International Journal of Scientific Research and Management (IJSRM)
||Volume||06||Issue||06||Pages||EC-2018-10-16||2018||
Website: www.ijsrm.in ISSN (e): 2321-3418
Index Copernicus value (2015): 57.47, (2016):93.67, DOI: 10.18535/ijsrm/v6i6.ec01

Agadir Port And Digues Protection-What is the best protection of a port?

Moulay Ali Alaoui [1], Pr.Hassan Fatmaoui [1], Pr.Jamal Chaoufi [1]

University Ibn Zohr, Faculty of Science of Agadir, LETSMP, Agadir, Morocco

Abstract:
At all times, the man wanted to tame the surrounding elements, first by pride and curiosity and then by security measures because they threaten his own existence, and to do so, it was essential to understand how these phenomena occur, then to develop strategies, protectors, or build megastructures; for example, it was imperative to explore deeply the nature of waves and currents in order to build dikes, or even take advantage of this abundance of inexhaustible energy (tidal power). Thus, it is proposed to cover this vast field of applications that is the swell on the harbor dike.

Keywords : Agadir, Dolos, Tétrapode, Accropode, BCR, dikes.

1. INTRODUCTION

Current climate changes are causing atmospheric upheavals that generate severe storms. The latter raise considerable masses of seawater in the form of swells which, through their mechanical effects, attack the protective structures of the ports, destroying them, threatening ipso facto human lives and economically sensitive and costly installations. These effects may be transient or persistent, on the time scale. For example, the Atlantic coast suffered during the month of January 2014, a series of storms that affected in particular the Moroccan coasts (Atlantic / Agadir). This case is particularly interesting for measuring the extent of the damage that waves can produce on a dike. And because of this, it becomes important to understand exactly what is happening at the wave / dike interface to find effective technical solutions increasing the resistance of these breakwaters. This work, synthesis intends to shed light on the various devices used, and to provide as faithfully as possible their advantages, disadvantages, prices and utilities.

The sizing of the port protection works is strongly linked to the degrees of hydraulic stress they undergo (swells and tides), moreover the rise in the average level of the seas, now accepted by the scientific community, and the possible evolution of Swells and surges at large, due to climate change will accelerate these solicitations by a permanent and sustained dynamic and chemical wear of these structures, directly threatening their stability, not to mention the increase in crossing rates.

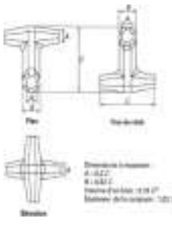
Thus, here is a table listing almost all types of existing blocks used in dike protection:

We will see the most usual, either:

- ✓ The dolosse
- ✓ The Tetrapods;
- ✓ The acropods I and II;
- ✓ The BCR, Block Cubic Grooved.

THE DOLOS:

Is a concrete block in a complex geometric form weighing up to 20 tons, used in large numbers to protect the walls of the port from the erosive force of the waves of the ocean.




Figures 2 and 3: South Pier of Durban with a nested dolosse line, South Africa.

They were developed in East London, a port city in South Africa, in 1963.

Dolosse are normally made from unreinforced concrete, poured into a steel mold. The concrete will sometimes be mixed with small welded steel mesh, to reinforce it in the absence of reinforcement. The construction is as close as possible to the installation site because the dolosse are very heavy.

They are used to protect port walls, breakwaters and earthworks. They are also used to trap sea sand to prevent erosion. An order of 10,000 dolosse is required for one kilometer of coastline.

They work by dissipating, rather than blocking, the energy of the waves. Their design deviates most of the wave action energy to the side, making them more difficult to dislodge than similar weight objects with a flat surface. Although they are placed on top of each other by cranes, they tend to tangle over time, as the waves move them. Their design ensures that they form an interlocking but porous wall. However, they are not indestructible. In extreme storm conditions, they hammer and fight in the rubble Individual units are often numbered so that their movements can be tracked. This helps engineers to evaluate whether to add more dolosse to the stack.

The design of the Dolos is generally attributed to the South African engineer Eric Mowbray Merrifield, a former East London harbor engineer (1961-1976). At the end of the 1990s.

It appears that:

It is an artificial device which was invented on a simple practical idea, but which has proved itself, however, of smooth design which is destabilized and interferes easily it will evolve enormously with the time.

THE TETRAPODS:

Figure 4: reserve tetrapods field

Tetrapods: have been the most commonly used in the past.

A tetrapod is a structure composed of four open fingers where each finger is 109.5 ° from the other three, as in the tetrahedral molecules. Made of often

Figure 4, field of tetrapods of reserves.

Reinforced concrete, it has four members whose curved profile is calculated in such a way that it minimizes the impact of the seaflows. The design of the structure allows nesting blocks that, used in mass, can strengthen a coastal protection or even gaining areas out of water on the sea.

