Coastal Erosion Management at Yucatan, Mexico: Engineering Efforts and Experiences

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INTRODUCTION

The coast of Yucatan, located in the Gulf of Mexico, is a fragile island barrier system where beach erosion has turned into a problem since the last 25 years. This, in combination with hurricane strikes (Gilbert (1988), Isidore (2002)), led to environmental damages along about 300 km, in 60 km of which, the coastal infrastructure is at risk; fact that decreased the coastal development. Mitigate the erosion required emergency protection works mainly made by beach property owners. The lack of planning and engineering design resulted in areas with high erosion rates and the destruction of neighboring beaches and properties.

Is known that in order to achieve a sustainable management of coastal system changes, it´s necessary to involve the expertise and knowledge of stakeholders (local residents, government, academic groups and private consultants). The purpose of this poster is to present the experiences from projects dealing with coastal erosion issues that AXIS Ingenieria has conducted being the goal of these efforts, the development and implementation of a Yucatan beach management program.

BACKGROUND OF HUMAN CAUSES FOR COASTAL EROSION

Among the most important causes that enhanced erosion phenomena along Yucatan are: **(1)** construction of Progreso pier affecting littoral drift causing erosion at the west side beaches[1], **(2)** shore normal rock-timber and sand-bags groins constructed empirically by property owners accelerating erosion and stimulating even more groin construction, **(3)** during 90´s groin construction shifted to the east (up-drift) of Progreso Port, where the shoreline used to have natural behaviour and **(4)** in the last 25 years urban, touristic and fisher industries growth in the region, force the construction of jetties for small harbours along the coast.

