

THE ECOPODE™ UNIT

“The Coastal Protection solution that blends most effectively into the surrounding landscape”





The ECOPODE™ Single Layer system for coastal protection

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Introduction

Single-layer systems consist of un-reinforced concrete armour units specifically designed for the protection of exposed coastal structures. Their combined qualities produce solutions which are as reliable as conventional double-layer systems and at the same time cost-effective.

Invented in 1981 by Sogreah Consultants in France, the ACCROPODE™ technique is backed by extensive research and experience gained with the Tetrapod unit invented by Sogreah in 1950 and supplied on a large number of projects.

Another armour unit being proposed is the CORE-LOC™ unit, invented by the U.S. Army Corps of Engineers and patented in 1995. The CORE-LOC™ is one of the most economical units available, and is ideally suited for moderate wave exposure sites.

Based on the experience gained at that time, the shape of the ACCROPODE™ has been improved to make a new step forward: Invented and patented by Sogreah since 1999 for particularly exposed sites and difficult work conditions, the new generation known as ACCROPODE™ II has been developed for industrial applications in 2003-2004.

With its rock-like appearance and adaptable colour, the ECOPODE™ unit, patented in 1996, enables to meet the aesthetic requirements on sensitive sites, and blends perfectly into the surrounding landscape.

Moreover, most of the improvement made to the ACCROPODE™ II unit have been drawn from the ECOPODE™ unit development.

The ECOPODE™ unit as well as the other units mentioned here above, are distributed by CLI (Concrete Layer Innovations), a subsidiary of Sogreah Consultants.





History

The pioneer in single-layer technology, the ACCROPODE™ technique has become the benchmark for modern breakwater armouring since its creation in 1981.

Right from the 1980s, the ACCROPODE™ single-layer technique was a success. Recognising the research behind the single-layer invention, the profession had no doubts about its advantages; that is why the number of applications has grown steadily ever since.

Today, the best proof of contractors' and clients' confidence in the merits and advantages of the single-layer technique is the many successful projects for which it has been adopted worldwide.

Through the use of these units, CLI has gained experience on over 200 breakwater projects worldwide. Continuous research over the past 20 years has led to the concept and optimisation of the ACCROPODE™ unit. Initially, these improvements were integrated into the design of the ECOPODE™ unit and then into that of the second-generation ACCROPODE™.

The ECOPODE™ unit with its rock-like skin enhances the appearance of this man-made system with a natural look, making it unobtrusive in sensitive sites such as marinas, coastal protection works and land reclamation sites within populated urban areas.

The other assets of the ECOPODE™ unit just like the ACCROPODE™ II units are its enhanced hydraulic performance, greater sturdiness and easier placement. These aspects have been checked and validated since 2003 by specific studies and in real site conditions.

The ECOPODE™ technology is protected worldwide. Rights are granted by CLI and technical assistance systematically provided by CLI to any qualified marine contractor. CLI continuously acquires knowledge in the field of rubble mound breakwaters through the success of each project as well as through research and development studies.



Eruptive rock appearance



Limestone appearance



Alternative appearance



The advantages of the ECOPODE™

Natural appearance

Concrete armour units with smooth skin surfaces are less accepted by local communities and users of environmentally sensitive coastlines. However, natural rocks are not always available and the extraction and haulage are destructive to the environment (disruptive traffic, noise, pollution, etc).

The innovative feature of the ECOPODE™ unit is its natural-looking bumpy and/or grooved surface. The units are moulded so that they resemble the geomorphology of the area in which they are to be used. This means that they can be used instead of natural rocks without harming the site, eliminating the quarrying problems and other nuisance mentioned previously.

Several types of rock finish can be produced: limestone, sandstone and basalt with associated typical colours. For very sensitive projects, the exact type and colour of rock can also be reproduced to suit Clients requirements.

However, the general shape of the ECOPODE™ unit is similar to that of the ACCROPODE™ II and offers the following advantages:

- Hydraulic performance of the armour;
- Structural integrity of the unit;
- Construction methods.

