Beach Nourishment combined with the PEM System

The PEM System is used to prevent beach erosion by draining the beach and thus reducing water pressure in the beach. Sand is less likely to wash back to sea and sediment is readily deposited on the beach.

The PEM System may be used to retain sand on a nourished beach. In this way future beach nourishment can be postponed or avoided.

Two methods are used.

1. Single layer
On a nourished beach the PEM System can be installed in a grid below the surface in the same way as it will be done in a natural beach. The PEM System will retain the sand, and the method has been used numerous times. See example from Ribersborg Beach, Malmø, Sweden.

2. Double layer
Before beach nourishment PEM is installed in a grid on the beach to pre-drain the beach. Then sand is added and left for a few months until the beach finds an equilibrium profile. Then a second set of PEMs are installed on the now nourished and elevated beach. In this way PEM will be installed in a double layer close to the dune and a single layer close to the sea. See example from The Hyatt Resort Hotel in Kuantan, Malaysia.

1 - Single Layer
The method is similar to a normal PEM installation on a beach. The PEMs are installed from the dune foot to the mean low water line.

An example is Ribersborg in Sweden. Ribersborg is located in Øresund between Denmark and Sweden, in a low energy area with small waves and tide ranges below 2 ft.

Ribersborg is an artificial beach constructed many years ago. In spring the town used to fetch sand that had drifted off shore during the winter. The PEM system was installed in September 2001 and only 2 months later the natural sand started to accrete.

Note the convex shape of the swash zone and the color difference in Fig. 1. Color differences will even out over time - see insert.

The installation in Ribersborg is a commercial, leased installation.

Since the installation of the PEM System 5 years ago it has not been necessary to re-nourish the beach.

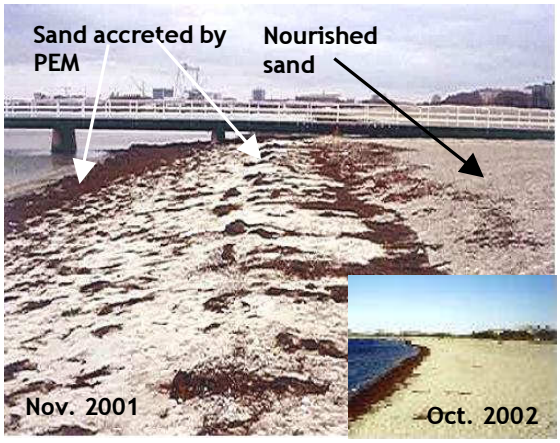


Fig 1. Ribersborg 2 months after the PEMs were installed

2 - Double layer
Double layer requires collaboration between the company handling traditional beach nourishment and EcoShore as their efforts must be coordinated.

An example of double layer can be seen in Malaysia in front of the Hyatt Resort Hotel in Teluk Chempedak, Kuantan, where the local PEM licensee (MRCB) performed a project combining PEM and beach nourishment.

Based on 30 years of data the expected lifetime of normal beach nourishment on the location was 3-4 years. See project location in Fig 2.

Project profile
The total length of the project is 900 meter.

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

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

The rainfall in Kuantan is approx. 100 in. per year, and may exceed 40 in. over a 5-day period during the monsoon time.

The tidal range is 7-10 ft.

Construction
The construction schedule was the following:
July 2003: The beach was pre-drained with the PEM System
May-July 2004: The beach was nourished with 177,000 cubic m sand.
August 2004: The beach was drained again with the PEM System.

Fig 2. Location of the project

The Beach profile is surveyed three times a year in March, July, and Oct.

Surveying and calculation of loss or gain is done by a licensed survey company.

Fig 3. The new beach at The Hyatt Resort Hotel, Kuantan

Results
In July 2004 new sand was added totalling 177,000 cubic m, see Design profile in Fig 4. From July to October 2004 the new sand packed/shifted and the beach reached an equilibrium profile. During this process the beach was reduced by 37,000 cubic m.

Since the end of the stabilizing period in October 2004 the beach has remained stable.

During this period the area has gone through two monsoon periods from October to March, with heavy rainfall in the area.

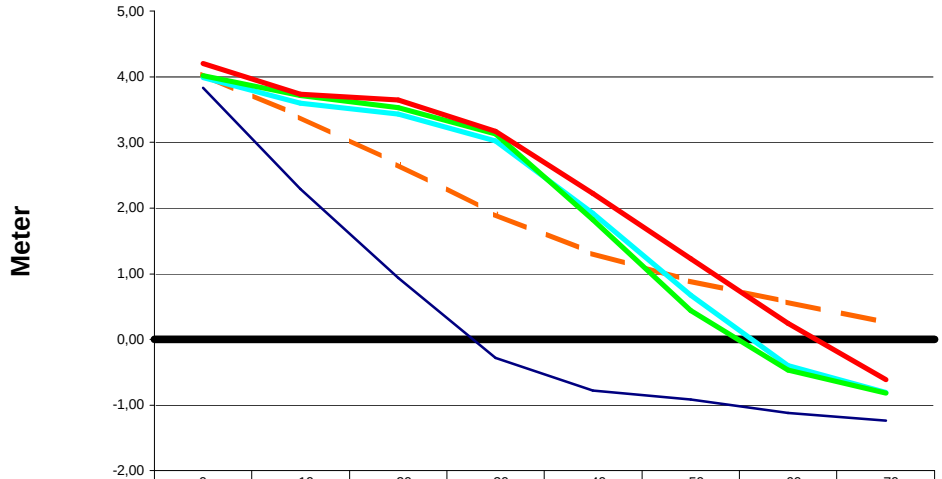
The graph below (Fig. 4) illustrates how the beach developed. It shows the average beach elevation before nourishment (thin blue line), the design of the nourished beach measured after nourishment in July 2004 (dotted orange line), and 3 surveys where the PEM System has been installed (thick light blue, green, and red line).

In spite of the beach having receded after the beach nourishment (orange dotted line) due to packing/shifting, the beach remains stable and the height of the beach has in fact increased.

The PEM System combined with Beach Nourishment

Average beach elevation at X meter from the dune

Thin blue line: Before beach nourishment
Dotted orange line: Beach nourishment design
Thick light blue, green, and red lines: After PEM was installed



	0	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
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
March 06	4,02	3,71	3,53	3,13	1,82	0,44	-0,47	-0,82
July 2006	4,20	3,73	3,64	3,17	2,22	1,23	0,24	-0,61

Fig 4. Average beach elevation at different distances from the sea wall over 3 years.
Example: 30m from the sea wall the beach elevation was 1.9m after nourishment (July 2004) and 3.17m in July 2006

Summary
The PEM System was used to drain a beach in Malaysia in combination with beach nourishment. The normal lifetime of traditional beach nourishment on the location is 3-4 years, based on 30 years of data. Following a packing and stabilization period of 3-4 months during which the beach reached an equilibrium profile, the beach has remained stable over a 2-year period.

It is not possible to predict if similar results can be obtained in the USA. However it seems likely that the PEM System in combination with beach nourishment will be able to extend the lifetime of a nourished beach considerably.

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