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# *Design of Artificial Beaches and Improvement of Rocky Shore Natural Beaches*

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## ▶ **CONTENTS**

- Solutions for artificial beaches and improvement of rocky shore natural beaches
- Design approaches of artificial beaches
- Selected examples of artificial beaches in Venezuela and Chile



# ***ARTIFICIAL BEACHES AND IMPROVEMENT OF ROCKY SHORE NATURAL BEACHES***

- ▶ Marine works may be required where:
  - There are not natural beaches
  - Existing beaches are in a rocky shore



# ***SOLUTIONS FOR NEW BEACHES OR IMPROVEMENT OF EXISTING BEACHES***

- Construction of protection structures (arc breakwaters, T- head groins, submerged breakwaters)
- Sand nourishment and removal of bottom rocks

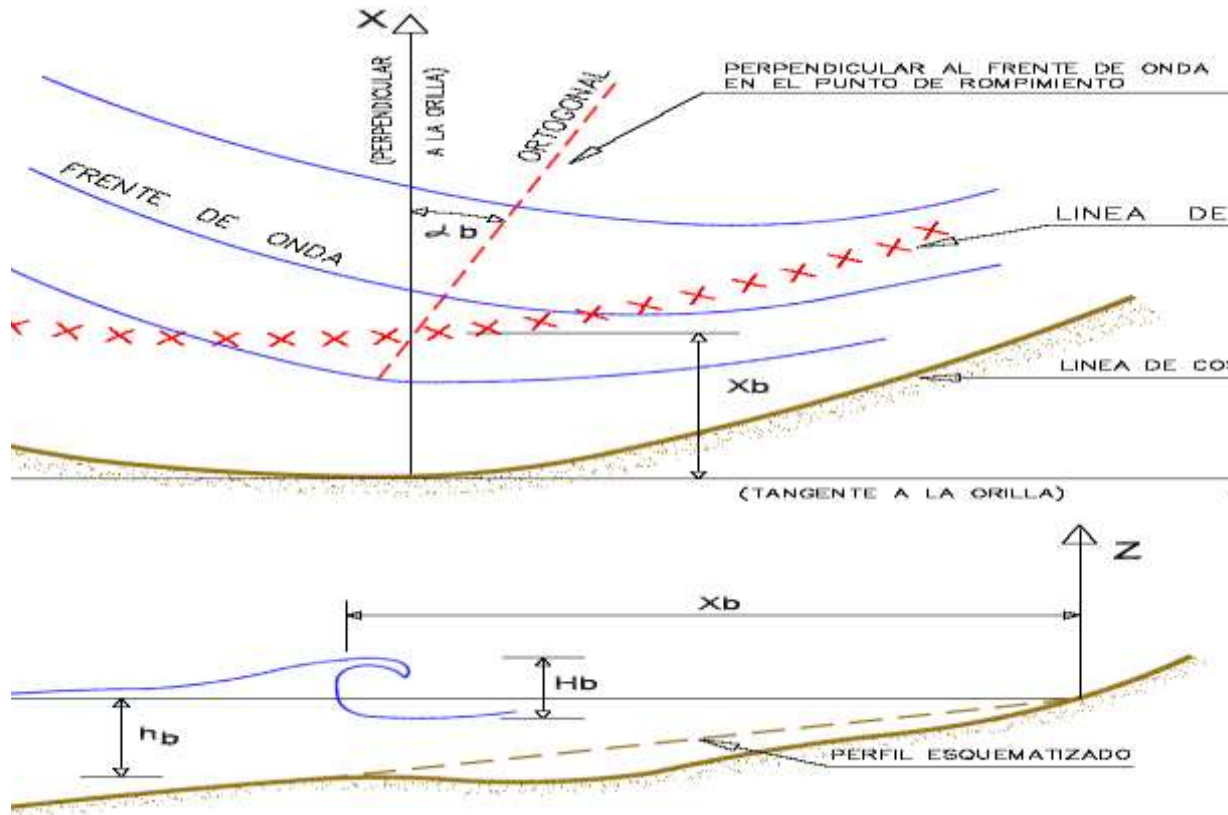


# ***DESIGN APPROACHES OF ARTIFICIAL BEACHES***

- Geometric approaches: empirical bay shape equations (Hsu and Evans, 1989; Hsu, Yu, and Silvester, 2010)
- Hydrodynamic approaches: zero net transport (Suárez Bores, 1974; Font, Sanabria and Silva, 1974; Broker, 2006; Weesakul et al, 2010)



