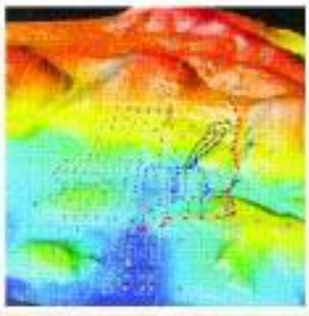
CERUN 1

Public Works Department Malaysia





GUIDELINES ON SLOPE MAINTENANCE IN MALAYSIA

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August 2006

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FOREWORD

These guidelines on slope maintenance in Malaysia are prepared by adopting and modifying Geoguide 5: Guide to Slope Maintenance, produced by the Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

This guide presents a recommended standard of good practice for the maintenance of man-made slopes and retaining structures, disturbed terrain features and natural terrain hazard mitigation measures. It is aimed primarily at the engineering profession, but will be of use to other parties concerned with slopes and retaining structures maintenance. It allows slope owners to accord maintenance efforts to slopes and retaining structures with respect to their consequences. It also addresses other issues, including maintenance requirements for disturbed terrain features and measures implemented for the mitigation of natural terrain hazard.

The preparation of this guide is under the overall direction of a Technical Committee. The membership of the Technical Committee, given on the next page, includes representatives from PWD Slope Engineering Branch and various government agencies with slope maintenance responsibility. Consultation among professional bodies, consulting engineers, contractors, academics and other government departments was made. Many individuals and organisations made very useful comments, which have been adopted to produce this guide. Their contributions are gratefully acknowledged.

As with other guides produced by PWD Slope Engineering Branch, this document gives guidance on good engineering practices, and its recommendations are not intended to be mandatory. Practitioners are encouraged to provide comments to PWD Slope Engineering Branch at any time on the contents of this guide, so that improvements can be made to future editions.

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August 2006

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1. INTRODUCTION

1.1 PURPOSE AND SCOPE OF THIS GUIDE

Regular maintenance is essential for all man-made slopes and retaining structures, disturbed terrain features and natural terrain hazard mitigation measures to avoid deterioration or to upkeep their functions.

The purpose of this guide (Cerun 1) is to recommend a standard of good practice for the maintenance of man-made slopes and retaining structures, disturbed terrain features and hazard mitigation measures provided to natural terrain (e.g. boulder fences and check dams). The document is aimed at professional geotechnical/civil engineers, although it will also be useful to the general public, many of whom carry responsibility for slope maintenance as owners of property. The general public may refer to an abridged version of the guide: Layman's Guidelines to Slope Maintenance (Cerun 2), produced by Cawangan Kejuruteraan Cerun JKR for simplified guidance on matters related to slope maintenance.

This guide deals basically with the maintenance inspections and maintenance works necessary to keep in good condition well-designed and properly constructed slopes and retaining structures and man-made mitigation measures provided to natural terrain. The maintenance inspections and works recommended herein can also reduce the probability of instability of slopes and retaining structures and disturbed terrain features which are not up to the current geotechnical standards for design and construction.

Maintenance inspections are sub-divided into four categories:

(a) Routine Maintenance Inspections, which can be carried out by any responsible person with no professional geotechnical/civil knowledge,

(b) Engineer Inspections for Maintenance, which should be carried out by a professionally-qualified geotechnical/civil engineer,

(c) Regular Checks of Buried Water-carrying Services, which should be carried out by a specialist leakage detection contractor, and

(d) Regular Monitoring of Special Measures, which should be carried out by experts in the particular type of monitoring service required. Such monitoring is only necessary where the long term stability of the slope or retaining structure relies on specific measures which are liable to become less effective with the passage of time.

Chapter 2 describes the recommended approach to maintenance management and provides guidance on the necessary action to be taken for slopes and retaining structures, disturbed terrain features and natural terrain hazard mitigation measures. In addition, the importance of a Maintenance Manual and maintenance records is highlighted.

Chapter 3 provides guidance on the scope of maintenance requirements for man-made slopes and retaining structures, including the purpose and scope of Routine Maintenance Inspections and Engineer Inspections for Maintenance. It describes the requirements for the frequency and personnel for these inspections. In addition, the need to undertake Regular Checks of Buried Water-carrying Services is presented. It also outlines the need for, and the types of, Regular Monitoring of Special Measures.

Chapter 4 describes technical aspects of maintenance inspections pertinent to the well keeping of man-made slopes and retaining structures, and **Chapter 5** prescribes the use of preventive maintenance works to improve man-made slopes and retaining structures.

Chapter 6 gives guidelines on the maintenance of disturbed terrain features.

Chapter 7 provides guidance on the maintenance of hazard mitigation measures that are provided to natural terrain. The mitigation measures include stabilization measures to prevent failure and defence measures to protect developments from landslide debris originating from natural terrain.

It is important to remember that maintenance inspections and works as specified in this guide will only serve to maintain the existing level of stability (i.e. existing margin of safety against failure), or to bring about marginal improvement. That is to say, slope maintenance alone may not be adequate in ensuring that a slope or retaining structure meets current geotechnical standards (e.g. Geotechnical Manual for Slopes (GCO, 1984)). To determine whether the slope or retaining structure meets the required standard, the owner or the party required to maintain the land may have to arrange for a Stability Assessment to be carried out by a professionally-qualified geotechnical/civil engineer. Upgrading works will be required in case the slope or retaining structure does not satisfy the current safety standards.

1.2 MAINTENANCE RESPONSIBILITY

In Malaysia, the responsibility for maintenance of land, including slopes and retaining structures, rests with the owner, as defined in the Land Ordinance, or the party assigned such a responsibility. Ownership is conferred by a lease document issued by the Lands Department, such as a government lease or conditions of grant, conditions of sale, and conditions of exchange. The public can have access to these lease documents and records of owners at the Land Registry.

Occasionally, the lease document issued by the Department of Lands and Mines may include a clause relating to maintenance responsibility for an area outside the lot boundary, as shown on a site plan attached to the lease document. Owners may also be liable for maintenance of land adjoining their lot, without such responsibility being stated in the lease document, when they have given themselves responsibility by their actions. For example, they may have cut into adjoining land, an action which could render them responsible for the slope maintenance under common law.

Private owners, including owners of individual flats in a multi-storey building, have opportunities to examine the lease documents on purchase. They should carefully examine the lease documents to ascertain the extent of the land they are required to maintain. Where appropriate, professional advice may need to be sought from lawyers or estate surveyors on the interpretation of the lease documents in respect of maintenance responsibilities.

Cawangan Kejuruteraan Cerun JKR will maintain a Catalogue of Slopes that registers sizeable man-made slopes on roads and retaining structures on any Government project within Malaysia.

2. MAINTENANCE MANAGEMENT

2.1 MAINTENANCE MANAGEMENT ACTIONS

A slope or retaining structure that is not properly maintained will deteriorate and may become so unstable that it may collapse and cause injury to persons or damage to property. If this happens, great expense may be incurred in the remedial works. Retaining structures, except masonry walls, demand less maintenance on the wall structure but routine maintenance of the drainage provision to the wall is essential. Examples of well-maintained and poorly maintained slopes and retaining structures are shown in Plates 2.1 to 2.4. Similarly, maintenance of natural terrain hazard mitigation measures is necessary to ensure their continued functioning.

Owners or parties required to maintain land should undertake regular maintenance inspections and works. They can do this themselves or through an agent. For slopes and retaining structures maintained by a single owner, arranging maintenance action is fairly straightforward. For owners of individual flats in a multi-storey building, it is necessary in practice for an Owners' Corporation to discharge the maintenance responsibility on behalf of the individual owners, usually through a property management company. The Building Management Ordinance requires the Owners' Corporation to maintain the common parts of a building, which include slopes and retaining structures, in a state of good repair. The Deed of Mutual Covenant, which is registered in the Land Registry, defines the rights, interests and obligations of owners among themselves. In this document, the obligations of the owners, property managers and other parties, as appropriate, towards maintenance of slopes or retaining structures should be defined.

For government slopes, individual departments set up their own systems as appropriate to manage their maintenance actions.

If a slope or retaining structure has not been properly maintained before, the owner or party required to maintain land should take the following actions:

(a) Start Routine Maintenance Inspections and then carry out the maintenance works needed.

(b) Commission the first Engineer Inspections for Maintenance (Section 3.2) as soon as possible, particularly for slopes and retaining structures with no Maintenance Manual.

Thereafter, maintenance inspections and necessary maintenance works should be carried out regularly and as recommended in the Maintenance.

(a) Vegetated Surface

(b) Guniting Surface

(c) Stone-pitched Surface

Plate **2.1 Well-maintained Slope Surface Cover**

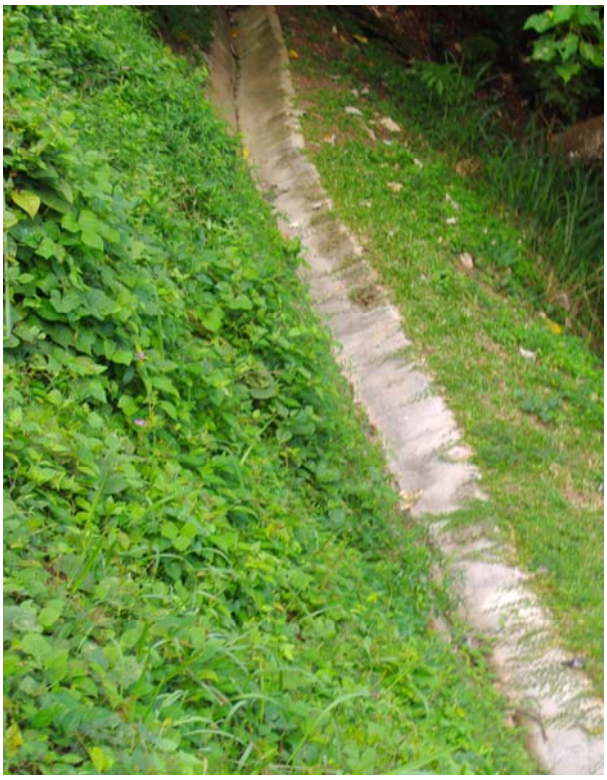
(a) Vegetated Surface

(b) Guniting Surface

(c) Stone-Pitched Surface

Plate 2.2 Poorly-maintained Slope Surface Cover

(a) V-drain along Toe of Slope



(b) V-drain along Berm of Slope

(c) Drain and Sump

(d) Cascade Drain

Plate 2.3 Well-maintained Surface Drainage Measures

(a) U-drain at Toe of Slope

(b) V-drain along Berm of Slope

(c) Culvert at Toe of Slope

(d) Sump at toe of Slope

Plate 2.4 Poorly-maintained Surface Drainage Measures

2.2 MAINTENANCE MANUALS

In order to assist the owners or parties required to maintain land to appreciate the maintenance requirements, the engineer who designs a slope or retaining structure or natural terrain hazard mitigation measure should prepare a Maintenance Manual as part of his design services or refer to a related standard manual, if available.

A Maintenance Manual constitutes a key part of maintenance management. For existing slopes, retaining structures or disturbed terrain features for which a Maintenance Manual is not available, the engineer commissioned for Engineer Inspection for Maintenance or responsible for any upgrading works should prepare this document. Where a Maintenance Manual is available, it needs to be updated by the engineer, where necessary, in each Engineer Inspection for Maintenance.

