The greater sensibility for the increasing problem of the coastal erosion induced MACCAFERRI SPA and EUROBUILDING SPA to invest in the research of innovative solutions, creating COASTAL PROTECTION SYSTEMS that, using the international experience accumulated in the years from both partners, proposes to develop, produce and commercialize technologically advanced solutions with a low impact on the environment, finalized to the protection and to the recovering of the coasts with a strong synergy with the multidisciplinary techniques that characterize the coastal protection: the beach nourishments with submarine sands.

Research and Development

Coastal protection

CPS is studying, through an advanced research project, a prefabricated dissipating system as an alternative to the submerged barriers, whose aim is not only to give a technically equivalent solution, but also to reduce the impact on the environment, avoiding the need of huge amounts of large rocks coming from onshore quarries.

The activities necessary to the implementation of the research project are:
- a numerical modelling with hydrodynamic and morphodynamic analysis;
- a scaled physical modelling 2D in a flume and 3D in a tank.

The numerical outputs of such modelling will allow to quantify the actual performances of this new structure and to eventually design it. The preliminary results obtained so far have provided positive outputs in relationship to the coast dynamics induced by the structure.

Seabed re-greening

Another front on which CPS is involved is the "re-greening" of the seabed through Posidonia planting. At the end of September 2006, in the seabed of the Elba island (Italy) the first plant relating to this experimentation has been performed: the site is continually monitored and the first outputs underline a good re-greening effectiveness of the plantation.

The proposed solutions are ideal for the following applications:
- construction of transversal or longitudinal submerged works to protect the coastline
- provisional support of eroded beach bars subject to a nourishment
- re-construction of dunes

MacTube™

MacTube™ is a cylindrical element of variable diameter made of woven geotextile, filled on-site with a mixture of sand and water: the permeability of the geotextiles allows the expulsion of the water and the retention of the fine material consenting therefore the MacTube™ filling.

MacTube™ are built assuring the required characteristics of both structural and hydraulic resistance needed for the specific project using basically, but not exclusively, high tenacity woven geotextiles resistant to the UV rays. MacTube™ have diameters varying between 1 m and 4 m and length between 20 and 50 m.

MacBag™

MacBag™ is a bag made by a woven geotextile and filled with sand (or a concrete-sand mix) for the protection of the coastal works base (breakwaters, groynes) and also as a support for submarine works (e.g. pipelines).

MacBag™ is produced in elements of different dimensions according to the project needs.

Marine Geotextiles™

Marine geotextiles are specifically designed to guarantee the safety of the typical coastal defence works foundations made by quarry stones (submerged/emerged breakwaters, groynes...).

Operating as a filter bed and separator they avoid the scouring due to currents and the wave motion, avoiding the structure instability and reducing the need of maintenance works.
The Ballasted Filter Mattress

An innovative filter bed for foundations

The construction of the mobile gates for the MO.S.E. project in Venice has involved also the implementation of a sea bottom protection both on the sea side and on the lagoon side, with the final aim to guarantee the stability of the anticorrosion protection works and the correct manoeuvring of the structures in the future. The bathymetric conditions and meteoric climate of the Venice lagoon inlets (depth 6-15 m, Hmax wave 1.5 m) have required to design a suitable base filter that, besides its filtration, resistance and durability properties, remained constantly in contact with the bottom both before the laying of the antierosion rockfill layer, and during the exercise phases when it is subjected to the action of the wave motion, tidal currents and the actions due to the ships passages.

The Ballasted Filtering Mattress are assembled on site in elements 10 m wide (11.2 m with the side band for the overlapping), length between 150 m and 250 m and are rolled upon a 4 m diameter drum and finally laid on the inlets bottom through a special pontoon whose installation operations are controlled by a DGPS system connected to the construction site network. The installation technology allows for a tolerance of 20 cm with respect to the theoretical positioning.