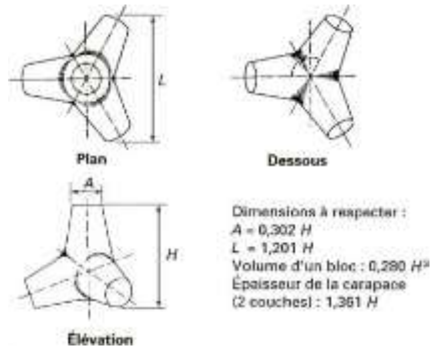
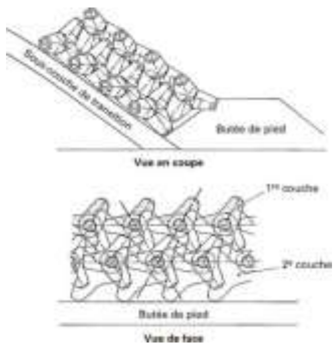


Figure 5 and 6: Tetrapods and Laying Plane.



The tetrapod is laid in two layers: the first consists of tetrapods laid flat according to a rigorous laying plan, one of the edges being perpendicular to the local plane of the dike. The second layer is also positioned very precisely, each tetrapod being placed inversely to those of the previous layer.

Having experienced great interest until the beginning of the 80s are practically no longer used in France (ex).

Figure 7: Tetrapods template.

The tetrapods make it possible to realize particularly rough carapaces, which absorb the energy of the swell with a low reflective power: they thus make it possible to limit the amplitude of the partial lapping formed by the reflection of the swell on the facing of the dikes, and by consequently reduce the risks of crossing.
In a dike, the shell consists of either natural rock or artificial concrete blocks when the wave intensity requires weights of natural elements that the available quarries are unable to provide.
It is considered that the tetrapod, designed and patented by Neyrpic in 1950, represents the first artificial block if we exclude simple shapes such as the cube or parallelepiped. Rather than withstanding its own weight, Neyrpic sought to improve permeability and interlocking between units. It is the most used block in the world. Placed in two layers with a porosity close to 50%, it has outstanding performance in terms of crossing limitation. At the end of the 1950s, the United States wrapped the Tribar that looked like a concrete tripod. Many other types of blocks followed such as modified cube (1959, US), Hexapod (1959, US), Stabit (UK, 1962), Akmon and Tripod (Netherlands, 1962), Dolos (South Africa, 1963) and the Grooved Cube (Antifer, France, 1973).
In an attempt to make a comparative summary of the majority of the blocks used, we have tried to draw up a summary of the main types of elements. This is a very basic assessment giving group behaviors within which the blocks can nevertheless have very distinctive performances. We chose to retain the following criteria:

- ✓ Hydraulic stability;
- ✓ Performance in terms of crossing;
- ✓ Structural resistance;
- ✓ The ease of implementation;
- ✓ Flexibility, it is the ability of the shell to conform to deformations of the body of the structure, such as general or differential settlements as well as the geometrical irregularities of the shell support;
- ✓ Security;
- ✓ The economy.

We considered that the blocks stored, especially when perforated have the best hydraulic performance. On the other hand, as this performance is obtained thanks to the close contact obtained between the neighboring elements, it is important that the initial implementation actually allows this contact and that during the life of the work, this contact does not come from to break up.
Thus, the engineers do not stop thinking about very sophisticated and effective concepts to approach the natural rip rap.

THE ACROPODS:

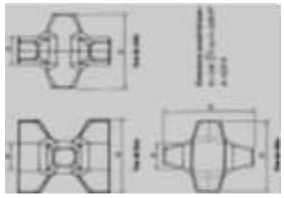


Figure 8: Plan of the Acropods.
Acropods was developed in the late 1970s by Sogreah from the tetrapod experiment and observation on bilayer systems allowing undesired movement in the upper layer. In fact, the Acropods is the first monolayer artificial block. A concrete saving of up to 40% compared to traditional bilayer techniques is claimed by its designers.
In terms of placement, this block can be laid in two ways:
• A position with 3 points of contact (2 ends of anvils and a nose (end of axis)),
• 1 point and a line of contact (a nose and anvil stop).

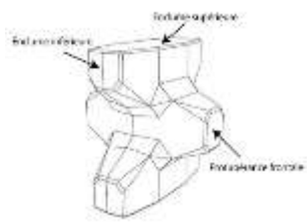


Figure 9: Acropods details.
The so-called monolayer shells that protect dikes exposed to waves consist of unreinforced concrete blocks designed specifically to be arranged in a single layer. Experience shows that this type of shell is as reliable as conventional bilayer systems while being more economical.
Invented in 1981 by Sogreah Consultants (SOGREAH) in France, the ACCROPODE ™ technique was already based on extensive research and considerable experience with the Tétrapode block invented by SOGREAH in 1952.

