ALLEGATO n. 2

6.1.4 Conventional rubble mound

Once the layout of the harbour has been chosen, the determination of the size and layout of the components of the cross-section is a principal design objective. The selection of design conditions, accepted damage levels and maintenance policy allows the armour criteria to be calculated using design equations for armour layer stability given in Section 5.2.2.2 for armourstone on non-overtopped structures, Section 5.2.2.3 for concrete armour layers and Section 5.2.2.4 for armourstone on low-crested (and submerged) structures. The main dimensions of the cross-section can then be estimated. Each typical cross-section applies along a length of the whole structure. Different cross-sections need to be developed if seabed levels and exposure to waves vary significantly along the length of the structure. The wave climate and bathymetry along the full length of the breakwater need to be known. The bathymetry should be surveyed for a distance of at least several wavelengths in front of the structure, as seabed features may cause localised wave energy concentrations (see Section 4.2.4.7).

When the main dimensions have been settled, the budget cost of the structure can be calculated. This can be used to make a comparison between the different project options. Once the preferred option is selected, the next step is to define the roundhead and the design details of the structure.

6.1.4.1 *Main dimensions*

A definition sketch for a conventional rubble mound breakwater is shown in Figure 6.13. The structure typically consists of a core of quarry run (and possibly some alternative materials such as dredged gravel or secondary materials) (see Section 3.4.4) protected by armour on the seaward slope, on the crest and on (part of) the lee-side slope. A filter or underlayer is generally needed between the core and armour, depending on the filter requirements (see Sections 5.2.2.10 and 5.4.3.6) and the need to protect the core against wave attack during construction. A filter layer may also be required between the structure and the sea bed. A toe is often built to support the armour layer. Scour protection may also be provided seaward (and landward of the toe) to prevent scour of the adjacent sea bed, which could affect breakwater stability.

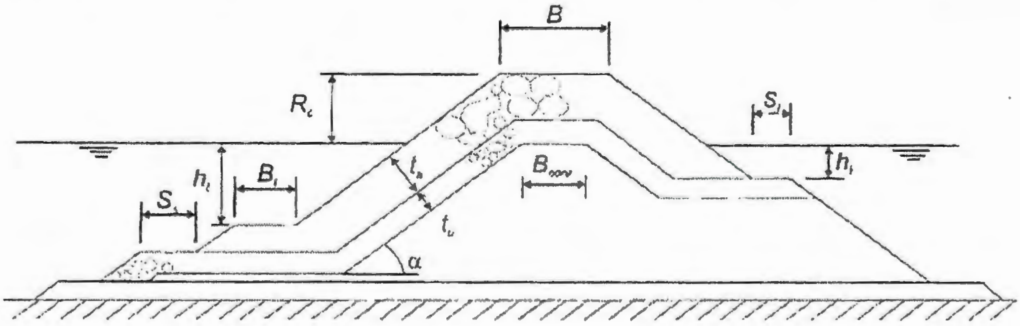

Figure 6.13 ***Definition sketch for a rubble mound breakwater***

The parameters defined in Figure 6.13 are as follows:

- crest freeboard, R_c (m)
- crest width, B (m)
- slope angle, α (deg)
- armour layer thickness, t_a (m)
- underlayer thickness, t_u (m)
- seaward toe level, h_t (m)
- leeward berm or shoulder level, h_l (m)
- toe width, B_t (m)
- shoulder width, S_s, S_l (m).

These are discussed in more detail within this section and in Section 6.1.4.2.

Crest freeboard, R_c

The elevation of the crest is generally dictated by acceptable overtopping discharge or wave transmission, based on the functional requirements that have been determined for the structure and the facilities in its lee. In some situations, the structure's visual appearance may also be an issue. The minimum crest freeboard, R_c (m), follows from overtopping requirements for stability, operability and safety (see Section 5.1.1.3). Conventional rubble mound breakwaters without crown walls are not accessible to the public or vehicles. Acceptable overtopping thresholds are in that case only governed by permissible disturbance inside the harbour (see Section 5.1.1.4) and stability criteria for crest and rear face armouring (see Section 5.2.2.11). Appropriate overtopping thresholds for these criteria are given in Table 5.4 in Section 5.1.1.3. In the case that a breakwater has to be accessible, additional, sometimes more restrictive, thresholds are applicable. Assessing the crest level is a major design issue; the slope angle (see Figure 6.13) and the type of armouring of the seaward face not only determine the degree of overtopping, but also the stability of the armour layer. See also the special note as annex to Box 5.4 in Section 5.1.1.3 "Considerations related to overtopping calculations".

The crest elevation may also be determined by the level of the core relative to the water level if the structure is to be constructed with land-based equipment. This normally requires a level of at least 1 m above high water. When marine equipment is employed, the level of the crest can be chosen arbitrarily, recognising that all material above 3 m below low water level cannot be simply dumped and therefore needs to be placed by crane barges.

The crest freeboard when concrete armour units are used is governed by the same parameters as applicable to rock armour layers. Single-layer units require less layer thickness, thus allowing a higher core level and a wider core crest for easier working.

The design crest elevation should allow for post-construction settlement (see Section 5.4) and a rise of the mean sea level due to climate change (see Section 4.2).

The freeboard may occasionally be referred as the armour freeboard, R_{ca} , particularly when a crown wall is present (see Section 5.2.2.12). R_{ca} is the distance from the water level to the top of the armourstone.

Crest width, B

The crest width, B (m), should be sufficient to permit at least three stones or artificial units to be placed on the crest. This is a particularly important requirement if significant overtopping is expected to occur. In the case of armourstone, a crest width of three to four stones is typically a minimum value. The stones on the crest should be placed with maximum interlocking or packing density to ensure the greatest stability under wave action. The packing density on the crest may be different from that achieved on the slope (see Section 3.5.1 for discussion of stone packing and packing density). With artificial units a crest width with a minimum of three rows is recommended for safe placement and interlocking of the blocks. In both cases, the actual crest width also depends on the core crest width B_{core} (m). If the core is built out with dump trucks, B_{core} should allow traffic of two trucks or one truck and one crane, as illustrated in Figure 6.14. Dimensions of the trucks are governed by the volume of material to be placed in the core, the dimensions of the crane are governed by the mass of and the reach for placing the heaviest armourstone (see Sections 9.3.2 to 9.3.6). For this purpose the crest width, B_{core} , is measured at least 1 m above high water level and in exposed conditions 2–3 m above MHWS is preferable.