39th IAHR WORLD CONGRESS
GRANADA, SPAIN 2022
From Snow to Sea
19-24 June 2022

Proceedings of the 39th IAHR World Congress
19–24 June 2022, Granada, Spain
doi://10.3850/IAHR-39WC2521716X20221061

A sea to city approaching pattern

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1. Abstract

The Port of Almería, situated in the Mediterranean Coast of Spain, has a unique location due to its proximity to the city center. That is why, in recent years, the Almería Port Authority is developing a series of actions to promote the Port-City model defined in its Master Plan. For a first phase of action, intervention is proposed in the area close to the promenade, specifically in the areas of (1) the Levante Quay, (2) the Cable Francés structure, and (3) the Almadrabillas Maritime Front. For this purpose, the Joint Venture PROES/ ESTUDIO 7 is developing a detail engineering with two main objectives: (1) Improve infrastructures for cruise ship traffic, and (2) Provide the necessary infrastructures to the seafront in order to accommodate the Port-City actions. In this paper, the current situation of the area is first described and then the main activities to carry out are described, showing the main solutions proposed for each element.

Keywords: Port-city concept; Human-water integration; Urban-port planning; Maritime structures

2. INTRODUCTION

It is undoubted the relevance and impact that harbours have within our surroundings. Due to its proximity to the city, we cannot speak about port development without considering urban development. This fact has been the cause of the importance that the Port-city model has gained in recent years.

This concept acquires special relevance in the Port of Almería (Spain) given its proximity to the city center. Almería is faced with an unique opportunity to regenerate its city and turn its Port into a reference model. The current planning of the Almería Port Authority already presents a clear criterion regarding its future growth, and this is the growth towards the outer zone of the Port. It is a trend shared with many other Spanish and international ports, to move commercial traffic away from the areas closest to the urban centers, and to expand the infrastructures in order to meet the growing activity demand.

For that reason, in 2016, an agreement was signed between the Almería Port Authority, the Almería City Council and the Bahía Almeriport Foundation; in which they undertook to initiate and promote the necessary steps to change the current uses of disused port areas, as well as to plan the long-term integration of the Port-City of Almería. The Master Plan promotes the long-term transformation of the entire port front of the city in different areas (A.1 to A.6 in Figure 1).

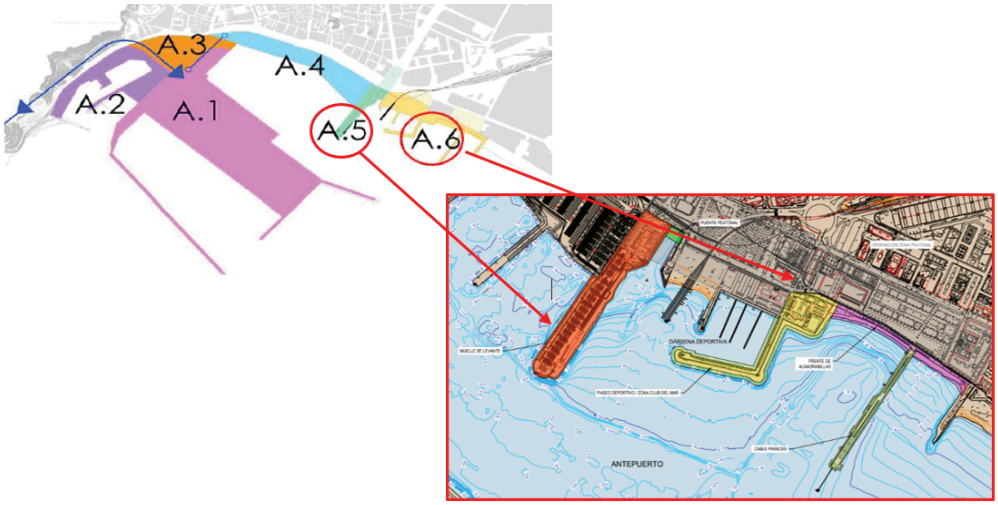

Figure 1. Areas of action considered in the Master Plan Port-City.

