Shoreform

Developing Coastal Stability

World Market for Coastal Protection

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1. Introduction

Beaches are only now being recognised as the best defence against the threat to coastal infrastructure from attack by the sea. Beach erosion is the first stage of such attack. Removal of the beach paves the way for undermining of coastal property, as well as anything that might have been installed to protect it, such as seawalls and revetments. As waves are responsible for the erosion, it is possible to erect barriers such as breakwaters in an attempt to stop it. However, as these are basically offshore seawalls, their sandy foundations can be undermined to collapse and re-expose the coast.

Other means of retaining beach sediment have included groynes, which are wooden or rocky structures jutting out to sea. These are supposed to work by trapping drift material as it makes its way along the coast. Unfortunately, they do not take account of storm events that can generate rip currents near the groynes and carry future drift sediment well beyond their reach. As a result of this, eroded material is never returned to the beach from where it came, yielding a net loss after a sequence of storms. A better means of retaining beach sediment (such as that described below) is needed.

Shoreform offers a unique solution to the problem of eroding coastlines. It achieves this by the use of circular islands that disturb the waves in a way completely different from that typical of seawalls, groynes or breakwaters. These linear structures reflect and concentrate wave energy, which promotes rapid sand transport along the walls. Once the sediment reaches the end of the wall, vortices generated by the waves maintain it in suspension. A Shoreform circular island gently diffracts both reflected and incident waves to allow the immediate deposition of sediment where it is most needed, ie in the lee of the island. In this way, it can generate a landbridge between island and shoreline.

The landbridge can then collect drift sediment in the way that groynes are supposed to do, yet without the vulnerability to rip currents typical of groynes. Enough sand results in a robust beach connecting the island to the shore. An array of such structures along an otherwise vulnerable coastline would replace the original beach with a series of stable bays. These bays will retain their beaches and no longer depend on being sheltered from the sea. Sand removed from any given beach will be returned to that beach, thus avoiding net erosion. A description of this operating principle is available[1].

Market information gathered for this technology exists in two forms, one a database of hyperlinks[2] to instances around the world where this technology is needed. The other is a table of coastline lengths[3], drawn from various sources[4-6] and taking into account the fractal character[4] of this length data. The market size may be estimated from this by making a few reasonably based assumptions about what is needed to preserve them. The basis, essentially an ongoing need for beach replenishment, for these assumptions is explained in **Section 2**. Beach replenishment may still be needed for the Shoreform solution, but only once. **Section 3** gives a guide to the market information, analysed in **Section 4**.

2. Market Size Estimation

If beaches are indeed the best defence against attack by the sea, then it makes sense to preserve them at whatever cost. If conventional structures cannot hold beach sediment in place, replenishment of lost sand is the only way to do this. The newly supplied sand will not last forever, as the erosive forces generating its requirement remain in effect. To estimate the market for this, we first need to know the fraction of world coastline that might be eroded enough to need regular replenishment. We can then use the size, cost and life of a typical project to estimate the annual world market.

A recent report on coastal erosion in Europe estimates 20% of European coastal regions[7] (about 10% of the world total length) to be subject to erosion. As all coastlines may be regarded as subject to the same physical processes and consisting of the same proportion of sandy seabed, the 20% estimate can also be used for the world estimate. To determine how often replenishment is needed, an estimate of

residence time of 3-5 years may be used from previous experience with this technology[8]. We must also estimate the size of a typical replenishment, parameters for which are defined in **Figure 1**.