A Maintenance Manual for man-made slopes and retaining structures should include the following information:

(a) a plan of the site showing the slopes and retaining structures to be maintained (Figure 2.1),

(b) record sheets containing general information on the slopes and retaining structures, (Appendix B)

(c) as-built plans and typical cross-sections of all slopes and retaining structures, including details of surface cover, surface drainage, subsurface drainage, access points and stabilization measures such as soil nails,

(d) layout plans of water-carrying services on or adjacent to the slopes or retaining structures, and proper documentation of any special features (e.g. ducting system) related to the services,

(e) as-built record photographs of the slopes and retaining structures,

(f) a list of man-made items requiring routine maintenance,

(g) recommendations on the frequency of Routine Maintenance Inspections, Engineer Inspections for Maintenance, and Regular Checks of Buried Water-carrying Services (including ducting systems) on or adjacent to the slopes and retaining alls, as appropriate,

(h) maintenance requirements for protection of reinforcement components in a reinforced fill slope or reinforced fill structure, if applicable,

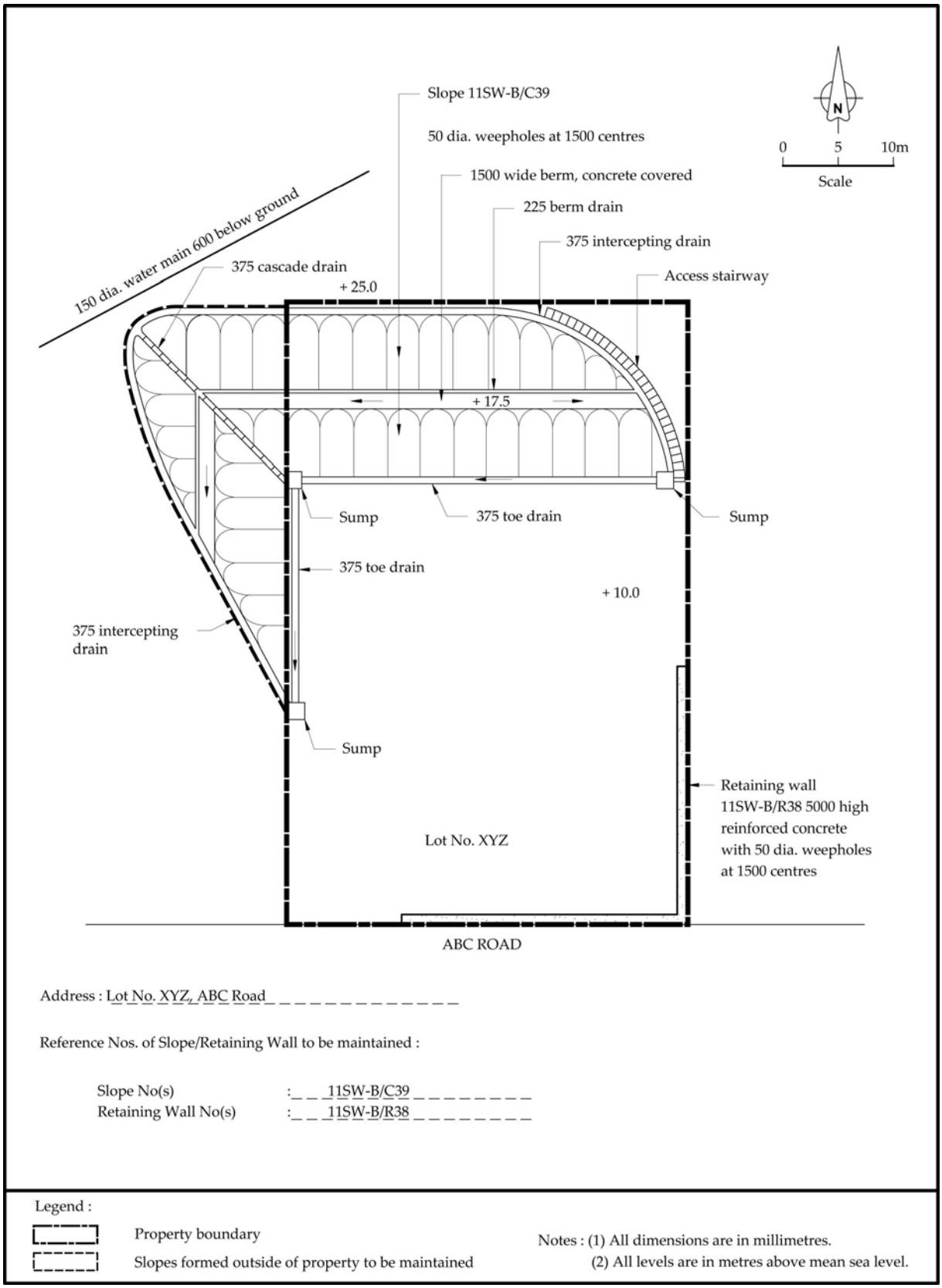


Figure 2.1 Typical Plan of Slopes/Retaining Structures to be Maintained

(i) maintenance requirements for landscape items on the slopes and retaining structures and the rationale for their selections,

(j) outline of the basis of design and/or findings of Stability Assessments, including the consequence-to-life category of each slope and retaining structure,

(k) a monitoring schedule detailing requirements for Regular Monitoring of Special Measures where the long-term monitoring of specific measures included in the slope or retaining structure is a design requirement (e.g. ground anchors and designed horizontal drains are required by the Cawangan Kejuruteraan Cerun JKR to have long-term monitoring), and

(l) a list of other available documentary information pertaining to the slopes and retaining walls, e.g. geotechnical report.

(m) geological records on or adjacent to the man-made slopes such as distribution of geologic materials, and where applicable, information on existing geological structures, weathering profile and hydrological regime etc. and,

(n) aerial photographs or satellite images to show the land use and other development activities surrounding the location of the slope / retaining structure which may pose a threat to the integrity of the slope / retaining structure. The photographs and images can be purchased from Malaysian Centre for Remote Sensing (MACRES).

An indicative format for the Maintenance Manual for man-made slopes and retaining structures is given in Appendix A. The format is also applicable for preparing Maintenance Manual for disturbed terrain features. Key aspects of the Maintenance Manual for natural terrain hazard mitigation measures are given in Chapter 7.

In order to assist the Routine Maintenance Inspection personnel, the Maintenance Manual should also include some guidelines on when an immediate Engineer Inspection for Maintenance should be arranged, e.g. where signs of leakage or suspected leakage, or ground subsidence are observed.

Construction drawings and details of design are seldom held by private owners. For slopes and retaining structures which have been processed by the statutory checking system, the engineer undertaking the Engineer Inspection for Maintenance may approach the local council. For slopes and retaining structures which were constructed by the Government, information on the slope or retaining structure design is usually available in JKR.

Engineers should always review previous Stability Assessments or designs of upgrading works to ensure that the factual information given therein is not out of date and the findings are still relevant, prior to incorporation into the Maintenance Manual. Superseded records or drawings that could provide useful information for understanding the history of the slopes and retaining structures should be appended in the Maintenance Manual.

2.3 CO-ORDINATED APPROACH TO SLOPE MAINTENANCE

Sometimes maintenance actions such as Routine Maintenance Inspections, Engineer Inspections for Maintenance, Regular Monitoring of Special Measures and Regular Checks of Buried Water-carrying Services are carried out by different maintenance parties at different times. In such circumstances, the person or party responsible for overseeing slope maintenance, such as the property management agent (in the case of private slopes) or the project engineer (in the case of government slopes) should arrange a review of all records of maintenance inspections and works. The purpose of this integrated review is to examine all relevant records together to provide insightful information for making a decision on whether additional maintenance works or other actions are required to be carried out.

2.4 MAINTENANCE RECORDS

Maintenance Manuals and all records of maintenance inspections and maintenance works should be kept by the owner, the party required to maintain the land or the appointed agent. In practice, it is advisable to keep duplicate copies of all records and to store them in separate locations. Comprehensive and accurate record keeping is important for good maintenance management. In addition, where the owner or the party required to maintain the land is responsible for the maintenance of a large number of slopes and retaining structures, considerations should be given to keeping the Maintenance Manuals and maintenance records in electronic format for effective record management.

3. MAINTENANCE REQUIREMENTS FOR MAN-MADE SLOPES AND RETAINING STRUCTURES

3.1 ROUTINE MAINTENANCE

3.1.1 Purpose and Scope of Routine Maintenance Inspections

Typical man-made items on slopes and retaining structures that require maintenance are illustrated in **Figure 3.1**. As a minimum, it is recommended that Routine Maintenance Inspections are carried out to ascertain the need for maintenance of man-made items, including:

(a) clearance of accumulated debris from drainage channels and slope surface,

(b) repair of cracked or damaged drainage channels or pavement,

(c) repair or replacement of cracked or damaged slope surface cover,

(d) unblocking of weepholes and outlet drainpipes,

(e) removal of any vegetation that has caused severe cracking of slope surface cover and drainage channels,

(f) re-turfing of bare soil slope surface areas,

(g) repair of missing or deteriorated mortar joint in masonry walls,

(h) removal of loose rock debris and undesirable vegetation from rock slopes or around boulders,

(i) repair of leaking exposed water-carrying services,

(j) repair or replacement of rusted steel slope furniture, and

(k) maintenance of landscape items on the slope.

In addition, a Regular Check of Buried Water-carrying Services on or adjacent to soil slopes or retaining structures should be undertaken (Section 3.3).

Where leakage is suspected from buried water-carrying services such as water pipes, water supply mains, sewers, stormwater drains or their ducting systems, prompt action should be taken to investigate and repair the services. Examples of suspected leakage are a significant increase in moisture on the surface or an increase in seepage from weepholes in slopes or retaining structures or from joints between masonry blocks.

Figure 3.1 Typical Man-made Items on Slopes and Retaining Structures that Require Maintenance

Abnormal features on slopes or retaining structures should also be noted and an immediate Engineer Inspection for Maintenance should be carried out if necessary (Section 3.1.5).

Where repeated maintenance works are required for a particular aspect of a slope or retaining structure, such as repair of cracked drainage channels or surface cover, clearance of severely silted-up drainage channels, or reinstatement of areas of serious erosion, the problems should be investigated.

3.1.2 Frequency and Timing of Routine Maintenance Inspections

In general, Routine Maintenance Inspections should be carried out in accordance with Table 3.1.

Table 3.1 Recommended Frequency of Routine Maintenance Inspections

Consequence-to-life Category of Slopes and Retaining structure (Refer Appendix I)	Frequency (minimum requirement)
Category 1 and 2	Once every year
Category 3	Once every two years

Designers or engineers undertaking Engineer Inspections for Maintenance may specify more frequent Routine Maintenance Inspections than those given in Table 3.1 if considered appropriate (e.g. where a high indirect consequence is anticipated in the event of failure of the slope or retaining structure). Conversely, less frequent maintenance inspections may be adopted for a slope or retaining structure taking into account its size, the stabilisation measures adopted, and the cost-benefit of the maintenance inspections. For example, less frequent Routine Maintenance Inspections may be adopted for small slopes and retaining structures with height not exceeding 5 m.

If Routine Maintenance Inspections are carried out not more than once a year, they should preferably be carried out during the dry season and any required maintenance works should be completed prior to the onset of the wet season.

In addition, it is necessary to inspect the drainage channels and clear any blockage after a heavy rainstorm.

3.1.3 Personnel for Routine Maintenance Inspections

Since the primary purpose of Routine Maintenance Inspections is to establish the need for basic maintenance of man-made items, such inspections do not demand professional geotechnical knowledge and can be carried out by any responsible person, including property management staff or maintenance staff.

Depending on the availability of manpower, owners or parties required to maintain land may decide to employ technically-qualified staff for the inspections. For example, government departments generally deploy staff at the rank of Technical Assistant or Technician to undertake Routine Maintenance Inspections.

3.1.4 Routine Maintenance Works

As a result of Routine Maintenance Inspections, typical routine maintenance works that may be needed are given in Table 3.2.

Most of the routine maintenance works can be carried out by general building or civil engineering maintenance contractors. The Government holds a list of Registered Contractors who have indicated their willingness in carrying out slope maintenance works. This list is available for public reference at Cawangan Kejuruteraan Cerun JKR.

For minor surface erosion on slopes of consequence-to-life Category 3, little or no works are needed if the erosion has been assessed by a professionally-qualified geotechnical/civil engineer as not requiring treatment, taking due account of factors including cost-effectiveness of the repair works, direct and indirect consequence of failure, visual impact of the eroded surface, and whether the erosion is a precursor to a large failure or further deterioration of the eroded surface would be detrimental to the stability of the slope.

Soft landscape treatment of slopes and retaining structures, in form of vegetation, is normally designed to be ecologically sustainable and self-supporting once fully established. Routine maintenance should be carried out to prevent the vegetation from adversely affecting the functions of drainage channels and slope access. This includes clearing of litter and local trimming of overgrown vegetation near drainage channels or slope access. For specific maintenance works related to planted and natural vegetation including existing trees, advice from horticulturists or specialist contractors should be sought where necessary.

3.1.5 Need for Immediate Engineer Inspections for Maintenance

During Routine Maintenance Inspections, particular note should be taken of anything considered to be unusual or abnormal, such as signs of leakage, widening of cracks, settling ground, bulging or distortion of masonry walls, or settlement of the crest platforms. Some examples of such defects can be seen in Plate 3.1. These defects or observations have to be reported promptly to the owner or the party required to maintain the land, who should then appoint a professionally-qualified geotechnical/civil engineer without delay to undertake an immediate Engineer Inspection for Maintenance, and to recommend any necessary actions.

Where a change in the land use in the vicinity of a slope or retaining structure is noted in a Routine Maintenance Inspection, the inspection personnel should report it to the owner or the party required to maintain the land. The responsible party should then review whether this would result in any change in the consequence-to-life category of the slope or retaining structure and the required frequency of maintenance inspections. Advice should be sought from a professionally-qualified geotechnical/civil engineer when needed.

