Technology Fact Sheet for Adaptation

Rock revetment [i]

Technology: Rock Revetment

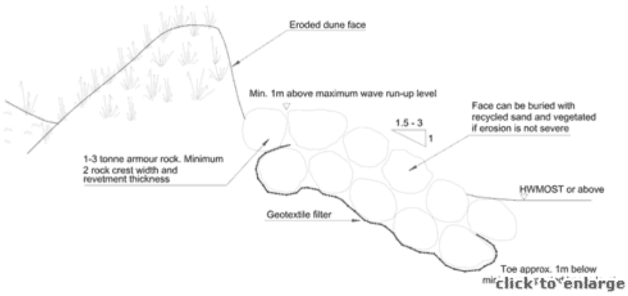
Sector : Coastal Zone

Subsector :

Technology characteristics

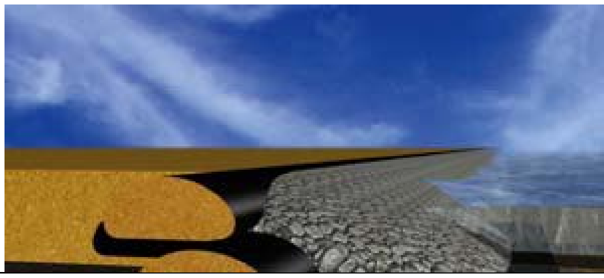
Introduction

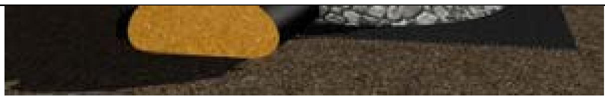
A revetment is a sloped facing of stone, concrete or other durable materials build to protect a scarp or embankment against erosion by wave action (Baird & Associates – Reef Watch, 2003). In this Fact Sheet, some reference may be is made to sea walls, as a revetment can be viewed as a sloped sea wall. Vertical sea walls reflect wave energy, whereas sloped sea walls (or revetments) also dissipate this energy.



Cross-sectional view of revetment.

Revetments can also be carried out using synthetic geotextile technology in conjunction with vegetation techniques. An example of revetment is illustrated below:



	
Technology characteristics/highlights	• Depends on the underlying embankment for support. • Can be considered as flexible as the structure can endure some settlement or other movement without failing. • The size of the material depends on the severity of the current or wave attack. (Baird & Associates – Reef Watch, 2003)
Institutional and organizational requirements	At present, the advice given in developing countries for modern seawall construction appears to be informal, if given at all. If effective design and construction is to occur, local communities must be given at least basic design guidance. This may come from government or voluntary organizations. The design and construction of revetments is relatively straightforward for experienced practitioners. Additionally, contractors can achieve good outcomes, as can land manager works teams with general civil experience supervised by an experienced coastal engineer. Some complexities and sensitivities in design include: • estimating design conditions (wave or flow dominance) • consideration of existing bank conditions and history of change • selection and specification of filter layers and geotextiles • ensuring the toe is well founded and risk of undermining is low • appropriate crest height with consideration of overtopping scour, amenity and drainage • specification of locally available materials • site access • maintaining public access (Swan River Trust, 2009)
Operation and maintenance	The design life of revetments depends on the initial design conditions and maintenance regime. A robustly designed and constructed revetment should have a design life in excess of 20 years, with a modest degree of maintenance. Generally, a significant maintenance exercise would be required in the first few years of construction as the structure settles and is bedded down. Inspections undertaken biannually and following severe storms and floods would determine the ongoing maintenance requirements. Maintenance of well designed and constructed revetments should be limited to occasional repacking and replacement of armour. Other types of structures may be more dependent on the maintenance regime for their intended design life. Responsive approaches to a severe erosion event (emergency works) often result in poorly sized and poorly interlocked dumped rock revetments. These structures may meet the immediate needs of the foreshore manager but require a high level of ongoing maintenance or significant upgrade to meet

