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Engineering geological mapping: selected case studies in Malaysia

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ABSTRACT

Engineering geological maps are essential background data to the planning of land use, and design, construction, and maintenance of civil engineering works. They contain important information on ground conditions for the safe engineering construction. This paper provides three examples of the advantages of engineering geological mapping during the planning stage of the projects. The maps provided the preliminary information to engineers who were then able to make decisions regarding further investigation and feasibility of the projects. The paper further highlights the importance of executing a thorough engineering geological mapping before the commencement of a project.

INTRODUCTION

Engineering geological maps provide essential background information to the planning of land use as well as design, construction and maintenance of civil engineering works. They contain information pertaining to actual ground conditions and are aimed towards understanding the relationship of geological environment to the engineering situation as well as the modifications that are likely to arise from the engineering construction.

In this paper, three examples of the advantages of engineering geological mappings are highlighted. The maps were prepared at the planning stage of the projects to provide the necessary preliminary information to engineers who were then able to make decisions regarding further investigation and feasibility of the projects.

In the first study, a 6 km stretch of a proposed six-lane North-South Expressway at Gunung Tempurung, Ipoh, was mapped. The mapping of the densely vegetated, mountainous terrain revealed various elements of the ground such as the soil-rock unit, geomorphology, geodynamic features, and hydrogeological conditions. From these, extensive colluvial deposits, large landslides, and large amount of water loss in colluvium-natural ground boundary along the alignment were respectively identified.

In the second study, mapping of a proposed site for a hillside resort development in the mountainous region of Bukit Tinggi, Pahang, was conducted. This area was found safe without much geological activities. However, owing to its steep topography and thick residual soil, it was foreseen that any uncontrolled development might cause rapid degradation.

The third mapping was at a proposed municipal sanitary landfill area at Rawang, Selangor. The mapping revealed that this area was partly on old illegal dumping site consisting of thick non-engineered fill material. Past indiscriminate dumping had resulted in the formation of a few small man-made ponds.

ENGINEERING GEOLOGICAL MAPS

Engineering geological maps (EGM) are types of geological maps that provide generalised representations of all components of the geological environment. They provide the essential background information to the planning of land use, design, construction, and maintenance of civil engineering works (UNESCO 1976). The EGM contain information on actual ground conditions aimed at understanding the relationship of the geological environment to the engineering situation, and the modifications of the works that are likely to arise from the engineering construction (Dearman 1991).

Engineering geological mapping cannot substitute a detailed site investigation. However, it must be emphasised that a good engineering geological map can be extremely useful in the planning of site investigations, design, construction, and maintenance of various engineering projects such as dam sites, roadways, toxic waste disposal sites, land reclamation, and tunnel investigations. This valuable map will be able to narrow down or reduce the geotechnical uncertainties that underlie the site.

ENGINEERING GEOLOGICAL INFORMATION

An engineering geological map presents various information on geological conditions of the entire project area. It essentially presents four major elements:

- Information on soil and rock units,
- Geomorphology and type of landform,
- Geodynamic features, and
- Hydrogeological conditions.

Ideally, the mapped information should be presented in a series of maps, one for each category mentioned above, together with a map showing the locations of sources of data such as borehole, test pit, and sounding locations. If the information gathered is not too congested, then the maps can be combined.

IAEG (1981a,b) and Dearman (1991) recommend various symbols and colours to highlight the above elements mapped in the field. The information in the map is largely controlled by the data available from surface and subsurface investigations. For example, maps prepared prior to subsoil investigation will contain far less information compared to the map of the same area with borehole data. It must also be remembered that the scale of mapping and information mapped will vary according to the project requirement. Broadly, the engineering geological mapping must fulfil the following criteria:

- The map must be suitable for the purpose stated, and irrelevant information should not be cited.
- Scale must match the purpose.
- Nature of the information must be suitable for the purpose and the scale.
- Types of data used and method of data collection must provide adequate information required by the map user.

Case 1: Gunung Tempurong stretch of the North-South Expressway, Perak

A 6 km stretch of a section between Gopeng and Ipoh on the North-South Expressway was one of the last stretches to be completed on this massive national highway construction project. This delay was due to the difficult terrain along this stretch of the highway. Interpretation based on the aerial photographs of this area revealed that there are granite and metamorphic rocks with colluvial slopes and landslide areas. Engineering geological mapping was carried out to identify the types of material and the problems likely to be encountered during construction. Though the mapping was done before borehole data were obtained, abundant signs of incipient instability, which were visible at the site, were sufficient for the further assessment.