Table 3.2 Typical Routine Maintenance Works for Slopes and Retaining structures

Man-made Item	Typical Maintenance Works Required	Guidance
Surface Drainage Channels, Sumps and Silt Traps	(a) Clear debris, undesirable vegetation and other obstructions. (b) Repair minor cracks with cement mortar or flexible sealing compound. (c) Rebuild severely cracked channels. (d) Replace missing or deteriorated joint fillers and sealant.	(a) Works may be required outside site boundaries to prevent debris from blocking the drainage system. (b) Where large tree roots have damaged drainage channels, appropriate portions of the roots should be removed, taking care not to jeopardise the stability of the tree. Alternatively, the channels may be realigned
Weepholes and Horizontal Drains	(a) Clear obstructions (e.g. weeds and debris) in weepholes and pipe ends. (b) Probe with rods for deeper obstructions.	(a) Pipes/ Horizontal Drains are prone to being blocked. Where pipes have been used on slopes and are leaky or severely blocked, they should be replaced.
Impermeable Surface Cover (e.g. guniting and shotcrete)	(a) Remove undesirable vegetation growth. (b) Repair cracks or spalling. (c) Regrade and repair eroded areas. (d) Replace surface cover that has separated from underlying soil. (e) Replace missing or deteriorated joint fillers and sealant. (f) Remove dead, decaying or unstable trees.	(a) Cracked impermeable surface cover should be repaired by cutting a chase along the line of the crack, which is to be filled with a similar slope cover material or a flexible sealant. (b) Where large tree roots have damaged the surface cover, the cover should be replaced and tree rings should be provided. (c) Specialist advice may be sought in treating trees. Tree felling application should be obtained from relevant authority where necessary.
Vegetated Surface Cover	(a) Regrade eroded areas with compacted soil followed by re-planting. (b) Replant vegetation in areas where the vegetated surfacing has died. (c) Trim vegetation if overgrown. (d) Remove dead, decaying or unstable trees.	(a) Where erosion is shallow and does not affect the performance of existing surface drainage channels, the eroded area may be regraded by trimming, and make good to normal condition. (b) Surface erosion may indicate an inadequate drainage system. Possible sources of concentrated flow should be identified and rectified. (c) Specialist advice may be sought on types of cover or species in areas where there is insufficient sunlight to support vegetation growth.
Rock Slopes and Boulders	(a) Repair cracked or spalled concrete surface and support. (b) Remove loose rock debris. (c) Remove undesirable vegetation.	(a) Trees giving rise to prising action in rock joints should be removed. The entire stump of the tree should be removed.
Facing	(a) Repair deteriorated mortar joints on masonry face. (b) Repair cracked or spalled concrete surface and replace missing or deteriorated joint fillers and sealant	(a) Continual distress (e.g. widening cracks) of a wall should be reported to the owner of the party required to maintain the land.

Note: Safe and efficient access is important for maintenance works.

(a) Tension Crack on Slope

(b) Crack in Retaining Structure

(c) Cracked Surfacing on Rubble Wall

(d) Surface Crack on Slope Drain

Plate 3.1 Abnormal Features

3.1.6 Records of Routine Maintenance

Indicative record sheets for Routine Maintenance Inspections and works are shown in Appendix B. The record sheets should be completed in two stages, namely, on completion of a Routine Maintenance Inspection and on completion of maintenance works.

3.2 ENGINEER INSPECTIONS FOR MAINTENANCE

3.2.1 Scope of the Inspections

The purposes of an Engineer Inspection for Maintenance are:

(a) to determine if Stability Assessment have previously been carried out and if so, to review previous Stability Assessment reports to check whether the engineering approach used, the assumptions and the conclusions made in these reports are reasonable in light of current practice and safety standards,

(b) to identify all visible changes and signs of distress, including landslides that have taken place at or in the vicinity of the slope or retaining structure, in particular changes since the previous Stability Assessment if this has been carried out, and any discrepancies between records and site conditions, which could have implications for stability of the slope or retaining structure, and to judge whether these might be significant,

(c) to re-assess the consequence-to-life category of the slope or retaining structure,

(d) to check that Routine Maintenance Inspections have been carried out and documented satisfactorily,

(e) to assess the adequacy of routine maintenance works and supplement the list of man-made items requiring routine maintenance, as necessary,

(f) to re-assess the required frequency of Routine Maintenance Inspections, Engineer Inspections for Maintenance and Regular Checks of Buried Water-carrying Services,

(g) to look for and consider the implications of problems that are not explicitly included in the list of man-made items requiring routine maintenance, and bring to the attention of the owner or party required to maintain the land any immediate and obvious danger noted and, if necessary, recommend emergency measures (e.g. repair works or detailed investigations),

(h) to identify the presence of exposed and buried water-carrying services on or in the vicinity of the slope or retaining structure (including relevant areas outside the lot boundary), check for signs of leakage of the services and recommend immediate detailed leakage checks, regular checks, repair or re-routing of the services, as necessary,

(i) to determine whether the Regular Checks of Buried Water-carrying Services and/or Regular Monitoring of Special Measures (if required) have been carried out and documented satisfactorily,

(j) to advise whether a Stability Assessment of the slope or retaining structure is necessary,

(k) to recommend the necessary preventive maintenance works (Chapter 5), and

(l) to prepare or update the Maintenance Manual to include all relevant information extracted from the previous Stability Assessment and the desk study and site inspection(s) from this Engineer Inspection for Maintenance.

(m) to assess if there is any deterioration of the geologic materials, geological structure and groundwater condition.

An example of term of reference for an Engineer Inspection for Maintenance is given in Appendix C. This is to facilitate private owners in procuring such a service.

For government slopes, some additional tasks in relation to the management of the slope inventory held by the respective maintenance departments should be carried out in Engineer Inspections for Maintenance. The detailed scope of such tasks is given in Appendix D.

3.2.2 Frequency of the Inspections

The frequency of Engineer Inspections for Maintenance should normally be recommended by the designer in the Maintenance Manual, or as considered appropriate by the engineer commissioned to carry out the inspection. An Engineer Inspection for Maintenance may also be requested by those who carry out the Routine Maintenance Inspection. In general, the frequency of maintenance inspections should be once every five years for slopes and retaining structures in consequence-to-life Categories 1 and 2 and once every ten years for those in Category 3 (Table 3.3).

Table 3.3 Recommended Frequency of Engineer Inspections for Maintenance

Consequence-to-life Category of Slopes and Retaining structures (Refer Appendix I)	Frequency
Category 1 and 2	Once every five years
Category 3	Once every ten years

More frequent Engineer Inspections for Maintenance than those given in Table 3.3 should be recommended if considered appropriate (e.g. where a high indirect consequence is anticipated in the event of failure of the slope or retaining structure). On the other hand, less frequent inspections may be adopted for the slope or retaining structure taking into account its size, the stabilisation measures adopted, and the cost-benefit of the maintenance inspections. For slopes or retaining structures stabilised with robust measures such as soil nail support, and where a post-construction performance review has confirmed the satisfactory performance of the works, the frequency of Engineer Inspections for Maintenance may be curtailed.

3.2.3 Personnel for the Inspections

An Engineer Inspection for Maintenance should be carried out by a professionally-qualified geotechnical/civil engineer. Where necessary the engineer should get geological input from an engineering geologist.

Where considered necessary, the inspecting engineer should advise the owner or party required to maintain the land to consult a professionally-qualified structural engineer, e.g. a Registered Professional Engineer (Structural), for any suspected structural problems identified during the inspection.

3.2.4 Recommendations of the Inspections

The engineer undertaking the Engineer Inspection for Maintenance should recommend preventive maintenance works (see Section 5) or other maintenance actions, such as Regular Checks of Buried Water-carrying Services or Regular Monitoring of Special Measures, where considered necessary.

If an immediate and obvious danger is noted, the engineer should inform promptly in writing, together with a recommended course of action to the owner or party required to maintain the land. At the same time, a copy of this notification should be sent to Cawangan Kejuruteraan Cerun JKR for government slopes and retaining structures, and to the local authorities for private slopes and retaining structures. The recommended course of action, such as evacuation or repair works, will depend on specific circumstances. If the danger can be reduced or eliminated by simple emergency repair works, these should be implemented without delay. In more complex situations, it is necessary to initiate a detailed investigation to establish the cause of the problem and to facilitate the design of upgrading works. The owner or party required to maintain the land should commission such an investigation without delay. In addition, interim precautionary measures (e.g. sealing off the dangerous areas) should be considered.

A Stability Assessment may be recommended if there is doubt on whether the slope or retaining structure is adequately safe, or if significant modifications have occurred to the slope, or retaining structure or to the adjacent area, or if there is reason to believe that significant deterioration of the slope, or retaining structure has occurred since the last Stability Assessment or slope upgrading works were undertaken. The urgency, likely outcome and cost-effectiveness of conducting the assessment should be considered in making such a recommendation.

A Stability Assessment should include an investigation of the slope or retaining structure with consideration of geology, hydrogeological conditions and mechanical properties of the ground materials. Information from existing records (e.g. slope monitoring records, previous instability reports) on the slope or retaining structure and the adjacent area should also be reviewed. An example of term of reference for a stability assessment of a slope or retaining structure is given in Appendix E.

It is sometimes more cost-effective to carry out preventive maintenance works or upgrading works than to undertaking a stability assessment involving ground investigation field works. Where it can be foreseen that upgrading works will be required anyway upon

completion of a stability assessment, such an assessment need not be recommended. For instance, a slope with a history of failure does not require a stability assessment to prove that it does not meet current safety standards. In such cases, the owners or parties required to maintain land should be recommended to carry out preventive maintenance works or upgrading works for these slopes and retaining structures.

3.2.5 Records of the Inspections

Indicative record sheets for Engineer Inspections for Maintenance are given in Appendix F.

3.3 REGULAR CHECKS OF BURIED WATER-CARRYING SERVICES

3.3.1 General

Leakage from buried water-carrying services, e.g. water supply mains and stormwater drains, may not produce visible signs on the surface of a soil or retaining structure and yet may adversely affect its stability. Therefore, owners or parties responsible for maintaining water-carrying services that may affect slopes and retaining structures should arrange for Regular Checks of Buried Water-carrying Services, regardless of whether signs of suspected leakage have been observed. If a ducting system has been provided to the services, regular checks of the ducting system should also be carried out to detect any water flow in and leakage from it.

Occasionally, water-carrying services owned or maintained by other parties may traverse a private lot. The owner of the private lot should grant access to the services' owners to carry out Regular Checks of the Water-carrying Services.

3.3.2 Frequency for Regular Checks of Water-Carrying Services

For those buried water-carrying services belonging to the slope owner or the party required to maintain the land, the Maintenance Manual should specify the frequency of the regular checks. Otherwise, the engineer appointed for the Engineer Inspection for Maintenance should recommend the frequency of the regular checks.

The frequency and extent of the examination of the services should take account of the nature of the material and construction of the pipes (e.g. rigid or flexible system), performance history in respect of leakage, the possible presence of loose fill, and likely effect on the stability of the slope or retaining structure should leakage occur.

3.3.3 Methods for Checking Buried Water-Carrying Services

Checking of buried drains, sewers, water pipes, water mains and ducting systems should be carried out by qualified water contractors. Guidelines on methods for checking buried water-carrying services should be referred to the relevant water authority.

3.3.4 Repairs of Services

Any buried water-carrying services that are found to be damaged or leaking should be repaired without delay. Care should be taken to ensure that any repair works do not impair the hydraulic performance of the pipes.

3.3.5 Records of the Checks

Forms and records for Regular Checks of Buried Water-carrying Services should be designed by the engineer who recommends the regular checks, or by the qualified water contractor who conducts the regular checks.

3.4 ACCESS AND SAFETY PRECAUTIONS

Many slopes and retaining structures are high and steep, and care has to be taken for personal safety when inspections are carried out. Dense vegetation may pose difficulties in access.

Safe access is essential for maintenance inspections. Guidance on the provision and arrangement of access for slope maintenance that is safe for maintenance personnel, visually pleasing and where necessary, secure against trespassers, is given in GEO Report No. 136 entitled "Guidelines on Safe Access for Slope Maintenance" (Lam et al, 2003). Some examples of typical access arrangements for the inspection and maintenance of slopes and retaining structures are given in Plate 3.2.

For the personal safety of the inspecting personnel, it is advisable for the maintenance inspections to be carried out by at least two persons.

3.5 REGULAR MONITORING OF SPECIAL MEASURES

3.5.1 Need for the Monitoring

Regular Monitoring of Special Measures is only necessary in fairly rare circumstances, where the design relies on support or drainage measures that are critical for the continued stability of the slope or retaining structure and will become less effective with the passage of time. For example, Cawangan Kejuruteraan Cerun JKR requires prestressed ground anchors and designed horizontal drains to be regularly monitored.

Requirements for Regular Monitoring of Special Measures are normally established by the designer. The design engineer should discuss with the client on the use of special measures and the associated obligations. The engineer should ensure that the owner or party required to maintain the land is aware of the obligations. The engineer should prepare a Monitoring Schedule, for inclusion in the Maintenance Manual (Section 2.2), to provide details including the recommended frequency of monitoring, guidance on qualifications and experience of

monitoring personnel, protection of monitoring instruments, and 'alert levels' for monitoring results and the contingency actions if these levels are exceeded.

If there are special measures but there is no such Monitoring Schedule in the Maintenance Manual, then the owner or party required to maintain the land should commission the engineer undertaking the Engineer Inspection for Maintenance to prepare one.

The monitoring should be conducted at the recommended frequency, or more frequently as required. Where the results of monitoring exceed the 'alert levels' given in the Monitoring Schedule, the owner or the party required to maintain the land should promptly appoint a professionally-qualified geotechnical/civil engineer to implement the stipulated contingency actions and to determine whether upgrading works are required. Such events should also be brought to the attention of engineers undertaking subsequent Engineer Inspections for Maintenance.