3. PROJECT SCOPE

For a first phase of action, intervention is proposed in zones A.5 and A.6 corresponding to the area of the Levante Quay, the Cable Francés structure, and the Almadrabillas Maritime Front; for which the drafting of a Project is awarded to the Joint Venture PROES / ESTUDIO 7, with two main objectives:

i. Improve infrastructures for cruise ship traffic.
ii. Provide the necessary infrastructures to the sea front to accommodate the Port-City actions.

The main activities are listed below:

- Levante Quay: It is intended to carry out the expansion, as well as the adaptation of the internal face of this quay to give a correct service to cruise traffic, given the advanced state of deterioration that it presents. It is a conventional vertical quay and is the oldest in the commercial dock of the Port of Almería.
- Cable Francés: This structure is an old mineral loading dock (constructed in 1920) in the beach. Because of its situation of deterioration, the Port of Almería wants to recover this space to turn it into another attraction for the city seafront.
- Almadrabillas Maritime Front: It will be developed a reorganization of the waterfront giving continuity to the promenade throughout the area.

The need for the adequate longitudinal interconnection of each and every one of the areas is proposed, providing them with adequate paving, services and urban furniture. This implies the need to widen the current pedestrian bridge, so that the current promenade connects its entire width with the Levante Quay.
The entire complex must be equipped with pavement and street furniture suitable for the new uses and that are compatible with the use of future developments of the Port-City Action.

4. CURRENT SITUATION

4.1 Levante Quay

The Levante Quay is actually a 40 m wide platform that penetrates the sea perpendicular to the coastline for just over 300 m. This infrastructure is protected from the waves on its eastern side by the corresponding mound breakwater, and in its western area it is a berthing structure made up of masonry blocks.

This quay is the oldest in the Port of Almería, currently housing cruise ship traffic. It has a 220 m long mooring line, 8 m draft and 2 m freeboard.

The existing public use facilities on this platform are the main offices of the Port Authority (2040 m^2), public toilets (40 m^2) and Harbor Master's Office and SASEMAR (629 m^2). Additionally, a public car parking extends along the esplanade that serves the Maritime Lines Terminal and other users, due to its proximity to the center of Almería. This quay is accessible to citizens, with two points of interest: the Royal Staircase and the quay viewpoint.

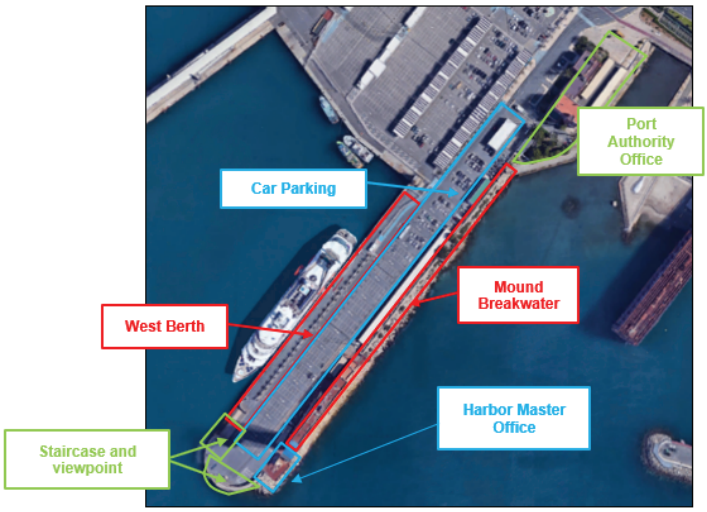

Figure 2. Plan view of the Levante Quay.

In addition to hosting the administrative facilities of the Port Authority and the port control tower, current port activity at the quay is limited to cruise ship traffic, always in transit. Therefore, the purpose of the remodeling and expansion of the Levante Quay is to boost cruise traffic, creating an attractive space for tourism through the creation of leisure, commercial and cultural activities.

One of the limitations of this quay for the development of cruise traffic is the impossibility of accommodating two vessels, simultaneously. Nevertheless, the main problem of the current quay is the process of degradation that it is suffering over the years due to a multitude of existing actions such as ship propellers, or by erosion and the constant loss of fines.