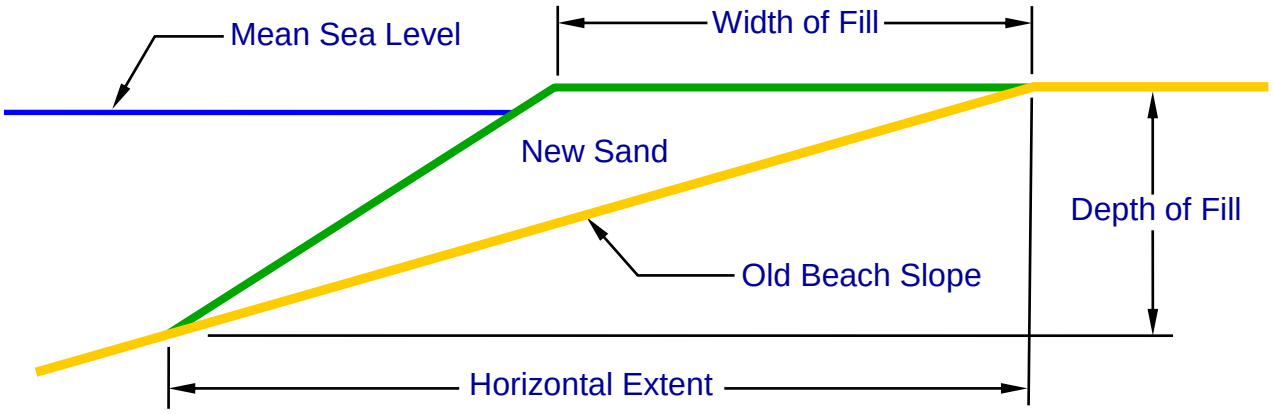

Figure 1 – Cross-sectional geometry assumed for estimate of replenishment market

Figure 1 is similar to Figure 5.9 on page 295 of **Coastal Stabilization**[9], which provides a summary of beach nourishment experience up to 1997. On page 112 of the same source, there is a table of stable beach slopes for different grades of beach sand. These cover the range 1°-9° for very fine to very coarse sand, with 3°-5° more typical for the fine-medium range. A typical depth of fill might be taken as 5 metres[10], which would allow for a 25-metre width of fill. This is based on a 5° slope for medium sand and a horizontal extent no less than twice the width of fill. Even this creates a new bed slope of nearly 9°, stable only for very coarse sand, not the medium grade used for the fill. This steep face of sand will cause the new sand to be swept away faster than the originally eroded material, which is why beach replenishment needs to be repeated, as long as there is nothing to hold the sand in place. To sum up the position so far, **Table 2** sets out the key parameters for a 25-metre width of fill.

Table 1 – Beach Renourishment Data			
Beach Sand	**-**	**Fine**	**Medium**
Grain Size	**μm**	63-125	125-250
Old Beach Angle	**°**	3.00	5.00
Old Beach Slope	**-**	5.24%	8.75%
Width of Fill	**m**	25	25
Depth of Fill	**m**	3	5
Horizontal Extent	**m**	57.24	57.15
New Beach Slope	**-**	9.30%	15.55%
New Beach Angle	**°**	5.32	8.84
Cross-Section of Fill	**m^2**	37.5	62.5

The bottom line here is the cross-sectional area, from which the cost of the project, at least in terms of the sand requirement, may be estimated for a given length of coastline. To complete the process, we

need to estimate the cost of the sand required. For the cost of sand, a figure of "around $20 a cubic yard, conservatively" may be used[11]. The majority of this may be attributed to dredging and transport costs. Hence, with a world coastline length in the region of 1.63 million kilometres, a replenishment budget of up to **US$178 billion** should be set aside each year for the supply of sand alone[3].

3. Market Information

Gathered together in spreadsheet form[2], the market information analysed in this report has been taken from a well known coastal news site[12]. The table below shows what countries have been featured on this news site and how many links relating to that country, continent or category have been found.

Table 1 – Number of Links per Country up to 2014-06-30

Index	Country	Links	Index	Country	Links
1	Abu Dhabi	1	21	Ireland	5
2	Africa	2	22	International	5
3	African Islands	1	23	Jamaica	3
4	Argentina	1	24	Japan	2
5	Australia	16	25	Kenya	1
6	Bahamas	1	26	Liberia	1
7	Bangladesh	3	27	Marshall Islands	1
8	Barbados	1	28	Malaysia	1
9	Brazil	1	29	New Zealand	11
10	Canada	2	30	Pakistan	1
11	China	2	31	Russia	2
12	Cyprus	2	32	Singapore	1
13	Egypt	1	33	South Korea	2
14	Europe	4	34	Sri Lanka	1
15	Fiji	1	35	Taiwan	1
16	Ghana	1	36	Thailand	5
17	Gulf Coast	2	37	Trinidad	2
18	Guyana	1	38	UK	33
19	India	11	39	USA	91
20	Indonesia	4	40	Viet Nam	3
Total			**230**		

In the narrative below, the hyperlink relating to any news item appears in the master reference list for this document. There is also a list of key extracts[13] taken from each of the links found in the database. In addition to this, the database has had a further 42 links added over the past month to bring it fully up to date[14]. The list of extracts has also been extended[15] to take these new items into account. Each database link has been numbered and any such source used here appears with this number in the reference list below. A sample of representative sources has been selected.

4. Market Analysis

Current thinking about coastal protection is captured in the following quote[16]: "Coastal councils will waste money if their sole focus is on hard engineering solutions to recent extreme weather, according to an expert. Ireland also needs to build up its own expertise in coastline management, rather than hiring in international consultants, University College Cork Beaufort Research senior engineer Jimmy Murphy says. At about €1 million per 100 linear metres, hard engineering protection such as revetments, rock armour and groynes are an expensive and often ineffective approach, and one which other countries have moved away from. Beach nourishment research has shown that such heavy protection can be of limited use, merely passing the erosion further along the coastline. Beach nourishment, whereby suitable sand is pumped in from offshore on a periodic basis, was about half the cost and had proven to be very effective in parts of Europe and North America, Mr Murphy said." As a comparison with the market size estimation given above in Section 2, a figure of €10 million/km, as quoted above for hard defences, has been applied to the 327,000 km of world coastline estimated to need protection. This leads to an estimate of **€3.27 trillion** for hard defences that will not last.