(a) Concealed Access to Stairway

(b) Ladders with Safety Loops

(c) Fencing Recessed into the Vegetated Land

(d) Combined Stepped Channel and Stairway

Plate 3.2 Example of Access for Slope Inspection and Maintenance

3.5.2 Types of Monitoring

Regular Monitoring of Special Measures will generally be necessary for:

(a) permanent prestressed ground anchors,

(b) purposely designed horizontal drains which are not used in a prescriptive manner, and

(c) performance monitoring of other special measures which has been specified by the local authority or by Cawangan Kejuruteraan Cerun JKR

Horizontal drains installed as a prescriptive measure are not considered as "Special Measures". Regular monitoring is not mandatory. However, regular inspections and routine maintenance of all horizontal drains should be carried out to ensure their continued performance.

3.5.3 Records of the Monitoring

The forms and records for Regular Monitoring of Special Measures should be designed by the designer or the specialist firm that conducts the inspection.

4. TECHNICAL ASPECTS OF MAINTENANCE FOR MAN-MADE SLOPES AND RETAINING STRUCTURES

4.1 GENERAL

Most landslides in Malaysia are shallow and small-scale failures caused by surface infiltration or erosion during heavy rainfall. Such landslides are often related to deficient or poorly-maintained slope surface covers and drainage provisions. Therefore, visual inspections and subsequent maintenance recommendations should be directed principally towards measures that minimise the infiltration of surface water and scouring by surface water flow. The provision of effective surface protective cover and adequate drainage, along with proper maintenance, is essential for the continued stability of man-made slopes and retaining structures.

Slopes undergoing progressive movement are liable to deteriorate and deform without full detachment during severe rainstorms, but could suddenly fail in a subsequent less severe rainstorm. Prolonged movement of a slope is reflected by open tension cracks infilled with foreign material, displacement of infilled discontinuities, etc. Care is needed to look for signs of distress and slope deformation during the Engineer Inspection for Maintenance by detailed examination of the slope and the nearby areas, including any steep natural hillside beyond the crest of the cut slope. Where situation warrants, the surface cover should be removed locally to check for any signs of distress.

During an Engineer Inspection for Maintenance, apart from signs of distress, particular note should also be taken of changes that can affect stability, with due regard to the assumptions made in the design of the slope or retaining structure. Examples of adverse changes are additional surcharge imposed by new developments, diversion of a watercourse towards the slope or retaining structure, or an increase in height or gradient of the slope or retaining structure.

Prior to undertaking a site inspection, the engineer should search and review all documentary information pertaining to the slope or retaining structure, together with that of the nearby areas which may provide clues on possible problems at the slope or retaining structure under consideration. The extent of the study of existing information depends on specific circumstances, such as the availability of a Maintenance Manual, previous design and construction records, and the likely consequences should the slope or retaining structure collapse. Useful information on the past performance of the slope or retaining structure may also be obtained through talking to the maintenance personnel and the owner or party required to maintain the land. For documentary information provided by the owner or party required to maintain the land, the engineer should verify with the appropriate authorities or persons that the information is correct and up-to-date.

The information reviewed by the geotechnical/civil engineer should be fully documented and listed in the Engineer Inspection for Maintenance Report so that the work will not be duplicated unnecessarily during each Engineer Inspection for Maintenance, and effort should be focused on the new information that has become available since the last inspection. This also facilitates independent audit of the reports (see Section 4.16)

4.2 SURFACE PROTECTIVE COVER ON SOIL SLOPES

Many slopes are protected by impermeable surface covers that could be rigid or flexible. Rigid surface covers, such as guniting, shotcrete and rubble-pitched facing, are susceptible to cracking. Bitumastic covers, though more flexible, may also crack. Details of cracking should be included in the inspection records, and recommendations for the necessary repair works should be made. Inspections should also be made for displaced, cracked or weathered stones on rubble-pitched facings.

Rigid surface covers on soil slopes should be checked to see if they are in contact with the soil underneath. This can be done by tapping the cover gently with a light hammer. While doing so, care should be taken to avoid damaging the cover. A dull thud rather than a ringing sound may indicate that the cover has lost contact with the underlying soil, usually as a result of ground subsidence or erosion. The affected surface cover should be replaced, and the causes should be investigated. When the impermeable surface cover is removed for maintenance works, opportunity should be taken to inspect and check whether there are any hidden tension cracks or signs of movement in the slope beneath the protective surface.

The durability and effectiveness of the various forms of surface cover depend on the thickness of the cover as well as the type of material and quality of workmanship during construction. Properly designed and suitably spaced movement joints should be provided for rigid surface covers. Where a rigid surface cover has been repaired locally, it is useful to check that no shrinkage cracks develop between the original surface and the new surface.

An impermeable surface cover surrounding or adjacent to trees should be examined for signs of distress caused by possible jacking action of tree roots. General and indiscriminate removal of vegetation and tree roots is not appropriate. The provision of tree rings should be considered. In severe cases, the trees may need to be felled. Consideration may also be given to replacing the tree species with one that does not have an extensive and strong root system. If the vegetation obstructs the flow of water from weepholes, it should be suitably trimmed to ensure proper functioning of the weepholes. Where necessary, specialist advice should be sought on the appropriate treatment for trees.

In inspecting vegetated slopes, details of any erosion scars should be noted, and recommendations should be made for repair works. An erosion control mat helps reduce the likelihood of surface erosion on a vegetated slope surface. Where an erosion control mat has been used, the anchorage system should be checked to ensure that it is sufficiently robust and secured to support the weight of the mat, the soil contained inside the mat and the subsequent vegetation growth. A wire mesh is sometimes used to secure the erosion control mat on a slope surface. Any rusted or damaged wire mesh should be repaired or replaced. The maintenance of proprietary surface protection products should follow any specific requirements in the manufacturers' specifications.

Surface erosion may indicate inadequacy of the drainage system or blockage of surface channels, culverts or sumps. Possible sources of concentrated flow should be identified and any deficiency in the drainage system should be rectified to prevent recurrence of the erosion (see also Section 4.3).

Erosion is particularly critical for reinforced fill slopes. The minimum soil cover specified for geosynthetic reinforcing elements should be maintained, and measures incorporated for

the protection of the reinforcing elements and connections should be checked to ensure that their effectiveness is not reduced by post-construction activities in the vicinity of the slope, e.g. laying of utility services.

4.3 SURFACE DRAINAGE

The surface channels at the crest or on the berms of soil slopes or at the tops of retaining structures should be checked for the presence of gaps in the ground alongside the channels, because such gaps permit surface water to infiltrate into the ground.

The potential for water ponding near the crest of a slope or retaining structure should be assessed, and if necessary, improvement works should be recommended.

It may be necessary to inspect the area beyond the boundary of a slope or retaining structure. For example, where there are culverts or natural drainage lines that may affect the slope or retaining structure, these should be inspected for signs of cracking, blockage or insufficient capacity.

Environmental factors, including topographic features and human activities such as stockpiling and littering, may promote convergent surface water flow towards the slope or retaining structure, leading to washout failures or landslides if the surface water can find a path seeping into the ground. Such factors usually arise from the environment outside the confines of the site and should be carefully considered, and where necessary, works to prevent or protect against the action of such running surface water should be recommended. It is important that all conceivable water flow pathways that might affect a slope or retaining structure are considered.

Repeated erosion of the slope or the ground downslope may also reflect problems with the surface drainage system such as inadequately-sized channels and poor layout. Drains with sharp bends or convergence of several channels to a single sump often cause spillage of surface run-off. Preventive maintenance works should be carried out to increase the drainage capacity by enlarging the size of channels, modifying the alignment of sharp bends, constructing buffer walls, etc., where necessary. For a large catchments area, the layout of the drainage channels should be suitably planned so that the catchments area is partitioned into smaller sections and surface run-off is evenly diverted to several safe discharge points. This helps avoid the need for constructing overly large and deep drainage channels.

It is easier to identify drainage problems by inspections during heavy rainfall. Inspection personnel should arrange for such inspections if the adequacy of the drainage system is in doubt. They should also remind the owner, or the party required to maintain the land, to record substantial surface water flow outside the drainage system, e.g. by taking photographs or videos. Detailed inspections should be carried out immediately after the heavy rainfall.

4.4 GROUNDWATER SEEPAGE

Seepage traces on and adjacent to slopes or retaining structures should be recorded in photographs or detailed hand-sketched drawings. Flow from seepage sources, weepholes, cut off drains, joints between masonry blocks, horizontal drains, etc. should be recorded and examined for signs of migration of solid material to check whether internal erosion of the ground is taking place. Account should be taken of those seepage traces that indicate the highest seepage level.

Where there are signs of abnormal seepage from, or moisture on, the surface of a slope or masonry wall, or signs that the seepage has increased substantially and suddenly, the causes should be investigated.

Arrangements should be made for clearing weepholes where blockages are suspected.

Where there are traces of seepage from a slope or retaining structure in an area where weepholes, horizontal drains or proprietary drainage mats have not been provided, the source of seepage should be determined and consideration should be given to recommending adequate drainage to be installed.

4.5 ROCK SLOPES

Many failures in rock slopes involve minor rockfalls. Rock slopes should be examined for the presence of loose blocks, and these should be removed or stabilised if found.

Small rock blocks are common at locations with weaker, more weathered or closely spaced joints. Rock mass with such local features is especially vulnerable to deterioration and, if exposed on a rock face, is likely to be a recurring source of rock blocks.

Where adversely orientated rock blocks are at risk of being dislodged by tree roots, consideration should be given to removing the rock blocks or the trees. Not all unplanned (e.g. natural) vegetation is detrimental to rock slope stability and factors such as the type of vegetation, and condition and orientation of rock joints need to be considered in deciding the removal of the vegetation. Indiscriminate removal of all unplanned vegetation should be avoided.

Observation should be made for the presence of open joints, and these might require treatment to prevent the ingress of surface water.

Where the risk of minor rockfall is high, measures such as installation of rock mesh netting and provision of a rock trap ditch or buffer zone (where space permits) could be more effective in mitigating the hazards. In particular, the provision of rock mesh netting is strongly recommended for protection against minor rockfall for unprotected steep rock faces of consequence-to-life Category 1 slopes, unless the rock mass is massive and very tightly and favorable jointed such that there is no credible minor rockfall potential.

Guidance on these measures for improving the stability and preventing the deterioration of rock slopes is given in Geo Report No 161: Guidelines on the Use of Prescriptive Measures for Rock Cut Slopes.

The condition of existing stabilisation measures should be assessed. Anchorage points for rock mesh netting should be examined to ensure that they remain intact and are firmly fixed to the rock slope rather than loosened rock blocks. Severely corroded anchorage points should be replaced. Engineers undertaking Engineer Inspections for Maintenance should also note the presence of any dislodged blocks or trapped loose rock fragments behind the mesh. Damaged mesh should be replaced.

For rock bolts protected with a concrete cover, the cover should be examined for signs of cracking and any defects so found should be repaired. Extensive cracking may indicate that significant movement has taken place in the rock mass and its causes should be investigated. Where monitoring of rock bolts is considered necessary, the monitoring requirements, including frequency of monitoring, testing procedure and the required lock-up torque, should be specified in the Maintenance Manual.

Detailed examination of rock slopes is sometimes difficult due to lack of proper access. In the case of a steep and high rock slope where an immediate access is not available for inspection, an assessment should be made by observing the condition of the rock slope from a vantage point, possibly with a pair of binoculars. This should be followed by detailed inspection using access, if considered necessary, e.g. by means of scaffolding and an elevated platform. Where a rock face is covered with vegetation to the extent that a proper inspection of the rock face cannot be made, judgment should be exercised in assessing how much vegetation clearance or thinning is needed.

Scaling of loose blocks should be carried out with care so as not to adversely affecting the stability of the remainder of the rock face. Removal of a tree should be complete with the removal of the stump and sterilising of the roots to prevent it from re-establishing. Appropriate means of effective tree removal should be sought from specialists. Where sealing of an open joint is needed, the works should be detailed to avoid blockage of drainage path that may lead to a build-up of cleft water pressure in the joint.

It is advisable to carry out a follow-up inspection of a rock slope after the completion of scaling and sealing works to review the adequacy of the works and to ensure that no other loose blocks are exposed following scaling and that the sealing of open joints has been done properly. The same applies to removal of trees or other vegetation.

Location of works on slopes are commonly recorded on plans. For steep slopes and where the works are local, marking on plans is not effective. For rock slopes, works recommendations are better marked on front elevation sketches or photographs.

4.6 TREES

Trees provide significant benefits in enhancing the quality of the environment and are often used in the soft landscape treatment of slopes and retaining structures. Unhealthy trees may fall down and result in casualties and loss in property. The health of a tree is affected by many factors such as change in soil conditions or damage to the root system by construction

works. During inspection, signs which are indicative of poor health of a tree, such as discoloration of foliage, presence of dead branches and cavities on tree trunks, should be noted. Serious leaning of isolated trees suggests potential instability of the trees. Under such circumstances, considerations should be given to seeking specialist advice from horticulturists on assessing the general health and necessary treatment of trees.

It is useful if photographic records of trees are taken during inspection so that comparison can be made to determine the condition of trees in future.

