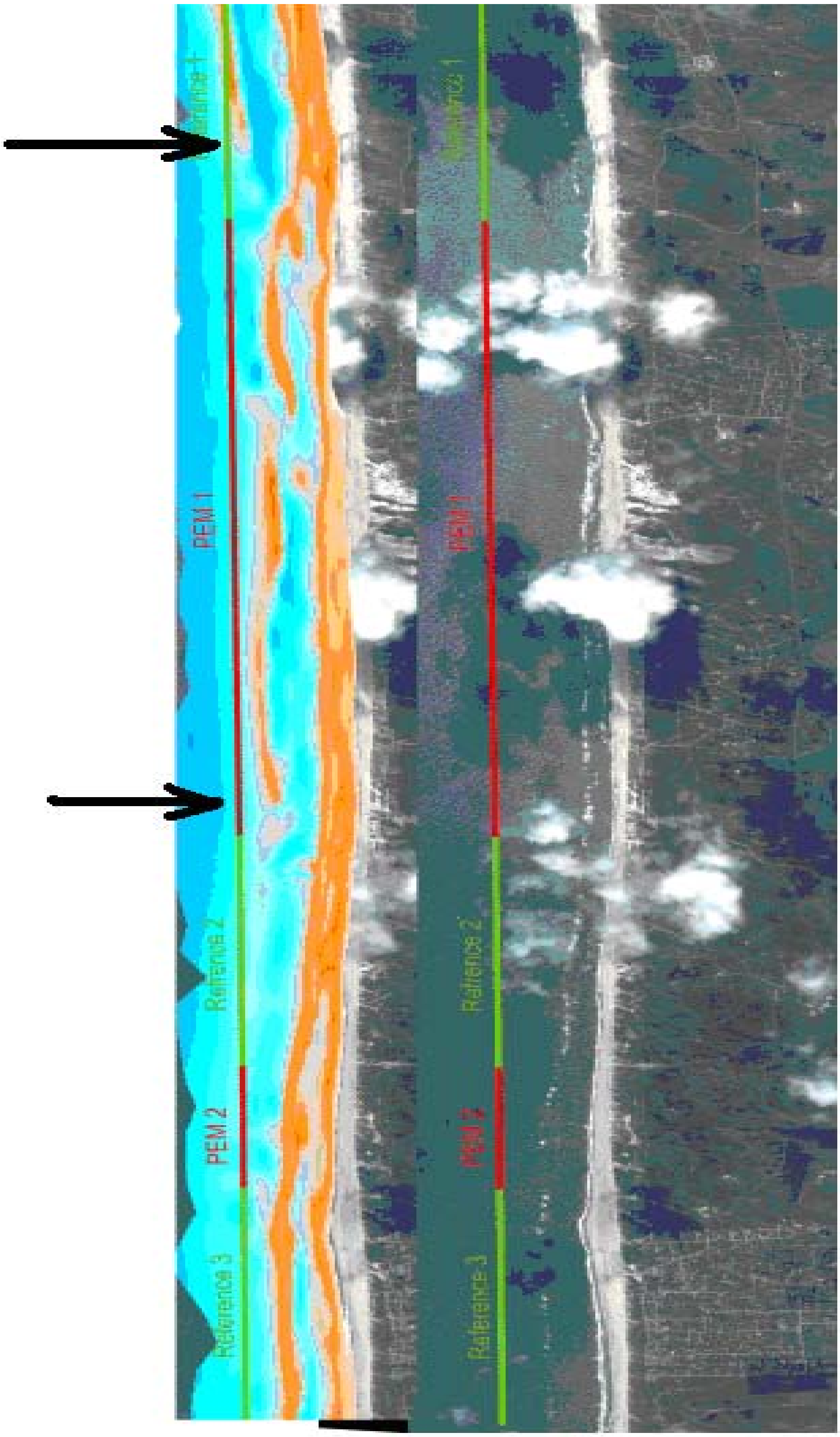


Figure 12.4. The outer bars terminate just up drift of the location of the transitions.

