Shore parallel pile row breakwaters, an example of an effective coastal protection scheme

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SUMMARY

At the West Coast of Malaysia, near the border with Thailand, the island Langkawi is located. On the exposed West Side of this island a natural sand spit has formed, in the lee of two small offshore islands. On this cuspate spit a beach resort has been built. Shortly after construction of the resort the owner became aware that the shoreline of the spit was eroding. Several measures were tried by the owner to halt the erosion, none of them were successful.

As palm trees started to topple into the sea, and wave run up flooded the swimming pool, a permanent solution became quite urgent. The spit had been slowly eroding before construction of the beach resort, most probably due to a change in environmental boundary conditions. Rapid erosion after construction of the beach resort occurred due to modification of the shoreline position to fit the architectural plan.

Two solutions were considered to stop the beach erosion; increasing the size of the offshore islands by rock breakwaters and construction of shore parallel breakwaters.

Because of economic reasons shore parallel breakwaters located at a distance of 75 m from the shoreline were chosen. To minimise the visual impact of the breakwaters, they have been designed and constructed as pile rows. Two pile rows of ca. 120 m length were built consisting of 350 mm concrete spun piles with a gap width of 70 mm. The distance between both pile rows is 210 m. The height of the pile rows is ca. 1.5 to 2 m above the seabed.

The effectiveness of the pile row breakwaters in stabilising the shoreline has been monitored, and is better than expected. Although the proposed beach replenishment was not carried out, the beach was restored well beyond its original plan shape within one monsoon season, by sand trapped in the lee side of the pile rows

LOCATION

Langkawi is an island on the West Coast of Malaysia. The Pelangi Beach resort on this island was constructed on an existing spit in the lee of two small islands. Waves diffract around the two offshore islands, creating a natural cuspate spit. A section of Admiralty Chart 834 is given in Figure 1 together with a key plan. Note that the depths are given in Fathoms.