The field mapping indicated that the expressway would run largely on colluvial deposit with high permeability. Water was also seen disappearing at the colluvium-residual soil boundary. Apart from this, a stretch of the proposed expressway was also found to be located on a large old landslide with an approximate volume of 300,000 m^3 of failed material. With such unfavourable conditions, it was foreseen that slopes cut on this stretch would have a high tendency to fail. The engineering geological map of this stretch is shown in Fig. 1.

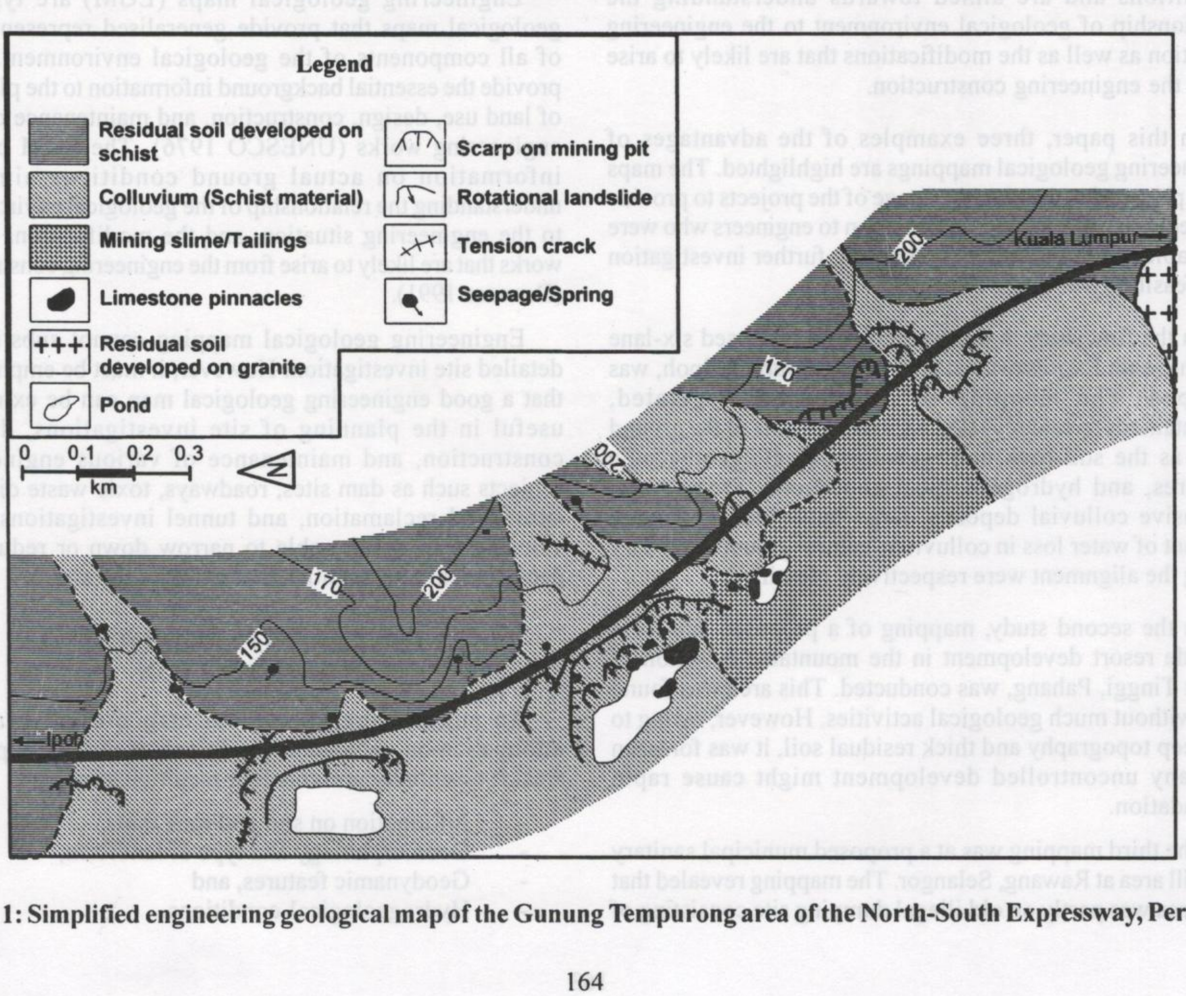

Fig. 1: Simplified engineering geological map of the Gunung Tempurong area of the North-South Expressway, Perak

Based on the findings from the engineering geological mapping, the expressway was realigned approximately 3 km away to avoid the landslide areas and the highly permeable and unstable colluvial deposits.