# BEACH PARAMETERS



$$Q_l = H_{sb}^2 \cdot C_{gb} \cdot (a_1 \cdot \sin 2 \cdot \alpha_b - a_2 \cdot \cos \alpha_b \frac{\partial H_{sb}}{\partial y}) = 0$$



# LONGSHORE TRANSPORT

In any generic point of the beach:

$$Q_S = Q_L + Q_G$$

Where:

$Q_S$  = Net longshore transport of sand

$Q_L$  = Longshore transport due to breaking wave obliquity

$Q_G$  = Longshore transport due to breaking wave height gradient

According to CERC:

$$Q_L = 0.11 H_b^{5/2} \cdot \sin 2\alpha_b \quad (\text{m}^3/\text{seg})$$

$$Q_G = K H_b^{5/2} \cdot \text{m}^{-1} \frac{\partial H_b}{\partial y} \cos \alpha_b$$

$$K = 0.2 - 0.7$$

$\alpha_b$  = angle of breaking wave front with the shore



From Incostas' experience from built artificial beaches:

$$Q_G = 0.3 H_b^{5/2} m^{-1} \left( \frac{\partial H_b}{\partial y} \right)^{0.7} \cos \alpha_b$$

The null transport condition from those equations are:

$$\sin \alpha_b = 0.13 m^{-1} \left( \frac{\partial H_b}{\partial y} \right)^{0.7}$$

For null longshore current (Font, Sanabria, and Silva, 1974)  
(Equilibrium in radiation stresses)

$$\left( \frac{\sin \alpha_b \cdot \cos \alpha_b}{3 - 2 \cdot \cos^2 \alpha_b} \cdot \frac{H_{sb}}{x_b} \cdot \frac{1}{\partial H_{sb} / \partial y} \right) = 0.5$$



***LOS CARACAS BEACH, Venezuela***



# ***EFFECTS OF SUBMERGED BREAKWATERS***

- Submerged breakwaters with crest elevation close to mean sea level reduce wave height approximately to half
- Breaking wave height is constant along the shoreline; therefore shoreline is straight and parallel to the wave front outside the submerged breakwater
- The waves overtopping the breakwater crest will induce strong balance currents in the lee side unless the beach is enclosed by transverse jetties
- Combination of submerged and embracing breakwaters may be required to obtain a desired shoreline configuration



# CAMURI CHICO BEACH, Venezuela



# ***SELECTED EXAMPLES OF ARTIFICIAL BEACHES IN VENEZUELA AND CHILE***



# ***ARTIFICIAL BEACHES IN VENEZUELA***

- Recreational artificial beaches have been built since the 1950s in the Caribbean littoral close to the city of Caracas (Nouel, 1962).
- It is a mostly rocky shore affected by the trade winds generated waves which are not very high (significant wave height normally between 0.75 m and 1.50 m) but almost without calm periods.
- Breakwater protection was required for the safety of bathers and retention of nourished sand.