The following image shows the current degradation of the blocks that make up the quay.

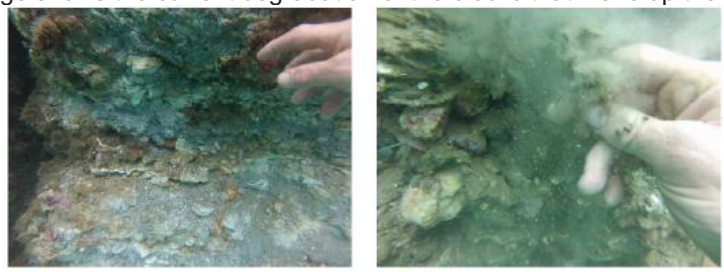

Figure 3. Block degradation in the Levante Quay.

4.2 Cable Francés

The Cable Francés is located within the surroundings of the San Miguel beach, specifically on the Almadrabillas beach, right between the commercial port and the marina, at the end of the Almería ravine. Currently in disuse, it was built with the aim of facilitating the unloading of iron material from the Alquife mines.

Figure 4. Cable Francés photograph. Mechanical moldboard in its last years of use (left) and current structure situation (right).

It is a concrete structure 315 m long and variable in width between 9 and 12 m, divided into three sections (built at different times).

The first section of 125 m built in 1920 (section A), has a lattice-shaped superstructure. With a width of just over 9 m, it was built on a foundation of precast concrete driven piles. Over the years, a widening was attached to it for the placement of the material transport belt, for which a new row of piles was driven, in this case metallic.

The central area (section B) is about 105 m long and was built shortly after the previous one. It also has a lattice-shaped configuration, with a width of 12 m. The foundation on driven concrete piles has both vertical and inclined elements.

For the protection of the pile foundations in section A and B, an enclosure of sheet piles was provided to prevent subsequent dredging tasks from causing them to erosion.

The final zone (section C) is 85 m long. It was built in 1975 and its configuration is completely different, with prestressed prefabricated beams on which the deck rests, founded by vertical and inclined metal piles.
The structure rises to a height of approximately +5 m above sea level and the water depth along the structure ranges from 0 m at the start to -15 m at its end. Over time, due to the lack of maintenance and wave action, this structure has been gradually deteriorating, having nowadays a worrying state of degradation that does not allow its use to the citizens.

4.3 Almadrabillas Maritime Front

The sea front covers, from east to west, the following elements: (1) the Levante Quay, (2) the pedestrian bridge of the Almería ravine, (3) the Cable Inglés, which is an ore loading dock that was in use from 1904 to 1970, (4) the marina, (5) the sailing club called Club del Mar, (6) the Cable Francés, and finally the (7) San Miguel beach breakwater; as can be observed in Figure 5.

Figure 5. Current arrangement of the Almería seafront.

The mouth of the ravine is formed by different channels that converge within the city. This area is normally a dry riverbed, with some occasional flood.

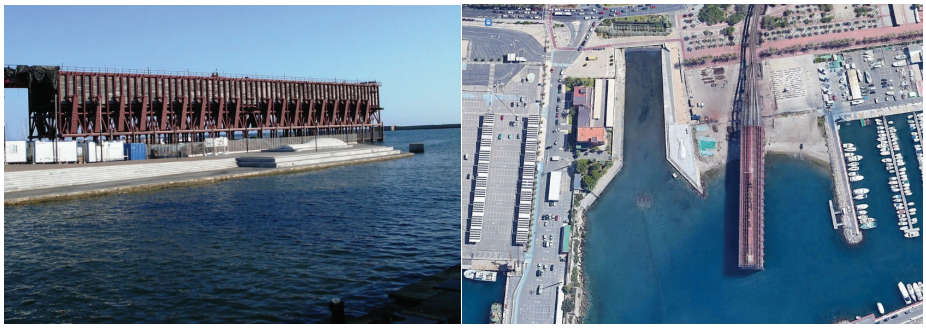

Figure 6. Ravine of Almería.

As commented before, there is no pedestrian communication with the Port itself, and the access of the citizens to the promenade is not easy as they have to cross different main roads with very intense traffic.