ECOPODE™ can be placed in the visible upper part of the breakwaters, above the low water line, over ACCROPODE™ II units which have similar geometry.

A special mould process for a particular unit shape.

The rock appearance of the ECOPODE™ units requires a specific type of mould. Sogreah has performed effective research and thorough investigations to find the most effective mould system for casting this complex shape.

The mould system has evolved from the first ECOPODE™ mould made of steel with an added polyurethane lining in the inside, to the current mould system consisting of two symmetrical shells made of fibre glass, backed by a steel spider frame mounted on wheels. Each mould of this new type is designed for about 300 re-uses, with very minor repair or maintenance.



- Difficulty of opening new quarries
- Large rocks are expensive to extract



Details of the ECOPODE™ unit



Fibre-glass moulds Sculpted to suit clients requirements



"Spider" steel frame



Mould shell detail



Enhanced hydraulic performance

The uneven surface of the ECOPODE™ improves the interlocking capability at placement, therefore increasing the stability of the armour under wave attack.

2D and 3D scale-model tests have shown that there is a distinct improvement in stability with respect to the usual criteria, such as extraction, rocking and settlement.

Consequently the stability coefficient K_D used in the Hudson formula has been increased while keeping a significant safety margin. At design stage, the K_D values to be taken into account in ordinary situations are 16 for the trunk section and 12.3 for the roundhead.

Greater sturdiness

The shape and skin effect of each ECOPODE™ have been designed so that the structural strength is unaffected. The general shape of the ECOPODE™ (excluding skin details) is very similar to that of the ACCROPODE™ II. For this reason, the studies results showing a better stress distribution for the ACCROPODE™ II unit compared to the ACCROPODE™ (which is already recognised for its good record in this respect) are relevant for the ECOPODE™ unit as well. These results have been confirmed in real site conditions.

Easy placement and minimum maintenance

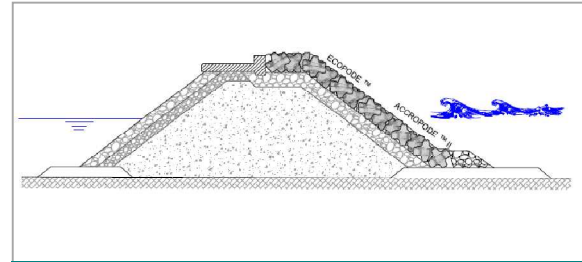
The ECOPODE™ unit just like the ACCROPODE™ II unit is easy to place (minimum placement rules) and requires less maintenance than the first generation ACCROPODE™ unit.

Experience has shown that the first-generation ACCROPODE™ has fully satisfied the requirements of the projects on which it was used, and in particular has not required any major maintenance to date.

These improvements are valid for the ECOPODE™ as well, provided that:

- Wave conditions are correctly determined,
- CLI Design recommendations are taken into account,
- Concrete strength specifications are met,
- The necessary quality of placing is ensured.

To help the users in meeting these criteria, CLI provides valuable technical assistance at all stages of each project.



Can be combined with ACCROPODE™ II smooth skin units



2D scale model



5.7 m³ ECOPODE™ unit above water



ECOPODE™ unit at the water level

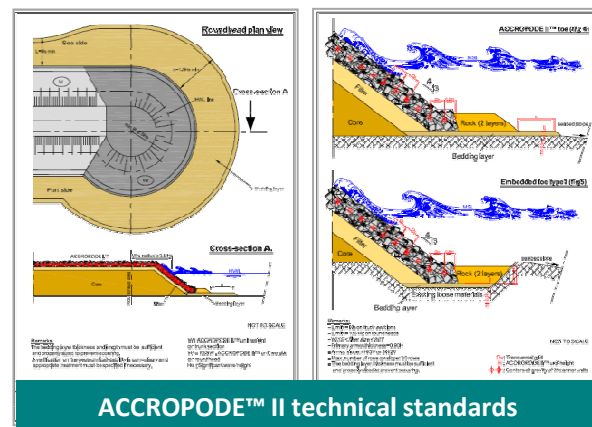


Knowledge-based technical assistance

Customised technical services are offered according to the requirements of each client, from the early design stage through physical model studies until the end of construction works, responding to the quality, safety and cost-saving requirements of the project:

