DHI CASE STORY

# SUPPORTING THE DESIGN OF A MAJOR NEW COASTAL HIGHWAY

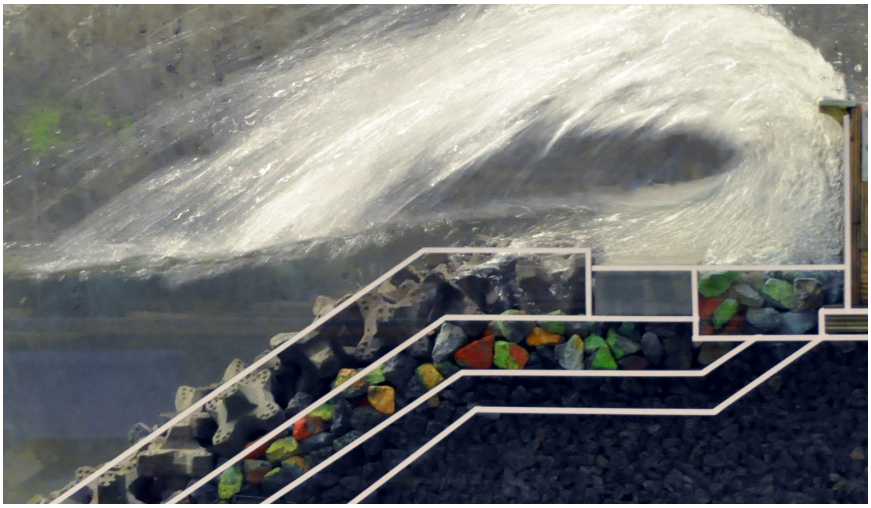
## Applying physical model tests to optimise and ensure structural performance

La Réunion's heavily trafficked coastal highway regularly faced threats from falling rocks and cyclones, often making it unsafe for vehicles to pass. As such, the Regional Government of La Réunion commissioned Egis to design and build a new, safer highway. We assisted them by using physical model testing to ensure the structural integrity of the new highway design.

### CONTRIBUTING TO THE DEVELOPMENT OF A NEW COASTAL HIGHWAY

Every day, more than 58,000 vehicles use the 13 km long coastal highway that connects Saint Denis and La Possession – La Réunion's two largest cities. In the past, falling rocks from the cliffs above the highway have caused many fatal accidents and road closures. In addition, the highway must also be closed when severe cyclones are predicted for the island due to the threat of heavy, cyclone-generated waves washing over the existing highway. In order to alleviate these threats, the Regional Government of La Réunion has decided to design and build a new, safer highway.

The Conseil Régional de la Réunion asked Egis (a French consultancy) to design the new highway. Specialised experts conducted detailed studies to determine the trajectories of the falling rocks and landslides experienced at the site.



*Testing stability and overtopping conditions in our wave flume of a cross-section armoured with ACCROPODE™ II units.*



## SUMMARY


### CLIENT

Egis, on behalf of the Regional Government of La Réunion

### CHALLENGE

Need to ensure the safety of the design of a new highway that will be located in a highly exposed coastal environment with high wave impact

### SOLUTION

Conducting physical model tests to optimise and validate the structural integrity of the new highway

### VALUE

Helped Egis develop safe and economically optimised structures for the new highway

### LOCATION / COUNTRY

Île de la Réunion, France

Based on this information, it was decided to build the new highway – partly on rubble mound revetments and partly on viaducts – located further away from the cliffs than the existing highway. This would still place the new highway in a marine environment with high wave impact, but at safe distance from the falling rock. To support Egis in building the new highway, we:

- determined the design wave conditions
- conducted physical scale model tests to optimise and verify the stability and overtopping conditions of the new coastal structures during extreme wave impact

## ASSESSING DESIGN WAVE CONDITIONS

Trade winds and cyclones govern the wave climate at La Réunion. Waves due to trade winds occur regularly, however they are not extreme. Cyclone waves, which strike the island occasionally, cause the extreme wave conditions that were used to design the new coastal road. We used our MIKE by DHI numerical modelling and analyses tools to determine the design wave conditions based on a hindcast study of historical and synthetic cyclones, followed by statistical analyses.

## PHYSICAL MODEL TESTING OF REVETMENTS CROSS-SECTIONS

First, we tested the efficiency of different types of cross-sections of the rubble mound revetments in a wave flume. We varied the following parameters:

- geometry of the cross-sections
- type of armour units
- toe structure
- deflecting wave screens

Since depths along the new alignment of the highway vary between 5 m and 11 m, we tested these cross-sections at four different depths (5 m, 7 m, 9 m and 11 m). Using the data from these tests, we developed a typical cross-section that met the criteria for acceptable overtopping discharges as well as armour and toe stability.

Next, we tested stability and overtopping conditions of specific stretches of the causeway in our wave basins, including:

- transitions between rubble mound and viaduct
- junctions
- bends
- outlets/culverts through the revetment
- outlets of canyons

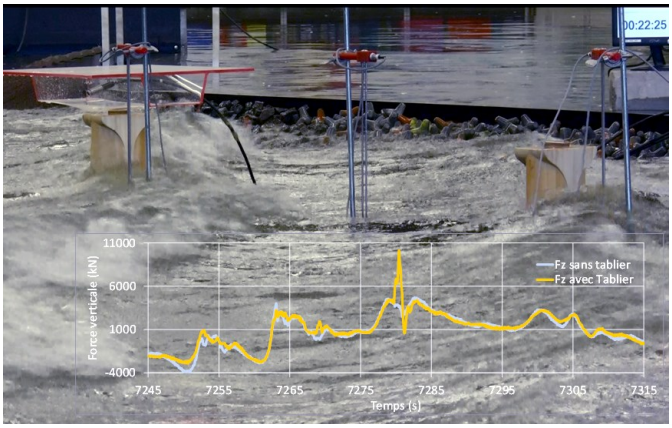
These tests assessed the effects of the three-dimensional geometry of the causeway and variations of the seabed in front of the structures, ensuring the successful design of these specific stretches.

## FORCES ON WAVE SCREENS AND BRIDGE PIERS AS WELL AS WAVE IMPACT ON BRIDGE DECK

We mounted strain gauges and pressure cells on the wave screens and bridge piers (both very exposed structural elements) to record the forces on them caused by wave impact, including wave slamming. Time histories of these forces and pressures – recorded with high sampling frequency during extreme wave impact – could then be used by Egis for the detailed structural design of the wave screens and bridge piers.

In addition to the wave screens and bridge piers, the air gap (height above sea level) of the bridge deck was an important viaduct design issue – extreme waves should not reach it. As such, we carried out detailed wave monitoring in the most exposed sections of the viaduct in our wave basins. We did this in order to provide the information necessary for the longitudinal profile design of bridge elevation – taking into account the effects of wave set-up and surf-beat in the coastal zone.

Our physical model tests enabled Egis to further optimise and validate the structural integrity of the design for the new coastal highway. This enabled them to ensure that the bridge is safe for the people who use it on a daily basis – even under harsh environmental conditions.




*Recording wave forces on bridge piers and deck as well as monitoring wave and water levels at the viaduct alignment.*

## CLIENT TESTIMONIAL

> *We hope to work together with DHI again. It was very rewarding!*
> *Jacques Piallat — Expert in coastal and port facilities — Egis Port*

Contact: info@dhigroup.com
For more information visit: www.dhigroup.com