JKR 20709-0337-95

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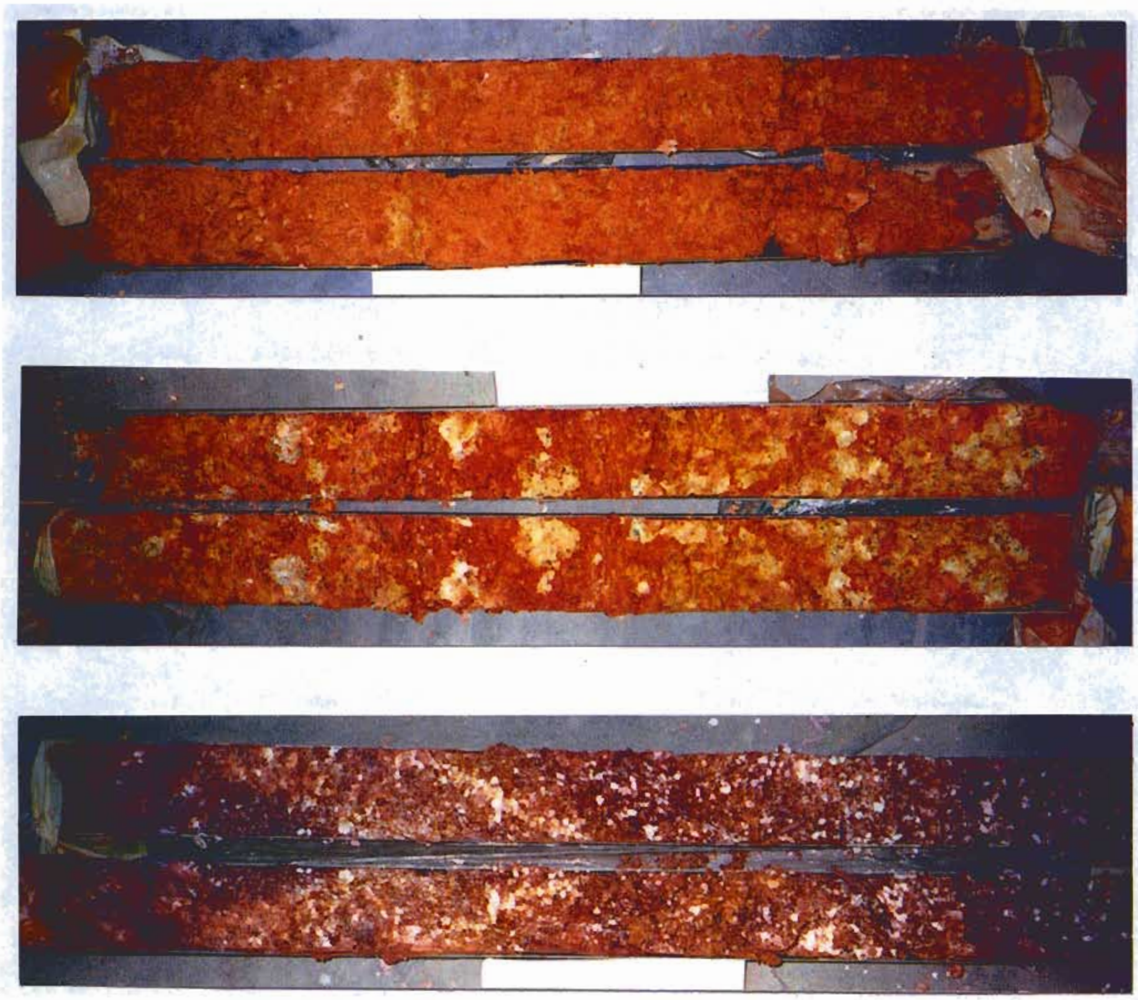

GEOGUIDE 2

TROPICAL WEATHERED IN-SITU MATERIALS

- SITE INVESTIGATIONS

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April 1996

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PREFACE

This geotechnical application guide is one of a series of documents prepared by J R Cook and Professor A McGown of the Department of Civil Engineering, University of Strathclyde, United Kingdom and the Institut Kerja Raya Malaysia (IKRAM). The object of these GEOGUIDES is to provide JKR engineers with a rational and practical methodology for the investigation and geotechnical characterisation of tropically weathered soil and rock masses.

GEOGUIDE 2 outlines methodologies appropriate to the site investigation of soil-rock masses whose character has been influenced by tropical weathering.

Other geotechnical application guides available are as follows:

GEOGUIDE 1 — *Tropical Weathered In-Situ Materials - Occurrence and General Nature*

GEOGUIDE 3 — *Tropical Weathered In-Situ Materials - Laboratory Testing*

GEOGUIDE 4 — *Tropical Weathered In-Situ Materials -Geotechnical Character of Profiles.*

GEOGUIDE 5 — *Tropical Weathered In-Situ Materials - Engineering Application of Characterisation*

1.0 INTRODUCTION

1.1 General Scope

The occurrence and general nature of tropical weathered in-situ materials (TWIMs) are outlined in GEOGUIDE 1. In GEOGUIDE 2 the general philosophy of site investigation design and application is set out together with the recommended procedures for site investigation planning, desk and field data collection, data collation and the programming of laboratory investigations. Laboratory testing procedures for TWIMS are dealt with separately in GEOGUIDE 3.

This guide refers to standard procedures of site investigation which are applicable to a wide range of soil and rock materials but places special emphasis on topics which are particularly applicable to the special character of Malaysian TWIMs and TWIM profiles. In this context the following topics will receive particular attention:

- systematic data collection
- terrain evaluation
- sample recovery
- visual soil/rock descriptions
- in-situ testing
- laboratory investigation programmes.

2.0 GENERAL APPROACH

2.1 Investigation Objectives

The objectives of a site investigation for a civil engineering project are defined in British Standard BS:5930 (1981), as follows:

Determination of Site Suitability	The assessment of the suitability of a site for the proposed works.
Determination of Design Parameters	The acquirement of design parameters for the proposed works, including those required for the design of temporary works.
To Assist with the Choice of Site	Where alternatives exist, to advise on relative suitability of different sites or different parts of the same site.
Identification of Appropriate Methods	To plan the best construction method, to foresee and provide against difficulties that may be arise during construction due to ground or other conditions. In appropriate cases to explore sources of indigenous materials for use in construction; and to select sites for the disposal of waste or surplus materials.
To Identify the Effects of Construction Changes	To determine the changes that may arise in the ground and environment either naturally or as a result of the works and the effect of such changes on the works and on the environment in general.

These objectives are likely to be achieved by the general aims of a good site investigation programme.

2.2 General Site Investigation Methodology

Site investigation has been described as an "operation of discovery", BS5930 (1981). It is also very much a process of elimination, whereby the early discarding of potential geotechnical scenarios is a key activity in the identification of the engineering geological environment. An effective site investigation programme should take fully into account the potential relationships between the materials likely to be encountered, the hydrological regime and the needs of the project. In broad terms the investigation should lead to an engineering assessment which should be relevant and make a significant contribution to the cost-effectiveness of proposed projects. In attempting to do this it should be structured to take cogniscence of the guiding statements:

material character + structure + water = mass character
mass character + physical setting = in-situ geotechnical environment
In-situ geotechnical environment + project = engineering performance.

In order to meet its general aims, a good site investigation programme ought then to contain a number of key elements:

i) Geotechnical characterisation of the mass and the materials.
ii) Accurate definition of geotechnical and project implications.
iii) Identification of engineering geological and hydrogeological environments.
iv) Correlation of design procedures with project effects and geotechnical character.

The planning of such investigations needs to take note of the following :

i) Stage of project.
ii) Aerial extent of project.
iii) Depth of soil-rock mass to be disturbed.
iv) Extent and nature of disturbance caused by the project.
v) The influence of the surface and ground water regimes on the project and vice versa.

The use of a phased investigation methodology is the most efficient means of ensuring that key investigation aspects are identified and effectively acted upon. In most investigations a phased methodology will involve a number of general activities:-

i) Desk studies.
ii) Field data and sample collection.
iii) Laboratory investigations.
iv) Data interpretation.

The relationship between these activities within the overall phased approach is indicated in Figure 2.1. One of the main objectives of such an approach is the ability to incorporate early data back into the overall programme.

2.3 Influence of TWIM Character on Site Investigation Design

Existing standard approaches to site investigation, particularly with respect to sampling and testing are, in many tropical material environments, incapable of adequately dealing with TWIM problems, either through the inadequacy of procedures in dealing with sensitive and unconventional materials or through an inability to represent a complex and non-homogenous soil-rock mass. The unconventional nature of many TWIMs, as discussed in GEOGUIDE 1, results in significant difficulties that have to be borne in mind in the design, initiation and interpretation of investigation programmes, Table 2.2. Some items have a greater significance for site investigations in tropical regions than for those in temperate zones, including:

i) Effects of construction on material behaviour.
ii) Design of temporary works.
iii) Nature and location of construction materials.
iv) Disposal of surplus materials.
v) Variations in surface run-off and groundwater regimes.

The amounts and extent of material disturbance are two items of particular concern with many tropical weathered materials. In order to adequately model project performance the effects of investigation techniques should bear a resemblance to those imposed by the construction works. As illustrated in Figure 2.2, this requires that laboratory sampling and testing effects must have an identifiable relationship to those resulting from the project.

The characterisation methodology proposed for TWIMs seeks to integrate general investigation principles into a project-related programme and utilise, where relevant, those ground investigation procedures most suited to their nature. This approach by itself is not specific to TWIMs, but the particular applicability is in the use of relevant data gathering and data interpretative techniques ranging from desk study data collection through to sampling and laboratory testing. Many techniques require adaptation from the norm for use in tropical environments. A fundamental aspect of the current approach to TWIMs is the utilisation of an integrated earth science approach incorporating aspects of geology, geomorphology, soil mechanics, mineralogy and rock mechanics.

It is commonly suggested, for example by Brand, (1984) and De Mello, (1972) that geotechnical design in the majority of TWIM environments would benefit from the application of modified precedent or semi-empirical methods rather than traditional classical methods. A key element in the modified precedent approach is the accurate collection of relatively easily obtainable and inexpensive site information which may be correlated with similar sites or otherwise be adapted for design purposes. There is therefore in the TWIM investigation procedure an emphasis on logical and accurate data collection and description techniques. Data are generally gathered under the broad headings of Site, Mass and Material Characteristics, Table 2.3.

3.0 THE STRUCTURE OF TWIM INVESTIGATIONS

3.1 Site Investigation Design

In broad terms the site investigation activities should seek to follow a sequence of identification, classification, characterisation and geotechnical assessment. The geotechnical assessment should be relevant and make a significant contribution to the proposed project from investigation through design and construction to final performance. The scale of activities to be included in the overall plan may vary greatly, from the microscopic study of materials to the macroscopic assessment of land systems.

Although there is no absolute "standard" site investigation procedure for TWIMs, the following general guidelines generally apply:

i) Use a staged investigation programme.
ii) Be aware of the general nature of TWIM profiles and masses.
iii) Use existing information as much as possible.
iv) Use accurate description techniques.
v) Be aware of the geological, hydrogeological and geotechnical setting of the project.
vi) Gather as much in-situ information as possible.
vii) Disseminate investigation data regularly in user-friendly form.

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Programme design is the first vital step in the cost-effective employment of a TWIM investigation. Projects may range in size from the very small to the very large, and cover stages from initial feasibility to final design and construction. Nevertheless, a sound programme plan is fundamental to achieving the sometimes delicate balance between budget, technical requirements and time constraints.

Although the investigation programme will be a function of the overall project type and its constraints it is likely to include the following phases:

i) Background data gathering.
ii) Preliminary Investigation.
iii) Main Investigation.
iv) Follow-up/Construction investigation.
v) Reporting.

Whatever the nature and stage of the investigation the effective employment of the processes of data collection, collation and dissemination will be the core of an overall programme aimed at the geotechnical characterisation of the relevant materials and masses.

3.2 Data Gathering

Data gathering is a primary site investigation activity that encompasses all phases from initial background studies through to final construction. The consideration of accurate and cost-effective data gathering processes is therefore fundamental to any site investigation programme. For the purposes of this GEOGUIDE relevant data are considered under the headings of existing data, field surface data and field subsurface data. Although there will be similar data sets within these groups, the methods of data gathering are largely different and require separate discussion. However, some procedures, for example soil-rock description, do form integral parts of several data gathering processes.

3.3 Data Collation

In order for site investigation information to be used in the most cost-effective manner possible, it is desirable to collate the data in a rational, easily retrievable and technically logical form. This will usually require the recovered information to be organised into an overall project database, which may include such items as existing reports, field information sheets, photographs, laboratory result sheets, maps and plans.

The implementation of a two-tier organisational procedure greatly aids in the rationalisation of project information. The first is the use of a PC-based database system and the second the collation of data into identifiable and technically relevant units or groups.

PC-based database systems are now a proven cost-effective means of storing and manipulating data. Once the initial phase of the database file design has been undertaken, the input of information becomes a straightforward procedure that enables more technical time to be spent on data manipulation and interpretation. The use of a geotechnical PC-database has already been shown to be of significant value at IKRAM both by use of the Site Investigation Borehole Database and the TWIMs Geotechnical Database set up for the IKRAM-University of Strathclyde research programme on tropical soils, the key elements of which are listed on Table 3.1 .

