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Secondary Flows and Sediment Transport due to Wave - Current Interaction

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Objectives:

The main purpose of this study is to determine the modifications of coastal processes driven by wave-current interaction and thus to confirm hydrodynamic mechanisms associated with the interaction at river mouths and tidal inlets where anthropogenic impacts were introduced. Further, the aim of the work has been to characterize the effect of the relative strength of momentum action of waves to the opposing current on the nearshore circulation where river flow was previously effective to entrain sediments along the shoreline. Such analytical information are useful to provide guidelines for sustainable design of coastal defense structures.

Methodology and Analysis:

Use is made of an earlier study reported by the authors (1983) on the interaction of horizontal momentum jets and opposing shallow water waves at shorelines, and of an unpublished laboratory study (1980). The turbulent horizontal discharge was shore-normal, directed offshore, and the incident wave direction was shore-normal, travelling toward shore. Flow visualization at the smooth bottom and the water surface, velocity and water surface elevation measurements were made. Results were obtained for wave , current modifications as well as the flow pattern in the jet and the induced circulation on both sides of the jet, for a range of wave and jet characteristics.

The experimental data, obtained from measurement in the 3-D laboratory basin, showed several distinct flow pattern regimes on the bottom and the water surface. The observed flow circulation regimes were found to depend on the ratio of the wave momentum action on the jet to the jet initial momentum.

Based on the time and length scales of wave and current parameters and using the time average of the depth integrated conservation equations, it is found that the relative strength of the wave action on the jet could be represented by a dimensionless expression; $\mathrm{R_{sm}}$

$$\mathrm{R_{sm}} \approx \frac{\frac{1}{2}\rho_{\mathrm{S}} \mathrm{a}_0^2 \mathrm{g} \left(\frac{\mathrm{L}_0}{\mathrm{h}}\right) \mathrm{C_g}}{(\mathrm{C}_0 - \mathrm{U})} / \rho_0 \mathrm{U}^2 \mathrm{w} \tag{1}$$

In the above dimensionless expression, ρ_{s} is the seawater mass density, ρ is the river current mass density, a_0 is the deep water wave amplitude, g is the acceleration of gravity, $\mathrm{C_g}$ is the wave group velocity, L is the deep water wave length, h is the average water depth near the river mouth, C_0 is the deep water wave phase velocity, U is the average jet exit velocity and w is the river or the tidal inlet effective width. The values of the above number were found to be in the range between 1.0 and 6.0-8.0 for the examined laboratory and field case studies for non-buoyant jets. Upper bound corresponds to cases of higher wave activity on the coast while the lower bound corresponds to cases of tidal currents with minimum wave activity,

Coastal Processes Modifications due to River and Ebb Current Interaction with Opposing Waves:

Confirmation of the obtained theoretical expression was obtained by comparison against field data for shoreline variability at river mouths and the formation of accretion shoals and erosion spots at tidal inlets and ocean outfalls in the USA and the Nile delta coastline. The predicted extent of the coast reshaping process, due to shoreline erosion and subsequent accretion, due to the absence of the river Nile current after 1965, east of the Rosetta headland, was determined. The obtained shoreline erosion spatial extent using the above correlation showed that the long term length of coastline recession would be in the neighborhood of 16-20 km east of Rosetta headland

(1990-2014). Such results were further confirmed by the recent satellite data (Ghoneim, et al, 2015). The results of the present work were well compared to the data on Fort Pierce Inlet, Florida, where severe erosion is known to exist on both sides of the inlet (Joshi, 1983). The current results are qualitatively in parallel to that obtained recently by the numerical model Delft3D coupled with the wave model SWAN (Nardin, et al, 2013) on wave-current interaction at river mouths and the formation of mouth bars.

Further analyses were also conducted to test the validity of the derived expression to the cases of wave interaction with buoyant currents in shallow waters. The buoyant jets represent the thermal discharges from power plants on coastlines of Diablo Canyon cove in CA at the Pacific Ocean (Ismail, et al,1988) and at the northern coast of Egypt at Al-Arish. The comparison showed higher values range of R_{sm} for the cases of buoyant jets.

References:

Ghoneim, E., Mashaly , J., Gamble, D., Halls, J., and AbuBakr, M. (2015). "Nile Delta Exhibited a Spatial Reversal in the Rates of Shoreline Retreat on the Rosetta Promontory; comparing pre- and post-beach protection", *Geomorphology*, 228,1–14.

Ismail, N. (2007). "Reynolds Stresses and Velocity Distributions in a Wave-Current Coexisting Environment", Discussion, *J. Waterway, Port, Coastal, and Ocean Engineering*,10.1061/(ASCE)0733-950X(2007)133:2(168),168-170.

Ismail, N.M., Wiegel, R.L., Ryan, P.J., and Tu, S. W. (1988). "Mixing of Thermal Discharges in Coastal Waters" , *21 st International Conference on Coastal Engineering*, ASCE, Malaga, Spain, 2521-2535.

Ismail, N. (1984). "Wave-Current Models for Design of Marine Structures" , *Journal of Waterway, Port, Coastal and Ocean Engineering*, Vol. 110, No. 4, 432-447.

Ismail, N.M. and Wiegel, R.L. (1983). "Opposing Waves Effect on Momentum Jets Spreading Rate", *J. Waterways, Port, Coastal and Ocean Division, Proc.*, ASCE, vol. 109, No.4, 465-483.

Joshi, P. and Taylor, R. (1983). "Circulation Induced by Tidal Jets." *J. Waterway, Port, Coastal, Ocean Eng.*, 109(4), 445–464.

Nardin, W., Mariotti, G., Edmonds, D., Guercio, R., and Fagherazzi, S. (2013). "Growth of River Mouth Bars in Sheltered Bays in the Presence of Frontal Waves." *Journal of Geophysical Research: Earth Surface*,10, 872-886.