	engineering standards, provide a reasonable design life and maintain the amenity of the foreshore (Swan River Trust, 2009).
Endorsement by experts	Rock revetments are a well-accepted method of coastal protection worldwide.
Adequacy for current climate	Adequate for current climate. May support dune and vegetation preservation and restoration.
Scale/Size of beneficiaries group	Variable depending on location. Beneficiaries may be villages, touristic developments, cultural sites, coastal infrastructures such as roads.
Disadvantages	• Revetments do not address the root cause of erosion. The underlying erosion process will continue unabated and any beach that is present will gradually diminish in width and eventually disappear altogether. Beach loss may be accelerated by wave reflection from the structure (Baird & Associates – Reef Watch, 2003). • By encouraging development, hard defences necessitate continued investment in maintenance and upgrades, effectively limiting future coastal management options. Although authorities may not have a responsibility to continue providing protection, the removal of defences is likely to be both costly and politically controversial. • In the absence of a seawall (or revetment), natural shoreline erosion would supply adjacent stretches of coastline with sediment, through a process known as longshore drift. Once a seawall is constructed however, the shoreline is protected from erosion and the supply of sediment is halted. This causes sediment starvation at sites located alongshore, in the direction of longshore drift and this has the capacity to induce erosion at these sites. • The down-drift end of the seawall (or revetment) is also typically subjected to increased erosion as a result of natural processes. This flanking effect can cause undermining and instability of the wall in extreme cases. • Seawalls increase security by reducing the risk of flooding and erosion. However, the coastal zone remains a high risk location not least due to the presence of residual risk. To combat unwise development of the coastal zone, future developments need to be carefully planned.
Capital costs	
Cost to implement adaptation technology	Construction costs (particularly at the time of writing) are highly variable and can escalate rapidly. Factors influencing price include proximity of quarry, availability of required size range, demand, site access and complexity of design. Unit rates for the construction plant and operators can vary depending on needs for smaller bobcats to larger excavators and loaders. A price schedule for a larger revetment should typically include the following items. • Preliminaries: insurances; mobilisation of plant and equipment; site

	establishment; survey; construction management plans. • Materials (supply, deliver and place): armour (various size ranges or classes) core; geotextile. • Plant hire: excavator; loader • Reinstatement works: as-constructed survey; demobilisation; and site clean-up. (Swan River Trust, 2009) For these reasons, it is difficult to provide a cost estimate. In Wicklow (Ireland), a revetment for coast protection of the frontage north of the Broad Lough Bridge was installed at a cost of approximately €6,300 per meter – i.e. about Rs 239,000/m (The Murrough Coastal Protection Study – RPS Consulting Engineers). Cost estimates of a rock revetment provided by Beach Authority: ~**Rs 100,000/m**. [Rocks are obtained for free. However, situation can be expected to change when MAAS has been completed. In that case, the cost could be similar as in the case of Wicklow assuming that cost of rock was Rs 400 / ton.] Information obtained from the ICZM Division, Ministry of Environment & SD puts the cost of rock revetment as **Rs40,000/m**. The cost of carrying out revetments with synthetic geotextile technology has been estimated to be around one third of the cost of conventional rock revetments, while providing the similar level of protection. (http://www.geofabricsinternational.com/webfiles/GeofabricsInternationalAU/files/TP-Cost_effective_coastal_protection_works_using_sand_filled_geotextile_containers.pdf)
Additional cost to implement adaptation technology, compared to "business as usual"	The cost of implementing the technology can be recovered at the level of the local economy, thanks to direct and indirect benefits provided (see next section).
Long term cost (i.e. 10, 30, or 50 years) without adaptation Note: This comment is extended to coastal protection of the island at large.	With regard to economic losses associated to no coastal protection, if no action Is taken, then the total cost to the island of Mauritius, which would have to be made by other sources of revenue, would be US$ 3.362 billion over 50 years, which is a composite of loss of beach tourism revenue ($2.55 billion), the cost of making repairs to coastal infrastructure and buildings ($0.5 billion), and the cost of re-locating communities which are exposed to storm surges and frequent flooding ($312 million).
Long term benefits (i.e. 10, 30, or 50	Reinforcement of coastal infrastructure and development of coastal defences will save US$ 0.5 billion in infrastructure repair costs over 50 years.

