Fingal County Council

Hard Defence Options for Portrane

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1 REVIEW OF POSSIBLE COASTAL PROTECTION SCHEMES FOR PORTRANE

1.1 GENERAL

RPS was commissioned to investigate the feasibility of several possible coastal protection works that could potentially reduce the threat of flooding and coastal erosion at the Burrow, Portrane. The coastal protection works that were investigated may be summarised under the general headings;

- Build offshore breakwaters
- Construct a rock revetment using boulders or gabion baskets
- Cover the dune using a resin bound stone
- Build a seawall
- Build a hydraulic floodwall along the shoreline

The choice of options is governed by a number of issues including:

- Engineering feasibility
- The capital and maintenance costs of the works;
- The impact on the existing coastal processes of the area;
- The value of the assets to be protected; and
- The environmental impact and consequences upon environmentally designated areas.

This report has been prepared to address issues 1, 2 and 3 in relation to possible hard defence works being undertaken at Portrane.

In 2013 the local residents of Portrane placed numerous sandbags just north of the main access to the bathing area; however these were completely destroyed by the high energy storm that hit the shoreline in early January 2014. Other than this, there are no other forms of coastal defence in place along the shoreline of Portrane to protect against either flood or storm-induced erosion damage.

2 OFFSHORE BREAKWATERS

Detached break waters can be constructed parallel to the shore as a single structure for localized shore protection or as multiple breakwaters with gaps between the segments for large scale beach protection schemes. In principle, these permanent structures which can be either submerged or emerging refract local wave currents around the ends of the breakwater which builds up the sand in either salient or tombolo formations on the beach depending on the length of the structure and distance from the shoreline in the lee of structure. The effect of the breakwater is that the shoreline behind the break water is no longer exposed to the full force of the incident waves.

Figure 1: Offshore and shore attached breakwaters

Offshore breakwaters are a well accepted and proven method of coastal protection and are used for this purpose in many places throughout Europe. They are most suitable for regions which experience small tidal ranges. From this perspective, it is unlikely that an offshore breakwater would be a feasible proposition for Portrane which has a large tidal range - often exceeding 3.0 metres.

The beach that is formed in the lee of breakwaters can provide considerable recreational benefits, however, if not designed and constructed correctly, offshore break waters can induce strong rip currents around the ends of the structures during mid flood and ebb tides and also during high wave events. As such, the structure can lead to significant scouring and difficulties for swimmers who take advantage of the sheltered water behind the breakwaters during extreme weather events. Other serious safety issues that arise include the possibility of bathers becoming stuck in the soft sediment in the lee of the structure and/or children climbing, becoming trapped between the rocks of the structure and being possibly caught out by incoming tides

Another important is that it is common for fine muddy sediment to be deposited in the lee of breakwater structures, particularly in regions which lack a significant long shore drift component to the overall sediment transport system. This is likely to be the case of Portrane. As such, a breakwater would result in a significant change in the nature of the sediment comprising the areas of the beach that are in the lee of the structure.

Unfortunately from a financial aspect, the cost of constructing an offshore breakwater is high at about €20,000 per metre of coastline protected, subject to various parameters including design, materials etc. Considering that at least two offshore break waters of approximately 200m each would have to be constructed in order to have the desired effect, it becomes clear that this form of protection for the frontage of Portrane would be technically inappropriate and economically unviable.

3 REVETMENT CONSTRUCTED FROM BOULDERS OR GABION BASKETS

Revetments are shore-parallel structures that armour the shore to protect the land behind it against episodic storm-induced erosion and/or longer term erosion by the sea. They can be either impermeable or permeable structures that serve to retain and to stabilize dunes and are generally smaller structure compared to sea walls. Most revetments do not significantly interfere with longshore transport processes. However in the longer term, erosion continues to occur in front of them, this is commonly accompanied by the differential erosion of the dunes at the end of structures.