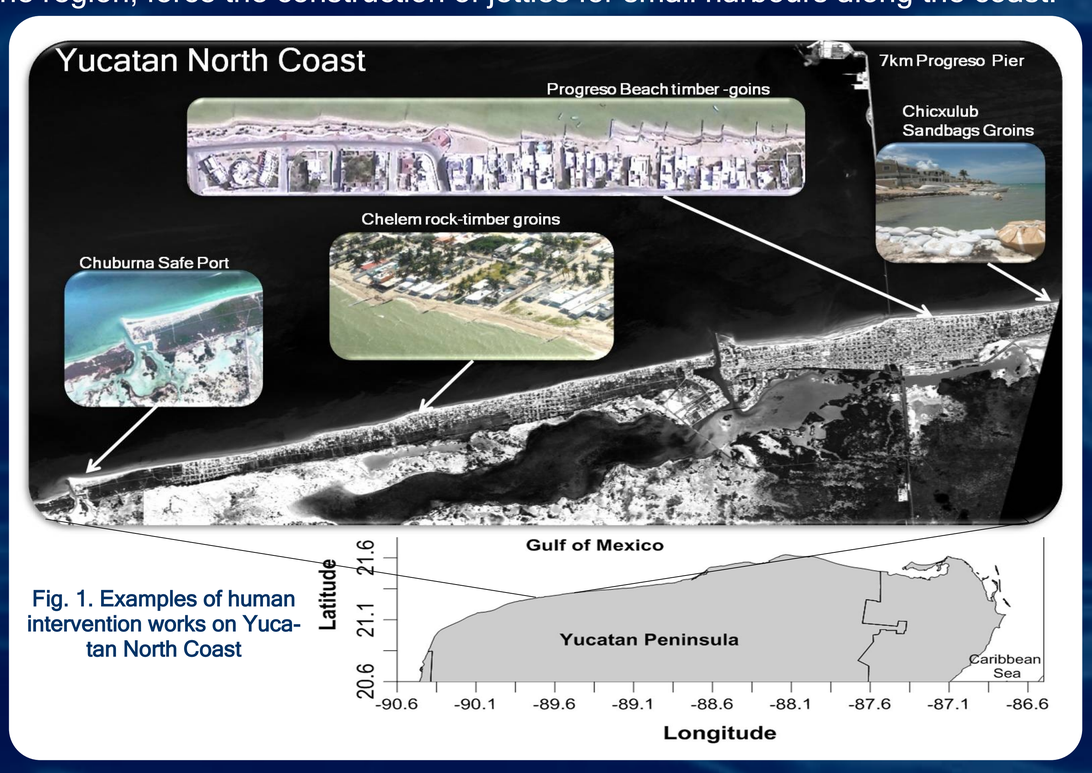

Fig. 1. Examples of human intervention works on Yucatan North Coast

EFFORTS TO MANAGE COASTAL EROSION

Different based-engineering's efforts have been made in order to mitigate and to try to solve erosion problem in the long term. Axis Ingeniería, as well as academic research institutions, in conjunction with federal and state authorities (i.e. Ministry of Environment - SEMARNAT) started in 2002 the promotion of programs for beach rehabilitation consisting on groins removal and the use of soft solutions (i.e. structures based on geosynthetics for shore protection)[2]. After the removal of groins, a nourishment in 2002 of Progreso Beach along 7 km, has been one of the most successful efforts (technically and economically) among the beach restoration program, allowing the development of a stable system for about 10 years, even without maintenance works.

These efforts started to have good results on coastal zone preservation in the short-term. However, as expected, local solutions will never offer the possibility to recover a healthy beach system under the same littoral dynamics processes.

Progreso Beach after timber groin remotion and nourishment

Fig 2. Based-engineering efforts for long term beach rehabilitation at Yucatan coast

INTEGRATING THE COASTAL SYSTEM KNOWLEDGE

Based on local knowledge obtained with the use of measures that have disregarded the equilibrium of sediment transport processes; Axis Ingenieria used these experiences in combination with technical, environmental legal requirements, capabilities of the local community and socio-economic tools to implement soft and easily removal structures using geotextile tubes along the coast, that had resulted on positive experiences for beach/dune protection and recovery (i.e. Progreso to Chicxulub , Telchac and Las Coloradas beaches , Yucatan).

Here, the coast is characterised by waves of low height (<0.5–1 m) approaching from NE[3] over a monotonic slope (1/1000 m) and a mixed tide regime (ranges 0.1 and 0.8 m neap / spring tides respectively).

These conditions determine the design parameters and the installation conditions of geotextile structures mainly as submerged detached breakwaters between 0.7–1 m depth and at -0.3 m (MLWL) referred to MSL. This cross section (Fig. 3) has proven to be an optimal design for the proper accumulation of sand and as an effective coastal protection measure for various stretches of coast along Yucatan.

Fig. 3. Geotextile tube cross-section at Chicxulub and beach accretion sequence

Monitoring beach surveys using DGPS between October 2010 and April 2012 show that shore parallel structures based on geotextile tube are capable to dissipate enough wave energy, creating calm zones that allowed the sand sedimentation and the consequent beach profile accretion. As an example, during this period, the coastal structure promoted along ≈500 m of coastline, the accumulation of ≈+6000 m³ of sand and a beach growth around 15 to 20 m, despite the wave climate variations (P1, P2, P3, Fig 4), remaining stable.

The accumulation process is enhanced by two reasons: **1)** the structure was constructed before the storm season (Hs > 1m, from N) changed to a low energy patterns, short period waves approaching from NE-ENE and **2)** by the fact that coast is dominated by longshore sediment transport processes.

Since erosion problems are due to gradients in longshore it means that the application of any kind of structures to stop or reduce erosion in a isolated way, always will results in a reduced input of sediments down-drift, only shifting the problems.