4.7 BOULDERS

Checks should be made for the location and extent of erosion around isolated boulders or outcrops of rock, the existence of basal and back-release joints, and the presence of water or evidence of past water flow. Due regard should be given to the presence of unstable upslope boulders which could impact on the boulder under consideration, particularly for those that are already overhanging or resting on other boulders where the contact is open or soil-filled or dipping out of the slope. Unstable upslope boulders outside the maintenance boundary of the slope or retaining structure should be reported to Cawangan Kejuruteraan Cerun JKR if they are on government land and to the Local Authorities otherwise.

4.8 RETAINING STRUCTURES

Inspections and repair should be made for missing or deteriorated joint fillers and sealant, minor cracking or spalling of concrete surfaces, and deteriorated mortar joints on masonry walls. If severe corrosion of the reinforcement or sulphate attack on concrete is suspected, advice from a professionally-qualified structural engineer should be sought.

Outlets of drainpipes provided to drainage layers behind retaining structures should be probed for blockage and cleared if necessary.

During inspections of retaining structures, signs of distress, such as settlement and tension cracks in the ground in close proximity to the retaining structure, severe cracking, deformation, tilting and bulging of the retaining structure, and dislocation of masonry blocks, should be noted, and recommendation should be made for further investigation[1].

For reinforced fill structures, the gaps between the facing panels should be free from any undesirable vegetation growth[2]. The measures incorporated for the protection of the reinforcing elements and connections should be checked to ensure that their effectiveness is not reduced by post-construction activities in the vicinity of the structure, e.g. laying of utility services.

Notes (1) More guidance on the maintenance requirements of retaining structure can be referred to Guide to Retaining structure Design (Geoguide 1: GEO, 1993).

(2) Further advice regarding maintenance of reinforced fill structures can be referred to Guide to Reinforced Fill Structure and Slope Design (Geoguide 6: GEO, 2002b).

4.9 WATER-CARRYING SERVICES

4.9.1 General

Leakage from water-carrying services, including water pipes, monsoon drains, sewerage pipes, catchwater channels and water tunnels, may adversely affect the stability of soil slopes, retaining structures, and rock slopes with unfavourable joint conditions. Ducting systems housing water-carrying services, as well as conduits such as telephone ducts, electric cable ducts or disused pipes, can transmit an appreciable amount of water. Water retaining structures, such as swimming pools and service reservoirs, may also leak. Their potential effects on the stability of the slope or retaining structure should likewise be considered.

The first step in the assessment of potential effects of water leakage on the stability of a slope or retaining structure is to identify the presence of buried water-carrying services in its vicinity. If this information is not already in the Maintenance Manual, the inspecting engineer should enquire owners of utility services. The inspecting engineer should also look for unauthorized buried services and other discrepancies from the record plans.

All services in the vicinity of the slope or retaining structure, together with manholes to which such services connect, should be examined for signs of leakage. In judging what the vicinity of a slope or retaining structure is, the inspecting engineer should note that leakage from services may travel long distances via subsurface seepage paths through permeable materials or preferential flow channels, particularly in loose fill and colluvial deposits.

4.9.2 Actions on Buried Water-Carrying Services

Whether leaking or not, consideration should be given to the possibility of diverting existing services away from a slope or retaining structure. Opportunities to divert existing services may arise when existing slopes within or adjacent to a lot are being upgraded or when existing services are being re-laid or repaired. The diversion can also be carried out as preventive maintenance works. In case diversion cannot be carried out, alternative measures, such as ducting the existing buried services or raising them above ground should be considered. However, diversion or ducting of existing services may be very costly and may even be impracticable due to site constraints. The inspecting engineer should establish that diversion or ducting is feasible before making such a recommendation.

If diversion and ducting of the services is not feasible, the inspecting engineer should give recommendations for regular checks of the services to verify their condition, together with the required frequency and extent of the checks.

Sometimes, buried water-carrying services owned by other private parties are found within or in the vicinity of the maintenance boundary of the slopes and retaining structures. Where no signs of leakage are observed on the slopes or retaining structures, but leakage from such services is likely to affect the stability of the slopes or retaining structures, the inspecting engineer should draw the attention of the relevant services' owners to the need to carry out regular inspections and maintenance of their buried water-carrying services.

The Government carries out regular inspections and repairs to its water-carrying services. If there are discrepancies between the layout of the services and the corresponding available utility plan, the inspecting engineer should inform the relevant government department.

4.9.3 Urgent Actions on Buried Water-Carrying Services with Signs of Leakage

Where leakage is suspected from buried water-carrying services for which the owner or the party required to maintain the land is also responsible, the inspecting engineer should recommend an immediate detailed leakage check of the services by a qualified specialist contractor.

Where leakage is suspected from buried water-carrying services on land beyond the jurisdiction of the owner or the party required to maintain the slope or retaining structure, whose stability could be deteriorated by the leakage, the inspecting engineer should identify the source of leakage, if any, and advise the services' owners to investigate and repair the leak or damage without delay. The inspecting engineer should also recommend to the slope owner other landslide risk mitigation measures if considered necessary.

If the suspected leakage is from services owned by private parties, the case should also be referred to Water Authorities or Concession Companies, Local Authorities or the Department of Land and Mines

4.10 SLOPE FURNITURE

Furniture made of steel, such as boundary fences, handrails in staircases and signage posts, is susceptible to corrosion. If severely corroded, whole or part of these elements may fall off the slope or retaining structure. A thorough inspection is essential and any dust, earth and scale should be scraped away in order that the extent of the corrosion can be examined and the appropriate repair works determined. Attention should be paid to hinges and bolts, which are particularly susceptible to wear. All rust should be removed prior to application of suitable surface protection. If a new surface protection is applied, consideration should be given to using a colour scheme most sympathetic to the surroundings and whether the repair works should be applied to part or whole of the furniture so as to minimise the visual impact. In case of severe corrosion, consideration should be given to replacing the furniture. The footings and supports to the furniture items should be examined for signs of cracking and instability.

4.11 CLASSIFICATION OF OVERALL STATE OF SLOPE MAINTENANCE

The engineer undertaking an Engineer Inspection for Maintenance should assess the condition of individual man-made items, as listed in Table 4.1, which could affect the performance of the slope or retaining structure. The principal factor to consider is the continuing function of the individual man-made items. Based on whether "Major" or "Minor" defects are observed, the overall state of slope maintenance is assessed in accordance with the criteria given in Table 4.2. The assessment of the overall state of slope maintenance provides a rational basis for the engineer to review the adequacy of maintenance and to take necessary actions as appropriate.

Regardless of the assessed overall state of slope maintenance for a slope or retaining structure, maintenance works should be carried out in accordance with the recommendations arising from Routine Maintenance Inspections and Engineer Inspections for Maintenance. This is to prevent the slope or retaining structure from deteriorating to such an extent that its stability would be adversely affected. Priority should be given to maintenance works for slopes and retaining structures whose overall state of slope maintenance is assessed as Class 2, as in Table 4.2.

Table 4.1 Classification of Defects on Individual Man-made Items

	Man-made Item	Defects Affecting the Function of Particular Man-made Items Man-made Items	
		Minor	Major
1	Surface protection (e.g. vegetation or rigid cover)	The maintenance condition of the item would still allow it to continue to serve its intended function satisfactorily.	The maintenance condition of the item has severely hampered its adequate functioning.
2	Surface drainage system (including surface channels, sumps and silt traps)		
3	Subsurface drainage system (including weepholes and subsurface drains)		
4	Water-carrying services		
5	Special measures (such as designed horizontal drains or prestressed ground anchors)		

Note: Assessment of defects is normally by visual inspection, such as checking for signs of unusual surface seepage, blockage of outlet drains and signs of surface erosion. The inspecting engineer should also use other measures to determine the defects, such as probing or dye colour test or any other available test, as necessary.

Table 4.2 Classification System for Overall State of Maintenance of Slopes and Retaining structures

Overall State of Slope Maintenance	Criteria
Class 1	None or only minor defects are identified. The overall state of maintenance of the slope or retaining structure is considered to be satisfactorily in general.
Class 2	Major defects affecting the function of one or more man-made items are identified. There is a need for significant improvement in the maintenance actions implemented for the slope or retaining structure.

4.12 REASSESSMENT OF CONSEQUENCE-TO-LIFE CATEGORY

When reassessing the consequence-to-life category of a slope or retaining structure, the engineer should take into consideration factors, such as:

(a) possible failure mechanisms

(b) site conditions,

(c) the scale of failure,

(d) proximity of buildings and facilities to the slope or retaining structure,

(e) the likely density of occupation and frequency of usage of the affected buildings and facilities in the event of failure,

(f) the likely travel distance of landslide debris,

(g) the resistance of buildings and facilities to debris impact,

(h) vulnerabilities of occupants and users.

Guidance on the assessment of the consequence-to-life category of a slope or retaining structure is given in Appendix I.

4.13 CHECKING AND COMMENTS FOR SLOPE AND RETAINING STRUCTURES

For government slopes and retaining structures where its designs or Stability Assessments have been done, the designs and assessments should be sent to Cawangan Kejuruteraan Cerun for checking and comments.

If the engineer undertaking the Engineer Inspection for Maintenance considers that the engineering approach, the assumptions and the conclusions made in previous Stability Assessment reports of a slope or retaining structure are reasonable in light of current practice and safety standards and that no further investigation and upgrading works are recommended, the relevant authorities should submit the relevant documents to Cawangan Kejuruteraan Cerun JKR for comments.

4.14 UNAUTHORISED CULTIVATION

Infiltration through unauthorised cultivation areas on or above a slope or retaining structure is detrimental to the stability of the slope or retaining structure. In addition, unauthorised cultivation may change the landform and affect the effective drainage of surface water during heavy rainfall. The engineer undertaking the Engineer Inspection for Maintenance should identify and assess the possible effect of any such unauthorised cultivation areas. Where unauthorised cultivation areas are found, the relevant government authorities (e.g. the Land Office or the Local Authorities) should be notified for follow-up actions.

4.15 PRIORITISING MAINTENANCE ACTIONS

Where an Engineer Inspection for Maintenance or otherwise identifies that a slope or retaining structure is in need of preventive maintenance works or upgrading works, these should be arranged and carried out at the earliest possible opportunity. If a maintenance party has a large number of slopes and retaining structures that require action, the slopes and retaining structures could be prioritised for action, according to the consequence of failures and the condition of the slopes and retaining structures. For those slopes and

retaining structures where preventive maintenance works or upgrading works are awaiting action, appropriate precautionary measures (e.g. inspection of the slopes and retaining structures at regular intervals) should be carried out to ensure that the condition of the slopes and retaining structures do not deteriorate to a state that warrants more urgent action. Advice on prioritisation and precautionary measures should be sought from a professionally-qualified geotechnical/civil engineer where needed.

4.16 INDEPENDENT AUDIT OF ENGINEER INSPECTION FOR MAINTENANCE REPORTS

It is good practice to carry out an independent audit of the Engineer Inspection for Maintenance Reports, particularly for an assignment that covers the inspection of a large number of slopes and retaining structures. Generally, about 0.5 to 1% of the inspection reports are taken at random for quality assessment by an independent professionally-qualified geotechnical/civil engineer. Where possible, the independent audit should be carried out in phases such that the early phases of audit would help benchmark the standard of the inspections. Working to the required standard at the start is much more effective than having to take corrective actions at a late stage. The auditing arrangement should be made known to the engineer undertaking the Engineer Inspection for Maintenance prior to implementation or be included in the scope of services of the Engineer Inspection for Maintenance where considered appropriate.

5. PREVENTIVE MAINTENANCE WORKS

5.1 GUIDELINES ON PREVENTIVE MAINTENANCE WORKS

The slope surface protective covers and drainage provisions at many old slopes in Malaysia may not be adequate. Where existing provisions are deficient (see Chapter 4 for examples), Routine Maintenance Works which entail only upkeep of the existing surface protective covers and drainage in a sound condition is not sufficient to prevent ongoing deterioration of the slope. In such cases, recommendations on the necessary preventive maintenance works, which are works of preventive nature to reduce the rate of deterioration of slopes, should be made by the engineer undertaking the Engineer Inspection for Maintenance.

Where preventive maintenance works are planned, consideration should be given to include provision of nominal support and re-grading where appropriate. In certain cases, it is sufficient to meet the required existing geotechnical standards such as the Geotechnical Manual for Slopes (GCO, 1984). Such measures, without the need for detailed ground investigations and design analyses, are 'prescriptive measures'[1] as denoted in the second edition of Guide to Retaining structure Design (Geoguide 1: GEO, 1993). These can be readily incorporated in conventional slope maintenance works and can be carried out by qualified specialist contractors.

Typical preventive maintenance works for soil cut and rock cut slopes are illustrated in Figure 5.1 and Figure 5.2 respectively.

It is preferable that the engineer designing and recommending the preventive maintenance works be assigned the task to review the completed works.

Note: (1) Recommended standards of good practice for the application of prescriptive measures to improvement works on cut slopes and retaining structures can be referred to GEO Report No. 56 (Wong et al, 1999), Technical Guidance Note No. 13 (GEO, 2003b) and Technical Guidance Note No. 17 (GEO, 2004).