Figure 2: A rock (left) and a gabion revetment (right) providing protection against erosion

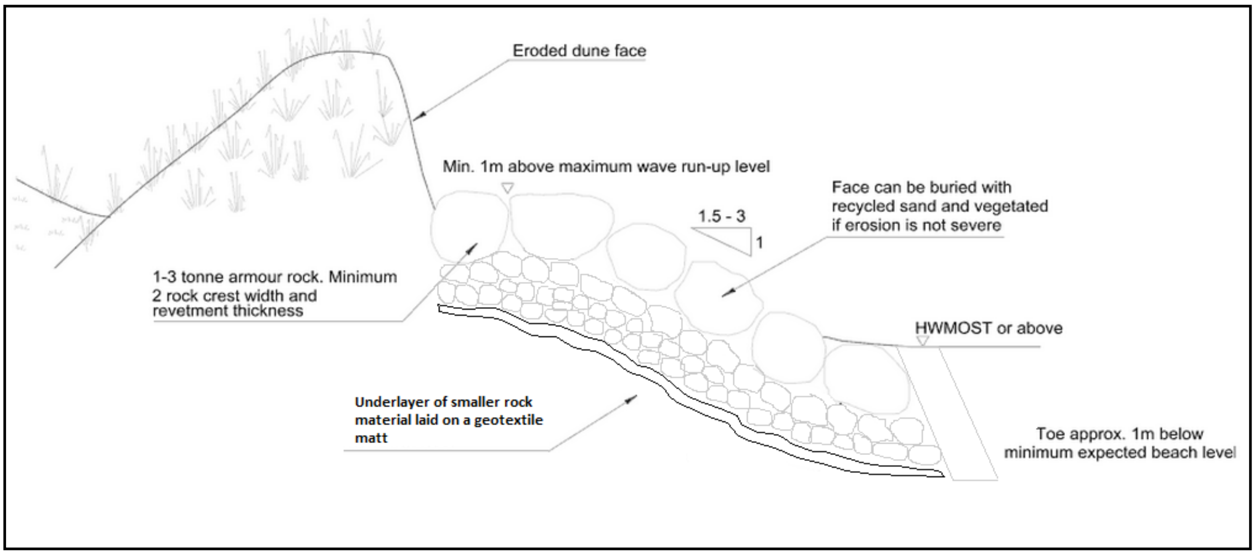

Figure 3: Cross section of a typical rock revetment

A rock revetment is heavily cladded structure comprising of 1-3 tonne armour rocks that provide protection against shear forces produced by current, eddies and wave action. This cover layer must be semi permeable and slightly flexible to accommodate any settlement or migration of the underlying layer without creating a void in the defence. The underlying layer usually consists of smaller granular material which of laid on a geotextile matting which provides pressure dissipation, drainage and containment of the fines in the subgrade of the granular material (see Figure 3).

Alternatively, gabions are wire mesh baskets that are filled insitu with cobbles or crushed rock. Like rock revetments they can absorb some wave and wind energy and to an extent mitigate against storm-induced erosion.

As both rock and gabion revetments interfere with the natural interchange of sand between the dune and beach components of the shoreline, the dune will fail to act as a sand reservoir and cease to feed sand onto the beach, ultimately leading to an overall depletion in beach levels. When the beach levels are depleted, the shore-face is exposed to increased wave attack which in turn intensifies the transport capacity of the offshore currents and hence intensifies erosion further (negative feed-back system).

Aside from interfering with the natural exchange of sand across the system, under active conditions the galvanised wire mesh forming the basket soon erodes and cracks. This usually results in the structural failure of gabion during the proceeding storm event and the release of non-indigenous rocks from the gasket over the immediate shoreline as well as creating a serious public safety hazard (see Figure 4).

Figure 4: Damaged gabions creating a serious public safety hazard and releasing non-indigenous rocks onto the beach.

In order to prevent differential erosion at the lateral ends of the structure, a rock or gabion revetment would have to extend virtually the full length of the shoreline of Portrane. Considering that at a cost of between €2,000 and €4,000 per metre, the initial capital cost of protecting the shoreline, excluding maintenance would be well in excess of €4 million. It is therefore evident that constructing a revetment to protect the shoreline of Portrane would be economically unviable.

4 COVER THE DUNE USING A RESIN BOUND STONE

The principles behind this coastal protection system are the same as a stone or gabion revetment, except that instead of being formed from either gabion baskets filled with stone or concrete blocks, this revetment structure is made from stones that are coated in a resin based product known as elastocast. As with traditional revetments, resin bound stone revetments are built parallel to the shore and protect the land behind it against episodic storm-induced erosion and/or longer term erosion by the sea.

Figure 5: Elastocast bound stone revetment providing coastal protection.