The filing of data with respect to geotechnical groups is a logical step in the overall data collation and dissemination process. The make-up of these groups are largely determined by the type of project involved. A small building project might necessitate only the listing of data with respect to similar geotechnical behaviours or weathering grades, whilst a large-area construction project benefits from a more complex division on the basis of geology, terrain and behaviour. The use of terrain systems can prove a powerful tool in the context of data organisation. This is discussed further in Section 5.5.

3.4 Data Dissemination

The presentation of investigation information is a frequently under-rated aspect of a geotechnical programme. Presentation is the means by which geotechnical information may be passed on to, for instance, the civil engineering designer, who may have little first hand knowledge of the site.

The geotechnical report is the traditional medium by which this transfer occurs. However, within this reporting activity there are a number of procedures which can significantly enhance the effective transfer of site understanding, as follows:

i) Borehole and test pit logs.
ii) A schematic profile.
iii) An Index properties profile.
iv) Geotechnical profiles and sections.

Borehole logs are frequently the fundamental means of data dissemination in geotechnical investigations. It is worth emphasising that the final borehole/test pit log should not be based on brief visual descriptions alone but should be a combination of the following:-

i) Visual log of core and samples.
ii) Laboratory test results.
iii) Correlation with adjacent boreholes.
iv) Correlation with relevant in-situ tests.
v) Geomorphological location.
vi) Groundwater observations.

The interpretation of material type, particularly in TWIM regimes, may only become clear when all the above are taken into account. Geomorphological location and hydrogeological regime are of particular importance in TWIM environments where they have a major influence on the nature of in-situ profiles. The definition of a schematic soil-rock profile, or catena, for relevant terrain units within the project area may be useful in indicating behaviour patterns in the TWIM environment.

The plotting of Index test results in profile form can prove valuable in appreciating the geotechnical character of soil-rock profiles. The use of properties that can link together soil and rock behaviours is particularly important for TWIM profiles. In this respect the use of void ratio, dry density and slake durability data is recommended. The combination of Index property plots and the visual impact of annotated photographs of materials at macro to micro scale can prove most effective in many project situations

Geotechnical sections are commonly used to portray data to the design engineer. They may be used to advantage to portray relevant engineering behaviour and groundwater information, possibly in conjunction with geotechnical unit divisions and geotechnical hazard assessments.

4.0 COLLECTION OF EXISTING DATA

4.1 Scope and Objectives

The aim of a Desk Study is to identify and collate available information relating to the proposed project and to incorporate this into the investigation and design process. Initial desk studies should collect available information and identify potential sources of further data. These further sources may vary from previous project work to information held within relevant Government Departments. The desk study should also be used to collect preliminary information with respect to site characterisation. The early establishment of general site characteristics in conjunction with, for example, a geological or soil map may provide invaluable geotechnical clues as to potential engineering performance.

Secondary phases of desk study may be used to make correlations between the project and sites that appear to have similar characteristics. This process is particularly important in TWIM environments where "design by modified precedent" is a frequent necessity.

4.2 Methodology

Desk study data collection falls naturally into two parts; firstly the identification of information sources and secondly the extraction of relevant data. Typical data sources are outlined in Table 4.1. Appendix A contains the proformas to be used for the collection of desk study data.

The desk study work should be closely integrated with an early site exploration phase and form a sound foundation to the project database with respect to the following topics:

i) Project definition.
ii) Project objectives .
iii) Geology.
iv) Terrain character.
v) Geotechnical character.
vi) Suitable classification systems.

If at all possible the desk study activities should include a visit to the site. The advantages gained from being able to place existing data in the context of the site as opposed to conceptions obtained from maps or photographs can contribute significantly to the investigation as a whole.

5.0 SURFACE DATA COLLECTION TECHNIQUES

5.1 Scope

Relevant technical information may be obtained rapidly by the examination of surface terrain, geology and mass engineering behaviour. In some projects this information forms the core of the whole programme whilst in others it may be used in a supporting role as a tool for defining effective sub-surface work. Even in a supporting role it provides valuable clues to likely geotechnical performance in an environment where the recognition of behavioural patterns is a vital link in the overall investigation process.

Techniques of surface data collection vary widely in detail and are dependant on the constraints of each project.

5.2 Geological and Geomorphological Information

The production of some form of site geological and geomorphological map is a basic requirement for most projects. Surface geological and geomorphological information can be collected using traditional mapping methods aided, where appropriate, by air photos or satellite imagery. The integration of this information with terrain mapping and evaluation is in many projects a key step in the systematic organisation of geotechnical information.

On some projects the detailed enhancement of the basic geological map over the whole site may not be appropriate either for technical reasons or due to manpower constraints. In cases where it may be necessary to collect data without the use of experienced geological mapping personnel, the use of a standardised approach should be considered. Appendix B contains the proformas for the collection of basic location and geological information. There are a number of data sets that are generally common to the majority of investigations. These have been included in the standard forms and are summarised in Table 5.1.

5.3 Mass Behaviour Inventories

The recognition and appreciation of actual soil-rock mass behaviour on site is a valuable input to any geotechnical design programme. Mass behaviour inventories can play a key role in TWIM investigation programmes. Although they can be set up to collect data on a range of behaviours they are most commonly undertaken with respect to slope condition. Inventories of slope condition, have been successfully employed as aids to geotechnical characterisation in tropical terrains, Anderson et al (1990) and Cook et al (1992). Most recently in Malaysia they have been used as a basis for the identification of geotechnical hazards on the Gerik to Jeli East-West Highway, JPZ, (1995).

The design of slope condition surveys varies widely depending on the project requirements and constraints and may range from a quick identification survey to very detailed work. Typical data sets that are included in most slope surveys are listed in Table 5.2

5.4 TWIM Description Techniques

Qualitative descriptions of TWIM materials may be as important as quantitative measurement of their physical properties. Effective communication of soil-rock information requires an acceptable vocabulary of terms which are capable of definition and understanding. One of the principal aims of any geotechnical description system must be to identify and define materials such that an engineering related classification can be adopted as an aid to technical communication.

Standard description procedures, (e.g. BS5930, ASTM, ASHTO), use a basic division of coarse and fine materials. This is done solely on a particle size basis. Actual practice is to make this distinction on the basis of behaviour; but even this in the context of some TWIMs is fraught with problems, i.e. variable behaviour under differing conditions.

The fundamentals for a description system have been summarised by Norbury et al (1985) as:

i) All factors are considered and examined in logical sequence.
ii) All essential information included.
iii) As much operator error as possible is eliminated.
iv) All data is accurately disseminated

The adopted TWIM description system is based on the systematic description of profiles and their constituent materials using standard proformas and data codes backed by comprehensive guides to their use. This system relies on factors such as mineralogy, fabric and behaviour as much as on particle size to define materials and masses. Description forms and guides are included within Appendix B.

The description guides may be applied for use with exposures, individual samples or boreholes. In the case of cores from indurated or rocklike materials there will be a requirement to use established fracture logging techniques:

i) Total Core Recovery (TCR).
ii) Solid Core Recovery (SCR).
iii) Rock Quality designation (RQD).
iv) Fracture Index (If).

Material behaviour may be described in response to field Index tests undertaken within the overall description and identification framework. The requirements of such field tests are that they should be rapid, simple and be relevant to the classification and geotechnical characterisation of the materials in question. Standard approaches to the field collection of discontinuity data can be incorporated into the overall system, ISRM (1980).

Bearing in mind the increasing ability of computer databases to scan and store photographic and map data the use of mass and material photographs and annotated sketches is strongly recommended as an effective means of visual information transfer.

5.5 Terrain Evaluation

Terrain evaluation is a method of summarising and evaluating the physical aspects of defined areas, including geotechnical behaviour, each area having reasonably uniform characteristics composed of both "typical" and "unique" features. It can provide a basic framework for data collection, collation and assessment. It follows that the some initial terrain classification, as a precursor to terrain assessment, should be form part of the desk study work.

The objective of terrain classification, is to separate areas of ground having different arrangements of topography and soil. In a comprehensive guide to terrain evaluation, Lawrance et al, (1993), defined the usefulness of classification as follows:

"A terrain classification can be carried out at any level of detail to suit the requirements of the project, starting with a generalised classification of a large area, and ending with a detailed classification of a small area. Terrain classification thus mirrors the aim of a site investigation, which is to start with an overview of the site and work towards a concentration of effort in the area in which construction is to take place. Once set up, a terrain classification can act as a referencing system for geotechnical data collected throughout the project period. Thus all the geotechnical data for one terrain unit can be brought together for comparison. The terrain classification acts as the basis for the subsequent evaluation."

Terrain evaluation is particularly useful in tropical zones because of the close relationship between terrain and the underlying soil-rock masses, thus giving a crucial indication of in-situ behaviour and response to proposed construction activities.

At the desk study stage the initial terrain classification can be undertaken utilising available remote sensing data and existing topographic and geological maps. In some areas of Malaysia, terrain classification has already been undertaken, eg. Lawrance, (1978) and this can usefully be taken into account in setting up new systems.

6.0 SUB-SURFACE DATA COLLECTION

6.1 Boreholes and Test Pits

Boreholes may be sunk by a number of percussion, or rotary methods. The techniques employed should be chosen to take into account the type and condition of material involved. Rotary coring methods are more appropriate to TWIMs materials than cable percussion drilling. For minimising disturbance, core barrels are superior to open drive samplers.

Double and preferably triple tube core barrels should be utilised; with the use of Mazier or Pitcher type barrels being very advantageous. Serious problems may occur with scouring of the sample by drilling fluid. In the ideal situation the use of air-foam with a large diameter triple tube barrel is to be recommended. Because of the high cost of such methods, there may be an argument for using different types of drilling and sampling on one site, ie key holes sunk by high cost methods and augmented by the use of lower cost holes, with the use of Index testing for correlations between points.

The use of "twin" boreholes at investigation locations with one concentrated on continuous high quality sampling and the other on insitu testing is a useful practice for developing good TWIM geotechnical profiles

Test pits may be either hand or machine dug. They are particularly cost effective in the examination and logging of material fabric and the delineation of mass structure. Caution should be exercised in geotechnical interpretation of duricrust masses by test pitting alone as weaker material may underlie stronger. Nevertheless test pits are very useful for obtaining bulk undisturbed samples in sensitive materials. Where possible the use of deep test pits or even shafts can be used to great advantage.

Augering can range from hand augering to machine driven hollow stem methods with undisturbed sampling and insitu testing. They may be particular cost-effective in the early stages of an investigation in some materials.

The use of boreholes and, to a lesser extent test pits, to identify groundwater tables and to monitor their variation is a vital aspect of site investigation in the TWIM environment. Methods that may be employed are summarised in Table 6.1.

6.2 Sample Collection

A variety of established techniques are currently used to recover samples for description and laboratory testing. For some projects samples will also be required of the groundwater, usually for some form of chemical analysis.

TWIM profiles are likely to contain materials that will be difficult to sample in an undisturbed and representative manner. Particular attention should be paid to the class of sample recovered as compared to that required for testing, Table 6.2 The quality of sample obtainable from different TWIM types is variable, as indicated on Table 6.3

In addition to being an integral part of the borehole and test pit procedures discussed above, samples may be recovered form natural or man-made exposures. In the case of the EWH project, the use of existing road cuttings gave an excellent opportunity to obtain good quality samples from material that would other wise have been difficult to sample. On this project the use of simple large diameter plastic tubes cut into soil-rock materials proved effective in soil and very soft rock materials.

6.3 In-Situ Testing

Because of the problems of effective sampling and testing, the extensive use of in-situ testing methods is recommended in TWIM environments,

In-situ testing of materials includes a range of currently utilised techniques as outlined in Table 6.4. Probing techniques are relatively inexpensive procedures that can be effective in delineating the boundaries of soft or weak materials and in the recording of general in-situ material condition. Specific procedures that are currently employed include the Mackintosh Probe and the Dynamic Cone Probe, however, these may be of limited use in lateritic environments.

Engineering geophysics may be used to effect in some TWIM environments. Seismic refraction is the most generally used procedure and is best utilised to interpolate or extrapolate in-situ conditions in conjunction with boreholes. Caution is required in the interpretation of seismic data in TWIM environments with respect to the following:-

i) The survey will tend to ignore weaker layers beneath stronger layers - an important consideration in a lateritic environment.
ii) Insitu boundaries in most TWIM environments are extremely gradual, however, the survey may impose artificial "average " boundaries.
iii) Corestones are likely to be missed.

Increased use is being made of cross hole seismic work to correlate with geotechnical parameters. The logging of boreholes by means of a suite of geophysical procedures is now a well-established ground investigation procedure that can be of particular use in the TWIM environment. Other geophysical procedures that can be utilised are Resistivity, Gravity and Magnetic Survey techniques

There are a number of well established techniques for investigating in-situ permeability, mainly by utilising some form of borehole or combination of boreholes. The principal methods are outlined in Table 6.5. The methods adopted should be compatible not only with the materials involved but also the groundwater changes likely to be imposed by the project.

