Mitigation of erosion of the coastline at the Spanish Antarctic Base Gabriel de Castilla

English version provided by the author

Mitigation of erosion of the coastline at the Spanish Antarctic Base Gabriel de Castilla

**Information Paper presented by Spain**

***Summary***

Since the 2014-2015 Antarctic summer, a series of actions have been carried out at the Spanish Antarctic Base (BAE) Gabriel de Castilla to mitigate the erosion of the slope where this station is situated. The first step was a pilot project to assess the results of the proposed solutions. After observation over six Antarctic campaigns, along with several technical studies during that same period, civil engineering works were carried out during the 2019-2020 campaign to mitigate the slope’s erosion, in an attempt to avoid the coastline’s advancing into the area where the installations are located, and halt their potential destruction.

***Background***

Personnel working at the BAE Gabriel de Castilla had observed serious erosion of the terrain around the station, resulting in the loss of surface area around it, since the 2008-2009Antarctic campaign. This trend was confirmed over five consecutive campaigns, with the loss being quantified during the 2011-2012 and 2012-2013 campaigns at 1 m per year. Given the risk for the stability of the installations, during the 2014-2015 campaign a partial intervention was proposed for the 100 m of the slope most directly affecting the station.

Surface stabilization using a cellular confinement system was used due to its simplicity and the need to carry out the work with materials available near the station. After a preliminary environmental impact study determined that the activities would have a less-than-minimal or transitory impact, works on a gabion retaining wall were begun.

The project was carried out during the 2014-2015, 2015-2016 and 2016-2017 campaigns, with the following phases:

Phase 1, 2014-2015 campaign: 65 m built on the beach and the slope.

Phase 2, 2015-2016 campaign: 30 m built on the western side of the original access ramp.

Phase 3, 2016-2017 campaign: 33 m built on both sides of the ramp.

Phase 4, 2017-2018 campaign: Expert evaluation, data collection and replacement of deteriorated gabion baskets from previous phases.

Phase 5, 2018-2019 campaign: Expert evaluation, data collection and construction of 15 m of gabion wall on the western edge, and shoring up of the gabion walls already built.

The technical projects carried out during the 2017-2018 and 2018-2019 campaigns contributed to a preliminary evaluation of the civil engineering works, as well as providing data for determining the origin of the slope’s erosion.

The conclusions were:

1. According to the data obtained, there was no evidence of slope shift. The gullies observed around the station seemed to form part of a generalized pattern throughout the area, which does not seem to be related to the human activity there and appears to be an intractable problem.
2. A thickening of the active layer of permafrost has been observed throughout the Antarctic Peninsula. Consequently, the recommendation was to excavate and clear out the module foundations to allow an exchange of energy and avoid overheating the bottoms of the modules.
3. The receding crest line of the slope was clearly evident, and quantified in the area around the station at approximately 9 m between 2001 and 2013.
4. In the area where the gabion walls were built, the pace of shoreline erosion was observed to have diminished, although this was not enough to ensure the stability of the Gabriel de Castilla.
5. With a view to future replacement of the station’s modules, these new modules must be separated from each other as much as possible, with higher pylons to enable energy exchange with the atmosphere, lessening impact on the ground.
6. It will be necessary to initiate corrective measures for the receding crest line of the slope, using gabion baskets, given the insufficient results of the previous measures. This must include removing the gabions placed between 2014 and 2017, replacing them with new gabion walls more efficiently placed along the entire coastline, as well as relocating the access ramp from the beach to the station.

***Works during the 2019-2020 campaign***

Throughout 2019, a preliminary environmental impact study was carried out which determined that the activities would have a minimal or transitory impact, and therefore the activity was approved for execution during the Antarctic summer of 2019-2020. During that campaign, seven engineers from the Spanish Army were deployed to the BAE Gabriel de Castilla to build the gabion walls, as well as a platform for unloading material from the beach to the station.

*Retaining wall*

A retaining wall 125 m long was built of gabion baskets, with three different heights—a 53-m section being the highest—adapting to the terrain on which the station is located. The wall was built of 1.1 x 1.4 x 1.1-m gabion baskets filled with material from the area, and shored up on its windward side with a foot-wide base unit made of cement paving slabs on the two lower levels, and a half-foot base at the highest level, to provide greater resistance to the effect of spring tides and winter ice floes. This system was reinforced on the inside with 2-m stakes, to reduce the effect of the action of the sea. The entire wall has an inclination of 15º; it leans up against the slope, and was artificially backfilled. Finally, as coping for the top of the wall, 280 m2 of concrete blocks interlaced with stainless steel cable were installed to control erosion, minimizing the particles of terrain carried away by runoff waters.

*Loading platform*

A structure of approximately 38 m2 was built to facilitate the operation of the telescopic handlers necessary for transporting material from the beach area to the station. This installation comprised cages of electrowelded wire mesh filled with a layer of 0.4 x 0.4 x 0.2-m concrete blocks with other material from the area, and another layer of 0.2 x 0.2 x 0.1-m concrete paving slabs. A 45 m2 layer of concrete was laid on top of this structure, interlaced with stainless steel cables, giving the platform a total dimension of 9 x 5 m.

***Conclusions***

The project was planned for two Antarctic campaigns, but in the end it was possible to carry it out during a single campaign, that of 2019-2020, with the exception of part of the coping on top of the wall and its backfill, since it was not feasible to include that material in this campaign. The proposed solution, it is hoped, will guarantee the slope’s stability for at least the next 15 years. It is important to indicate that both the retaining wall and the loading platform have been constructed in such a manner as to be removable at any time from the Antarctic Treaty area, as has been shown with previous actions.