Resin bound revetments are a well accepted and proven method of coastal protection and have been extensively used throughout Europe. They make an attractive alternative to regions where there is a shortage of large, appropriately sized boulders that are typically used to build revetments. However, this is generally not an issue in Ireland or in the U.K.

Considering that resin bound revetments impose the same negative impacts on the beach environment as concrete or gabion revetments (as discussed in section 3) and that they typically coast at least 50% more than standard revetments, the construction of a resin bound revetment cannot be justified from an financial or an engineering perspective.

5 SEA WALLS

A sea wall is a vertical, sloping or concave retaining structure made from either concrete masonry or sheet piles and is designed to protect against heavy wave-induced scour (see Figure 6). They are usually built along limited sections of a shoreline as a last line of defence against wave attack, when natural beaches and dunes are too small or low to prevent erosion. A seawall is not built to protect or stabilize the beach or shoreline in-front or adjacent to the structure. Therefore, chronic erosion due to gradients of longshore transport will not be reduced and chronic erosion of the beach in front of the sea wall is likely to continue.

Figure 6: Concave (left) and vertical (right) concrete sea walls providing coastal protection.

If a community's only priority is to preserve residential property that is in close proximity to the beach front then seawalls will very often effectively achieve this goal. However, as with the gabion and stone revetments there are several significant negative impacts associated with the construction of sea walls (see section 3).

As a sea wall is a hard engineering solution designed to be an impermeable defence against wave and tidal action, it will disrupt the natural beach-dune interaction and the exchange of sand between these systems. Consequently, over the course of the defence's lifespan, beach levels will gradually dropped.

Considering that wave heights at the shoreline are a function of water depth, a drop in beach levels will result in a significant increase the height of the incident waves attacking the dune line and will in turn increase scouring at the toe of the sea wall. As a sea wall is impermeable, it will reflect incident waves and increase scouring at the toe. This depletes the beach levels further, allowing larger incident waves strike the shoreline.

Another impact associated with sea walls is that differential erosion rates result in the accelerated erosion of sections of beach adjacent to the defence as the structure is outflanked by incident waves. This can ultimately result in the defence becoming more exposed and the narrowing of the beach in front of the wall by accelerating longshore currents around the protruding wall.

From a financial perspective, sea walls generally cost between €4,000 and €6,000 per metre to construct, this price excludes the on-going maintenance costs associated with such a structure. Considering that if a sea wall was to be constructed, that it would have to extend over half of Portrane to avoid differential erosion rates at vulnerable areas of the shoreline, it becomes clear that this option is not economically justifiable. This is ignoring the significant negative impact a sea wall would have on the internationally environmentally designated sites surrounding the area.

6 HYDRAULIC FLOOD BARRIERS

Hydraulic flood barriers are primarily designed to mitigate the risk of flooding to ground level or underground structures. Generally, the solid fixed barrier comprises a buoyant composite beam that is engineered to withstand extreme hydrodynamic loadings. The barrier can be operated remotely or automatically - once activated the hydraulic barrier system lifts upward and protects the region behind the defence from flooding (see Figure 7). Typically, hydraulic defences are used around fixed quay structures and wharfs and are particularly effective at protecting against fluvial (river) flooding.

Figure 7: A passive self closing hydraulic barrier used to protect against flooding

Although hydraulic barriers are very effective at protecting against fluvial flooding, they have virtually no application in protecting coastal dune systems from the threat of erosion. The primary reason being that hydraulic barriers are solid fixed structures; as such the defences need to be housed in a concrete structure which needs to be embedded into the ground.

This may be easily achieved in towns or on fixed structures such as quays, but it is very difficult and extremely expensive to build foundations that will not succumb to shear failure for any structure on a dune/beach system.

Unlike many coastal erosion defences, the hydraulic barrier is a solid impermeable vertical structure that will reflect waves and increase scouring at the toe of the defence. This will lower beach levels and ultimately increase the size of the incident waves impacting the shoreline. Furthermore, sand from the beach/dune environment will inevitably end up in the housing of the barrier and will likely damage the hydraulic mechanisms that operate the barrier.

These problems arise as the hydraulic barrier has been designed to be used as a defence against flooding, not against coastal erosion. Considering only these issues, which exclude capital costs, on-going maintenance costs and potential environmental impacts, it becomes clear that from an engineering perspective alone, a hydraulic barrier would be neither structurally viable nor effective for the shoreline of Portrane.