Hard defences are so distrusted in some parts of the world, that they are illegal, such as is the situation in South Carolina. There has been a recent bid to make an exception for some homeowners to "rebuild the battered, 4,000-foot bulkhead in an attempt to save their homes" [17]. This has drawn the response from other quarters along the lines of "DeBordieu and the state would be better served by encouraging those homeowners, at their expense, to pump sand to the beach and install sand-retaining structures (groins or breakwaters) at the downcoast end of the development" [18]. There is here some recognition that beach-replenishment material will not stay put without some kind of sand-retention structure. This insight could well have emerged from what happened at Folly's Beach, elsewhere in South Carolina: "Some $30 million in sand placed on the Folly Beach shoreline. A month later, it's all gone. The newspaper quoted the manager of the Army Corps of Engineers' Folly Beach project as saying that placing sand on the shore 'doesn't stop erosion. It protects properties. We put the required amount of sand out there. The sand didn't hold up.' And this was not the first time in recent years that loads of sand have been dumped on Folly Beach" [19]. It would seem as though soft defences, if replenishment can be considered typical of this class, cannot by themselves provide a permanent solution.

Even if beach renourishment is not a permanent solution, it is still considered to be cost effective in the light of preserved amenities. The following quote from ASBPA (American Shore & Beach Preservation Association) is relevant: "More than twice as many people visit America's coasts as visit our state and national parks, all of them combined. Each year, governments take in $320 in taxes from beach tourists for every dollar it spends on beach restoration. Well over half of the nation's gross domestic product ($7.9 trillion) is generated in 673 counties along the oceans and Great Lakes, according to NOAA's National Ocean Economics Program" [20]. The situation can be different in other countries, such as the UK, where there is more local demand for coastal protection than can be met by national funds. A particular example is at Hemsby in Norfolk, where "seven cliff-top homes were badly damaged as the biggest tidal surge in 60 years hit the Norfolk coast. Three properties fell into the sea at Hemsby and four more were 'seriously undermined' in the east coast storms" [21]. This experience was nevertheless insufficient for them to succeed in a bid for funding from the government's Coastal Communities Fund (CCF), as there "had been 'very high demand' for funding. Rona Alexander, head of funding, said in a letter to the group: 'Your application was unsuccessful because we decided other applications offered

us a stronger fit with the CCF outcome. We experienced very high demand for funding from this programme, and other applications demonstrated more strongly how their project would achieve the Coastal Communities outcome' " [22]. In both the USA and the UK, the demand for protection is there.

There are sites in the UK where various options for dealing with erosion are being discussed. One example is Llandudno in North Wales: "The report outlines four recommendations to put to Conwy's Cabinet to tackle coastal erosion at Llandudno in future. **Option 1**: Do nothing and allow the natural coastal processes to take their course. But that could 'expose sea defences (dating from 1930 and 1960) ultimately leading to potential catastrophic failure requiring major flood response involving the reconstruction of the defences or relocation of residents'. **Option 2**: Continue to maintain the beaches in using shingle. **Option 3**: Remove the defences that have been placed following the 2013/14 storms. **Option 4**: Do further research about beach management. This could involve commissioning an independent study as requested by Restore Our Beach Group, or commissioning an independent coastal plan as outlined in Llandudno Town Council, or setting up a Llandudno Coastal Forum (LCF) of interested parties" [23]. Clearly Options 1 and 3 above admit defeat in the face of storms and erosion, with Option 2 offering a kind of replenishment approach. Option 4 is certainly to be recommended, as it opens the field to ideas not yet considered by Conwy's Cabinet, such as Shoreform's solution.

The situation in other parts of the world is typified by property, livelihoods and lives put at risk, due to the absence of a proper solution: "The People's Committee of southern central province of Phu Yen has declared a state of emergency over the sea erosion in the coastal city of Tuy Hoa's Ro neighbourhood. The Committee has also asked the provincial Board of Irrigation Project Management and Disaster Control (BIPMDC) to coordinate with the city's People's Committee in putting out warning signs in places affected by erosion which could endanger people's lives and damage property. Families living in dangerous areas affected by sea erosion and tides will be relocated to safe places soon. The first 690 metres of a 1500-metre-long sea embankment has been constructed since last August in order to protect 180 households living by the seashore. However, the VND12 billion (US$577,000) dyke itself has been eroded by waves and tides during the rainy season, leaving people exposed to danger" [24]. This example from Vietnam (typical of most places around the world) depends in no way on sea-level rise for its threat to human welfare. Wave-induced erosion is all that is needed to remove the beach.

5. Concluding Remarks

Whether or not sea levels rise, there remains a worldwide need for protection of coastal regions from wave-induced beach erosion. The annual bill for beach replenishment is estimated to be **$178 billion** if there is no means of retaining the beach material in place. Shoreform stable bays remove the need for regular beach replenishment and provide an attractive coastline at significantly lower cost.

6. References

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23] http://www.dailypost.co.uk/news/conwy-council-meeting-consider-four-7382076 (247).

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