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Development impacts, direct and indirect benefits	
Direct benefits	• Revetments are primarily intended to control the erosion of the backshore (i.e. the land behind the structure) due to direct wave attack – this will block the dynamic removal and return of dune material during and following a storm. • If appropriately designed, revetments and sea walls have a high amenity value – in many countries, seawalls incorporate promenades which encourage recreation and tourism. • Potentially long-lived structures provided they are adequately maintained. • Direct economic benefit by growth in material and construction expertise demand.
Reduction of vulnerability to climate change, indirect	Reduction in physical damage to property, infrastructure and economic output (caused by evacuated facilities).
Economic benefits, indirect Employment Growth & Investment	 Creation of jobs: • For leisure, touristic or other commercial activities on the amenities provided necessary agreements are made or permits are issued. • Supporting associated operations, such as quarry operations or construction of infrastructures and operating loading equipment. • For the implementation of complementary coastal protection technologies. Can create investment in: • Supplying equipment and service in installation. • Specialist coastal erosion studies for guiding maintenance, upgrade and complementary operations.
Social benefits, indirect Income Education Health	 Potential income from above-mentioned employment and investments. Increased awareness of SLR, flooding risks and coastal protection for development. Similarly to sea walls, revetments provide coastal flood protection against extreme water levels.

Environmental benefits, indirect	• Causes problems of sediment starvation • Potential re-growth of vegetation and marine life on the revetment.
Local context	
Opportunities and Barriers	**Opportunities:** • Seawall construction is one of several options available when high value land cannot be protected in other ways. The approach provides a high level of protection to valuable coastal areas although the long-term sustainability of the approach should also be taken into account. • Less technologically advanced designs can be implemented at local levels, utilising local knowledge and craftsmanship. This requires less investment and a reduced need for involvement of large organisational bodies such as national or sub-national government or non-governmental organisations (NGOs). While ad-hoc implementation is possible, technological guidance from expert organisations is desirable to ensure sufficient levels of protection. • Seawalls can also be implemented as part of a wider coastal zone management plan which employs other technologies such as beach nourishment and managed realignment. Placement of seawalls inland, following managed retreat, reduces interference with coastal zone processes and creates a buffer zone to protect against coastal flooding and erosion (French, 2001). The seawall therefore acts as a last line of defence. Use of seawalls in conjunction with beach nourishment can also address some of the negative impacts of seawall construction, such as beach lowering and down drift erosion. **Barriers:** • Cost: The design of an effective seawall requires good quality, long-term environmental data such as wave heights and extreme sea levels. This is frequently unavailable in developing countries and can be costly to collect. Secondly, because seawalls are frequently exposed to high wave loadings, their design must be highly robust, requiring good design, significant quantities of raw materials and potentially complicated construction methods. In locations of high energy waves, additional cost must be expended on protective measures such as rip-rap (Wide-graded quarry stone normally used as a protective layer to prevent erosion (Coastal Research, 2010)) to protect the structure's toe. • A case study from the Pacific island of Fiji (Mimura & Nunn, 1998) shows seawall construction to be very costly even when local materials were utilised in conjunction with other materials supplied by the government. Seawall construction in Fiji consumed the villagers' time and also required significant time and money to be spent on the provision of catering services for workers. • The availability of experience, materials, labour and specialised machinery for the construction of seawalls may also pose a barrier to the implementation of this technology. • French (2001) recommends proactive construction of seawalls at some

	distance inland. This reduces interference with coastal processes and creates a buffer zone to protect against coastal flooding and erosion. A key barrier to this type of approach lies in convincing and educating landowners of the necessity for, and benefits of, these measures (Mimura & Nunn, 1998).
Market potential	Yes, construction contractors may develop expertise with this technology and bid for works tendered.
Status	Practiced. The recent Adaptation Fund proposal entitled "Climate Change Adaptation Programme in the Coastal Zone of Mauritius" mentions that revetments and sea walls have been implemented in the past as 'stop-gap' measures within the dynamic beach zone leading to local scour. These technologies have had limited life spans.
Timeframe	Short term, with long term maintenance and upgrades.
Acceptability to local stakeholders	Seawalls (or revetments) may reduce beach access for handicapped people and for emergency services. This can be problematic if the beach fronting such structures is to be used for recreation. The appearance of seawalls can be aesthetically displeasing which can further negatively affect beaches dependent upon a tourist economy.

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Adaptation – Mauritius. You can access the complete report from the TNA project website http://tech-action.org/**