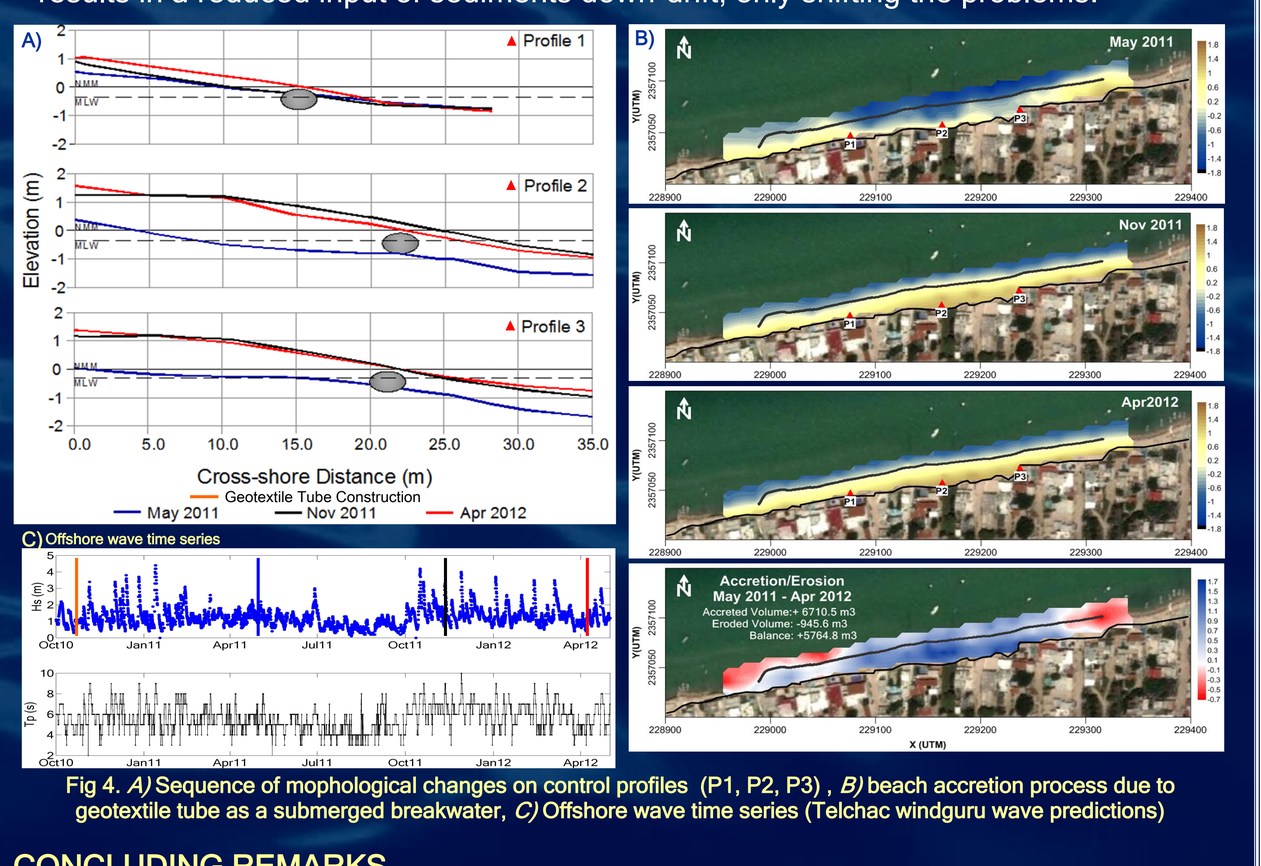

Fig 4. *A)* Sequence of mophological changes on control profiles (P1, P2, P3) , *B)* beach accretion process due to geotextile tube as a submerged breakwater, *C)* Offshore wave time series (Telchac windguru wave predictions)

CONCLUDING REMARKS

Although these efforts and experiences have been positive and useful for this type of coast; are still isolated and therefore insufficient to manage erosion problems from a global perspective.

The short-term goal for Yucatan coast is to achieve the development of methodologies for designing science-based, cost-effective and socially embraced intervention alternatives, suitable for coastal erosion management.

Based on lessons learned using geotextile tubes for coastal protection, it is necessary combine other strategies; specifically, by-pass systems and beach nourishments to reach this goal.

The iterative process of communication and the urgent information exchange between research (science driven) and coastal zone management agencies (federal government) including consultants is imperative.

The challenge for a long-term solution is the integration of the expertise and knowledge of all the stakeholders, to generate sustainable actions and programs for a planned coastal management of erosion in Yucatan.

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Funding is kindly appreciated from FIT-CONACYT Project: ECO-2011-CO1-164549.