In addition, the use of specialist infiltration testing techniques may be appropriate for some project situations, as in the assessment of groundwater response to precipitation for slope stability analysis.

7.0 LABORATORY TESTING PROGRAMMES

7.1 Scope

A detailed discussion of appropriate laboratory testing procedures is included within GEOGUIDE 3. This section serves only to indicate some general points that a programme of TWIM testing ought to take into account.

TWIM profiles may consist of soil, rock or soil-rock materials and a testing programme needs to consider the use of both soil mechanics and rock mechanics type procedures. Programmes need to pay particular attention to the areas of overlap between soil and rock testing to ensure effective correlations.

7.2 Phased Laboratory Programmes

It is recommended that laboratory testing programmes in TWIM environments be staged such that the maximum use can be made of early data in order to determine the form of the bulk of the testing. Early phases of the laboratory test programme will generally concentrate on Index testing, with specific attention given to the effects of laboratory procedures and to gaining early clues to unusual behaviour, eg swelling or collapse potential. Particular aspects include:-

i) Moisture content variation with drying temperature.
ii) Aggregation of clay particle to silt/sand on drying.
iii) Variability of Atterberg limits with mixing.
iv) Variable specific gravities.
v) Variation of particle size distribution with handling procedures and dispersant concentrations.
vi) Relevance of particular Index tests.

In general terms, bearing in mind the difficulties of sample recovery, many testing programmes will be based around large numbers of relevant Index tests allied to a limited number of high quality more sophisticated tests, specialist mineralogical investigations and fabric examinations. Vaughan et al (1988) recommend the use of void ratio and bulk density as suitable Index tests in tropical soil-rock profiles.

Following the assessment of laboratory procedures the main testing programme may be planned.

The established range of soil mechanics tests may be utilised, with variable modification provided adequate caution is employed in their interpretation. In addition many aggregate testing methods may be adopted for pedogenic lateritic materials.

The major differences in testing tropically weathered as opposed to traditional sedimentary soils are in response to the following:-

i) Dealing with a chemically altered material rather than a physically produced one.
ii) Dealing with in many cases a non saturated material and negative porewater pressures, (i.e. soil suction).
iii) Great difficulty in obtaining high quality undisturbed samples.
iv) Difficulty in obtaining truly representative geotechnical parameters from heterogeneous samples and materials

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GEOGUIDE 2

TROPICAL WEATHERED IN-SITU MATERIALS SITE INVESTIGATION

TABLES

3.1 Typical TWIMs Database used for EWH Project.

4.1 Desk Study Data Sources

5.1 Data Sets for Initial Site Geological Information
5.2 Data Sets for Slope Condition Survey

6.1 Groundwater Monitoring Methods in Boreholes
6.2 Sample Quality Assessment
6.3 Suggested Sample Classes for TWIMs Samples
6.4 In-situ Testing Techniques
6.5 In-situ Permeability Testing Procedures

Table 3.1 Typical TWIMs Database used for EWH Project

DATABASE FILE	DESCRIPTION OF DATA
East-West Highway Research Database	
EWH_EXP.DBF	Location and topography of soil-rock masses
EWH_GEOL.DBF	Summary information on rock types
EWH_MAT.DBF	Detailed descriptions of materials.
EWH_DISC.DBF	Details of material discontinuities
EWH_DIPS.DBF	Orientation of principal mass discontinuities
EWH_SMP.DBF	Details of recovered sample
EWH_INDX.DBF	Index, collapse and slake test results
EWH_SBOX.DBF	Shear box test results
EWH_SUC.DBF	Filter paper suction results
Additional Files Used in Typical Site Investigation Database	
SI_LOCDAT.DBF	Investigation location (borehole, test pit) data
SI_STRATA.DBF	Depths and types of materials
SI_EWORKS.DBF	Compaction, CBR lab results
SI_SPT.DBF	Standard Penetration Test data
SI_GWATER.DBF	Ground\water monitoring data
SI_TRIAX.DBF	Triaxial test results
SI_CONSOL.DBF	Consolidation test results
SI_CHEM.DBF	Chemical test results

Table 4.1 Desk Study Data Sources

MAPS	**REMOTE SENSING**
Geological maps	Air photographs - Vertical and Oblique
Geological memoirs	Radar Photographs
Topographic maps	Satellite images
Land system maps	
Rainfall maps	
Hydrogeological maps	**LITERATURE**
Soil Survey Maps	Conference Proceedings
	Technical Journals
REPORTS	**DATABASES**
Consultant Geotechnical	Research Institutes
Contractors As-Built	JKR
Research - JKR	Technical Libraries
Research - University	
Geological Survey	

Table 5 .1 Data Sets for Initial Site Geological Information

DATA GROUP	DATA SET
Soil-rock mass location	Position Geological formation Geomorphology General geological structure Terrain unit Earthworks Surface drainage paths General TWIM profile Exposure condition Previous investigations Samples Photographs Sketch
Soil-rock exposure	Position Bedrock/Parent materials Constituent materials Material condition Boundaries Discontinuities Hydrogeology (permeability) Photographs Samples Sketch

Table 5.2 Data Sets for Slope Condition Survey

LOCATION
- Location by road\map reference
- Geology
- Land system

NATURAL SLOPES
- Slope height & angle
- Slope profile
- Terrain setting
- Slope material
- Geological structure
- Land use
- Vegetation cover
- Hydrological conditions
- Recent weather
- Slope condition
- Failure
- Photograph\sketches
- Date of inspection

EARTHWORK SLOPES
- Overall slope height & angle
- Slope geometry (profile/plan/shape)
- Slope length
- Road section & profile
- Berm numbers & width
- Bench heights & angles
- Slope material
- Geological structure
- Slope condition
- Drainage
- Remedial/stability works
- Vegetation cover
- Hydrological conditions
- Recent weather
- Upslope height, angle & condition
- Downslope height, angle and condition
- Photograph\sketches
- Date of inspection

SLOPE FAILURES
- Failure type and size
- Failure location on slope
- Failure profile
- Back-scar height & angle
- Failure angle
- Failure condition
- Failure causes
- Failure material
- Actual & potential damage
- Remedial works & effectiveness
- Failure date
- Photograph\sketches
- Sketches
- Date of inspection

Table 6.1 Groundwater Monitoring Methods in Boreholes

TECHNIQUE	GENERAL DESCRIPTION	APPLICABILITY
Open Standpipes	Slotted or perforated stand-pipe tube placed in a borehole within a sand or gravel pack.	Cheap and easy to install. Generally only of use in coarser soil or cleanly jointed rock where siltation is unlikely to be a problem. Usually manual monitoring; automatic systems can be attached. .
Standard Casagrande Piezometer	A porous tip attached to the end of an open plastic tube (around 12-15mm dia.) and sealed at the required depth within a sand filter. Sealing usually by bentonite grout mixture.	Relatively simple and inexpensive to install. Does not require de-airing. In its simplest form requires monitoring using dip meter.
Hydraulic Piezometer	A closed version of the Casagrande installation in which the pipe is filled with water and changes in pressure at the piezometer tip are reflected in changes in a pressure gauge or transducer at the surface.	More expansive and less robust then an open system; requires regular de-airing. More applicable to constant monitoring (using a transducer) of response to rain storms. More rapid response time than open systems Piezometers in a compact site can be read from a central location. Can handle small negative pore pressures.
Pneumatic Piezometer	Closed system in which a water pressure in the porous tip is balanced by pneumatic pressure. Changes in pressure are reflected in a transducer monitor.	Complicated and expensive to install. Cannot be used in cases where negative porewater pressures are likely to occur.
Vibrating Wire Piezometer	Changing pressure on a diaphragm at the piezometer tip causes alteration to the tension and hence the resonant frequency of an electromagnetically vibrated wire. This in turn is transmitted to an electronic monitoring and calibration system.	Initially expensive to install. Small negative pore pressures can be measured although partially saturated soils may require a specifically designed high air-entry filter. Rapid response time with the possibility of long lead cables to central monitoring stations.
Halcrow Bucket System	Simple systems of a series of tilting buckets installed within a borehole. As groundwater rises successive buckets are tipped.	An unsophisticated and very limited but, never the less a cheap and effective means of monitoring only maximum groundwater levels over a set period.
Tensiometer Systems	A variety of systems used to measure soil suction by obtaining equilibrium across a high air entry porous medium between the soil suction and a confined reservoir of water within the tensiometer system.	Measures matrix suction. Systems can be manual or automatic, including "quick draw" portable methods. Used generally in the range 0-90kPa suction, although this reduces at significant levels above sea level.

Table 6.2 Sample Quality Assessment

CHARACTERISTICS	SAMPLE CLASS
General Material Boundaries	1 2 3 4 5
Classification (PSD, Att.Limits) Remoulded Earthwork (MDD, CBR)	1 2 3 4
Moisture content Mineralogy	1 2 3
Density, Void Ratio	1 2
Undisturbed Strength; Deformation; Consolidation	1

Adapted from Idel et (1969) and BS5930:1981

Table 6.3 Suggested Sample Classes for TWIMs Samples

SAMPLE PROCEDURE	SAMPLE CLASS A	SAMPLE CLASS B	SAMPLE CLASS C	COMMENT
Wash Returns	5	5	5	Material boundaries only
SPT Tube	N	3	3	Split for fabric/structure examination
Open thin wall sampler	N	1	2-3	Much more disturbance it driven rather than pushed
Single tube core	4	5	5	Not recommended
Double tube core	2	4	4	Effectiveness increases with core size and liner
Triple tube core	1	2	3	Should be a minimum used in sensitive soils
Mazier/Pitcher	1	1	2-3	May be expensive
Bulk (Pit)	4	4	4	Opportunity for large samples for procedure correlations
Block (Pit)	1	1	1	Also from exposures
Tube (Pit)	3	3	3	Small tubes for moisture content and mineralogy analysis in some materials

Notes:

A: Pedogenic material
B: Non fabric-sensitive soil
C: Fabric-sensitive soil

1,2,3 etc = Sample Classes
N = Not applicable

Table 6.4 In-situ Testing Techniques

TECHNIQUE	GENERAL ADVANTAGES-LIMITATIONS	APPLICABILITY FOR TWMS
Standard Penetration Test	Combination of sample plus test. Progress 10m/day. Discontinuous. Moderate to high disturbance. Low cost.	Requires careful interpretation. Existing strength correlations may not be valid.
Static Cone Test **Light 2-10 tonne** **Truck mounted 20 tonne** **Piezocone**	No sampling. Continuous record with minimal disturbance. Piezocone will give pore water pressure figures. Access may be problem unless using smaller machines. Progress 50-100m/day.	Existing strength correlations may require reinterpretation. Of limited use in materials with indurated layers or corestones which may cause significant damage to machinery.
Continuous Dynamic Probing **Mackintosh Probe** **DCP**	Cheap methodology. Easy access. Limited depth penetration. Semi-continuous. No sampling.	Useful index tools for easy field use.
Swedish Ram Sounding (RST) **Swedish Weight Sounding (WST)**	More expensive but higher quality results; good depth penetration except for concretionary layers. Continuous profile. Progress 50-100m/day. No sampling	Already used with success in some TWIM environments, Pitts (1990)
Pressuremeter **Self Boring Pressuremeter (SBP)** **High Pressure Dilatometer**	Costly. Need careful site operation. Can give good soil-rock mass information. Requires good calibration techniques (Curtis, 1990)	Reported that interpretation techniques have not kept pace with the development of equipment, Johnston et al (1990). Particularly so with TWIMs.
Shear Vane **Borehole mounted** **Hand operated**	No sampling. Of use only in weakest materials.	Probably limited use in TWIM profiles.
Large Shear Box	Reasonable measure of material variability; minimum disturbance (Marsland 1990)	Potentially useful tool. Interpretation will require knowledge of moisture state. Only uppermost layers usually accessible in TWIM profiles.
Plate Bearing Test	As above, information generally only obtainable in vertical direction.	Only uppermost layers usually accessible in TWIM profiles.

Table 6.5 In-situ Permeability Testing Procedures

TECHNIQUE	GENERAL DESCRIPTION	APPLICABILITY
Open Borehole Tests	Constant, rising or falling head tests can be undertaken through the base of a cased borehole, or the uncased section of a borehole in a stable material.	Low cost method of obtaining permeability information in coarse soils or fractured rock. Results may be approximate only, particularly in variable materials. Results may be influenced by boring disturbance.
Piezometer Tests	Constant or falling head tests may be undertaken in a zone sealed by installation of Casagrande piezometer. Constant head generally recommended	Can give good in-situ values of permeability in fine soils. Groundwater must be in equilibrium before testing. May require specialist technician support. Radial drainage may not model project situation.
Packer Tests	Sections of a borehole may be sealed off by single or double packer systems. Testing generally by water injection into test zone under increasing steps of pressure. Pumping out tests from packer zones may be undertaken in saturated materials.	Convenient and rapid test for estimation of in-situ permeability, traditionally used for assessing grout take in fractured rock. Can suffer from leakage problems (particularly in the bottom packer) and hydraulic fracture. Interpretation may require a detailed appreciation of hydrogeological environment. Pumping water under pressure into a soil-rock mass may not accurately model the project situation
Pumping Tests	Pumping undertaken from a central hole and the draw-down effects noted in adjacent monitoring holes over timescale up to several days in duration	Expensive and time-consuming. requires the sinking of screened pumping and monitoring holes. More likely to monitor the project situation in cases of dewatering and ground excavation.