Close to the transition from ref1 to rør 1 and also from rør1 to ref2 the beach is weak. From the offshore measurements we have identified, that the outer bars terminate just up drift the narrow beaches, so this has a natural explanation. But you can also conclude that these locations of transition sections are chosen very unfortunate.

Table 1 shows the condensed outcome of three years investigation: plus is in favor of tubes, minus is in disfavor and zero is nothing. The tables tell that everything is random, like nature!

The details of the table are given in chapter 11.

	Reference 1	Rør 1	Reference 2	Rør 2	Reference 3
Dune box: (D1)	-	+	+	+	0

	Reference 1	Rør 1	Reference 2	Rør 2	Reference 3
Beach box: (D2)	+	0	+	-	-

	Reference 1	Rør 1	Reference 2	Rør 2	Reference 3
Inner Offshore box: (D3)	+	-	-	+	-

	Reference 1	Rør 1	Reference 2	Rør 2	Reference 3
Outer Offshore box: (D4)	-	-	+	-	-

Table 12.1. Integrated evaluation of the test. + means accretion in rør, or erosion in ref, and vice versa.

The most relevant table above is the one regarding the beach (put in green), because this is the location, where the tubes are! Whether the dune boxes shall be included as a box indicating the usefulness of the tubes is a bit open for discussion. There can be a link because a wider beach may cause more windblown sand to the dunes. All this is discussed in chapters 10 and 11. The offshore boxes deserve even less attention regarding the accounting of the sediment budget in relation to the tubes, but are included for reasons of completeness.

Conclusions regarding large scale boxes.

The variation in the beach volume through the year is large; the average beach level fluctuates up to 30-50 cm a year. Because the signal from the tubes is weak, a possible signal is totally overshadowed by natural variations, so you can conclude nothing after only three years. This is confirmed by the table 12.1, from where you can see no sign of systematic changes in favor of the tubes. All observed changes observed in the beach can be related to natural processes like migrating bars and breaching in the dunes.

The *overall conclusion* is that you after three years of testing can see no distinct fingerprint of the PEM-system on the coast. All processes can be identified by natural causes.

For this reason it can not be recommended as a coastal protection measure.

D

Abschließende Erklärung beider Experten zum dreijährigen Versuch mit PEM Modulen bei Skodbjerge, Dänische Westküste 2005-2008

Drei Jahren lang ist auf einem 11 km langen Küstenabschnitt südlich von Hvide Sand (Dänische Westküste) ein Versuch mit senkrechten, perforierten Dränagerohren (PEM-Rohre) durchgeführt worden. Der Versuch dient der Evaluierung der angewandten PEM-Rohre als Küstenschutzmethode. Die PEM-Rohre sind vom Skagen Innovation Center (SIC) entwickelt worden.

Die übergeordneten Schlussfolgerungen sind:

1. Alle durchgeführten Messungen und Berechnungen weisen darauf hin, dass die Durchströmung der Rohre mit Wasser so gering ist, dass der zugehörige Dränageeffekt des Strandes mit PEM-Rohren im besten Fall ca. einer halben Promille ausmacht verglichen mit einer natürlichen Dränage durch Grundwasserströmung, Hochwasser oder Gezeiten.
2. Der geringe Dränageeffekt äußert sich darin, dass es um die Rohre zu keinen Sandablagerungen kommt, was normalerweise zu sehen ist wenn Wasser aus einer Dränage im Strand weggepumpt wird (die so genannte aktive Stranddränage im Gegensatz zu den PEM-Rohren, die eine passive Dränage darstellt).
3. Das Strandvolumen wächst und reduziert sich mit den Jahreszeiten und über die Jahre. An hand der gesammelten Daten kann keine klare Tendenz bezüglich eines Aufbaus oder einer Reduzierung des Strandvolumens in den vergangenen 3 Jahre festgestellt werden, da die natürlichen Variationen jede langfristige Tendenz überschatten. Dies bedeutet, dass die Rohre im besten Fall nur einen sehr geringen Effekt haben. Die Versuchsdaten zeigen auch, dass ein solcher Versuch mindestens 15-25 Jahre oder länger durchgeführt werden muss um Gewissheit zu bekommen, ob ein solch geringer Effekt überhaupt existiert.
4. Das Versuchsgebiet ist eingeteilt in Abschnitte mit Rohren und Abschnitte ohne Rohre. Es wurde kein klarer Zusammenhang zwischen Strandaufbau und Stranderosion in den verschiedenen Abschnitten festgestellt. Dies ist eine weitere klare Indikation für den sehr geringen Effekt der Rohre.

