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Simulating Submarine Slope Instability Initiation using Centrifuge Model Testing

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COSTA is addressing the questions of why seafloor slope failures occur where they do, and with what frequency they occur. The original program has been recently complemented by COSTA-Canada, (Université Laval, 2000) to include:

1. Assessment of historical records of slope instability, slope parameters, seismicity, and tectonic setting;
2. Understanding of seafloor failure dynamics through 3-D imaging of sediment architecture and geometry of slope failures;
3. Understanding of sediment properties of slip planes and areas prone to slope sliding;
4. Determination of presence of gas hydrate and its significance for slope stability;
5. Modelling of forces and mechanical processes that control the initiation of slope instabilities (release mechanisms), flow dynamics and initiation of tsunamis; and
6. Assessment of risk-fields related to slope stability.

The initiation of slope instability under task 5 will be addressed using numerical and centrifuge modelling. Centrifuge model testing is a physical modelling tool for geotechnical engineers. Analogues to this technique exist in other branches of civil engineering, such as wind tunnel testing in aeronautical engineering and flume testing in hydraulic engineering. To achieve mechanical similitude in geotechnical models it is necessary to reproduce the material behaviour both in terms of strength and deformability. This behaviour is primarily a function of the effective stress resulting from self-weight, pore pressure and external loads.

Centrifuge modelling is a technique for investigating gravity dependant phenomena, such as soil slope behaviour, using reduced-scale physical models. If the model is made at 1/100th scale and is accelerated in a centrifuge to 100g, the stresses due to self-weight will be similar to the stresses in the prototype at homologous points. The model can then reproduce the phenomena of cracking, rupture or flow that would be observed in the prototype because the stress dependency of soil behaviour has been correctly simulated. Murff (1996) describes the principles, scaling laws and some offshore applications of centrifuge modelling.

The failure of a 16^{o}, 8.8m high loose sand submerged slope was simulated by centrifuge modelling (Phillips and Byrne, 1995). Surcharging the slope crest caused the model slope to liquefy and flow with deep-seated lateral movements to an angle of 7^{o}. The initiation of submarine slope instability has been attributed to triggers such as earthquakes, erosion, oversteppening, wave loading, gassy soils and sedimentation. Centrifuge modelling has been used to simulate most of these loading conditions in similar boundary value problems. For examples, the VELACS (Verification of Earthquake Liquefaction Analysis by Centrifuge Studies) program included simulations of lateral spreading of submerged slopes due to earthquake effects (Popescu and Prevost, 1995). Wave loading has induced seafloor liquefaction and mobility (Phillips and Sekiguchi, 1992). Continuous rapid sedimentation induces persistently high pore pressures (McDermott et al, 1999) that may result in subsoil instability.

References:-

Université Laval (2000) http://www.costa-canada.ggl.ulaval.ca/

Murff, J.D., 1996, The geotechnical centrifuge in offshore engineering. OTRC Honors Lecturer, Proceedings of Offshore Technology Conference, Houston, Texas.

Phillips, R. & Byrne, P.M. 1995. Modelling flowslides due to static loading. Transportation Research Record, 1504: 12-21, National Academy Press, Washington.

Phillips, R. and Sekiguchi, H. (1992) Generation of water wave trains in drum centrifuge. Proceedings of Techno-Ocean '92, Yokohama, Japan, volume 1, pp29-34.

Popescu, R. and Prevost, J.H. (1995) Comparison between VELACS Numerical 'Class A' Predictions and Centrifuge Experimental Soil Test Results, Soil Dynamics and Earthquake Engineering, 14(2): 79-92.

McDermott, I.R., Hurley, S.J., King, A.D. and Smyth, S.J. (1999) "Development of an instrumented settling column for use in a geotechnical centrifuge". Proceedings of Symposium on the Geotechnics of High Water Content Materials, American Society for Testing and Materials, ASTM, Memphis, TN.