GEOGUIDE 2

TROPICAL WEATHERED IN-SITU MATERIALS
SITE INVESTIGATION

FIGURES

2.1 Typical Phased Investigation Programme

2.2 Relationship Between Character, Project and Performance

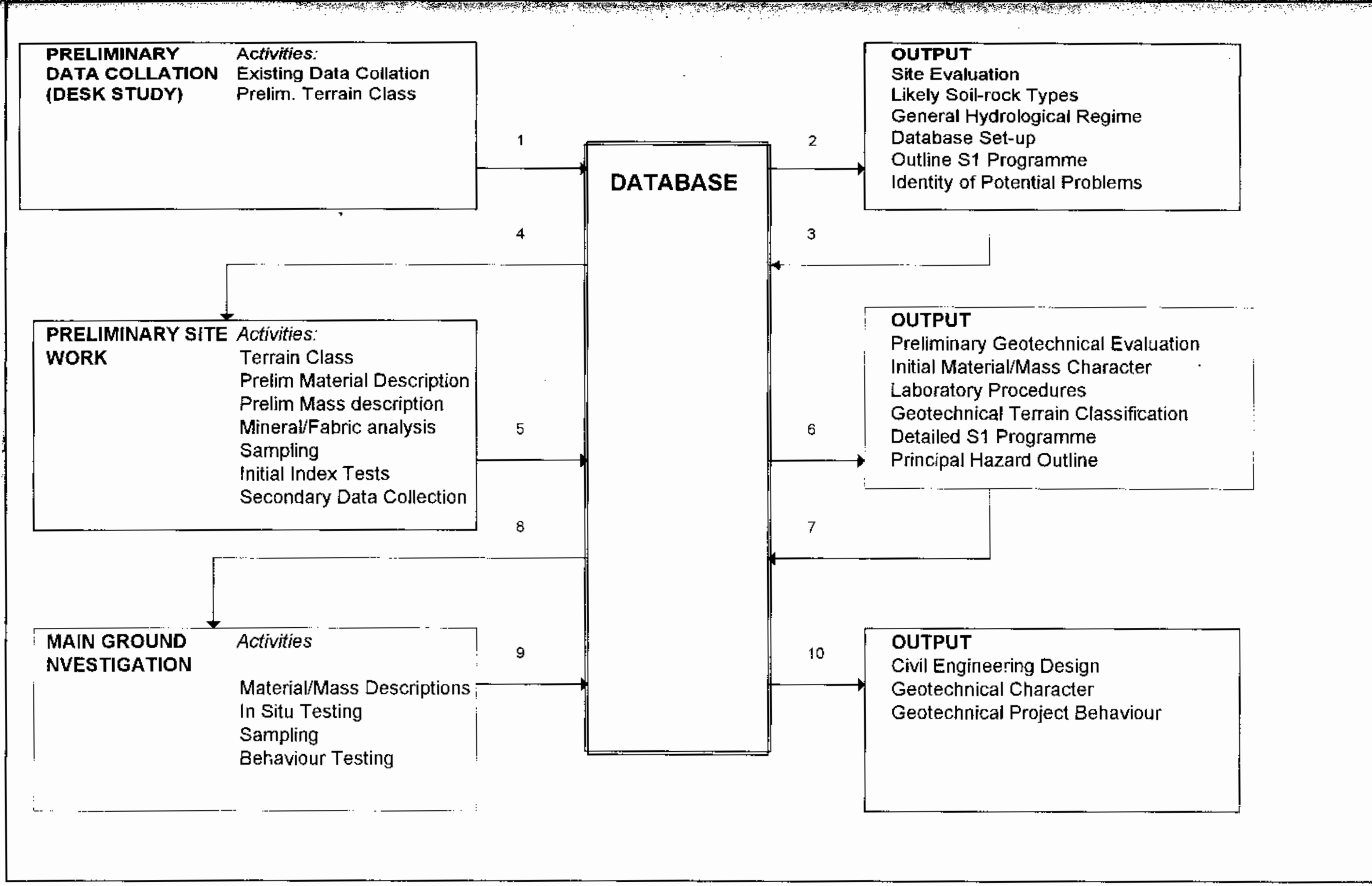
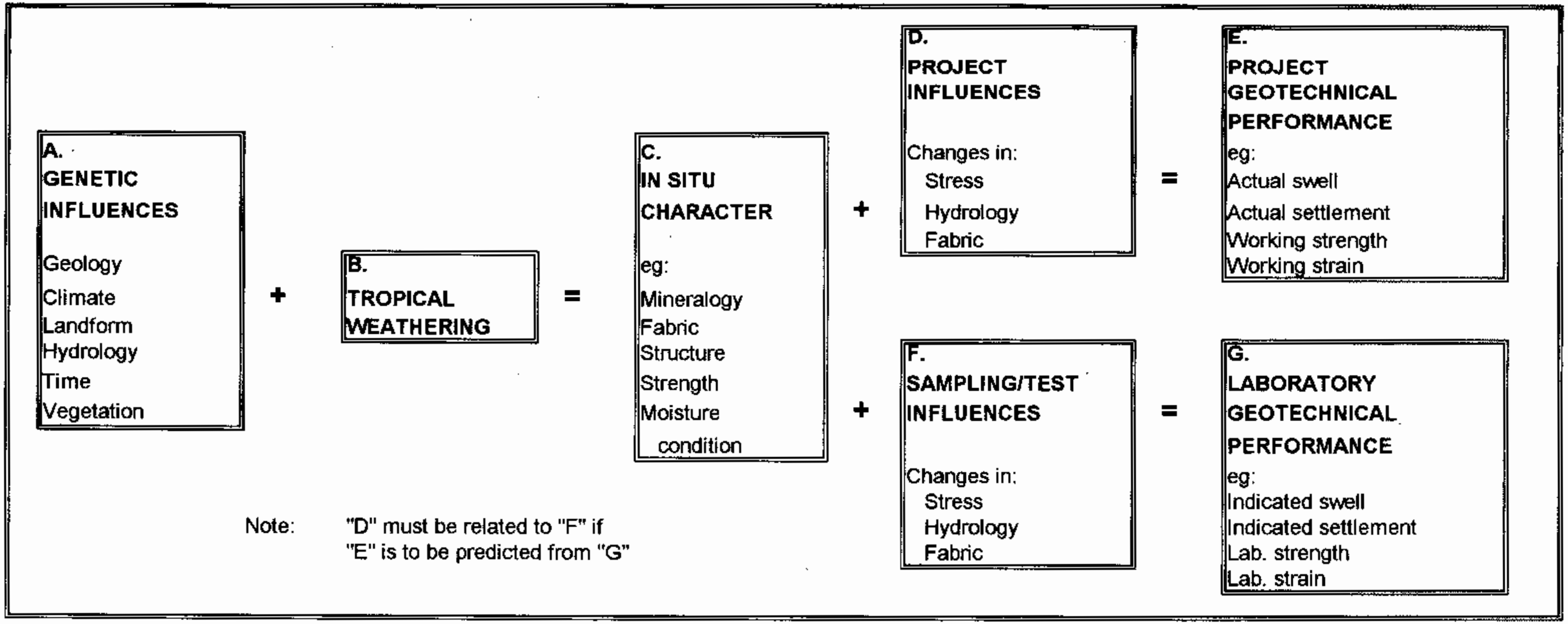

PRELIMINARY DATA COLLATION (DESK STUDY)
Activities:
Existing Data Collation
Prelim. Terrain Class
1
DATABASE
2
OUTPUT
Site Evaluation
Likely Soil-rock Types
General Hydrological Regime
Database Set-up
Outline S1 Programme
Identity of Potential Problems
3
4
PRELIMINARY SITE WORK
Activities:
Terrain Class
Prelim Material Description
Prelim Mass description
Mineral/Fabric analysis
Sampling
Initial Index Tests
Secondary Data Collection
5
6
OUTPUT
Preliminary Geotechnical Evaluation
Initial Material/Mass Character
Laboratory Procedures
Geotechnical Terrain Classification
Detailed S1 Programme
Principal Hazard Outline
7
8
MAIN GROUND NVESTIGATION
Activities
Material/Mass Descriptions
In Situ Testing
Sampling
Behaviour Testing
9
10
OUTPUT
Civil Engineering Design
Geotechnical Character
Geotechnical Project Behaviour

Figure 2.2 Relationship Between Character, Project and Performance



<u>GEOGUIDE 2</u>

<u>TROPICAL WEATHERED IN-SITU MATERIALS SITE INVESTIGATION</u>

APPENDICES

Appendix A: Desk Study Data Collection Form
Appendix B: Field Data Collection Forms
Appendix C: Data Management.

APPENDIX A

Desk Study Data Collection Form

DESK STUDY DATA REVIEW FORM

REPORT NAME

AUTHOR(S)

TYPE | 4 REF.No. | 5 PROJECT No.

GENERAL SUBJECTS

Single slope/failure	Sub-surface investigation
Multiple slopes/failure	Terrain evaluation
Large landslide	Geotechnical analysis
General review	Remedial design
Earthwork review	Investigation proposals
Earthwork design	

GENERAL LOCATION

TECHNICAL SUMMARY

SLOPE DATA

0 GEOTECHNICAL DATA

1 ILLUSTRATIONS

a Location
b Site plan
c Cross section
d Geology map
e Photographs
f Sketches

2 DATA VERIFICATION

a Date of data
b Date of review
c Review by
d Manager
e Data extraction

3 DATA LOCATION

GUIDE

TO

DESK STUDY DATA REVIEW FORM

GUIDE TO THE DESK STUDY DATA SET REVIEW FORM

Item No.	Description
1	**Report Name**. Title of report
2	**Author(s)**. Author, Contractor or Consultant name; if none available then the general origin of the report may be included, eg "Anon. (JKR)".
3	**Type**. The general category of the report; choose one from the following:-

1	technical advice
2	research report
3	conference paper
4	published paper
5	project progress
6	project review/summary
7	manual/technical guide
8	internal report/memo
9	personal notes
10	press report
11	factual geotechnical report
12	interpretative geotechnical report

4 **Ref. No.** The assigned reference number to the report; eg "IKRAM: A123/89/01". If there is no assigned number then enter the originating agency and the date, eg "JKR 12.91".

5 **Project No.** All examined reports to be assigned a unique EWH reference number.

6 **General Subject(s)**. This is a listing of the topics covered by the report. Tick those relevant.

7 **General Location**. Give the location of the information with respect to the project, for example under the headings of CHAINAGE; SLOPE No. and/or UNIT.

8 **Technical Summary**. This is to be a **short** summary of the report contents, eg " Factual report containing SI data for slopes 32-45 on the EWH. Included is information from BH logs, trail pits and laboratory testing" or " This report reviews the landslide hazards in Perak and the mechanisms of failure and relates these to terrain evaluation techniques. Several examples are described."

9 **Slope Data**. This is a listing of the various **types** of slope data included in the report. Pick options from the following:-

1 Slope types	2 Slope shape
3 Slope dimensions	4 Slope angles
5 Failure types	6 Failure dimensions
7 Failure angles	8 Slope/failure age
9 Land use	10 Erosion
11 Geology	12 Structure
13 Engineering data	14 Failure causes
15 Detailed survey	16 General geomorphology
17 Damage effects	18 Vegetation

Geotechnical Data. This is a listing of the **types** of geotechnical data contained within the report. Pick options from the following:-

1 Lab - strength/consolidation	2 Lab - classification
3 Lab - earthwork	4 In-situ strength
5 Soil/rock descriptions	6 Stability analysis
7 Remedial design	8 Geophysical data
9 Borehole logs	10 Test pit logs
11 Surface water data	12 Sub-surface water data
13 Ground movements	14 Rainfall data
15 Earthwork design	16 Construction materials

Illustrations. The type and number of illustrations in the report. Put the number (or zero) after the appropriate type.

Data Verification. Enter the required dates and names in the boxes "a" to "c". For "d" the relevant project team leader should enter yes/no as to whether he has seen the report in question. Enter yes in box "e" only when the next phase of detailed data extraction has been completed.

Data Location. This section defines the current location of the report depending on whether it is in a library, on temporary loan from some other agency or actually held by some other agency. If the latter then if possible enter the contact name.