# ORICAO CLUB, Venezuela



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# MARINA GRANDE, Venezuela



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# MACUTO BEACHES, Venezuela



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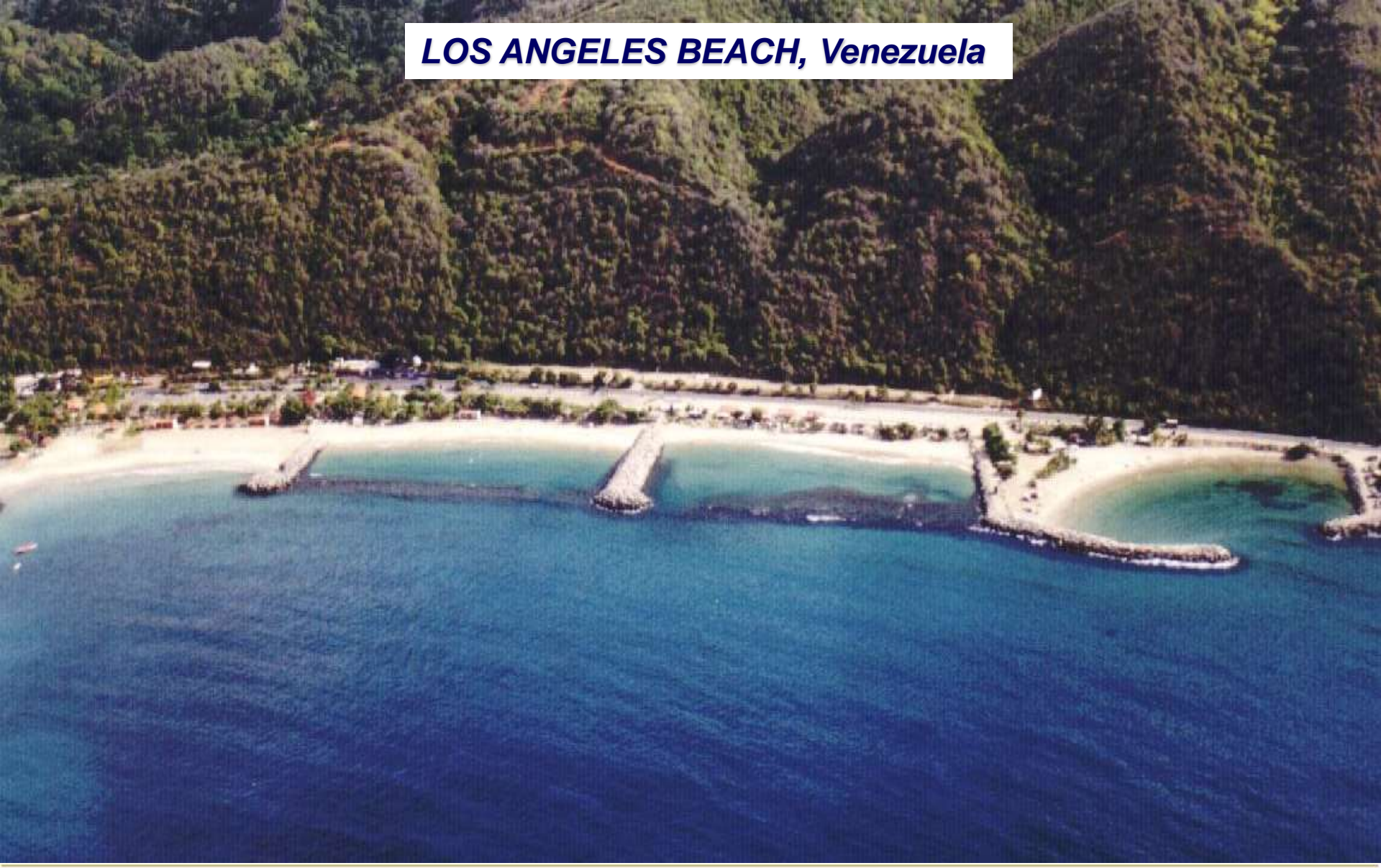


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# SHERATON HOTEL, Venezuela (built in 1956)