Case 2: Bukit Tinggi golf course and resort, Pahang

The purpose of this engineering geological mapping was to ascertain the stability of the existing natural ground in the mountainous terrain at Bukit Tinggi, Pahang. Aerial photographs were used for the initial interpretation. Based on the studies, the area was found to be devoid of major geodynamic activities. This area was underlain by granitic residual soil and huge boulders covered valleys. Two areas with gentle topography were identified as underlain by the old alluvial deposits (Fig. 2).

Although the slopes in the region were dipping between 30 and 40 degrees, no mass movements were evident in the virgin terrain. Only minor slope failures and erosional gullies were present along the slopes that were cut for access roads. Large boulders were found only in the streams in this hilly terrain. The area studied was frequently waterlogged.

Based on the data collected during engineering geological mapping, it was evident that this area was generally stable. Some slope destabilisation occurred only when human activities encroached the area without due consideration to the natural ground conditions. The results of the findings were useful in the planning of the entire development with due consideration given to the thick weathering profile and the topographical conditions. The engineering geological map (Fig. 2) of this area provided vital information on geodynamic conditions, i.e. soft and water logged areas, potential slope instability regions, and other potential geohazard potential areas.

Case 3: Sanitary landfill, Rawang

The main purpose of the engineering geological mapping on this proposed sanitary landfill was to identify the suitability of the site for a municipal landfill area. The area was underlain by residual soil of highly weathered material derived from graphitic and quartz schists. The valleys were covered by slope wash and alluvial deposit.

During the field investigation, abundant non-engineered fill material was found dumped in this area. The dump material comprised coal, shale, and concrete wastage from nearby cement plant. Local residents have also used this area as their dumping ground. The thickness of the coal, shale, and dump was up to 23 m. This material was hazardous as it was combustible.

The saprolite (Grade VI to IV) in this area was moderately to highly permeable ($K=10^{-4}$ to 10^{-7}). The permeability increased with depth i.e. Grade IV material was more permeable compared to Grade VI material. The coal and shale dump material was highly permeable as indicated by no water return from the drill hole. Another interesting feature observed in this area was the existence of ponds. These ponds were initially thought to be either of natural origin or due to former mining activities. However, detailed