- ECOPODE™ alternatives and comments on designs are offered free of charge and without obligation at the various stages of the project (preliminary design, calls for tender, etc.) giving the clients, engineers and contractors an opportunity to assess the advantages of the technique while benefiting from feedback gained on numerous projects.
- Physical modelling is strongly recommended for optimisation purposes. Model units are supplied to any qualified hydraulics laboratory. When necessary, a CLI technician can be sent to the laboratory to help perform the initial placement of the model units and train the laboratory staff to repeat this task.
- Technical on-site services are supplied during key construction phases. Practical advice is given on manufacturing, handling and positioning. A CLI specialist is assigned to each project to follow-up casting and placement progress, thus helping the contractors to implement the technologies properly. It has also been recognized that early involvement of CLI at the actual project site is preferred: i.e. well thought casting and placement operations can benefit the Contractor as the CLI specialist can discuss and suggest where improvements can be made.

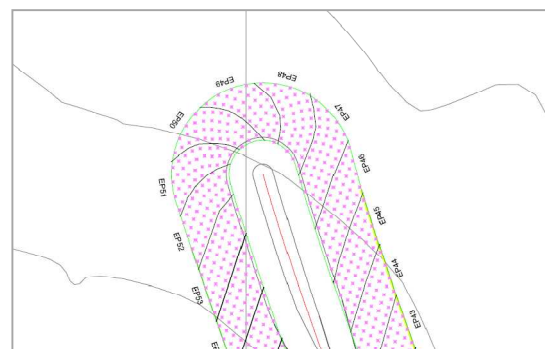
The experience gathered through many single layer projects during the design stage, physical modelling and on the field in various conditions and over many years is made available to the users.



ACCROPODE™ II technical standards



Assistance in placing model units



Placing drawings supplied to contractors



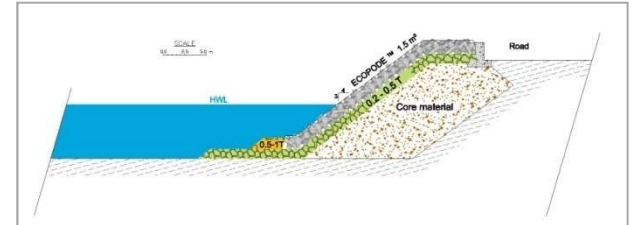
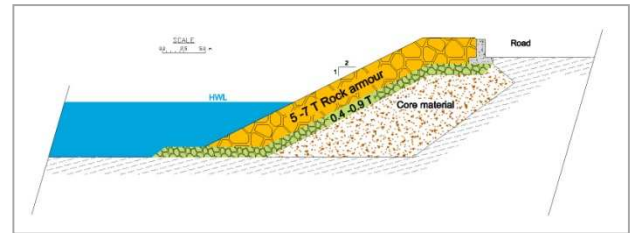
Assistance to contractors on site



Time saving and cost-effectiveness

ECOPODE™ armours require less materials than natural rock armours, thus reducing the constraints linked to quarrying and transporting large rocks. ECOPODE™ has sufficient interlocking capability to permit their use in a single layer, which saves not only on costs but also on construction time.

In addition to the advantages of the ECOPODE™ technique itself, the related services provided by CLI allows great savings at design stage by helping the Designers optimise the design and during construction stage by the tailored assistance provided to Contractors, leading to safe and economical alternatives and structures. The quantities of concrete are optimised, the construction time is shorter, and in the long term, the maintenance cost are proved to be limited.



Single Layer consumes less volume of materials than an equivalent rock armour solution

Partnerships

In its pursuit of solutions, CLI develop partnership with high-level specialists. This is why CLI is proactive on all requests in in relation with artificial armour units.