Among the other shell blocks proposed, the CORE-LOC ™ block, invented by the US Army Corps of Engineers and patented in 1995, is one of the most economical blocks on the market, and ideal for medium wave conditions. Made of a high void index and therefore increased dissipation.

Patented in 1996, the ECOPODE ™ block because of its rocky aspect and its modular color allows a better integration in the site partly visible works. By relying on a large number of projects, the shape of the

ACCROPODE ™ block has been improved to give birth to the ACCROPODE ™ II block. Invented and patented by SOGREAH in 1999 for particularly exposed sites and particularly difficult implementation conditions, its industrial development was finalized in 2003 - 2004. The ACCROPODE ™ II block like the other blocks above is distributed by CLI (Concrete Layer Innovations) subsidiary of Sogreah Consultants.

Accropodium II:

Figure 10: Acropods II details.

The qualities of the ACCROPODE ™ II block

This new form ACCROPODE ™ II, is an evolution of the shape of the ACCROPODE ™ block, this mutation being derived from the experience accumulated on the set of CLI blocks. Large flat surfaces and right angles have been replaced by smaller areas and chamfers. In addition, the general shape of the block has been redesigned to improve the following aspects:

- ✓ Hydraulic performance of the shell;
- ✓ Structural integrity of the block;
- ✓ Constructive methods.

Improved hydraulic performance the new shape of the ACCROPODE ™ II block makes it possible to obtain better nesting capacity during the laying of the blocks, improving the resistance of the shell to the swell.

In fact, the 2D and 3D model tests have shown a marked improvement in stability with regard to the criteria such as extractions, oscillations and settlements on the slope. As a result, the stability coefficient KD, appearing in the Hudson formula, could be increased, while maintaining a wide margin of safety.

At the study stage the Kd values to be taken into account in ordinary cases are 16 in current section and 12.3 in the head.

Greater robustness

Improved robustness is the result of research and development programs to optimize the shape initialization of the ACCROPODE ™ block.

Figure 11: Acropods II technical details.

THE BCRS, GROOVED CUBIC BLOCKS:

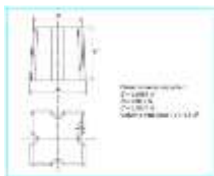


Figure 12: BCR Plan.

The block Antifer is a cubic block which presents on the four non-parallel faces a semicircular groove. It was developed in Le Havre during the construction of the oil port of Le Havre-Antifer, hence its name, to overcome the defects of the smooth cubic block: bad hanging and especially pronounced tendency to adopt a provision paving. The grooves make it possible to evacuate the overpressures, even if the carapace is strongly reworked. In addition, they facilitate a stowage blocks between them that improves their behavior and makes them acquire a behavior that is quite similar to that of a group. The overall qualities are quite similar to those of the tetrapods, but the block is easier to manufacture, to store, to handle or to pose, thus of a lower cost. In addition, it is significantly less fragile, given its compactness.

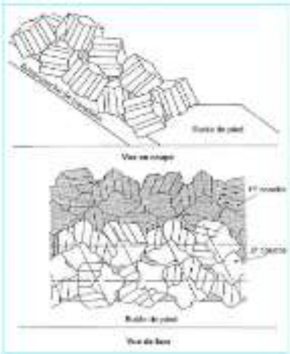


Figure 13: Application of BCRs.

Cubic block

The cubic block or cubic is the substitute of natural riprap, its main stability comes from its mass. Stability also results from friction between the blocks. The resistance of friction against wave action depends mainly on the weight of the block and the degree of entanglement with the adjacent blocks. Blocks are usually laid in multiple layers. However, Van Gent et al. (2001) conducted a large number of tests with cubes in two aspects:

- ✓ A carapace consists of a single layer of the cube;
- ✓ A carapace made up of denser blocks.

A comparative reduction, the traditional layer (two layers) was considered as one of the most important aspects. Another advantage of cubes in comparison to nested blocks is that placement of cubes below water is easier, especially for areas where underwater visibility is too low to use the tools for nested block placement. (Van Gent (2003)).

The placement method of the cubes is important for the hydraulic performance and structural response of the shell. The irregular placement of the cubes improves hydraulic performance because crossing and reflection can be reduced.

Single layer cubes have recently been researched which suggests that, in some cases, this arrangement has advantages over a double layer shell.

The grooves allow a better circulation of the water inside the carapace and a reduction of the overpressures. In addition, they facilitate a stowage blocks between them that improves their behavior and gives them a 'group' behavior. It is arranged in two layers on slope slopes generally between 4/3 and 2/1. The lower layer acts as a separator with the blocks of the upper layer. The method of placing grooved cubic blocks is an important parameter that has been recently developed by several studies. Yagci and Kapdasli (2003); Yagci et al. (2004) analyzed the stability of the BCR with different laying techniques such as: regular placement technique, irregular placement technique and inclined wall placement technique (parallel to carapace slope).