Therefore, the final objective of the environmental recovery of the Almadrabillas Maritime Front is to bring the citizen closer to the edge of the sea.

5. DESIGN PARAMETERS

5.1 Geotechnical information

A geotechnical survey was conducted in 2021. Seventeen boreholes were drilled in all areas of interest. In general, the stratigraphic column consist of two substrates: a more superficial one with medium/dense sand and a deeper one of dense sandy gravels, where rejection usually occurs in NSPT tests. However, in the surroundings of the ravine and the Levante Quay, another more superficial layer can be identified that varies between loose compact sand and muddy black clay.

5.2 Tidal information and sea level references

The reference sea levels are those obtained from the tide station located in the Port of Almería (Long: 2.48º W, Lat: 36.83ºN), with measurements from 01/01/2006 to 03/10/2021.

Table 1 shows the representative values of the sea water levels referred to the mean sea level (MSL), combining astronomical-meteorological tide, following the methodology of ROM 2.0-11 (2012). The reference level (Cero level) is situated +0.386 m over the MSL.

Table 1. Representative values of water levels referred to MSL, combined astronomical-meteorological tide (m). Values corresponding to 90% confidence intervals.

SEA WATER LEVEL	EXTREME VALUES (C.I. 90%)			MEAN VALUES (I.C. 90%)	
	T_R=500y	T_R=50y	T_R=5y	Non-excedence prob = 85%	Non-excedence prob = 50%
High Level	0.84	0.67	0.50	0.19	0.11
Low Level	-0.77	-0.63	-0.48	-0.27	-0.15

5.3 Wind

For wind characterization in the area, 30 years data series corresponding to the SIMAR node 2054080 (Long: -2.5º E, Lat: 36.667ºN) were obtained to Puertos del Estado, in a similar way to the waves; since its temporal extension allows the performance of a reliable statistical analysis both in average and extreme terms.

The most frequent wind speed is in the range 2 < Wv(m/s) < 4, with the maximum value recorded of 26.36 m/s. The most energetic winds take place in the months of October to April. The most frequent direction is the NE (19.5%), followed by the WSW (19.3%). Also, the most energetic winds come mainly from the WSW.

5.4 Wave agitation and overtopping

Historical wave data series were propagated using the SWAN model to the mouth of the port (Long: 2.46º W, Lat: 36.82ºN). For this, the data in deep waters of the SIMAR 2054080 node, provided by Puertos del Estado, was considered. Figure 7 shows significant wave height rose at the entrance of the port.

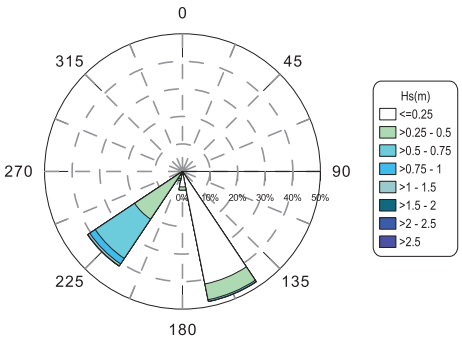

Figure 7. Significant wave height rose at the port mouth (Long: 2.46º W, Lat: 36.82ºN).

Once waves were characterized in this point, wave agitation was obtained inside the port using the MSP model developed by IHCantabria, considering the 27 agitation areas shown in the following figure.

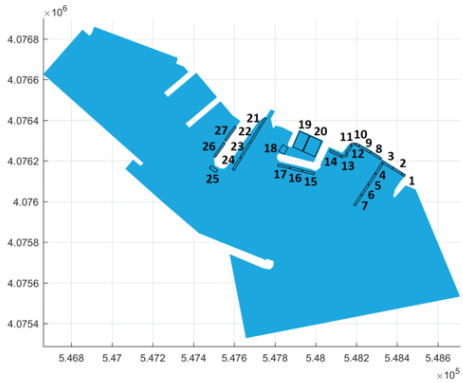

Figure 8. Control areas for wave agitation study.