APPENDIX B
TWIMs Field Data Collection Forms

SOIL-ROCK MASS LOCATION AND DEFINITION FORM
(Sheet 1)

1.POSITION

Survey [ ] Ref. No. [ ] Geology [ ]

Unit [ ] Chainages [ ]

Co-ordinates [ ]

2.GEOMORPHOLOGY

Landform [ ] Relief [ ] Angles [ ]

3.ENGINEERING

Cuttings [ ]

Embankments [ ] Highway [ ]

4.EXPOSURE

Type/Ref	Form	Condition	Access	Materials	Grades

5.ADDITIONAL

Investigations	
Air Photos	
Ground Photos	
Comments	
Field Team	
Date	

SKETCH PLAN

SOIL-ROCK MASS LOCATION AND DEFINITION FORM
(Sheet 2)

PHOTOGRAPH

CROSS-SECTION

SOIL - ROCK MATERIAL DESCRIPTION FORM (Sheet 1)

D

rvey [ ] Mass [ ] Loc. [ ] Type [ ]

	MATERIAL No.	1	2	3	4	5	6	7	8	9
OISTURE	State									
	Weather									
COLOUR	Main									
	Secondary									
	Form									
	Secondary									
	Form									
STRENGTH	Field estimate									
	Modification									
PARTICLE	Size-1									
	Size-2									
	Size-3									
	Size-4									
	Shape									
	Type									
	Strength									
.FABRIC	Form									
	Distribution									
	Orientation									
	Origin									
.DISCONTINIUTIES										
	Set A									
	Set B									
	Set C									
	Set D									
	Set E									
	Pattern - Meso									
	Pattern - Macro									
.MINERALOGY	Types									
	Amount									
.ORGANICS	Amount									
	Type									
0.CLASS.	Type\Zone									
	Grade									
1.SAMPLES	Nos.									
	Type									

SOIL - ROCK MATERIAL DESCRIPTION FORM (Sheet 2)

	MATERIAL No.	1	2	3	4	5	6	7	8	9
12. BEHAVIOUR	Plasticity (N)									
	Plasticity (w)									
	Feldspars									
	Carbonates									
	Durability									
	Permeability									
	Shrink/swell									
	Schmidt No.									
	Vane/Pen.									

13.MATERIAL SKETCHES

14. COMMENTS

15. ADDITIONAL

Logged By ______ Date ______ Checked ______

SOIL-ROCK PROFILE DEFINITION FORM

1. Definition

Survey		Loc.		Altitude		X-Ref.	
Mass		Chainage		Level 1			
E'work		Type		Level 2			

2.Materials

From	To	Mat.	Grade

3.Boundaries

Type	Dist.	Dip

4.Coring Details

TCR	SCR	RQD	If

GUIDES TO FIELD DATA COLLECTION FORMS

GUIDE TO SOIL-ROCK MASS LOCATION AND DEFINITION FORM

1. POSITION

Survey. A unique project reference code. For example for the East-West Highway project would use EWH.1.

Ref. No. A unique project reference code for each examined soil-rock mass.

Geology. The general geological setting; rock group, formation etc.

Unit. A reference to the terrain unit in which the soil-rock mass is situated,

Chainages. The chainages along any highway that cross the mass.

Co-ordinates. The easting and northing co-ordinates that give the location of the centre of the mass.

2. GEOMORPHOLOGY

Landform. The general shape of the natural slopes within the mass. the following options may be used:

Code	Term
1	Concave
2	Convex
3	Straight
4	Concavo-convex
5	Irregular

Relief. This is the relative topographic relief within the mass: it may be categorised as follows:

Code	Relative relief (m)	Term
1	<10	Very low
2	10 - 25	Low
3	25 - 50	Moderate
4	50 - 100	Mod. high
5	100 - 300	High
6	>300	Very high

Angles. The natural slope angles within the mass; they may be classified using the following:

Code	Angle (degrees)	Term
1	0-2	Level to very gentle
2	2-5	Gentle
3	5-10	Moderate
4	10-20	Moderately steep
5	20-30	Steep
6	30-45	Very steep
	45-70	Precipitous
	70-90	Sub-vertical

If more than one angle, slopes may be defined as ridge (R) or side-slope (S)

3. ENGINEERING

Cuttings. The project reference numbers of cuttings in the mass.

Embankments. The project reference numbers of embankments in the mass.

Highway. The influences or relationship between the soil-rock mass and any highway earthworks. See Fig. B1 for options.

4. EXPOSURES

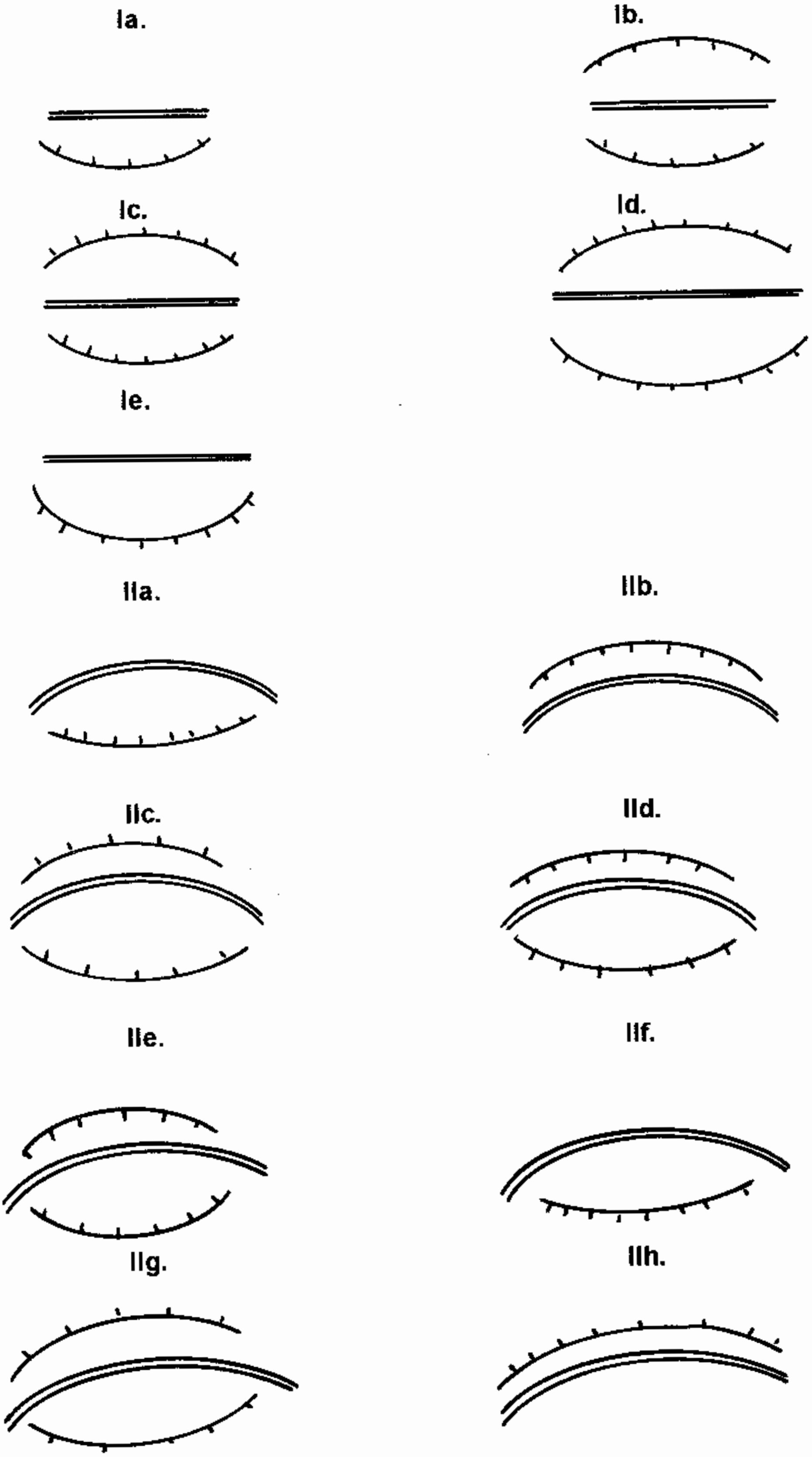
This section summarises information on typical exposures within the mass.

Type/Ref. The type and location reference number of the typical exposures; type as follows:

Code	Term
1	Cutting
2	Natural exposure
3	Trial pit

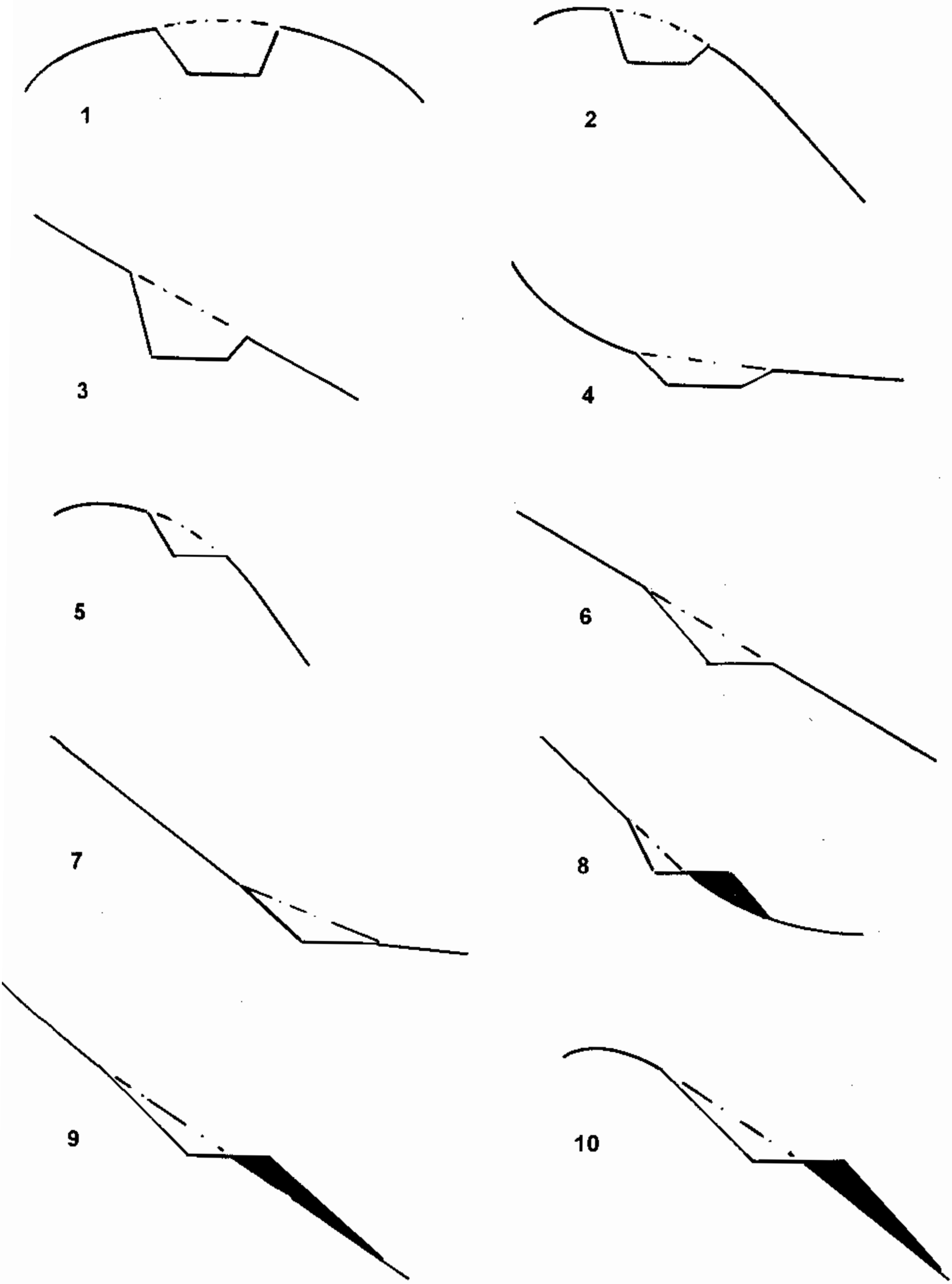
Form. The form and extent of the exposures with respect to the soil-rock mass as a whole. See Fig. B2 for options.

Figure B1 Relationship Between Soil-Rock Mass and Highway in Plan



As above but with tight curves **IV** Complex curves

Figure B2 Relationship Between Soil-Rock Mass and Highway in Section



Condition. The general condition of the identified exposures. Options are as follows:

Code	Term	Definition
1	Excellent	Total soil-rock exposure of the face
2	Good	Some limited vegetation or debris cover but representative profiles visible.
3	Moderate	Vegetation or debris covering significant areas of the face.
4	Poor	Vegetation or debris covering majority of face, very limited visible exposures
5	Very poor	Total cover. Virtually no visible exposure

Access. An evaluation of the ease of access for detailed examination of the identified exposure. Use the following options:

Code	Term	
1	Excellent	Easy access to whole exposure
2	Good	Good access to whole exposure but with significant climbing.
3	Moderate	Good access to only typical sections of the exposure.
4	Poor	Limited difficult access to sections of the exposure.
5	Very poor	Access to most of the exposure very difficult.