Some Partners:

- Imperial college, UK
- Itsaca, France
- Mesuris, France
- Mould manufacturers
- Expert divers
- Major marine consultants
- US Corps of Engineers
- Major hydraulic laboratories
- ...

References

- CLI Catalogue and brochures published in September 2004.
- The ACCROPODE™ II armour unit - Initial finite-element analysis results, by M. Fons and P. Wyniecki, September 2004.

In brief

The ECOPODE™ and the ACCROPODE™ II units are issued from the same development and offer the same improvements in comparison with the first ACCROPODE™ unit generation.

However, the additional advantage of the ECOPODE™ unit is its rock-like skin allowing a better integration in the natural site of the above water part of the breakwater. In order to obtain this complex skin shape, Sogreah and CLI have develop specific moulds today practical and reasonably priced.

On the basis of single-layer projects and research and development studies, CLI continues to improve its know-how in the field of artificial armouring to best serve its clients.

ECOPODE™ References

Project N°	SINGLE LAYER ARMOUR TECHNIQUE Projects	Unit size used (m³)	Start of work	End of work	Design wave		Max water depth	Max water level	Armour slope	Physical modelling	
					Hs (m)	Tpeak (s)	h(m)	HWL(m)	H/V	2D	3D
200	Italy - Ospedaletti marina - New yacht harbour located near San Reno Liguria - The breakwaters are 1200 m long – The ECOPODE™ units are placed above the low water line over ACCROPODE™ II units	4/6/8	Feb-08	In progress	5.1 to 7.1	10 to 12	-	-	4/3	No	No
122	Spain – Coastal protection at Garachico - on the West side of the Tenerife Island – The ECOPODE™ units are placed in the visible part of the structure over ACCROPODE™ units	5.7	Jan-00	Jan-01	9.0	16	-	+ 2.9	4/3	Yes	No

Practical Aspects



Sculpture of the master



Assembling steel and fiber shells



Mould ready for casting



ECOPODE™ shells made of fibre glass



Casting with a conveyor belt



Casting using a chute



Manual striking



Casting of ECOPODE™ units



Form removal



Ground level storage



Storage of units



Storage of units on site



General view of the casting yard



Placing of an ACCROPODE™ II unit underwater below ECOPODE™ units



Transporting a unit on site



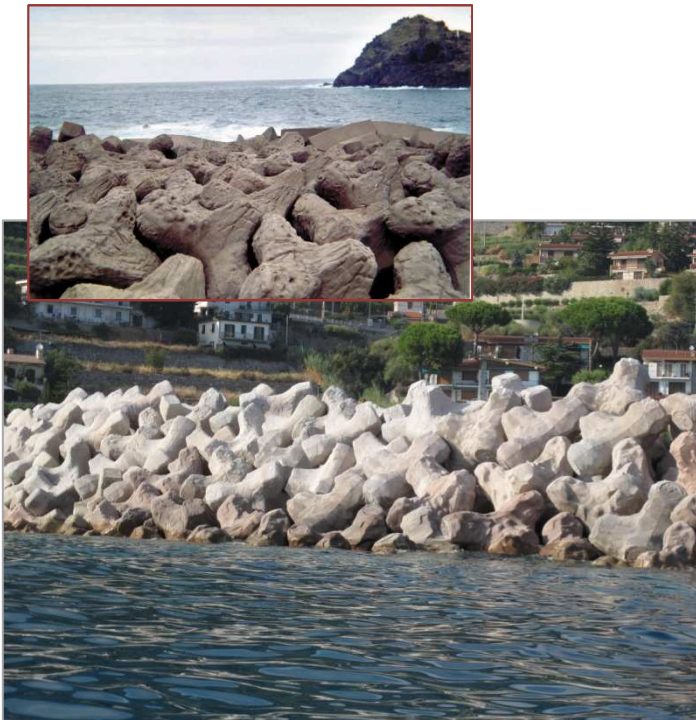
Above water ECOPODE™ armour in progress



6 m³ ECOPODE™ units placement in progress



Placing of ECOPODE™ units at Garachico, Spain



ECOPODE™ armour



ACCROPODE™ armour



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