Using the wave agitation results, wave overtopping was analyzed in all areas of interest considering EurOtop (2018) equations and the OpenFoam 3D model. The characteristics of the porous media of the model are were introduced based on literature studies (Higuera et al., 2014).

6. DESCRIPTION OF THE WORKS

Next sections summarize a description of the future works.

6.1 Levante Quay

In this infrastructure it is planned to conduct two interventions:

i. The repair of the west side (current quay)
ii. The enlargement of the quay, executing a new berthing line on the east side

Figure 9 shows a future plan view of the Levante Quay with the aforementioned actions.

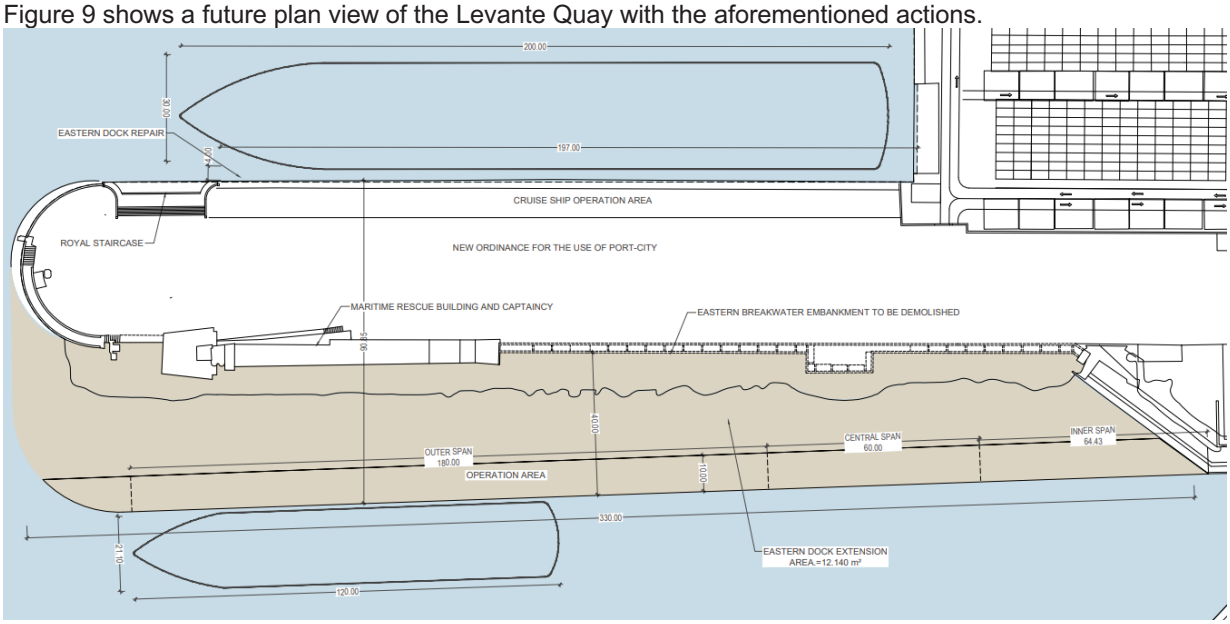

Figure 9. Plan view of the future Levante Quay.

6.1.1.Quay repair

This action is focused on the protection and reinforcement of the current quay. For this purpose, a new quay face will be executed, using an underwater formwork 3 m high and 10 m long. The new facing will be

anchored to the quay face to ensure its fixation. The anchor bolts will be made up of two threaded parts and will be placed inside PVC sheaths; In this way, when the formwork is removed, the outer part of the bolt can be removed, avoiding metallic elements to keep in contact with the sea water (the rest of the element can act as a connecting element between the concrete and the current blocks). Nevertheless, to guarantee the joint between the quay and the new concrete, additional metal bars will be placed.

Finally, the new superstructure will be built and bollards and defenses will be placed.

