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THE COLLAPSE OF THE NICOLL HIGHWAY on 20 April 2004

(*This summary is derived from the official report on the collapse entitled 'Report on the incident at the MRT circle line worksite that led to the collapse of the Nicoll Highway'*)

The collapse occurred as a consequence of the failure of a deep excavation adjacent to Nicoll Highway. The excavation was for the Mass Transit's new Circle line; it was the deepest ever cut and cover construction in Singapore and consisted of braced diaphragm walls with an excavation depth of around 33m. The bracing involved 10 levels of conventional steel struts with waling beams, and two additional jet grout struts (one of which was sacrificial). The steel struts were supported by piled king posts at mid span. The failure was initiated at the strut/waler joint at level 9, located just above the sacrificial jet grout strut which was being excavated. Level 10 struts were not effective at the time of failure.

The parties involved:

- Client
- Main D&B contractor
    - Base slab sub-contractor
    - Strutting sub-contractor
    - Diaphragm wall sub-contractor

The collapse occurred as a result of two primary errors:

- The under-estimation of the soil loads applied to the diaphragm wall (which had been calculated using what was known as 'Method A'-see below)

- The under-design by a factor of 2 of the waler/strut connection at level 9, and the inability of the overall system to redistribute loads after its failure. The under-design was independent of the under-estimation of soil loads (it arose from the omission of assumed splayed ends to the struts and a misinterpretation of BS5950) but had the effect of eliminating any spare capacity.

There were also a number of significant contributory factors:

- The failure adequately to heed aural and visual warnings of distress
- Management and organisational systems were inadequate
- There was a lack of design reviews, defensive mechanisms, and contingency provisions
- Abuse of the back analysis process, triggers levels, and monitoring regime.

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The key lessons from this event are:

- Trends during critical periods must be capable of being monitored.
- Those interpreting the outputs must be competent to do so. The dangers of drawing conclusions from past behaviour, without careful consideration of the actual conditions, must be recognised.
- The management of uncertainty must be robust. There must be approved and tested contingency plans.
- Those involved must be competent at both organisational level and individual level
- The project must operate within a safety culture conducive to safe working. This means, inter alia,

    - A 'stop work' procedure to be in place, clearly understood by all, and supported by management
    - Clarity in the chain of command and in responsibilities

Failure causation
The report schedules a number of causes for the failure:

1. A drained soil analysis (Method A) had been used instead of the more appropriate un-drained approach. The consequence of this analysis was to significantly under-estimate the loads on the temporary works by a factor of up to 2.
2. The load concentration at the strut/waler junction was severely under-estimated as the intended splay members, which would have distributed the load, were omitted.
3. The stiff bearing lengths were grossly over-estimated (misinterpreting BS5950)
4. The change to the stiffening arrangement (by using C channels), following buckling of plate stiffeners, was critically flawed.

It is noteworthy from the photos in the report that some of the basic rules on stiffening, particularly of temporary works, were not followed.