The Ballasted Filtering Mattress is approx. 5 cm thick, a weight of 50 Kg/m² in air (25 Kg/m² in water) and is constituted by:

- a nonwoven geotextile as bottom filter;
- a central body consisting in a polypropylene geomat, internally strengthened with a double twist wire mesh protected with an anti-corrosion layer of Galfan and a polymeric coating;
- a ballasting of the central body with small crushed rock, grading 4-8 mm;
- a nonwoven geotextile for the upper closure;
- a quilting with HDPE profiles and steel screws.

The Ballasted Filtering Mattress passed the most severe tests of filtering, mechanical resistance and durability, complying with the required minimum design life of 100 years. The product can be installed:
- by a pontoon with a drum as in the case of the MO.S.E. project;
- by a lifting frame in case of smaller size units (8x2 m, 10x2 m).

The Ballasted Filtering Mattress are therefore a solution extremely innovative for:

- the basal protection of the coastal structures made of loose stones;
- the reduction of the vertical settlements of marine works by allowing a less onerous maintenance;
- the safeguard of the bottom of harbour areas for the protection of the zones affected by the action of ships propellers.

Other application

Scour protection for quays

Foundation layer for coastal protection works

Foundation layer for breakwater or groynes

Laying system example
**Sarmac**

**Protection and anchorage for offshore pipelines**

Whenever the pipeline stability cannot be assured by its only submerged weight, the problem can be solved by adding an adequate quantity of anchoring units that are able to withstand to the unstabilising forces due to the meteomarine actions.

Since 1980 Sarmac bituminous mattresses represent a proven solution which has been widely used to stabilise and anchor the most important pipelines in the Mediterranean Sea. The pipeline stabilisation can be obtained through a continuous protective revetment along the unstable stretch or by means of a discontinuous positioning of the units, whose distance depends upon the stability checks.

In case of rocky seabeds, Sarmac units represent a valid solution to prevent damages to the pipelines.

**Technical Characteristics**

**Impact Resistance**

The mattresses ensure their functionality and structural integrity even in case of accidental impacts: tests have shown that Sarmac mattresses can withstand impact energies up to 16 kJ with a tip penetration not deeper than 50% of the unit’s thickness, and deformations limited only to the impact area.

This characteristic is very important when Sarmac is used for the protection of pipelines (e.g. falling objects, trawls, anchors).

**Indentation Resistance**

Sarmac mattresses can withstand to the designed static loads without limitations of their functionality and durability. Tests have shown a maximum indentation equal to 1/3 of the unit thickness, when subjected to a load equal to 9 t applied by a pipe 600 mm diameter.

This characteristic is very important whenever the Sarmac are used in pipeline crossings.

**High Flexibility**

The Sarmac units remain flexible even in low temperatures and are therefore able to mould themselves constantly to the seabed changes without structural failures.

**Environmental Compatibility**

When Sarmac mattress are immersed in water they do not release any contaminants such as PAHs, heavy metals and hydrocarbons exceeding the limits for drinking water when tested in accordance to ANSI/ANS 16/11986, as shown by SGS tests. This property makes Sarmac mattresses suitable to be used also in areas of high environmental value.

**Easy of installation**

The 25 years experience allowed to design specific lifting frames equipped with a mechanical device in order to have a contemporary unhooking of the lifting loops, thus assuring a fast and safe installation even in deep waters, without the divers assistance.

**Sizes**

The unit weight of the units is 2.3 t/m³ in air and 1.3 t/m³ in water. The standard sizes are:

- Length 3 - 4 - 5 - 6 - 7 - 8 m
- Width 2.35 m
- Thickness 0.12 - 0.20 - 0.25 - 0.30 m

**Mattress Design**

To evaluate the size and the quantity of Sarmac units needed to stabilise a pipeline, CPS can provide the design of the mattresses in order to guarantee the stability against the transverse sliding of:

- the pipeline-Sarmac system with respect to the seabed (global sliding);
- each mattress with respect to the pipeline and the seabed.