In order to maintain the depth of the quay (8 m), it will be necessary to dredge up to a level of -10.50 along its entire length, which represents an approximate volume of 4000 m^3 of inconsistent material (fine-sized sand with anthropic remains, gravel, even silt and clay). The section type of the projected works is shown below:

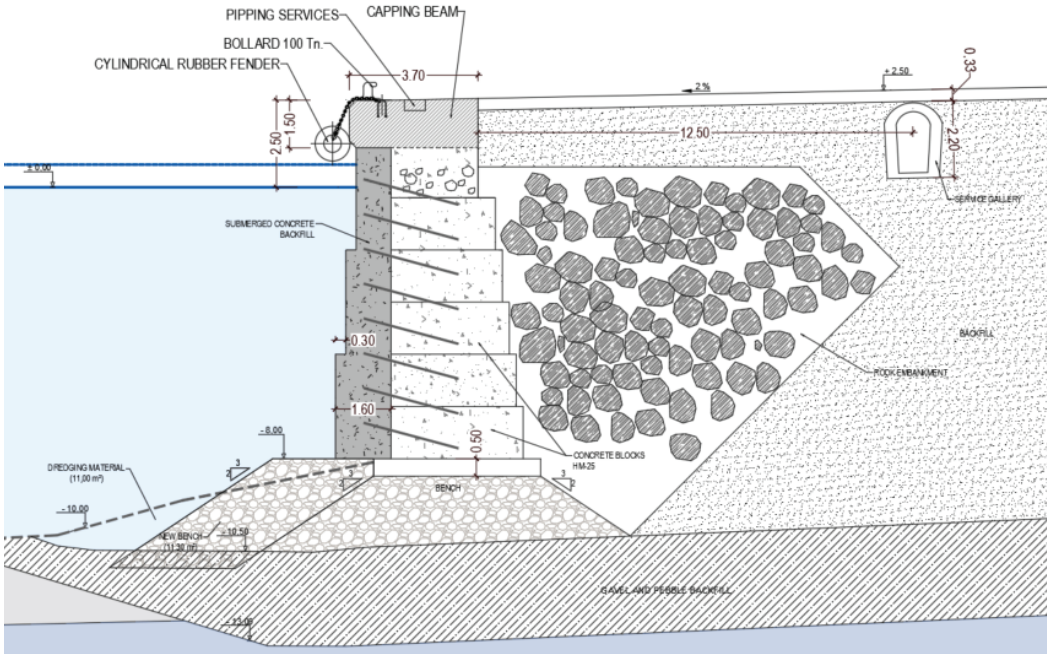

Figure 10. Proposed cross section for quay repair.

6.1.2.Quay enlargement

In the eastern side of the Levante Quay, actually covered by a mound breakwater, a new berthing line on will be constructed. The typology of this new alignment will be common vertical breakwater in order to make it easier for its esplanade to support the loads transmitted by the tourist and commercial uses. The construction of the quay will entail an extension of the current platform by 40 m in width along its entire length.

Due to the variation in water depth all along the quay, the alignment has been divided into three sections to optimize its design, each one founded at a different level.

The first section (section A) corresponds to the outer area of the quay. Its length is 180 m, starting from the head towards land. The structure in this section is founded at a height of -8.00, and its typology is defined as a concrete vertical breakwater with anti-reflective cells because of the problems of wave reflection in the area.

