

## FOREWORD

This report presents the findings of the Natural Terrain Hazard Study undertaken at the North Lantau Expressway. The Study Area comprises the natural terrain on the generally north-facing hillslopes below the mountain peaks of Pok To Yan and Por Kai Shan near Tung Chung New Town on Lantau Island. The North Lantau Expressway, which comprises the main vehicular link to the Hong Kong International Airport and Tung Chung New Town, is located at the toe of the natural terrain hillside.

The objectives of the Assignment are to study the natural hillside landslide hazards, evaluate the risks posed to the affected developments and facilities and, if necessary, identify suitable mitigation strategies and necessary mitigation works and the corresponding design requirements.

The natural terrain hazards within the Study Area have been investigated by undertaking a detailed desk study including aerial photograph interpretation, followed by geomorphological and engineering geological mapping fieldwork and a focused ground investigation.

Open hillslope landslides and channelised debris flows have been identified as the dominant landslide processes within the Study Area. No deep-seated landslides were identified. Rock fall and boulder fall hazards were also identified but were not found to be significant.

A Quantitative Risk Assessment was undertaken to estimate the potential losses associated with landslides that could be expected. The risks have been estimated in terms of Potential Loss of Life and Potential Economic Loss.

The main facilities at risk at the toe of the hillside include the North Lantau Expressway, Cheung Tung Road, Yu Tung Road, the MTR Airport Express Line, and the MTR Tung Chung Line. The North Lantau Expressway in particular is heavily used with average annual daily traffic of about 42,000 vehicles. The North Lantau Expressway is the main vehicular link to the Hong Kong International Airport. The daily value of airline passengers travelling to the Hong Kong International Airport via the North Lantau Expressway is estimated to be about HK\$ 230 million and the daily value of airline cargo travelling to the Hong Kong International Airport via the North Lantau Expressway is about HK\$ 1.25 billion.

The Potential Loss of Life is defined as the expected total number of deaths per year and is used to measure the risk to all the population exposed within the facilities to the full range of landslide hazards. The estimated Potential Loss of Life value for the Study Area is  $6.8 \times 10^{-3}$ . The North Lantau Expressway and Cheung Tung Road are the facilities that contribute most to the overall risk to life (i.e. 54 % and 17 % respectively). The risk to life associated with landslides in the Study Area has been assessed in accordance with the risk acceptance criteria proposed by ERM (1998). The Personal Individual Risk values are found to be well below the individual risk acceptability criteria of  $PIR = 1 \times 10^{-4}$ . The largest Personal Individual Risk value determined was for a bus driver on the North Lantau

Expressway with a value of  $PIR = 1.4 \times 10^{-7}$ . The risk to life can also be expressed in terms of the number of fatalities, N and the cumulative frequency of N or more fatalities per year, F referred to as an F-N curve. To permit comparison with the F-N curve based risk acceptance criteria, the region at the toe of the Study Area was divided into eight sections of approximately 500 m length. The F-N curves for each 500 m section plot within the As Low As Reasonably Practical (ALARP) region of the risk acceptance criteria.

The potential economic loss associated with landslide hazards impacting on facilities within and adjacent to the Study Area have been estimated by investigating the potential costs associated with damage to vehicles, delay caused to vehicles, and lost revenue due to delays caused to vehicles. Potential economic losses associated with delays to air travel passengers and air cargo due to delays to vehicles reaching the Hong Kong International Airport are expected to be the most significant. For air travel passengers, the Potential Annual Loss = HK\$ 782,000 and the Potential 120-year Design Life Loss = HK\$ 94 million. For air cargo, the Potential Annual Loss = HK\$ 2.8 million and the Potential 120-year Design Life Loss = HK\$ 334 million. The Total Potential Annual Economic Loss is about HK\$ 3.8 million and the Total Potential 120-year Economic Loss is about HK\$ 450 million.

Based upon the findings of the Quantitative Risk Assessment in terms of risk-to-life, natural terrain hazards in the study area did not pose a very severe problem. Nevertheless there was still a considerable risk-to-life and the maximum justifiable expenditure based on consideration of potential loss-of-life was found to be about HK\$ 20 to 27 million. Given the strategic importance of the North Lantau Expressway, the economic risk was assessed. Based upon these findings, it is recommended that landslide risk mitigation measures be provided to mitigate the level of risk associated with channelised debris flows. It is recommended that check dam basins be located at the toe of the hillside at six channel locations. The estimated cost of the recommended risk mitigation measures is HK\$ 28 million.

The Maximum Justifiable Expenditure for landslide risk mitigation measures has been estimated based upon the Potential Loss of Life and the Potential Economic Loss and is estimated to be about HK\$ 475 million. The benefit over a 120 year period is equal to the potential reduction in losses, which is estimated to be about HK\$ 450 million. The estimated benefit is much greater than estimated cost of the recommended risk mitigation measures and therefore, the recommended risk mitigation measures are considered to be very cost effective.

Ir Jack Pappin  
Director  
Ove Arup & Partners Hong Kong Ltd

Agreement No. CE 89/2002 (GE)  
Natural Terrain Hazard Study at North Lantau  
Expressway and Luk Keng Village -  
Feasibility Study