In parallel, they presented a new investment technique called the 'alternative investment technique' and made a comparison with existing methods.

The results of this research have shown that 'regular placement technique' produces much lower stability compared to other placement techniques. By contrast, the 'alternative investment technique' has proven superior to other existing investment techniques.

COMPARATIVE SUMMARY:

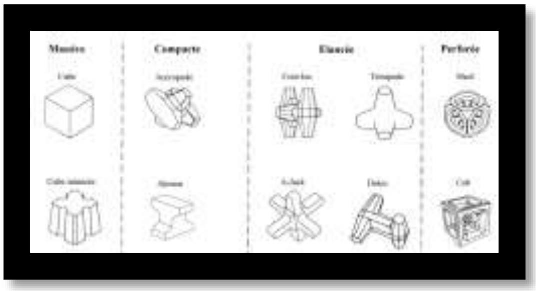


Figure 14: the different devices used.

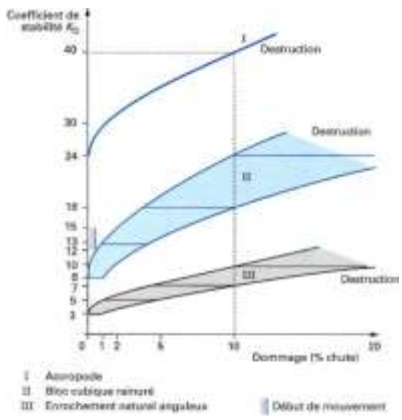
- ➢ **The most effective**: Acropods II, Acropods, BCR
- ➢ **The cheapest**: Dolos.
- ➢ **The least heavy**: Dolos, Tetrapods
- ➢ **The most stable**: Acropods II, BCR
- ➢ **The most common**: Tetrapods

Indeed, the technology evolves in the design, the studies, the realization the modeling of new very complex and expensive devices to actually approach as much as possible the effectiveness of the natural rocking's.

Notations et symboles	
Symb	**Déf**
d	profondeur d'eau devant l'ouvrage
e	épaisseur d'une couche
h	hauteur d'eau au-dessus de la berme
H	creux de la houle
$H_{1/3}$	creux moyen du tiers des vagues les plus fortes d'un enregistrement
$H_{1/10}$	creux moyen du dixième des vagues les plus fortes d'un enregistrement
$H_{1/100}$	creux moyen du centième des vagues les plus fortes d'un enregistrement
H_{max}	creux maximal de la houle
k_{Δ}	coefficient de forme
K_D	coefficient de stabilité
L	longueur d'onde de la houle
N_s	nombre de stabilité
T	période de la houle
W	poids d'un enrochement
α	angle d'un talus avec l'horizontale
ρ_s, γ_s	masse et poids volumiques des grains ou des enrochements (secs)
ρ_w, γ_w	masse et poids volumiques de l'eau de mer

Table 1 - Different calculation parameters of rock layers and shells

Nature	**Nombre de couches**	k_A	P (%)	K_D
Enrochement anguleux	2	1,15	37	4
Bloc cubique rainuré type Antifer	2	1,02	46	8
Tétrapode	2	1,04	50	8,3
Dolos	2	1,00	63	22
Accropode	1	1,30	(1)	10
(1) non significatif				



P porosity of the underlayer expressed in%.

Figures 15: and tables, technical data and legends.

NB: Kd ↑ → Stability ↓

References:

[1] The Accropode II block, Michel Denechere, CLI (Concrete Layer Innovations), michel.denechere@concretelayer.com;

[2] CAMINADE D (1987), Swell Protective Structure;

[3] CARPENTIER & DELAGE & INMAN & DATTARI & TOYOSHIOMA; BOUJIS (2000), the breakwaters;

[4] CETMEF, Design of the Works at Sea, chapter 6;

[5] History of the artificial block used in embankment dams, Safari1, F. Ropert2, D. Mouazé1 and A. Ezersky1, 1Université de Caen, UMR 6143 CNRS -M2C;
[6] HUDSON RY (1984), coastal protection works;
[7] Rock Manual (2008), published by CETMEF (Center for Maritime and Fluvial Technical Studies), Coastal Protection Dams;
[8] SOGREAH (2000), (Société Grenobloise d'Etudes et d'Applications Hydrauliques), the breakwaters;
[9] The ECOPODE ™ block, "The Coastal Protection Solution in Accordance with its Environment", Michel Denechere, CLI (Concrete Layer Innovations), michel.denechere@concretelayer.com;
[10] Coastal defense works, Jean Bougis.