# LOS ANGELES BEACH, Venezuela



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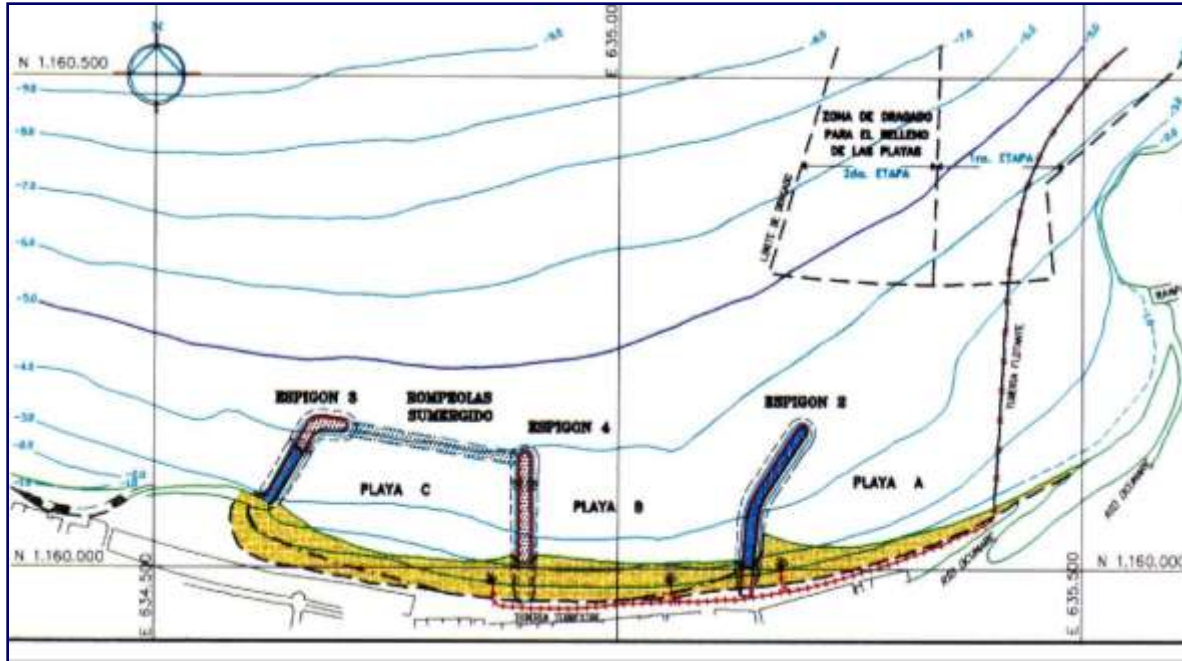
# CAMURI GRANDE CLUB, Venezuela



# LOS CARACAS BEACH, Venezuela



# OCUMARE DE LA COSTA BEACH, Venezuela





**PALMAR ESTE, Venezuela**



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# ARTIFICIAL BEACHES IN CHILE

Similar geological conditions to those found in the coastal area close to Caracas, are present in the Pacific shore in Northern Chile, where sea water temperatures and fair weather are favorable to beach recreation. But since the Pacific wave regime is rougher than in the Caribbean, the Coastal Engineering challenges were greater and physical hydraulic modeling was used in most cases. Several artificial beaches have been built in the past decade and are successfully performing.



# El Carboncillo Beach, Chile

## HYDRAULIC MODEL – NATIONAL HYDRAULICS INSTITUTE





**CARBONCILLO, ANTOFAGASTA, Chile**



# MUNICIPAL ANTOFAGASTA BEACH BEFORE IMPROVEMENT WORKS



# MUNICIPAL ANTOFAGASTA BEACH - DESIGN



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# MUNICIPAL ANTOFAGASTA BEACH AFTER IMPROVEMENT WORKS



# TROCADERO, ANTOFAGASTA, Chile



# TROCADERO, ANTOFAGASTA, Chile



# TROCADERO BEACH, ANTOFAGASTA, Chile



# COVADONGA BEACH HYDRAULIC MODEL NATIONAL HYDRAULICS INSTITUTE



# CONCLUSIONS

- ✓ Artificial beaches are a valid solution for recreation and shore protection
- ✓ Geometrical and hydrodynamic approaches could be used for design of artificial beaches
- ✓ Design of artificial beaches should carefully provide the desired plan form as well as a safe and comfortable environment to bathers
- ✓ Mathematical and physical models are useful tools for design of artificial
- ✓ In Venezuela and Chile there are many good examples of artificial beaches that are functioning properly



***THANK YOU***



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