Übergeordnet kann somit festgehalten werden, dass ein Effekt der Rohre im besten Fall sehr schwach ist. So schwach, dass einen solchen Versuch über mehrere Jahre durchgeführt werden muss um bewerten zu können, ob die Rohre überhaupt einen Wirkung haben. Die natürlichen zeitlichen und räumlichen Variationen sind außerordentlich dominierend, sodass jede Wirkung der Rohre durch sie überschattet wird.

Das SIC-Dränagesystem hat nach Einschätzung beider Experten eine nicht ausreichende Wirkung um als Küstenschutzmethode geeignet zu sein.

23. Mai 2008, Jørgen Fredsøe, Professor, DTU og Hans F. Burcharth, Professor, AAU.

DK

Konkluderende erklæring fra de to eksperter tilknyttet forsøget med PEM moduler ved Skodbjerge, Vestkysten 2005-2008.

Der har i tre år kørt et stort forsøg med lodrette perforerede drænrør (PEM-rør) på en 11 km lang strækning ved den jyske vestkyst syd for Hvide Sande for at evaluere om disse drænrør kan anvendes som kystbeskyttelsesmetode.. PEM-rørene er udviklet af Skagen Innovation Center SIC.

Hovedkonklusionerne er

1. Alle målinger og beregninger indikerer at strømningen af vand gennem rørene er så ringe, at den hertil hørende dræningseffekt i bedste fald udgør ca. en halv promille af det vand, der naturligt tømmes fra stranden som følge af ferskvandsafstrømning, højvande og tidevand.
2. Den ringe dræningseffekt giver sig udslag i, at der ikke samles sand omkring de enkelte rør, hvad man normalt ser når man pumper vand væk fra et dræn i stranden (såkaldt aktivt dræn modsat PEM-systemet, der er passivt).
3. Strandens volumen vokser og aftager med årstiden og over årene. Ud fra de observerede data ses ingen klar tendens til forøgelse eller formindskelse af strandvolumen over de 3 år, da variationerne totalt overskygger enhver langtids tendens. Dette indikerer, at rørene i bedste fald kun har en særdeles beskeden effekt. Forsøgsdataene antyder, at et sådant forsøg skal løbe mindst 15-25 år eller mere for at man kan få vished for, om denne beskedne effekt overhovedet eksisterer.
4. Strækningen er delt op i områder med rør og områder uden rør. Der er ikke konstateret en klar sammenhæng imellem tillæg eller erosion i de forskellige områder. Dette er igen en klar indikation af en særdeles beskeden effekt af rørene.

Overordnet må det derfor konkluderes, at rørenes virkning således i bedste fald er meget svag, så svag at man må køre et sådant forsøg mange flere år for overhovedet at vurdere om rørene har nogen virkning. De naturlige variationer i tid og sted er så dominerende, at de totalt overskygger nogen som helst virkning af rørene.

SIC-drænsystemet har efter eksperternes vurdering ikke en tilstrækkelig effekt til at være egnet som kystbeskyttelsesmetode.

23. Maj 2008, Jørgen Fredsøe, Professor, DTU og Hans F. Burcharth, Professor, AAU.