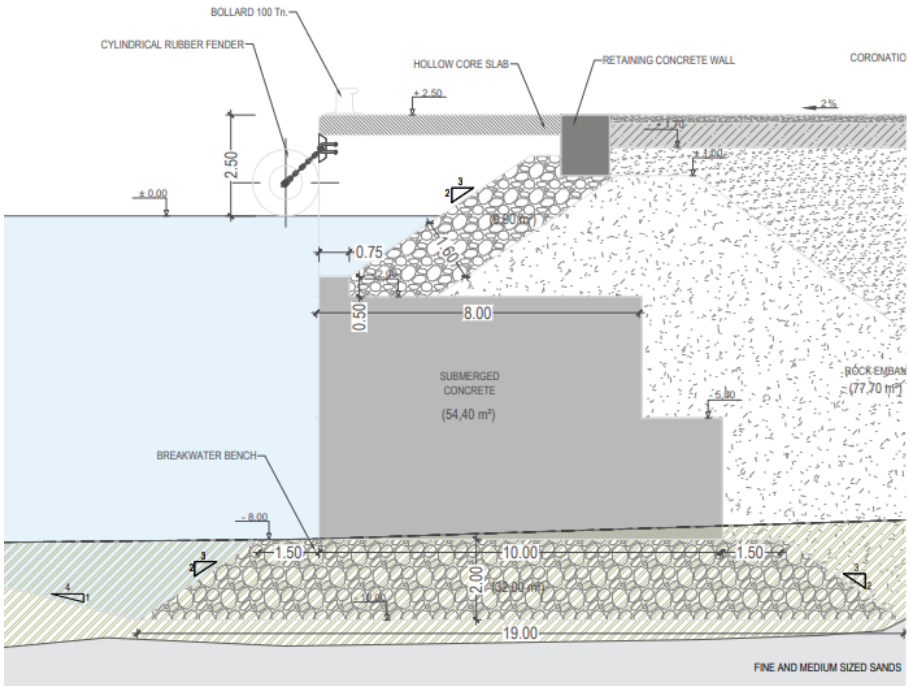

Figure 11. Proposed cross-section for quay enlargement.

The second section (section B) is very similar to section A with the main difference of the water depth (-5.0 m in this case instead of -8.0 m). Both sections rest on a rock foundation with mean weight of W_{50}= 200 kg.

The last part of the quay (section C) will be also very similar but without anti-reflective cells.

The new crest elevation will be +2.5 m.

As mooring systems, 25 bollards of 100 t and 25 cylindrical defenses will be placed every 12.0 meters.

6.2 Cable Francés

The proposal for the new Cable Francés consists of a double-height structure, with a lower area where the installation of different catering establishments is considered, and an upper level, which will be accessible through two ramps arranged on the sides of the deck. **Figure 12** shows the aforementioned proposal.

Figure 12. Future plan view of the new Cable Francés. Font: Sánchez.Cañete Arquitectos.

6.3 Almadrabillas Maritime Front

Among the actions to be carried out for the environmental recovery of the maritime front are those listed below:

- Remodeling of the coastal border: The maritime will be totally accessible to citizens. The review of the maritime climate and the elevation due to sea level will entail the redesign of the breakwater protections in the area between the San Miguel breakwater and Club de Mar. The front will be moved forward in order to provide greater width to the promenade for the enjoyment and use of

the population, taking into account the depth conditions in each area and, consequently, the allowable levels of wave overtopping that determine the structural typology.
In addition, the Club de Mar area will be also enlarged in order to have a continuous promenade with sea views.

Figure 13. Proposal for the expansion of the promenade. Font: Góngora Arquitectos.

- Citizen access to the marina: Access from the promenade to the marina is limited by the presence of the boatyard. Thus, this area will be relocated far from the promenade.
- Longitudinal interconnection of all the areas of the seafront: the current ravine located close to the Levante Quay (see **Figure 6**) will be widened and connected with the future promenade. For that, it will be required the creation of an infrastructure with its corresponding paving, services and urban furniture. In the next figure, it can be observed a photograph of the current situation of the pedestrian bridge over the ravine.

Figure 14. Current situation of the pedestrian bridge over the ravine.

7. CONCLUSIONS

Within the actions foreseen in the Port Authority Investment Plan, the Port of Almería intends to carry out the Expansion of the Levante Quay, as well as the adaptation of its internal face to provide a correct service to cruise traffic, given its advanced state of deterioration. The Levante Quay is built from masonry blocks and is the oldest in the commercial dock of the Port of Almería. Nowadays, it is dedicated almost exclusively to cruise ships. Given its type and the long period that the quay has been in service, it is convenient to improve and guarantee its operability in order to continue having this traffic. For this, it is necessary to proceed to consolidate both the superstructure of the face of the quay, as well as to provide it with the necessary equipment.

On the other hand, all the Almadrabillas area will be restored in order to give continuity to the entire promenade and with the main purpose of bringing the citizien closer to the seafront. To carry out these actions, a detail engineering is developed, taking into account wave conditions, wave overtopping, port operation and all the agents involved.

8. ACKNOWLEDGEMENTS

The authors thank the Almería Port Authority for the opportunity to develop this project and write this manuscript.

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