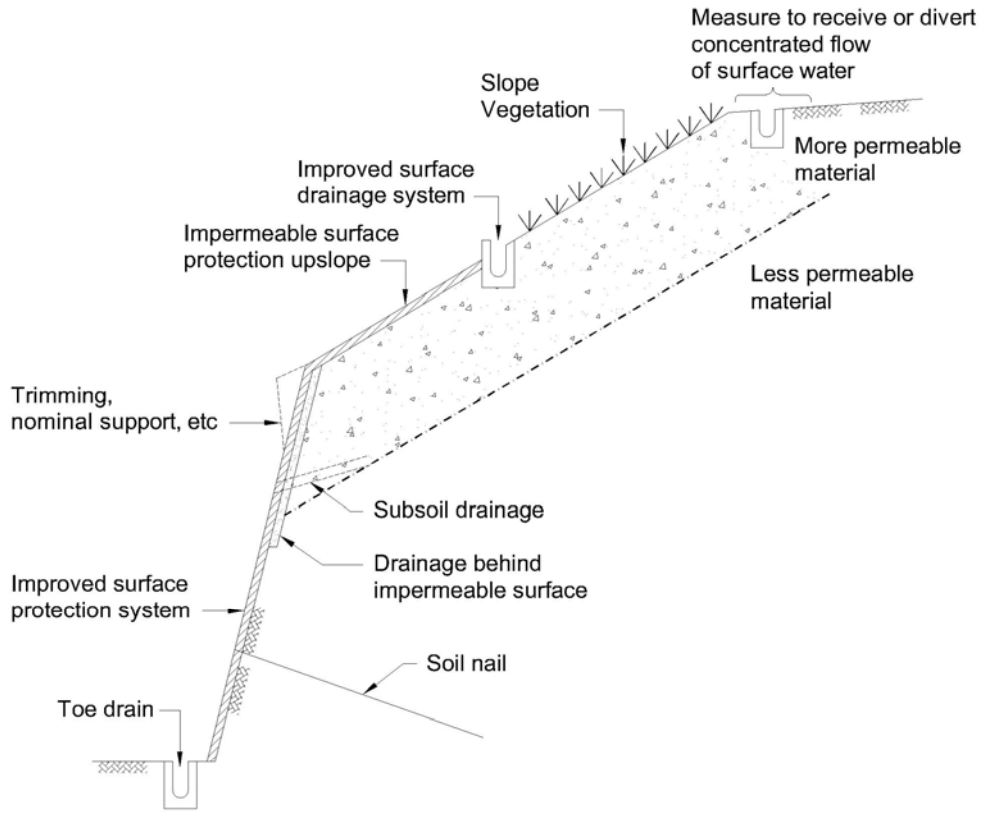


Figure 5.1 Typical Preventive Maintenance Works for Soil Slopes

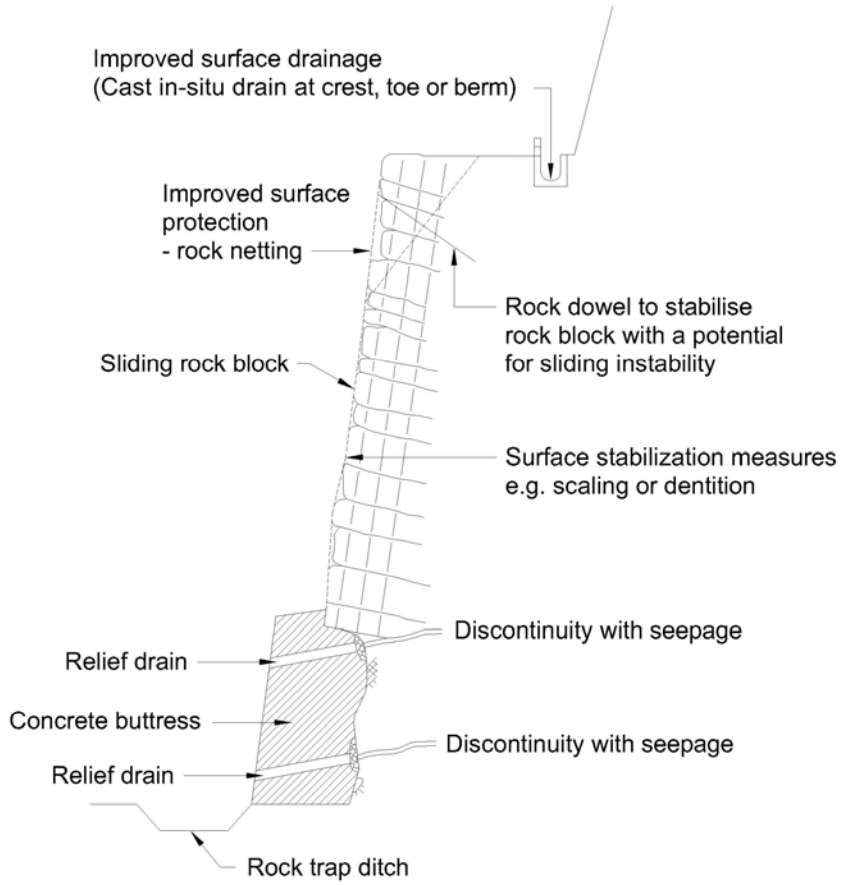


Figure 5.2 Typical Preventive Maintenance Works for Rock Slopes

6. MAINTENANCE REQUIREMENTS FOR DISTURBED TERRAIN FEATURES

6.1 GENERAL

Disturbed terrain features are tracts of hillside modified by human activities or landslides to the extent that its stability behaviour would be different from the original ground. There are two main types:-

(a) Repaired landslide scars.

(b) Terraced slopes resulting from illegal hill clearing, logging and agricultural activities. Other examples are sites of squatter activities and abandoned quarries/mines.

6.2 PURPOSE AND SCOPE OF MAINTENANCE INSPECTIONS

Disturbed terrain features may contain man-made items such as surface drains and surface protection measures. Routine Maintenance Inspections and Engineer Inspections for Maintenance should be carried out to ensure adequate functioning of the man-made items. The recommendations given in Chapter 3 for man-made slopes and retaining structures in respect of scope and timing of maintenance inspections, personnel requirements, maintenance manuals and records of inspections are also applicable to the maintenance of disturbed terrain features.

6.3 FREQUENCY OF MAINTENANCE INSPECTIONS

In general, the recommended frequency of maintenance inspections for disturbed terrain features is given in Table 6.1.

Table 6.1 Recommended Frequency of Maintenance Inspections

Consequence-to-life Category of Disturbed Terrain Features (Refer Appendix I)	Frequency of Routine Maintenance Inspections	Maintenance Inspections Frequency of Engineer
Category 1 and 2	Once every year	Once every five years
Category 3	Once every five years	Once every ten years
Category 3 located in a remote area(1)	React to known hazard(2)	React to known hazard(2)

Notes: (1) A disturbed terrain feature is in a remote area if it is surrounded by natural terrain such that a failure would bring no significant direct or indirect consequences (e.g. abandoned agricultural terraces in the countryside).

(2) Examples of known hazard are observed signs of distress and failures.

The designer or the engineer undertaking the Engineer Inspection for Maintenance may specify more frequent maintenance inspections than those given in Table 6.1 if considered appropriate (e.g. where a high indirect consequence is anticipated in the event of failure of

the feature). Conversely, less frequent Routine Maintenance Inspections may be adopted, taking into account the consequence of failure and whether man-made items are present.

Notwithstanding the above, where it is confirmed in an Engineer Inspection for Maintenance that a disturbed terrain feature does not contain any man-made items, it is not necessary to carry out Routine Maintenance Inspections for it, irrespective of its consequence-to-life category. However, Engineer Inspections for Maintenance should still be carried out.

A Category 3 disturbed terrain feature in a remote area is one that is surrounded by natural terrain such that a failure would bring no significant direct or indirect consequences, e.g. abandoned agricultural terraces in the countryside. Routine Maintenance Inspections and Engineer Inspections for Maintenance are generally not necessary for it. An example of significant indirect consequence is if debris from the disturbed terrain feature could travel to affect a watercourse.

6.4 MAINTENANCE WORKS

Maintenance works needed for disturbed terrain features with man-made items are similar to those for man-made slopes and retaining structures, as described in Chapter 3. They generally include clearance and minor repairs to man-made items, such as surface drains, rubble walls and the surface covers of small cut and fill slopes, to ensure their continued functioning.

Assessment of the need for maintenance works for disturbed terrain features should take into account the consequence of failures and the cost-benefit of the maintenance works. In general, Routine Maintenance Works should be carried out to maintain the man-made items found on disturbed terrain features.

Preventive maintenance works should be carried out for disturbed terrain features of consequence-to-life Categories 1 and 2 as needed. For those features of consequence-to-life Category 3, preventive maintenance works are generally not worth carrying out. Table 6.2 summarises the requirements for undertaking the maintenance works.

Table 6.2 Requirements for Undertaking Maintenance Works

Consequence-to-life Category of Disturbed Terrain Features (Refer Appendix I)	Routine Maintenance Works	Preventive Maintenance Works
Category 1 and 2	As recommended in Routine Maintenance Inspections and Engineer Inspections for Maintenance	As recommended in Routine Maintenance Inspections and Engineer Inspections for Maintenance
Category 3	As recommended in Routine Maintenance Inspections and Engineer Inspections for Maintenance	React to known hazard(2)
Category 3 located in a remote area (1)	React to known hazard(2)	React to known hazard(2)

Notes: (1) A disturbed terrain feature is in a remote area if it is surrounded by natural terrain such that a failure would bring no significant direct or indirect consequences (e.g. abandoned agricultural terraces in the countryside).

(2) Examples of known hazard are observed signs of distress and failures.

Where conditions warrant, studies of appropriate nature, with a view to undertaking any necessary stabilisation works, or defense and mitigation measures should be carried out taking into consideration the consequence, usage and site conditions of the disturbed terrain features. For example, for disturbed terrain features belonging to consequence-to-life Category 1, studies should be carried out if there are illegal development on them or if the overall ground gradient is greater than 25°.

7. MAINTENANCE REQUIREMENTS FOR NATURAL TERRAIN HAZARD MITIGATION MEASURES

7.1 GENERAL

Natural terrain hazard mitigation measures can be broadly classified into two categories:

(a) Stabilisation Measures constructed on natural hillsides to prevent failure, e.g. rock buttresses, soil nails, horizontal drains and retaining structures.

(b) Protection Measures to contain landslide debris or rock/boulder fall from the hillside above, e.g. check-dams, earth bunds and rock fences.

Natural hillsides do not require maintenance, and hazard mitigation measures do not normally result in substantial modification to the geometry and condition of the natural hillsides. The purpose of maintenance for hazard mitigation measures is confined to ensuring their physical integrity and satisfactory performance. The owner/occupier or the party required to maintain the mitigation measures is not required to maintain the natural hillsides or review the adequacy of the measures provided.

If a hillside is substantially modified by the stabilisation (e.g. major regrading) or Protection Measures, then it should be regarded as a man-made slope or retaining structure and should be maintained in accordance with the guidelines given in Chapter 3 for man-made slopes and retaining structures.

7.2 MAINTENANCE MANUAL FOR NATURAL TERRAIN HAZARD MITIGATION MEASURES

A Maintenance Manual should be prepared to assist the owner/occupier or the party required to maintain the mitigation measures to appreciate the maintenance requirements. The Maintenance Manual should include key aspects of the mitigation measures such as:

(a) a plan of the site showing the location of the natural terrain hazard mitigation measures,

(b) record sheets containing basic information on the natural terrain hazard mitigation measures,

(c) a list of maintenance actions,

(d) recommendations for the frequency of Routine Maintenance Inspections, and for requesting Engineer Inspections for Maintenance when anomalies are observed during Routine Maintenance Inspections,

(e) as-built plans and typical cross-sections of the natural terrain hazard mitigation measures,

(f) the purpose of the hazard mitigation measures and the developments or facilities to be protected,

(g) as-built record photographs of the natural terrain hazard mitigation measures,

(h) geological records on or adjacent to the natural terrain slopes such as distribution of geologic materials, weathering profiles, geological structures and hydrogeological regime, and

(i) aerial photographs or satellite images showing the status of land use and land development activities surrounding the natural terrain hazard mitigation measures. The photographs and images can be purchased from Malaysian Centre for Remote Sensing (MACRES).

An indicative format for Maintenance Manual for natural terrain hazard mitigation measures is given in Appendix G.

7.3 ROUTINE MAINTENANCE INSPECTIONS FOR MITIGATION MEASURES

Routine Maintenance Inspections should be carried out to identify any maintenance works required to ensure the integrity and physical condition of the hazard mitigation measures and continued satisfactory performance of the measures. The general principles given for the maintenance of man-made slopes and retaining structures in Chapter 3, and the recommended good practice given in respect of the maintenance management, personnel requirements, attention to safe access and precautions, are applicable to the maintenance of natural terrain hazard mitigation measures. When it is decided to provide a permanent access to the hazard mitigation measure, it is necessary to consider the environmental impact and avoid a visually intrusive access as far as possible.