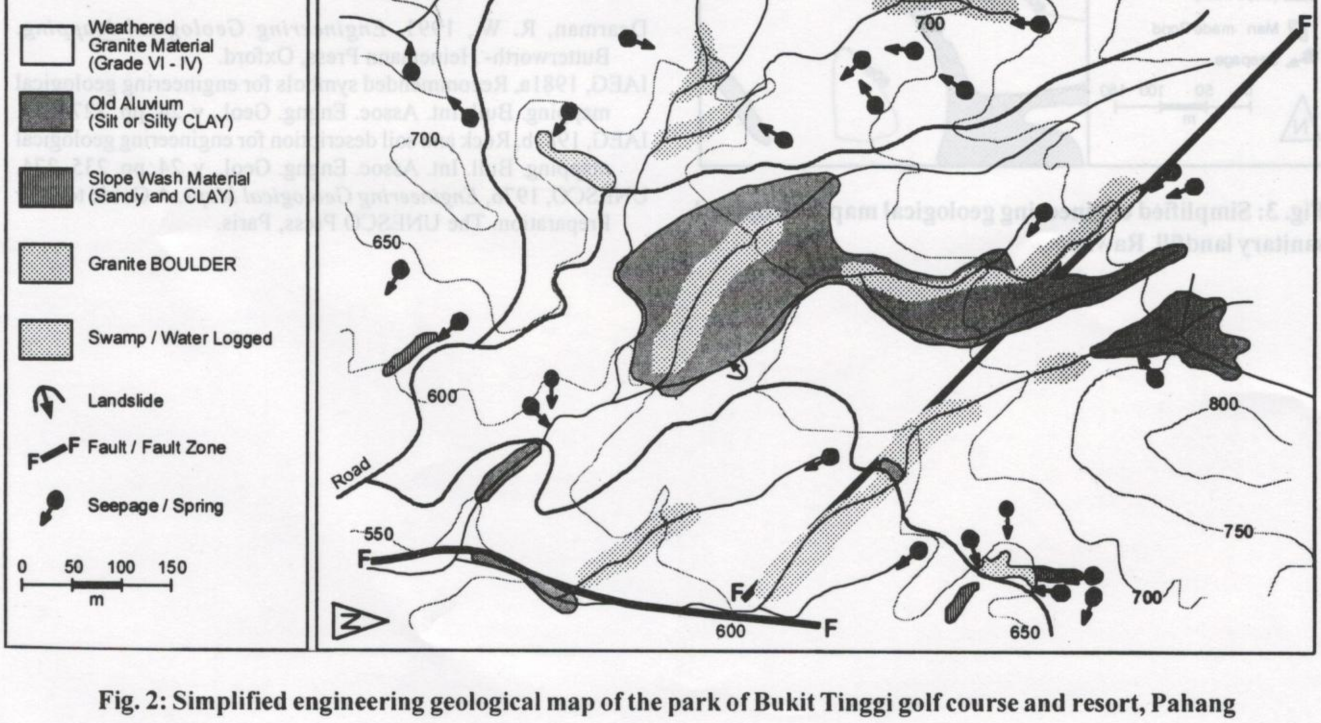

Fig. 2: Simplified engineering geological map of the park of Bukit Tinggi golf course and resort, Pahang

observation and interpretation revealed that they were a result of water entrapment due to indiscriminate dumping of waste materials.

An engineering geological map of the site is shown in Fig. 3. The site was identified to be not suitable for sanitary landfill due to the existence of very thick porous dump waste

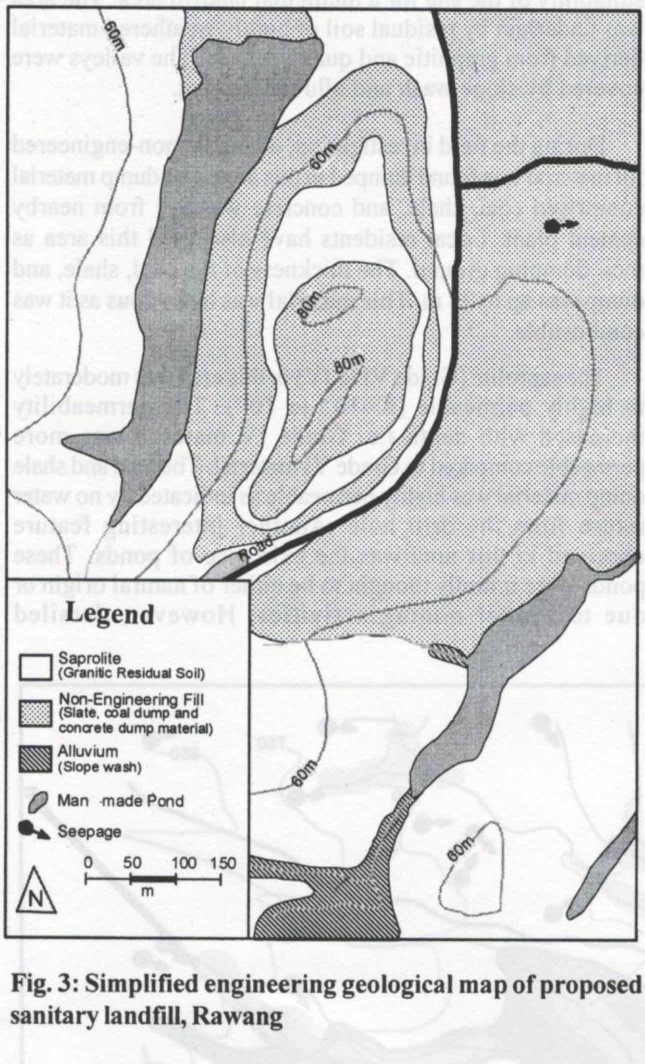

Fig. 3: Simplified engineering geological map of proposed sanitary landfill, Rawang

materials. Based on this finding, the project was deemed not feasible.

CONCLUSIONS

The information gathered from the engineering geological mapping of a site would vary according to the scale, data availability, and purpose of the project. It can also be seen that the maps come into handy and important documents that can be utilised at various levels of decision-making prior to the commencement of the project. A comprehensive engineering geological map will definitely serve as an important document during and after the completion of a project. Our experience shows that such mapping is essential even for small projects, as the information recorded will be useful for identifying signs of engineering problems and for future reference. The cost of mapping is generally cheap and requires only minor tools. Mapping exercises are inexpensive compared to any other site investigation procedures and the information obtained is invaluable. By foreseeing the impending problems, the feasibility of a project can be ascertained and the appropriate ground investigations can be carried out. This would further reduce the construction cost.

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