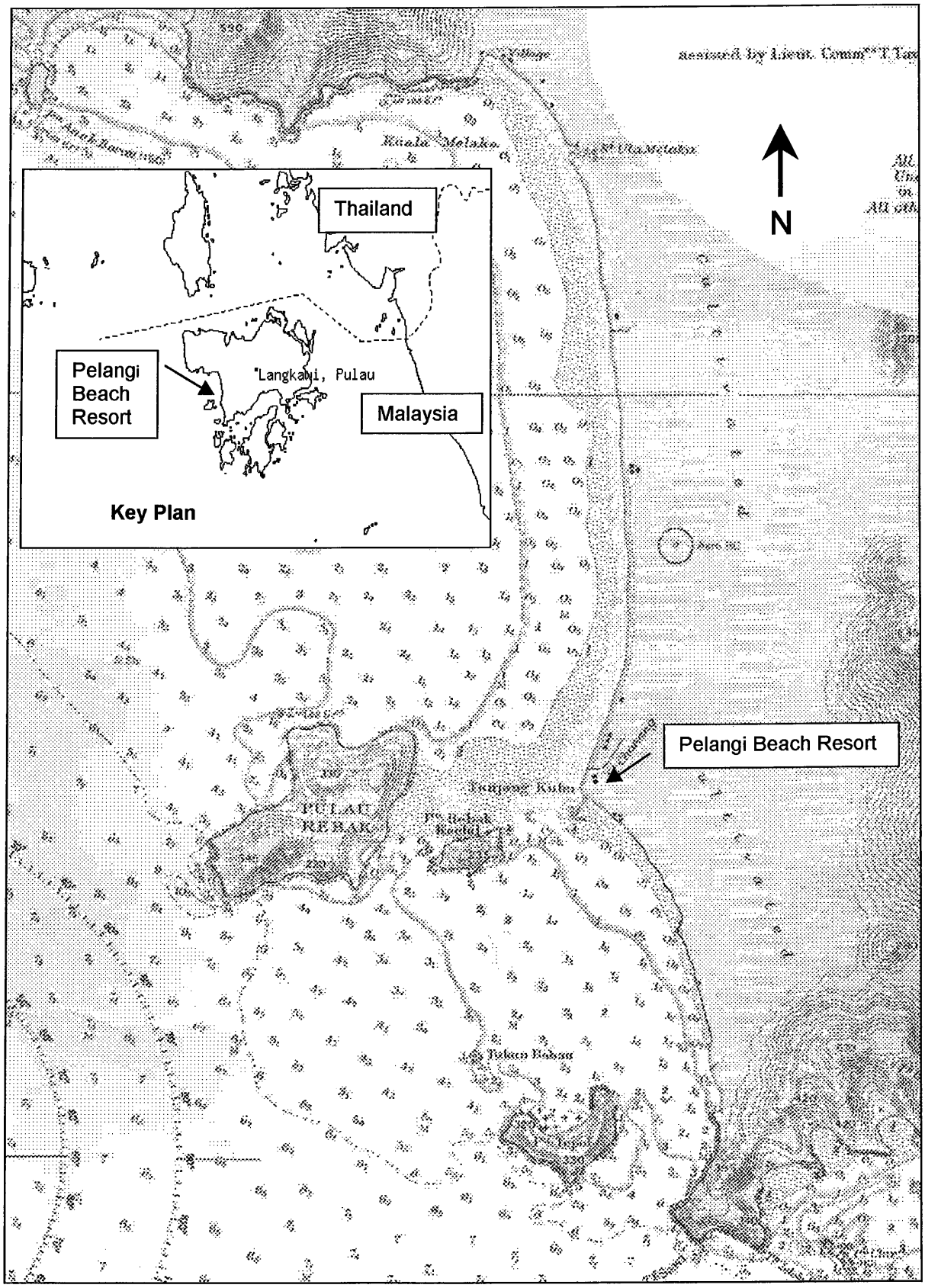

Figure 1 Bathymetry near the site

PROBLEM ANALYSIS

The location for the Pelangi Beach Resort was chosen, as it is one of the most beautiful locations on the beach on the West Coast of Langkawi. However, the location is morphological sensitive, as the shape of the spit depends on local wave climate, and the sediment supply by a small river. After analysis of historic charts and maps it was concluded that before construction of the resort the spit had been eroding at a rate of ca. 1.5 m per year.

An analysis was made of the shore line position using spiral beach theory [Silvester, Reference 1]. A complicating fact is that during higher stages of the tide a tidal current runs over the submerged part of the cuspate spit with a velocity of ca. 0.6 m/s. The analysis showed that the beaches north and south of the Pelangi Beach Resort do have shape, which can be described by a logarithmic spiral. However, due to the tidal flow the tip of the cuspate spit does not follow the spiral shape.

From the bathymetric charts only erosion of the shoreline could be observed. The foreshore (CD –5 and CD –10 m contour lines) was found to be stable.

The mouth of a small river, Sungai Chenang, is located near the tip of the spit. The discharge of this river is in the order of 20 m^3/s. One of the causes of the retreating shoreline may be a decline in sediment supply to the spit by this river, due to a reduction in forest clearing.

Another cause may be a change in environmental conditions, such as wave conditions, water levels and tidal currents. However, in the scope of the project it was not possible to do a detailed analysis of historic variations in these environmental conditions.

During construction of the beach resort it was decided to enlarge the spit, by reclamation, based on the architectural layout. The plan shape of the shoreline was changed, differing significantly from the original logarithmic spiral shape. At some locations the new shoreline was put over 20 m seawards. The river mouth was relocated 100 m to the north.

The initial rapid erosion, which took place directly after the construction of the resort, was caused by nature trying to restore the natural shape of the spit, as it was just before construction of the resort. This was concluded after comparison of bathymetric charts of 1989, before resort construction, and 1994, after resort construction.

The beach was severely eroded over a length of 300m causing palm trees to topple into the sea. Due to the beach erosion, wave run up reached the swimming pool, leading to flooding with salt water.

The resort owners tried several measures to stop the erosion. However, none of them were successful. First interlocking concrete blocks were put on the beach, but these disappeared below the sand after a storm. The remaining blocks are now in use as pavement for footpaths. Then small wooden walls were applied, but these were overtopped and undermined, as shown in photograph 1. Finally sandbags and rock were put on the beach, providing an unsightly view, as shown in photograph 2. After each storm new sandbags had to be placed, and the beach had to be reshaped with bulldozers.