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Consultative Group on Blasting Regulations
Task Group on Study of Effects of Blasting Vibrations on Soil Slopes
Progress Report No. 1

Background

1. A Task Group has been formed under the Consultative Group on Blasting Regulations to study the effects of blasting vibrations on soil slopes. Members include Richard Pang, Lorne Woodrow, Lok Pang and Royce Kwok of GEO, Joseph Lo of MGS, David Salisbury of Arup, James Rickard of Dragages and Alan Kwong of HKU. Other persons who could contribute are invited to join the group from time to time.
2. The terms of reference of the Task Group is to initiate research projects to gain improved understanding, in order to support preparation of improved technical guidance for blasting assessment and implementation of blasting vibration control for soil slopes.
3. The following research projects are being planned as the first step:
   (a) monitoring at blasting sites to obtain good quality data for both surface and subsurface blasting,
   (b) analyses of the monitoring data to understand the characteristics and attenuation of the blasting waves through rock and soil, and
   (c) exploring alternative procedures for derivation of site-specific attenuation relationships and their application in blasting assessment for soil slopes to see if improvements could be achieved.
4. The Task Group will also explore the carrying out of comparative analyses (dynamic modeling versus pseudo-static analyses given in GEO Report No. 15) for different soil slope profiles, and of conducting laboratory dynamic testing. The objective is to evaluate the available methods of dynamic slope stability analysis for soil slopes subject to blasting waves to give the allowable PPV at a suitable location on the slope.
5. Private and public works projects with blasting to be carried out are being identified for the research. Members of the Task Group will provide technical input towards the design of the monitoring scheme and interpretation of the results, and examine if improved guidance could be formulated.
6. Up to now one project, viz. the Ocean Park Redevelopment Project, has been identified. The research under this project will be funded and implemented by Dragages. The following paragraphs outline the progress achieved to date.

Research at Ocean Park

7. The plan is to place seismographs at a range of distances sufficiently close to the blasting source to measure PPV values at the soil and rock surfaces and to capture the corresponding time histories in the radial, transverse and vertical directions. These are in addition to the seismographs required to be placed at the sensitive receivers under the BAR.
8. As the soil cover is thin (around 1-2m), for the rock monitoring stations pits will be excavated to rock which will be prepared to a level surface by applying cement mortar. For the soil monitoring stations, the ground will be prepared to a level surface by applying cement mortar after removing the vegetation. The stations will be surveyed to obtain the coordinates to within 0.1m. Geological logging will be carried out at the excavated surfaces to provide data for formulating the engineering geological model. (N.B. Consideration will also be given to obtaining soil samples for laboratory tests to determine strength and stiffness parameters for the dynamic slope stability analyses).
9. The PPV values obtained from the seismographs on rock will be correlated with the scale distances to examine the blasting wave attenuation through rock (grades I to III tuff) at this site. The attenuation relationship through soil will also be obtained using the soil seismograph data. Response spectrum will also be derived where possible.
10. The time histories close to the blasting source will be used as input to examine if the dynamic modeling could reproduce the responses at the various soil and rock monitoring locations, and also at the sensitive receivers. (N.B. Consideration will also be given to the feasibility of carrying out seismic refraction surveys, using the blast as the excitation source, to provide shear wave velocities for both the soil and rock layers for the dynamic modeling).
11. The following procedures are to be adopted for planning the monitoring locations and deriving the site-specific attenuation relationship:
    (a) use the 50% confidence level attenuation relationship from Li & Ng to determine the monitoring distances (in order for the seismographs to pick up significant PPV values),
    (b) monitor at least 10 points (equal numbers on soil and on rock) at varying distances from the blasting source, the distances will be such that the predicted PPVs at these locations are within the range say 5 to 50mm/s, roughly equally spaced in terms of log PPV,
    (c) in the first trial blast, monitor all sensitive receivers identified in the BAR, with the objective of checking the adequacy of the initial blast design, the

workmanship and the blasting assessment,

(d) if confidence can be established in the first trial blast, it is proposed to monitor only at the stations where the predicted PPV is larger than say 5mm/s or 50% the allowable PPV whichever is smaller,

(e) monitor a few points at the surface of the natural slope (about 30 degrees) near the rock monitoring points to provide data for assessing the accuracy of dynamic analyses to determine the slope response,

(f) use the data from the first blast designed with research data collection to establish the site-specific 95% confidence level rock attenuation relationship (but include only data greater than say 5mm/s in the plots and ignore the lower PPV values that are not of engineering significance), and then obtain the scale distances for PPV at 13, 25 and 50mm/s (i.e. SD_{13}, SD_{25} and SD_{50}) using the derived relationship,

(g) add the data from the next blast to the first batch of data and determine the 95% confidence level curve for the combined data set, obtain the PPV values at SD_{13}, SD_{25} and SD_{50}, and then calculate the percentage differences by comparing with 13, 25 and 50mm/s respectively,

(h) the steps in (f) and (g) are repeated until the percentage differences are less than 10%, and the curve obtained could then be taken as the site-specific relationship for predicting the PPV (at rock or soil level) at the sensitive receivers,

(i) as the geology may vary across the site (e.g. faults, shear zones, dykes, etc.), the process should be repeated to check for possible deviations,

(j) repeat the same process to obtain the soil attenuation relationship,

(k) use the rock attenuation relationship to predict the PPVs at the soil monitoring stations and compare with the PPV measurements made at the same locations, to check if there is any amplification of PPV or damping due to the presence of soil cover (N.B. It will be necessary to resolve the wave measurements in the direction of maximum slope response if appropriate).

12. The above approach will be reviewed and if necessary refined during the research.