Materials. The material types evident within the exposures, may be described as follows:

100 Igneous Rock Types 101 Basalt 102 Andesite 103 Dacite 104 Rhyolite 105 Trachyte 106 Trachyandesite 107 Porphyry 108 Dolerite 109 Diorite	110 Gabbro 111 Granite 112 Granodiorite 113 Syenite 114 Peridotite 115 Serpantinite 116 Norite 117 Agglomerate 118 Tuff	119 Breccia 120 Lahar 121 Volcanic Ash 122 Pumicee 123 Porph. Granite 124
200 Sedimentary Rock Types 201 Breccia 206 Conglomerate 203 Sandstone 204 Siltstone 205 Mudstone 206 Claystone	207 Marl 208 Shale 209 Crystalline Lmst 210 Bioclastic Lmst 211 Oolitic Lmst 212 Argillaceous Lmst 213 Chert 214 Chalk 215 Dolomite	216 Evaporite 217 218
300 Metamorphic Rock Types 301 Schist 302 Gneiss 303 Hornfels 304 Marble 305 Phyllite 306 Psammite	307 Quartzite 308 Amphibolite 309 Argillite/pelite 310 Slate 311 Mica Schist 312 Calc. Schist 313 Talc Schist 314 Glauc. Schist 315 Hornblende Schist	316 Garnet Schist 317 Migmatite 318 Mylonite 319 Arenite 320 Chlorite Schist 321 Qtz Chlorite Schist
400 Fragments 401 Lithic fragments 402 Shell 403 Lateritic Nodules	404 Pumice 405 Volc.glass 406 Concretions 407 Soil peds	
500 Common Mineral Types 501 Alkali feldspar 502 Amphibole 503 Anhydrite 504 Asbestos 505 Augite 506 Barytes 507 Biotite 508 Calcite 509 Carbonate 510 Chalcopyrite 511 Chert 512 Chlorite	513 Dolomite 514 Evaporite 515 Feldspar 516 Fluospar 517 Galena 518 Glauconite 519 Goethite 520 Gypsum 521 Halite 522 Haematite 523 Hornblende 524 Iron oxide 525 Kaolinite 526 Limonite 527 Muscovite	528 Olivine 529 Plagioclase 530 Pyrite 531 Pyroxene 532 Quartz 533 Sericite 534 Serpentine 535 Silica 536 Sulphur 537 Talc 536 537

Grades. An estimation of the weathering grades evident in the exposure.

5. ADDITIONAL

Investigations. Investigations undertaken on the soil-rock mass including any from previous surveys. The relevant codes that may be used are as follows:

Code	Term
1	Profile description
2	Mass description
3	Borehole
4	Trial pit
5	In-situ test
6	Disturbed sampling
7	Undisturbed sampling
8	Structural survey

Air Photos. List reference numbers for relevant vertical and oblique air photos.

Ground Photos. List reference numbers for relevant ground photos.

Comments. Any other relevant information.

Field Team. The person or team collecting the field data.

Date. Date of data collection.

Sketch Plan. A sketch plan of the soil-rock mass indicating its main features. The following should be included:-

Topographic features
Earthworks
Highway
Identified exposure(s)
Access to exposure
Photograph points
Slope failures
North-south orientation
Major geological features

Cross-Section. A typical cross section (or sections) through the mass illustrating the main features.

Photograph. A typical photograph (or photographs) of the mass illustrating the main features.

GUIDE TO SOIL-ROCK MATERIAL DESCRIPTION FORM

1. IDENTIFICATION

This section identifies the location of the materials.

Survey. A unique project reference code. For example for the East-West Highway research project the code 101.

Loc. A unique reference number for the assemblage of materials being described.

Type. Defines the type of feature or assemblage containing the described materials. Option codes are as follows:

Code	Type
1.	Profile description
2.	Borehole
3.	Mass description
4.	Trial pit
5.	Disturbed sample
6.	Undisturbed sample

2. MOISTURE.

Defined in terms of the material state and the recent weather. Note that the date of survey will also give some guide as to weather influences with respect to rainy seasons etc.

State. Use the following options:

Code	Class	Description
1	Dry	Sands loose. Silty material brittle and crushes to dust. Clayey materials tend to be fissured and cannot be crushed in fingers.
2	Slightly moist	Usually slightly darker in colour than dry . Gradation between dry and moist.
3	Moist	Moist horizons tend to exhibit range of colour change. Fingers become moist when soil remoulded. Absence of wet or dry characteristics.
4	Very moist	Gradation between moist and wet.
5	Wet	Water films visible on grains and peds. Seepage.

Weather. Use the following options:

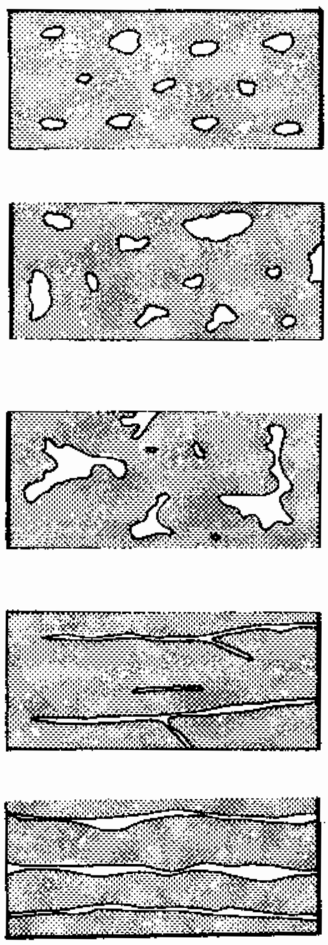
Code	Description
1	Very heavy rain for some days following a dry spell
2	Steady rainy season conditions for some weeks
3	Only occasional rain in last week
4	Only occasional rain in last month
5	No rain for more than 1 week
6	No rain for more than 1 month
7	Rain intermittent for 1-2 weeks
8	

Use the suffix "R" to indicate rain during the 24 hours prior to the survey.

3. COLOUR.

Where possible the use of the Geological Society of America "Rock Color Chart" is recommended. Colour is defined under a main option together with secondary mottling etc. The form of the secondary colours may be defined using Figure B3.

Figure B3 Form of Secondary Colour Patterns (after GCO, 1988)



1. Spotted
2. Mottled
3. Dappled
4. Streaked
5. Striped

4. **STRENGTH.** Estimated field strength is defined using the following :

Code	Strength (kN/m2)	Description
		COHESIVE SOIL
1	Very soft (<40)	Exudes between fingers when squeezed in hand.
2	Soft (40-80)	Easily penetrated by thumb. Moulded by light finger pressure.
3	Firm (80-150)	Penetrated by thumb with effort. Moulded by strong figure pressure.
4	Stiff (150-300)	Indented by thumb. Cannot be moulded by fingers.
5	Very stiff (300-600)	Indented by thumbnail. Penetrated to about 15 mm with knife
		NON-COHESIVE SOIL
6	Loose	Can be excavated by spade. 50mm peg can easily driven. Easily crushed in fingers.
7	Dense	Requires pick for excavation. 50mm peg hard to drive. Crushed by strong finger pressure.
8	Slightly cemented	Pick removes soil in lumps which can be abraded.
	(MN/m^2)	ROCK & INDURATED MATERIALS
9	Very weak (0.6-1.25)	Easily broken by hand. Penetrated about 5mm with knife.
10	Weak (1.25-5.0)	Broken by leaning on sample with hammer. No penetration with knife. Scratched with thumbnail.
11	Mod. weak (5.0-12.5)	Broken in hand with hammer. scratched with knife.
12	Mod. strong (12.5-50)	Broken against solid object with hammer.
13	Strong (50-100)	Difficult to break against solid object with hammer.
14	Very strong (100-200)	Requires many blows of hammer to fracture sample
15	Extra strong (>200)	Sample only be chipped by hammer.

This may have a modification, if relevant, as follows:

Code	Class	Description
1	Anisotropic	A tendency to break in one direction
2	Friable	Crumbles under firm pressure in the hand
3	Brittle	Breaks suddenly and cleanly under firm pressure in the hand
4	Fissile	A marked tendency to split along one plane

5. TEXTURE.

Structure is defined as being composed of the fabric, texture and discontinuity patterns making up the soil-rock material, mass or unit. Texture is defined as the morphology, type and size of component particles. It is described on the pro-forma under the headings of particle size, shape, type and strength.

Size of the constituent material particles is described for non-crystalline materials in line with current standard practice (BS 5930) this is defined in terms of primary (size_1), secondary (size_2), tertiary (size_3) and additional (size_4) constituents. Size codes for soils and non-cemented rock materials are as follows:

Code	Class (mm)	Description
1	>600	Large boulder
2	200 - 600	Boulder
3	60 - 200	Cobble
4	2.00 - 60	Gravel
5	0.06 - 2.00	Sand
6	0.002 - 0.06	Silt
7	<0.002	Clay

The above size description holds true for soil or cemented rock materials (eg sandstone or conglomerate). It may not be suitable for crystalline material. For crystalline rocks the following options are used:

Code	Class	Description
101	Very coarse	Generally greater than gravel-sized.
102	Coarse	Mainly gravel-sized
103	Medium	Mainly sand-sized
104	Fine	Mainly silt-sized
105	Very fine	Mainly clay-sized

Some materials may be described as crystalline but may in addition break down, or remould, to a particle dominated material. In these cases the crystalline definition should be followed by the particle definition suffixed by "R", eg 105| 6R

Shape. It may be defined using the following, in conjunction with Figure B4.

	Code	Description
Overall Shape	1	Equi-dimensional
	2	Flat
	3	Elongate
	4	Flat and elongate
	5	Irregular
Angularity	1	Rounded
	2	Subrounded
	3	Subangular
	4	Angular
Surface Texture	1	Glassy
	2	Smooth
	3	Granular
	4	Rough
	5	Crystalline
	6	Honeycombed
	7	Porous
	8	Striated

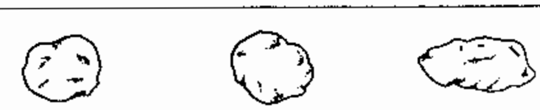
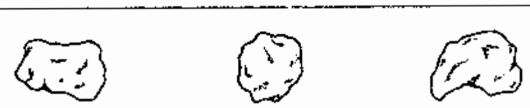
Figure B4

Particle Shape

Overall Shape

Term	Illustration
Equi-deminsional	
Flat	
Elongate	
Flat and Elongate	

Particle Angularity

Term	Illustration
Angular	
Sub-angular	
Sub-rounded	
Rounded	

Type. Particles may be defined using the following:

100 Igneous Rock Types 101 Basalt 102 Andesite 103 Dacite 104 Rhyolite 105 Trachyte 106 Trachyandesite 107 Porphyry 108 Dolerite 109 Diorite	110 Gabbro 111 Granite 112 Granodiorite 113 Syenite 114 Peridotite 115 Serpantinite 116 Norite 117 Agglomerate 118 Tuff	119 Breccia 120 Lahar 121 Volcanic Ash 122 Pumicee 123 Porph. Granite 124
200 Sedimentary Rock Types 201 Breccia 206 Conglomerate 203 Sandstone 204 Siltstone 205 Mudstone 206 Claystone	207 Marl 208 Shale 209 Crystalline Lmst 210 Bioclastic Lmst 211 Oolitic Lmst 212 Argillaceous Lmst 213 Chert 214 Chalk 215 Dolomite	216 Evaporite 217 218
300 Metamorphic Rock Types 301 Schist 302 Gneiss 303 Hornfels 304 Marble 305 Phyllite 306 Psammite	307 Quartzite 308 Amphibolite 309 Argillite/pelite 310 Slate 311 Mica Schist 312 Calc. Schist 313 Talc Schist 314 Glauc. Schist 315 Hornblende Schist	316 Garnet Schist 317 Migmatite 318 Mylonite 319 Arenite 320 Chlorite Schist 321 Qtz Chlorite Schist
400 Fragments 401 Lithic fragments 402 Shell 403 Lateritic Nodules	404 Pumice 405 Volc.glass 406 Concretions 407 Soil peds	
500 Common Mineral Types 501 Alkali feldspar 502 Amphibole 503 Anhydrite 504 Asbestos 505 Augite 506 Barytes 507 Biotite 508 Calcite 509 Carbonate 510 Chalcopyrite 511 Chert 512 Chlorite	513 Dolomite 514 Evaporite 515 Feldspar 516 Fluospar 517 Galena 518 Glauconite 519 Goethite 520 Gypsum 521 Halite 522 Haematite 523 Hornblende 524 Iron oxide 525 Kaolinite 526 Limonite 527 Muscovite	528 Olivine 529 Plagioclase 530 Pyrite 531 Pyroxene 532 Quartz 533 Sericite 534 Serpentine 535 Silica 536 Sulphur 537 Talc 536 537

Strength of the material particles may be defined, where possible, using the following:

Code	Strength (kN/m2)	Description
		COHESIVE SOIL
1	Very soft (<40)	Exudes between fingers when squeezed in hand.
2	Soft (40-80)	Easily penetrated by thumb. Moulded by light finger pressure.
3	Firm (80-150)	Penetrated by thumb with effort. Moulded by strong figure pressure.
4	Stiff (150-300)	Indented by thumb. Cannot be moulded by fingers.
5	Very stiff (300-600)	Indented by thumbnail. Penetrated to about 15 mm with knife
		NON-COHESIVE SOIL
6	Loose	Can be excavated by spade. 50mm peg can easily driven. Easily crushed in fingers.
7	Dense	Requires pick for excavation. 50mm peg hard to drive. Crushed by strong finger pressure.
8	Slightly cemented	Pick removes soil in lumps which can be abraded.
	(MN/m^2)	ROCK & INDURATED MATERIALS
9	Very weak (0.6-1.25)	Easily broken by hand. Penetrated about 5mm with knife.
10	Weak (1.25-5.0)	Broken by leaning on sample with hammer. No penetration with knife. Scratched with thumbnail.
11	Mod. weak (5.0-12.5)	Broken in hand with hammer. scratched with knife.
12	Mod. strong (12.5-50)	Broken against solid object with hammer.
13	Strong (50-100)	Difficult to break against solid object with hammer.
14	Very strong (100-200)	Requires many blows of hammer to fracture sample
15	Extra strong (>200)	Sample only be chipped by hammer.

