6.3 Remains of ancient breakwaters

Many breakwaters have been built in antiquity to improve sheltering for ships. Some have been luckily preserved and survived 2000 years of wave attack, but most of the ancient breakwaters were destroyed by wave action and remains are found under water as “submerged breakwaters”.

Rubble-mound breakwaters consist of piles of stones more or less sorted according to their unit weight: smaller stones for the core and larger stones as an armour layer protecting the core from wave attack.

This kind of structure has been around for over 2500 years and modern coastal engineers still build them to create harbours sheltered from wave penetration. It was widely used for breakwaters in water deeper than a few meters where positioning of ashlar headers by divers was difficult. Modern design made some progress since ancient times and ancient breakwaters may have been over- or undersized. The result is that some breakwaters are still in good shape today and many others are now submerged as a consequence of 2000 years of storms. Without going into the details of breakwater design, it can be understood easily that stability of a structure made of stones depends primarily on the stone size in relation to the strength of wave action: breakwaters in open waters exposed to storms acting on large areas and therefore inducing high waves, must consist of larger stones than breakwaters located in sheltered areas.

A study was carried out to find some simple relation between the governing parameters (water depth, structure height, stone size) and the equilibrium position of the crest of rubble mound breakwaters subject to long term wave attack in breaking wave conditions.

It was concluded that undersized emerging rubble mound breakwaters reduce to submerged breakwaters and that, for a given stone size, submerged breakwaters stabilise to a predictable crest level after long term wave attack in breaking wave conditions.

For ancient breakwaters, this means that:

- We may find ancient breakwater still in perfect condition: they were emerging and fulfilling modern design conditions (they were somewhat oversized!);
- If slightly undersized, we may find ancient breakwater that were reshaped into an S-shape by 2000 years of storms: the seaward side is lowered to below Sea Water Level (SWL) and the landward side may reach SWL;
- If more undersized, ancient breakwater will be lowered by wave action to a level depending on the stone size.

We must also remember that the SWL rose about 0.5 m since antiquity, so that breakwaters that were stable at that time in shallow water (a few meters water depth) may not be stable anymore because larger waves can reach them nowadays.

In tidal areas, the worst conditions for stability occur when the largest waves occur together with the highest water level. The probability of occurrence of this happening is smaller than for a fixed water level, but that may not change the final result for stability in the long term.

Careful examination of historical Google Earth images enables us to see quite a few breakwaters in shallow waters. A collection of such images is given hereafter, together with some other pictures made on site.

Some remarkable ancient rubble mound breakwaters can be listed as follows:

- Portus (Fiumicino, Italy): over 3000 m long, now inland;
- Pharos (Alexandria, Egypt): over 2300 m long, submerged in open water;
- Thapsus (Bekalta, Tunisia): about 870 m long, submerged in open water;
- Paphos (Kato Paphos, Cyprus): about 600 m long, with a parallel one 200 m long, submerged in open water;
- Leptis Minor (Lamta, Tunisia): about 560 m long pier, submerged in open water;
Leukas/Ligia (Lefkada island, Greece): about 540 m long, submerged in sheltered water;
Pythagoreion (Samos island, Greece): about 480 m long, submerged in open water;
Acholla (Ras Boutria, Tunisia): about 460 m long pier, submerged in open water;
Sullecthum (Salakta, Tunisia): about 350 m long, submerged in open water;
Tieion (Filyos, Turkey): over 350 m long, submerged in open water;
Mytilini (Lesbos island, Greece): about 350 m long, submerged in sheltered water;
Sabratha (Libya): about 320 m long, submerged in open water;
Leptis Magna (Lebda, Libya): about 300 m long, berm breakwater in open water;
Methone (Modon, Greece): about 250 m long, submerged in fairly open water;
Neftina (Lemnos island, Greece): about 200 m long, submerged in open water;
and many others, smaller ones.

Obviously, questions remain on many of these structures, e.g. is the structure at Emporia a
breakwater or a city wall falling into the sea? Was the Thapsus structure a rubble mound
breakwater or a vertical breakwater? Is the Kainopolis feature a breakwater or just some beach
rock? etc. etc.

An index of all breakwaters collected here is given hereafter.

Everybody is welcome to send me more information and pictures on ancient breakwater
remains …
Remains of ancient breakwaters

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