Routine Maintenance Inspections should cover the measures, the area containing the measures and the surrounding area. In general, the inspection should assess the need for carrying out maintenance works of man-made items such as:

(a) clearing debris from stormwater facilities, e.g. drains, sumps, trap facilities and trash screen,

(b) repairing or replacing damaged sections,

(c) clearing weepholes and drainage outlet,

(d) removing any vegetation that has caused severe cracking of channels or hard surfaces,

(e) repairing or reinstating the ground adjoining the measures if affected by severe erosion,

(f) other routine maintenance works to upkeep the integrity and function of the measures, and

(g) removal of loose boulders or rock blocks on the natural slopes or rock slopes.

7.4 FREQUENCY OF ROUTINE MAINTENANCE INSPECTIONS

Routine Maintenance Inspections should be carried out at least once every year. If the inspection is to be carried out annually, it should preferably be completed well before the onset of the wet season[1]. This will allow sufficient time for carrying out the necessary routine maintenance works. In addition, it is good practice to inspect Protection Measures and clear any significant volume of debris accumulated after a heavy rainstorm.

The designer or a professionally-qualified geotechnical/civil engineer may specify less frequent Routine Maintenance Inspections taking into consideration the consequence of failure in the natural terrain, e.g. where facilities on the land protected by the mitigation measures have been cleared or changed.

Note 1: Wet season in Malaysia vary from state to state according to respective monsoon period. For example, in East Coast of Peninsular Malaysia, the wet season normally starts in October and in the West Coast of Peninsular the wet season normally starts in July.

7.5 ENGINEER INSPECTIONS FOR MAINTENANCE OF MITIGATION MEASURES

The maintenance works required for Stabilisation Measures and Protection Measures are relatively simple, and do not normally require input from a professionally-qualified geotechnical/civil engineer. Engineer Inspections for Maintenance are not required unless specified otherwise by the designer or the authority. In cases where unusual conditions or problems are observed, e.g. a check-dam filled up with a large amount of landslide debris or significant movement observed at rock/boulders supported by buttresses, the owner/occupier or the party required to maintain the mitigation measures should seek advice from a professionally-qualified geotechnical/civil engineer.

7.6 OTHER MEASURES

In some circumstances, dealing with natural terrain landslide hazards involves use of other measures such as:

(a) provision of a buffer zone (e.g. an open space) between the hillside and developments or facilities, and

(b) incorporation of sediment basins, silt/sand traps, etc. as part of the drainage facilities.

Unless specified otherwise by the designer, there are no maintenance requirements for such measures from the geotechnical point of view, apart from regular clearance of debris.

Re-vegetation may be carried out in a prescriptive manner to repair hillsides that are affected by landslides, hill fires, etc. The vegetation species to be adopted in such circumstances should be maintenance free. If special bio-engineering measures are adopted for the mitigation of natural terrain hazards, the designer should specify maintenance requirements.

8. SOURCES OF INFORMATION

8.1 INFORMATION PROVIDERS

Useful information relating to the maintenance of slopes and retaining structures can be obtained from a number of agencies.

Cawangan Kejuruteraan Cerun JKR provides advice to the general public on matters relating to maintenance of slopes and retaining structures, and suggests appropriate sources for more specific information.

Cawangan Kejuruteraan Cerun JKR manages a Slope Information System that contains up-to-date information on registered man-made slopes and retaining structures within Malaysia.

Cawangan Kejuruteraan Cerun JKR also keeps records of previous ground investigations and landslides, and reports on Stability Assessments and upgrading works carried out by JKR under its Maintenance Programmed. In addition, other records of existing slopes and retaining structures are made available upon request.

Engineer Inspection for Maintenance Reports and Maintenance Manuals for government man-made slopes and retaining structures are held by various departments in JKR responsible for their maintenance.

For slopes along the highways, information should be sought through the Malaysian Highway Authority while for slope along other roadways, JKR's Road Branch should be able to assist. Relevant local authorities should be referred to, for other man-made slopes that do not fall under the government's jurisdiction.

Board of Engineers Malaysia and the Institution of Engineers Malaysia hold a list of Registered Professional Engineers (Geotechnical and Civil).

Cawangan Kejuruteraan Cerun JKR keeps a list of Registered Contractors who have indicated their willingness to carry out maintenance works for slopes and retaining structures.

The Department of Lands and Mines is responsible for land administration. Information about land records, land boundaries and lease conditions can be sought from the Department of Lands and Mines. Records of property owners, lease documents and Deeds of Mutual Covenant are kept at the Department of Lands and Mines, where the public can make a search of these records.

Large-scale plans and topographic maps can be purchased from the Department of Surveying and Mapping. Satellite images can also be purchased from Malaysian Centre for Remote Sensing (MACRES).

Geological information may be obtainable from the Minerals and Geosciences Department (eg. Geological Terrain Maps on a scale of 1:10,000).

The Water Supplies Authorities or Concession Companies provides information on the location of water supply mains upon request.

The Department of Irrigation and Drainage maintains as-built records of public monsoon drains.

Information on gas, electricity, telephone and similar services, including both the locations and details of existing facilities and the provision of future services, are available from the companies supplying the services.

Further information regarding the services provided by the relevant government departments and their contact details can be found at the web site www.gov.my.

8.2 DOCUMENTS

An abridged version of this guideline: Layman's Guide to Slope Maintenance (Cerun 2), has been produced by Cawangan Kejuruteraan Cerun JKR giving simplified guidance on matters related to slope maintenance for the general public. "Layman's Guide on Landscape Treatment of Slopes and Retaining structures" (GEO, 2002a) produced by the Geotechnical Engineering Office, Hong Kong provides guidelines to land owners/occupiers and encourage them to adopt landscape treatment to slopes and retaining structures when planning for the maintenance and upgrading works.

REFERENCES

CKC (2006). *Layman's Guide to Slope Maintenance. (First edition).* Cawangan Kejuruteraan Cerun JKR, Malaysia, 36 p.

GCO (1984). *Geotechnical Manual for Slopes. (Second edition).* Geotechnical Control Office, Hong Kong, 295 p.

GCO (1989). *Model Specification for Prestressed Ground Anchors (Geospec 1*). Geotechnical Control Office, Hong Kong, 168 p.

GEO (1993). *Guide to Retaining structure Design (Geoguide 1*). *(Second edition).* Geotechnical Engineering Office, Hong Kong, 258 p.

GEO (2000a). *Technical Guidelines on Landscape Treatment and Bio-Engineering for Man-made Slopes and Retaining structures (GEO Publication No. 1/2000).* Geotechnical Engineering Office, Hong Kong, 146 p.

GEO (2002a). *Layman's Guide to Landscape Treatment of Slopes and Retaining structures.* Geotechnical Engineering Office, Hong Kong, 24 p.

GEO (2002b). *Guide to Reinforced Fill Structure and Slope Design (Geoguide 6).* Geotechnical Engineering Office, Hong Kong, 236 p.

GEO (2003b). *Guidelines on the Use of Prescriptive Measures for Rock Cut Slopes (Technical Guidance Note No. 13)*. Geotechnical Engineering Office, Hong Kong, 2 p.

GEO (2004). *Prescriptive Soil Nail Design for Concrete and Masonry Retaining structures. (Technical Guidance Note No. 17).* Geotechnical Engineering Office, Hong Kong, 1 p. (under preparation).

Lam, J.S., Siu, C.K. & Chan, Y.C. (2003). *Guidelines on Safe Access for Slope Maintenance (GEO Report No. 136).* Geotechnical Engineering Office, Hong Kong, 58 p.

Wong, H.N., Pang, L.S., Wong, A.C.W., Pun, W.K. & Yu, Y.F. (1999). *Application of Prescriptive Measures to Slopes and Retaining structures (GEO Report No. 56). (Second edition).* Geotechnical Engineering Office, Hong Kong, 73 p.

Works Bureau (2001). GEO Checking *Certificate for Slopes and Retaining structures (Works Bureau Technical Circular No. 16/2001)*. Works Bureau, Government of the Hong Kong Special Administrative Region, 7 p.

Yu, Y.F., Siu, C.K., Pun, W.K. (2005). *Guidelines on the Use of Prescriptive Measures for Rock Cut Slopes. (GEO Report 161).* Geotechnical Engineering Office, Hong Kong, 31p.

APPENDIX A – INDICATIVE FORMAT FOR MAINTENANCE MANUAL FOR MAN-MADE SLOPES AND RETAINING STRUCTURES

MAINTENANCE MANUAL					**SHEET 1 OF 8**
Buku Panduan Penyenggaraan					
PART I – BASIC SLOPE / RETAINING STRUCTURE INFORMATION					
Bahagian I – Maklumat Asas Cerun / Struktur Penahan					
SLOPE / RETAINING STRUCTURE REFERENCE NO.					
No Rujukan Cerun / Struktur Penahan					
Location of Slope / Retaining Structure (address)					
Lokasi Cerun / Struktur Penahan (alamat)					
Map Coordinates Koordinat Peta	**Easting** Timur		**Toe Elevation (m)** Aras Tinggi Kaki Cerun (m)		
	Northing Utara				
Maximum Height of Slope/Retaining Structure (m) Tinggi Maksima Cerun/Struktur Penahan (m)					
Overall Slope Angle of Slope/Retaining Structure(o) Sudut keseluruhan Cerun/Struktur Penahan (o)					
TECHNICAL INFORMATION - (continue on separate sheets if necessary) Maklumat Teknikal (sambung dengan mukasurat yang lain sekiranya perlu)					
Slope Portion Bahagian Cerun			**Retaining structure Portion** Bahagian Struktur Penahan		
Material Description Perihalan Bahan			**Type of Wall** Jenis Tembok		
Slope Surface Cover Penutup permukaan cerun			**Location of Wall** Lokasi Tembok		
Maximum Height (m) Tinggi Maksimum (m)			**Maximum Height (m)** Tinggi Maksima (m)		
Length (m) Panjang (m)			**Length (m)** Panjang (m)		
Average Slope Angle (°) Sudut Purata Cerun			**Face Angle (°)** Sudut Permukaan (o)		
Berm Lereng	**No.**	**Min. Width (m)** Lebar Min. (m)	**Berm** Lereng	**No.**	**Min. Width (m)** Lebar Min. (m)
Drainage Saliran	**Size** Saiz (mm)	**Jarak** Spacing (m)	**Drainage** Saliran	**Size** Saiz (mm)	**Spacing** Jarak (m)
Weepholes Lubang Leleh			**Weepholes** Lubang Leleh		
Channels Saluran — **At crest** Di puncak			**Channels Saluran** — **At Crest** Di puncak		
On berm Di lereng					
At toe Di kaki			**At toe** Di kaki		
On slope Di cerun					
Down Pipes Paip Turun			**Down Pipes** Paip Turun		
Structural Measures (e.g. soil nail, anchor) Tindakan Struktur (spt. paku tanah,penambat)			**Structural Measures (e.g. soil nail, anchor)** Tindakan Struktur (spt. paku tanah,penambat)		
TYPE AND SIZE OF SERVICES (see drawing) Jenis Dan Saiz Perkhidmatan (rujuk lakaran)					
On Slope Di atas Cerun ----------					

At Crest Di puncak ----------					

MAINTENANCE MANUAL **SHEET 2 OF 8**
Buku Panduan Penyenggaraan
PART I – BASIC SLOPE / RETAINING STRUCTURE INFORMATION
Bahagian I – Maklumat Asas Cerun / Struktur Penahan

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No Rujukan Cerun / Struktur Penahan

INFORMATION ON CONSEQUENCE-TO-LIFE CATEGORY
Maklumat Berkenaan Kategori Akibat Kepada Nyawa

What facilities will be affected if this slope or retaining structure collapses (e.g. school, market, playground, highway and country park)?
(Apakah kemudahan awam yang terlibat sekiranya cerun atau Struktur Penahan ini runtuh (contoh; sekolah, pasar, taman permainan, lebuhraya dan taman rekreasi?)