6. **FABRIC.**

This is defined as the spatial arrangement of component particles. In the context of fieldwork this is confined to those features visible to the naked eye with the aid of a hand lens. Further micro-fabric work may be undertaken on selected representative samples. Fabric is defined under the headings of form, distribution, orientation and origin.

Form. It may be defined using the following:

Code	Term	Description
1	Crystalline	Interlocked crystalline form, eg igneous or metamorphic.
2	Degraded crystalline	Crystalline form but showing signs of separation or break-up.
3	Granular	Separate identifiable particles or grains.
4	Amorphous	No visible fabric form.
5	Strongly blocked	Clear development of peds
6	Weakly blocked	Poor ped development

Distribution. It may be defined using the following:

Code	Term	Description
1	Porphyritic	The matrix occurs as dense groundmass in which grains are set after the manner of a porphyritic rock
2	Homogenous	Completely homogenous groundmass/grain distribution
3	Agglomeritic	The matrix occurs as a loose or incomplete fillings in spaces between grains or groups of grains.
4	Intertextic	The grains are linked by intergranular braces or are imbedded in a porous groundmass.
5	Matrix Dominant	Almost all groundmass/matrix.
6	Interlocked	Grains or peds tightly interlocked with little or no matrix.
7	Separated	Grains or peds loosely interlocked.

Orientation. It may be defined as follows:

Code	Term	Description
1	Strong	>60% of the particles are orientated with their principal axes within 30 degrees of each other.
2	Moderate	40-60% of the particles are oriented with their principal axes within 30 degrees of each other.
3	Weak	20-40% of the particles are oriented with their principal axes within 30 degrees of each other.
4	Non-existent	No fabric orientation visible.
5	Random	Fabric visible but with no preferred orientation.

Origin. It may be defined as follows:

Code	Term	Description
1	Pedogenic	Peds formed in situ by soil forming process.
2	Organic	Root channels etc.
3	Secondary/Mineral	Nodules, mineral coatings, aggregates (laterisation).
4	Inherited	Parent material fabric.
5	Weathered	Parent fabric modified by weathering processes.

7. DISCONTINUITIES.

This section is used to identify any discontinuity patterns within the soil-rock materials. Detailed definition of structural patterns in profiles and masses may be undertaken using the appropriate Exposure or Discontinuity Data Sheet ASTM (1980). Discontinuity data are grouped within sets under the headings of type, spacing and condition which are defined as follows:

Type. It may be defined as follows:

Code	Term	Description
1	Fissures	Fractures occurring primarily as the result of the weathering process.
2	Joints	Inherited parent material fractures along which no movement appears to have taken place.
3	Bedding	Distinct planar surfaces parallel to the original sediment depositional process.
4	Laminations	Very thin discrete layering within the original parent material parallel to the original depositional process.
5	Foliation	Parallel orientation of minerals as in metamorphic rocks.
6	Faulting	Fractures along which discernable movement has taken place.

Spacing. It may be defined as follows:

Code	Spacing (mm)	Description
1	>2000	Very widely spaced
2	2000 - 600	Widely spaced
3	600 - 200	Medium spaced
4	200 - 60	Closely macro-spaced
5	60 - 20	Very closely macro-spaced
6	20 - 5	Extremely closely macro-spaced
7	5 - 2	Closely meso-spaced
8	2 - 0.5	Very closely meso-spaced
9	<0.5	Extremely closely meso-spaced

Condition. It may be defined as follows:

Code	Term	Description
1	Closed	Discontinuity surfaces in tight contact.
2	Fresh	No visible signs of weathering on surfaces
3	Stained	Discolouration on surfaces or surface trace
4	Residue	Weathering deposit on surfaces
5	Infilled	Space between discontinuity surfaces infilled with weathered deposit.
6	Disintegrated	Discontinuity surfaces significantly weaker or friable than surrounding mass.
7	Open	Discontinuity open.
8	Weathered	Area around discontinuity preferentially weathered.

Discontinuity sets should be further defined as to their scale level, which are defined as follows:

Code	Term	Description
1	Micro-level: <0.5mm	Generally only described with the aid of SEM or petrographic microscope.
2	Meso-level: 0.5-5mm	Generally seen with the aid of field microscope or good hand lens.
3	Macro-level: 5mm-50m	Patterns visible to the naked in the field
4	Mega-level: >50m	Patterns that become apparent by means of maps or remote sensing, although individual elements may be visible at field level.

In addition the general discontinuity patterns at the macro and meso levels should be recorded as follows:

Pattern. It may be described as follows:

Code	Term
1	Blocky - regular
2	Tabular - regular
3	Tabular - irregular
4	Columnar
5	Irregular
6	Platy - regular
7	Platy - irregular
8	Blocky - irregular

8. MINERALOGY

This section indicates the principal visible mineral types and approximate amounts. Mineral type codes may be taken from Table B1. Amounts will be by visual estimation.

9. ORGANICS

The type and amount of organic material is estimated in this section. The following options are available:

Organic types. It may be described as follows:

Code	Type
1	Rootlets
2	Roots
3	Fragments
4	Patches
5	Peat
6	General

Use the prefix by F for fresh and D for decayed.

Organic amount. It may be described as follows:

Code	Amount
1	Very minor
2	Scattered/occasional
3	Little
4	Moderately
5	Highly
6	Completely

10. CLASS

This section summarises the type weathering zone and grade of material described. Rock type codes may be obtained from the rock table and zones and grades from the appropriate material classifications, for example:

Zone P: Unaltered to slightly altered parent material - probably corresponding to grades I & II

Zone AP: Significantly altered parent material probably corresponding to grades III & IV.

Zone CAP: Parent material altered to soil - probably corresponding to grades V & VI

11. SAMPLES.

This section is a check list of recovered material samples. Information should comprise sample number and sample type.

Type. It may be described as follows:

Code	Type
1	HS: Hand sample
2	UD: Undisturbed sample
3	SD: Small disturbed
4	BD: Bulk disturbed

12. BEHAVIOUR.

This section describes a range of simple field behaviours, some of which may not be applicable to particular materials.

Plasticity It should be examined in both the materials' natural state (N) and in a completely remoulded and wetted-up state (W); the options are listed below:.

Code	Term	Definition
1	Non-plastic	A roll 40mm long and 6mm thick cannot be formed.
2	Slightly plastic	A roll 40mm long and 6mm thick can be formed and will support its own weight, but one 4mm thick will not support its own weight.
3	Moderately plastic	A roll 40mm long and 4mm thick can be formed and will support its own weight, but one 2mm thick will not support its own weight.
4	Very plastic	A roll 40mm long and 2mm thick can be formed and will support its own weight.

Feldspar decomposition. It may be examined as a clue to general material condition and may be described as follows:

Code	Grittiness Term	Degree of decomposition	Description
1	Hard	Fresh	Cannot be cut by knife, cannot be grooved by pin
2	Gritty	Moderate	Can be cut with knife or grooved with a pin under heavy pressure
3	Powdery	Highly to extremely	Crushed to silt sized fragments by finger pressure
4	Soft	Completely	Moulded very easily with finger pressure

Carbonate content. The action of 10% HCL on the material should be noted as follows:

Code	Term	Audible Effect	Visible Effect
1	Non-calcareous	None	None
2	Very Slightly Calcareous	Faintly audible	None
3	Slightly calcareous	Moderately to distinctly audible; heard away from ear	Slight effervescence just visible
4	Calcareous	Easily audible	Moderate effervescence; obvious bubbles up to 3mm in dia.
5	Very calcareous	Easily audible	Strong effervescence; ubiquitous bubbles up to 7mm in dia. easily seen

Durability. It may be examined by means of a simple jar slaking index test in which material samples are placed in still water for 10 minutes and the their reaction defined as follows:

Code	Field Slake Definition
1	No obvious effects
2	No immediate effect other than a slight but noticeable drop in strength
3	No immediate effect, breaks into large pieces using Minimum Finger Pressure (MFP)
4	No immediate effect, crumbles to small blocks on MFP
5	Rapidly splits. Breaks into smaller blocks on MFP
6	Rapidly splits. Crumbles to sediment under MFP
7	Rapidly breaks down into small blocks
8	Disintegrates to sediment

Permeability. It may in some cases be estimated where relevant from the observation of wetting/drying patterns or from the results of simple infiltration tests. Option codes are listed below:

Code	Term
1	Relatively impermeable
2	Low permeability
3	Moderate permeability
4	Highly permeable
5	Very highly permeable.

Shrink/Swell. This may be estimated from the observation of the drying behaviour of rolled out wet samples or the wetting-up of dry samples. Option codes are given below:

Code	Term
1	No volume change potential apparent
2	Minor volume change apparent
3	Moderate volume change apparent
4	High volume change apparent.

Schmidt Hammer. This procedure may be used in stronger materials as an in-situ strength index. Summary Schmidt numbers obtained after following the appropriate test procedure can be entered directly.

Hand vane/penetrometer should be used where appropriate. Summary values can be entered directly in the correct units.

13. MATERIAL SKETCHES.

Any relevant material sketches or material locations should be included here.

14. COMMENTS

Any relevant additional remarks including reference to any photographs.

15. ADDITIONAL

This section includes general information on the data collection activity.

LOGGED BY: The name(s) or other identifying code for the logging team.

DATE: Date of material description.

CHECKED: The name or other identifying code of the person, or persons, cross-checking the data.

GUIDE TO SOIL-ROCK PROFILE DESCRIPTION FORM

1. DEFINITION

Survey. A unique project reference code. For example for the East-West Highway project could Code.101.

Mass. A unique project reference code for each examined soil-rock mass.

Earthworks. A unique reference number for the relevant earthwork. In the case of the EWH the appropriate earthwork feature number could be used.

Location.. A unique identification number for the profile location.

Chainage. The project chainage location of the profile; with addition of L (left) or R (right).

Type. The type or origin of the profile being described; options are as follows:

Code	Type
1.	Earthwork exposure
2.	Natural exposure
3.	Borehole
4.	Trial pit

Attitude. The approximate orientation of the profile as an angle from the horizontal.

Levels. The levels of the top and bottom of the profile either with respect to a known value or as reduced levels.

X-Ref. Any cross reference for previously sunk boreholes etc.

2. MATERIALS

From and To define the position of the materials down or along the profile.

Mat and Grade The reference codes and weathering grade for the materials - as used on the appropriate materials description sheet.

3. BOUNDARIES

Boundaries between the materials should be defined, if possible, in terms of <u>type</u> and <u>distinctiveness</u>.

<u>Type</u>. It may be defined as follows:

Code	Type
1.	Weathering
2.	Lithological (bedding)
3.	Combined weathering and lithological
4.	Tectonic (eg faulting)
5.	Shear surface

<u>Distinctiveness</u>. It may be defined as follows:

Code	Term	Definition - Boundary Zone Thickness (mm)
1	Sharp	<5
2	Abrupt	5 - 25
3	Clear	25 - 60
4	Gradual	60 - 130
5	Diffuse	>130

<u>Attitude</u> in terms of dip and dip direction, should be noted where possible,.

4. CORING DETAILS

In the case of cored profiles the standard coring indices should be recorded. These are:

Code	Type
1.	TCR: Total core recovery
2.	SCR: Solid core recovery
3.	RQD: Rock quality designation
4.	If: Fracture index.

These indices are as defined in standard codes of practice, BS5930 (1981) and ASM (1980).

APPENDIX C

Data Management

DATA MANAGEMENT

An example of a TWIM's database is that set up for the the East-West Highway (EWH) research project. It was set-up to run on FOXPRO (version 2.6 for WINDOWS) using .dbf data files compatible with other standard database packages. A preliminary TWIMs database structure was outlined which was intended to comprise a number of related files holding data sets concerned with soil-rock mass and materials, laboratory test results and in-situ location. These files were designed to be linked and indexed by a number of common fields and be relatable to the database files set for the EWH long term stability study which were to hold the principal inventory and desk study geotechnical data.

As the research project progressed, the structure of the database and its component files was modified in line with the nature of the data being recovered. Once the initial phase of database file design had been undertaken the modification of fields and the subsequent input of information became a straightforward procedure that enabled more technical time to be spent on data manipulation and interpretation.

The filing of data with respect to geotechnical groups is a logical step in the overall data collation and dissemination process. In the case of the TWIMs database the main geological units and exposure locations were used as the principal organisational groupings. All the technical database files have been given the prefix "EWH_" and can be related through key fields containing combinations of location and material type. The principal data files in the TWIMs database file structures are listed in this Appendix. Data may be extracted from a number of the related files using the software query procedure and reported in tabular or graphic format using standard software packages.

EWH_MAS.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_REFNO	N	Mass ref. no.	
I1_UNIT	C	Terrain unit	Look-up table
I1_GGEOL	C	General geology	
I2_CHAIN1	N	Chainage from	
I2_CHAIN2	N	Chainage to	
I2_EAST	N	Easting	Not used this survey
I2_NORTH	N	Northing	Not used this survey
D1_LFORM	N	Land form	Look-up table
D1_RELIEF	N	Topographic relief	Look-up table
D1_ANGLES	N	Natural slope angles	Look-up table
D2_CUTS	C	Cuts present	
D2_EMBNKS	C	Embankments present	
D3_FORM	N	Route plan form	Look-up table
D3_NO_LOC	N	Number of profile exposures	
D3_MAT1	N	Material 1	Look-up table
D3_MAT2	N	material 2	Look-up table
D3_MAT3	N	Material 3	Look-up table
S1_INVEST	C	Site investigations	Not used this survey
S1_AIRPH	C	Air photos	Not used this survey
S1_GRNDPH	C	Ground photos	Not used this survey
A1_DATE_1	D	Date of survey	
A1_TEAM	C	Survey team	
A2_DATA_IN	D	Data input date	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	Look-up table
C1_COMMS	M	Comments	

EWH_EXP.DBF FILE STRUCTURE

FIELD NAME	N	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOC	N	Location/Exposure no.	
I1_PROFILE	C	Profile ref. no.	
I1_MAS	N	Relevent mass ref. no.	
I1_T_UNIT	N	Terrain unit	
I2_GGEOL	C	General geology	Look-up table
I2_DESCRIP	M	Description notes	
I2_CHAIN	N	Chainage	
I2_FEATNO	N	EWHLTSS feature no.	Link with EWHLTSS
I2_EAST	N	Easting	Not used
I2_NORTH	N	Northing	Not used
D1_MAT1	N	Material exposed 1	Look-up table
D1_MAT2	N	Material exposed 2	Look-up table
D1_MAT3	N	Material exposed 3	Look-up table
D1_GRAD1	L	Weath. grade I exposed	
D1_GRAD2	L	Weath. grade II exposed	
D1_GRAD3	L	Weath. grade III exposed	
D1_GRAD4	L	Weath. grade IV exposed	
D1_GRAD5	L	Weath. grade V exposed	
D1_GRAD6	L	Weath. grade VI exposed	
D2_FORM	C	Exposure form	Look-up table
D2_ACCESS	N	Ease of access	Look-up table
D2_CONDIT	C	Condition of exposure	Look-up table
S1_INVEST	C	Investigations	Not used
S1_GRNDPH	C	Ground photos	
A1_EXP_D	D	Date of examination	
A1_TEAM	C	Survey team	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	Look-up table
C1_COMMS	M	Comments	

EWH_MAT.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref.	
I1_MAS	N	Relevent mass ref.	
I1_EWH_P	C	Profile ref.	
I1_LOC	N	Location/exposure ref.	
I1_TYPE	N	Profile type	Look-up table
I1_MAT	N	Material ref. no.	
I1_LOC_MAT	N	Location-material key field	
I2_MOISTAT	N	Moisture condition	Look-up table
I2_WEATHER	C	Weather	Look-up table
I3_COLMAIN	C	Main colour	Colour chart
I3_SEC1	C	Secondary colour	Colour chart
I3_SEC1_F	N	Form of secondary colour	Look-up table
I3_SEC2	C	Secondary colour	Colour chart
I3_SEC2_F	N	Form of secondary colour	Look-up table
I4_STRNGTH	N	Material strength	Look-up table
I4_MODIF	N	Strength modification	Look-up table
I5_PRT_S_1	C	Primary particle size	Look-up table
I5_PRT_S_2	C	Secondary particle size	Look-up table
I5_PRT_S_3	C	Tertiary particle size	Look-up table
I5_PRT_S_4	C	Minor particle size	Look-up table
I5_PRT_SH1	N	Particle	Look-up table
I5_PRT_SH2	N	Particle	Look-up table
I5_PRT_SH3	N	Particle	Look-up table
I5_PRT_TYP	N	Particle material	Look-up table
I5_PRT_STR	N	Particle strength	Look-up table
I6_FAB_F	N	Fabric form	Look-up table
I6_FAB_DS	N	Fabric	Look-up table
I6_FAB_ORT	N	Fabric	Look-up table
I6_FAB_ORG	N	Fabric	Look-up table
I7_MACDISC	N	Macro discontinuity sets	Look-up table
I7_MESDISC	N	Meso discontinuity sets	Look-up table
I7_PTRN_ME	N	Meso pattern	Look-up table
I7_PTRN_MA	N	Macro pattern	Look-up table
I8_MIN1	N	Apparent mineralogy	Look-up table
I8_MIN2	N	Apparent mineralogy	Look-up table
I8_MIN3	N	Apparent mineralogy	Look-up table
I8_MIN1_PC	N	Mineral %	Look-up table
I8_MIN2_PC	N	Mineral %	Look-up table
I8_MIN3_PC	N	Mineral %	Look-up table
I9_ORG_PC	N	Organic %	Look-up table
I9_ORG_TYP	N	Organic type	Look-up table
I10_MATYP	N	Material type	Look-up table
I10_MATZON	C	Weath. group	
I10_MAT_GR	C	Weath. grade	
I12_PLST_N	N	Plasticity (natural)	Look-up table
I12_PLST_W	N	Plasticity (wet)	Look-up table
I12_FLDSPR	N	Feldspar condition	Look-up table
I12_CARB	N	Carbonate content	Look-up table
I12_DURB	N	Field durability test	Look-up table
I12_PERM	N	Est. permeability	Not used
I12_VOLCH	N	Est. volume change capacity	Not used
I12_SCHMT	C	Schmidt hammer no.	
I12_VNPEN	C	Hand penetrometer	
I13_COMMS	M	Comments	
A2_DATE_F	D	Survey date	
A2_TEAM	C	Survey team	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	
A3_FORM	N		

EWH_DISC.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOC	N	Location ref. no.	
I1_LOC_MAT	N	Location-material key field	
I7_TYPE1	N	Meso/macro	
I7_TYPE2	N	Meso/macro	
I7_TYPE3	N	Meso/macro	
I7_TYPE4	N	Meso/macro	
I7_TYPE5	N	Meso/macro	
I7_DTYPE1	N	Discontinuity type	Look-up table
I7_DTYPE2	N	Discontinuity type	Look-up table
I7_DTYPE3	N	Discontinuity type	Look-up table
I7_DTYPE4	N	Discontinuity type	Look-up table
I7_DTYPE5	N	Discontinuity type	Look-up table
I7_DSPAC1	N	Discontinuity spacing	Look-up table
I7_DSPAC2	N	Discontinuity spacing	Look-up table
I7_DSPAC3	N	Discontinuity spacing	Look-up table
I7_DSPAC4	N	Discontinuity spacing	Look-up table
I7_DSPAC5	N	Discontinuity spacing	Look-up table
I7_DCOND1	C	Discontinuity condition	Look-up table
I7_DCOND2	C	Discontinuity condition	Look-up table
I7_DCOND3	C	Discontinuity condition	Look-up table
I7_DCOND4	C	Discontinuity condition	Look-up table
I7_DCOND5	C	Discontinuity condition	Look-up table
I13_COMMS	M	Comments	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	

EWH_INDX.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOCNO	N	Location ref. no.	
I1_LOC_S	N	Location-sample key field	
I1_S_NO	N	Sample no.	
I1_MAT	N	Material ref no.	
I1_LOC_MAT	N	Location-material key field	
T1_MC_30	N	w% at 30 degrees drying	
T1_MC_50	N	w% at 50 degrees drying	
T1_MC_70	N	w% at 70 degrees drying	
T1_MC_90	N	w% at 90 degrees drying	
T1_MC_110	N	w% at 110 degrees drying	
T1_LL_AD	N	WL air dried	
T1_PI_AD	N	Plasticity air dried	
T1_LS_AD	N	Linear shrinkage air dried	
T1_GS_AD	N	Particle density air dried	
T1_AC_AD	N	Activity	
T1_LL_N	N	WL natural	
T1_PI_N	N	Plasticity natural	
T1_LS_N	N	Linear shrinkage natural	
T1_LL_NLC	N	WL large cone natural	
T1_BD_S	N	Bulk density	g/cm3
T1_DD_S	N	Dry density	g/cm3
T1_EO_S	N	Void ratio	
T1_SA_S	N	Saturation	
T3_LL_OD1	N	WL oven dried 1	
T3_PI_OD1	N	Plasticity oven dried 1	
T3_LS_OD1	N	Linear shrinkage oven dried 1	
T3_T_OD1	N	Temp. oven dry 1	
T3_LL_OD2	N	WL oven dried 2	
T3_PI_OD2	N	Plasticity oven dried 2	
T3_LS_OD2	N	Linear shrinkage oven dried 2	
T3_T_OD2	N	Temp. oven dry 2	
T1_GR	N	Gravel %	
T1_SA	N	Sand %	
T1_SI	N	Silt %	
T1_CL	N	Clay %	
T1_FI	N	Fines %	Silt + clay
T1_SLK_1	N	Slake durability 1 cycle	
T1_SLK_2	N	Slake durability 2 cycles	
T1_CPCNT	N	Collapse %	
T1_CPOT	N	Collapse potential index	
A1_TSTLAB	C	Test lab.	
A1_DATE	D	Test date	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	
A2_COMMS	M	Comments	

EWH_SBOX.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOCNO	N	Location ref. no.	
I1_LOC_S	N	Location-sample key field	
I3_S_NO	N	Sample no.	
I3_MAT	N	Material ref no.	
I3_LOC_MAT	N	Location-material key field	
D1_VLOAD	N	Normal stress	kPa
D1_F_STRES	N	Stress at failure	kPa
D1_MC	N	Initial W%	
D1_BD	N	Initial bulk desnity	g/cm3
D1_C1	N	Cohesion - 1	kPa
D1_PHI1	N	Friction angle - 1	
D1_C2	N	Cohesion - 2	
D1_PHI2	N	Friction angle - 2	kPa
D2_REM_UD	C	Undist. or remoulded	
D2_S_COND	C	Saturation condition	S=sat. US = unsat.
A1_TSTLAB	C	Test lab.	
A1_DATE	D	Test date	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	
A2_COMMS	M	Comments	

EWH_SMP.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOCNO	N	Location ref. no.	
I1_PROFREF	C	Profile ref no.	
I1_S_NO	N	Sample no.	
I1_LOC_S	N	Location-sample key field	
I1_MAT	N	Material ref no.	
I1_LOC_MAT	N	Location-material key field	
I1_CHAIN	N	Chainage	
I2_S_TYPE	C	Sample type	Look-up table
I2_G_GEOL	C	General geology	
I2_UNIT	C	Geology unit	
I3_LEVEL	C	RL of sample	
I3_DPTHB	C	Depth of sample	
I3_PARENT	N	Parent material	
I3_WZONE	N	Weath. group	
I3_GRADE	N	Weath. zone	
I4_S_DATE	D	Sampling date	
I4_S_OP	C	Sampling team	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	
A2_COMMS	M	Comments	

EWH_GEOL.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_CHAIN	N	Chainage	
I1_REF	C	Reference for data	
I2_MAT	C	Description	
I2_GEOL_GP	C	Geology group	
I3_UNIT	C	Geology unit	
I3_PET	L	Petrology	Additional work ?
I3_XCHK	L	Cross check	
I3_NOTES	C	Notes	
I4_DATE	D	Date of data	
I4_VALID	N	Validity	

EWH_DIPS.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOC	N	Location ref no.	
I1_MAS	N	Mass ref. no.	
I1_UNIT	N	Geological unit ref.	
I2_GGEOL	C	General geology	
I2_CHAIN	N	Chainage	
I2_FEATNO	N	EWHLTSS ref. no.	EWHLTSS link
I2_R_TYPE	C	Rock type	
D1_DIP	N	Dip	
D1_DIPDIR	C	Dip direction	
D1_D_TYPE	N	Discontinuity type	
D2_F_DIR	C	Direction of exposure	
D2_R_STRIK	C	Strike of road	
A1_SOURCE	C	Data source	
A1_DATE	D	Data date	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	
C1_COMMS	M	Comments	

EWH_SUC.DBF FILE STRUCTURE

FIELD NAME	FIELD TYPE	DESCRIPTION	COMMENT
I1_SURV	N	Survey ref. no.	
I1_LOC_S	N	Location-sample key field	
I3_LOC_MAT	N	Location-material key field	
D1_MC	N	Material moisture %	
D1_DD	N	Dry density	g/cm3
D1_FPMC	N	Filter paper moisture %	
D1_MC_V	N	Volumetric moisture %	
D1_SUC	N	Suction	kPa
D2_EO	N	Void ratio	
D2_GS	N	Particle density	
D2_SAT	N	Saturation	
A1_TSTLAB	C	Test laboratory	
A2_DATA_IN	D	Date data in	
A2_OPERAT	C	Operator	
A2_VALID	N	Validity	
A2_COMMS	M	Comments	

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DICETAK OLEH
PERCETAKAN NASIONAL MALAYSIA BERHAD,
IBU PEJABAT, KUALA LUMPUR
1996

IKRAM
ISBN 983-99855-3-1

Percetakan Istitute Kerja Raya Malaysia