At Creast (a) **Type(s) of facility**
Di Puncak Jenis Kemudahah

(b) **Distance**
Jarak

At Toe (a) **Type(s) of facility**
Di Kaki Jenis Kemudahan

(b) **Distance**
Jarak

Consequence-to-life category of the slope or retaining structure:
Kategori akibat-kepada-nyawa bagi cerun atau struktur penahan:

STUDY / UPGRADING / IMPROVEMENT WORKS
Kajian / Kerja-Kerja Peningkatan / Pembaikan

Types of upgrading or improvement works, date of construction, outline of basis of most up-to-date design or findings of Stability Assessment
(Jenis-jenis kerja-kerja peningkatan atau pembaikan, tarikh pembinaan, rumusan terkini rekabentuk atau pertemuan-pertemuan daripada Taksiran Kestabilan)

MAINTENANCE MANUAL **SHEET 3 OF 8**
Buku Panduan Penyenggaraan
PART II – MAINTENANCE SCHEDULE OF SLOPE / RETAINING STRUCTURE
Bahagian II – Jadual Penyenggaraan Cerun / Struktur Penahan
SLOPE / RETAINING STRUCTURE REFERENCE NO.
No Rujukan Cerun / Struktur Penahan
LIST OF ITEMS REQUIRING ROUTINE MAINTENANCE
Senarai Barangan Yang Memerlukan Penyenggaraan Rutin
(including requirements on man-made items, landscape item, etc)
(termasuk keperluan ke atas barangan buatan manusia, barangan lanskap, dan lain-lain)
MONITORING SCHEDULE FOR REGULAR MONITORING OF SPECIAL MEASURES
(Jadual Pemantauan Untuk Pemantauan Lazim Bagi Tindakan-Tindakan Khas)
Type and Spacing of Special Measures: Anchors/Horizontal Drains (see drawing for details)
(Jenis dan Jarak di antara Tindakan Khas: Saliran mengufuk (rujuk lakaran untuk perincian)
Details of Monitoring: (e.g, frequency of monitoring, types of tests and acceptance criteria
(Perincian Pemantauan: (contoh; kekerapan pemantauan, jenis-jenis ujian dan kriteria penerimaan)

MAINTENANCE MANUAL **SHEET 4 OF 8**
Buku Panduan Penyenggaraan
PART II – MAINTENANCE SCHEDULE OF SLOPE / RETAINING STRUCTURE
Bahagian II – Jadual Penyenggaraan Cerun / Struktur Penahan

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No Rujukan Cerun / Struktur Penahan

FREQUENCY OF MAINTENANCE INSPECTIONS
Kekerapan Pemeriksaan Penyenggaraan

(a) **Frequency of Routine Maintenance Inspection:**
Kekerapan bagi Pemeriksaan Penyenggaraan rutin:

(b) **Frequency of Engineer Inspection for Maintenance:**
Kekerapan bagi Pemeriksaan Jurutera Penyenggaraan:

(c) **Frequency of Regular Check of Water-Carrying services (including buried services, ducting systems):**
Kekerapan bagi Pemeriksaan Lazim ke atas Perkhidmatan-Saluran Air (termasuk perkhidmatan-bawah tanah dan sistem saluran)

Guidelines on when professional advice or an immediate Engineer Inspection for Maintenance is required:
(e.g. landslide, signs of distress, new or significant increase of seepage, or change of facility in the vicinity of slope or retaining structure.)
Garispanduan bila mana nasihat professional atau pemeriksaan jurutera untuk Penyenggaraan perlu di buat serta merta:
(contoh: tanah runtuh, tanda-tanda kegagalan, resapan yang baru atau banyak, ataupun pergerakan kemudahan berdekatan cerun atau struktur penahan)

OTHER INFORMATION
Maklumat Lain

Relevant records: (e.g ground investigation report, geotechnical report, landslide incident report and landscape design report.)
Rekod berkaitan: (contoh; penyiasatan tapak, laporan geoteknik, laporan tanah runtuh dan laporan rekabentuk landskap)

INFORMATION PROVIDER
Pemberi Maklumat

Prepared by: ……
Disediakan oleh

Firm: ……
Firma

Signature: ……
Tandatangan

Date: ……..……..
Tarikh

MAINTENANCE MANUAL	**SHEET 5 OF 8**
Buku Panduan Penyenggaraan **PART III – DRAWINGS AND PHOTOGRAPHIC RECORDS** Bahagian III – Lukisan-Lukisan Dan Rekod-Rekod Fotograf	
SLOPE / RETAINING STRUCTURE REFERENCE NO. No Rujukan Cerun / Struktur Penahan	
LOCATION PLAN AND SITE PLAN(with scale) Pelan Lokasi Dan Pelan Tapak (dengan skala)	

MAINTENANCE MANUAL **SHEET 6 OF 8**
Buku Panduan Penyenggaraan
PART III – DRAWINGS AND PHOTOGRAPHIC RECORDS
Bahagian III – Lukisan-Lukisan Dan Rekod-Rekod Fotograf

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No Rujukan Cerun / Struktur Penahan

PLAN / SECTIONS OF SLOPE / RETAINING STRUCTURE TO BE MAINTAINED
(Plan and sections based on as-built conditions. Include date of the plan, details of surface cover, surface drainage, subsurface drainage, access points, and stabilization measures)

Pelan/Keratan-Keratan Rentas Cerun/Struktur Penahan
(Pelan dan keratan-keratan rentas berdasarkan keadaan sebenar. Masukkan tarikh pelan, perincian mengenai tutupan permukaan, saliran permukaan, saliran bawah tanah, jalan masuk dan tindakan-tindakan penstabilan)

Note: All dimension are in millimeters and all levels are in meters
Nota: Semua dimensi dalam milimeter dan semua aras dalam meter

MAINTENANCE MANUAL **SHEET 7 OF 8**
Buku Panduan Penyenggaraan
PART III – DRAWINGS AND PHOTOGRAPHIC RECORDS
Bahagian III – Lukisan-Lukisan Dan Rekod-Rekod Fotograf

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No Rujukan Cerun / Struktur Penahan

LAYOUT PLAN OF WATER-CARRYING SERVICES ON OR ADJACENT TO SLOPE/RETAINING STRUCTURE (with date)
Pelan Susun Atur Saluran Perkhidmatan Air di atas atau Berdekatan Cerun/Struktur Penahan (dengan tarikh)

Note: All dimension are in millimeters and all levels are in meters
Nota: Semua dimensi dalam millimeter dan semua aras dalam meter.

MAINTENANCE MANUAL Buku Panduan Penyenggaraan **PART III – DRAWINGS AND PHOTOGRAPHIC RECORDS** Bahagian III – Lukisan-Lukisan Dan Rekod-Rekod Fotograf	**SHEET 8 OF 8**
SLOPE / RETAINING STRUCTURE REFERENCE NO. No Rujukan Cerun / Struktur Penahan	
RECORD PHOTOGRAPHS (with observations and date; and with the vantage points indicated on the plans) Rekod Fotograf-fotograf (dengan pemerhatian dan tarikh; dan dengan tempat fotograf-fotograf diambil ditunjukkan di atas pelan)	
Note: Add additional record sheets for photographs as necessary Nota: Lampirkan helaian tambahan bagi fotograf-fotograf sekiranya perlu	

APPENDIX B – INDICATIVE RECORD SHEETS FOR ROUTINE MAINTENANCE INSPECTIONS AND WORKS

RECORD OF ROUTINE MAINTENANCE INSPECTION **SHEET 1 OF 4** Rekod Pemeriksaan Rutin Untuk Penyenggaraan Cerun
SLOPE / RETAINING STRUCTURE REFERENCE NO. No.Rujukan Cerun / Struktur Penahan
Date of Inspection: Tarikh pemeriksaan:
Date of Last Engineer Inspection for Maintenance: Tarikh pemeriksaan terakhir oleh Jurutera:
Due Date of Next Engineer Inspection for Maintenance: Tarikh kerja Penyenggaraan seterusnya oleh Jurutera:
Weather Condition at Time of Inspection: Keadaan cuaca semasa pemeriksaan:

Map Coordinates: Koordinates Peta:				**Date of Construction:** Tarikh Pembinaan:
Easting: Timur:		**Northing:** Utara:		

Maintenance Action Item Perkara untuk Tindakan Penyenggaraan	**Location Reference** Rujukan Lokasi	**Action Required** Tindakan yang Diperlukan		**Works Completion Date** Tarikh Kerja Disiapkan
		No Tidak	**Yes** Ya	
Clear drainage channels of accumulated debris Membersihkan saluran perparitan dari sampah sarap yang terkumpul				
Repair cracked/damaged drainage channels or pavements along crest and toe of slope or retaining structure Membaiki saluran perparitan atau penutup jalan di sepanjang puncak dan kaki cerun atau tombok penahan yang mengalami retakan/rosak				
Repair or replace cracked or damaged impermeable slope surface cover Membaiki atau menggantikan tutupan cerun tidak telap air yang telah merekah atau rosak				
Remove surface debris and vegetation that has caused severe cracking of slope surface cover and drainage channels Membuang sampah permukaan dan tumbuhan yang telah menyebabkan rekahan serius pada pemukaan cerun dan perparitan				
Remove loose rock debris and undesirable vegetation from rock slopes or boulders Membuang batuan longgar dan tumbuhan yang tidak perlu daripada cerun batu atau batu tongkol				
Re-vegetate bare soil slope surface Penanaman semula tumbuhan pada permukaan cerun tanah yang gundul				
Repair mortar joints in masonry walls Membaiki dinding batu yang diikat dengan mortar jika ikatannya mengalami kerosakan				
Unblock weepholes and outlet drainpipes Memastikan lubang leleh dan alur keluar paip saliran tidak tersumbat				
Repair leaky exposed water-carrying services Membaiki paip air atau pembentung yang bocor dipermukaan cerun				
Repair or replace rusted slope furniture (e.g. steel gates, boundary fences and stairs Membaiki atau menggantikan perabut cerun yang telah berkarat (cth. pagar besi, pagar sempadan dan tetangga)				
Remove debris from screen Membuang puing daripada penapis sampah				
Others Lain-lain (sila nyatakan kerja yang telah dilakukan)				
Recommended Date for Completion of Above Works Tarikh Dijangka Kerja-kerja di atas akan Diselesaikan				

RECORD OF ROUTINE MAINTENANCE INSPECTION **SHEET 2 OF 4**
Rekod Pemeriksaan Rutin Untuk Penyenggaraan Cerun

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No.Rujukan Cerun / Struktur Penahan.

SITE PLAN (Reference numbers should be assigned to locations of man-made items for which maintenance works are required. The corresponding reference numbers should be quoted in the photographic records.)
Pelan Tapak (Nombor rujukan hendaklah dinyatakan pada lokasi di mana kerja-kerja penyenggaraan diperlukan. Nombor rujukan yang sesuai hendaklah dinyatakan di dalam fotograf-fotograf yang telah diambil)

Note: Add additional record sheets for site plan as necessary
Nota: Tambah helaian rekod tambahan untuk pelan tapak jika perlu.

RECORD OF ROUTINE MAINTENANCE INSPECTION **SHEET 3 OF 4**
Rekod Pemeriksaan Rutin Untuk Penyeggaraan Cerun

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No.Rujukan Cerun / Struktur Penahan

Immediate Engineer Inspection for Maintenance needed? Yes/No
Adakah pemeriksaan untuk penyenggaraan perlu dilakukan oleh Jurutera dengan segera? Ya/Tidak

Immediate arrangement for investigation and repair of buried water-carrying services needed? Yes/No
Adakah penyiasatan dan pembaikan segera perlu dilakukan pada paip air atau Pembentung yang tertimbus? Ya/Tidak

OTHER OBSERVATIONS (continue on separate sheets if necessary)
(e.g. conditions of trees for which specialist advice is needed)
LAIN-LAIN PEMERHATIAN (sila gunakan kertas berasingan jika perlu)
(contoh. keadaan pokok di mana nasihat pakar diperlukan)

Inspected by:
Diperiksa oleh:

From:
Daripada:

Signature: **Date:**
Tandatangan: Tarikh

Due to of next inspection:
Tarikh untuk pemeriksaan berikutnya

:

Received by:
Diterima oleh:

From:
Daripada:

Signature: **Date:**
Tandatangan: Tarikh

Note: Defects or anomalies, such as signs of leakage, widening of cracks, settling ground, bulging or distortion of a masonry wall or settlement of the crest platform, should be reported to the Cawangan Kejuteraan Cerun, JKR
Nota: Kecacatan atau keadaan luar biasa seperti tanda-tanda kebocoran, penambahan saiz rekahan, enapan tanah, perubahan bentuk pada struktur penahan atau enapan pada puncak cerun hendaklah dilaporkan kepada Cawangan Kejuruteraan Cerun, JKR

RECORD OF ROUTINE MAINTENANCE INSPECTION **SHEET 4 OF 4**
Rekod Pemeriksaan Rutin Untuk Penyeggaraan Cerun
SLOPE RETAINING STRUCTURE REFERENCE NO.
No. Rujukan Cerun/Struktur Penahan

RECORD PHOTOGRAPHS (with description, date, and reference numbers as given on the site plan)
Rekod Fotograf-fotograf (disertakan dengan perihalan, tarikh dan no. Rujukan seperti yang ditunjukkan di dalam pelan tapak)

Note: Add additional record sheets for photographs as necessary. Record photographs should show in detail areas where maintenance works are required and signs of distress observed (e.g. tension cracks, bulging of wall) and be annotated with descriptions.

Nota: Sila gunakan helaian rekod tambahan jika perlu. Rekod fotograf-fotograf hendaklah menunjukkan kawasan di mana kerja penyenggaraan diperlukan, tanda-tanda kegagalan yang dilihat (cth. retak tegangan, pembonjolan tembok), dan hendaklah dicatatkan dengan perihalan

RECORD OF ROUTINE MAINTENANCE INSPECTION **SHEET 1 OF 1**
Rekod Pemeriksaan Rutin Untuk Penyeggaraan Cerun

SLOPE / RETAINING STRUCTURE REFERENCE NO.
No.Rujukan Cerun / Struktur Penahan

Maintenance works arranged by:
Kerja Penyenggaraan
diuruskan oleh:

From:
Daripada:

Signature:
Tandatangan:

Date:
Tarikh:

Maintenance works carried out by:
Kerja penyenggaraan dilakukan oleh:

From:
Daripada:

Signature:
Tandatangan:

Date:
Tarikh:

Maintenance works carried out on:
Kerja Penyenggaraan dilakukan pada

RECORD PHOTOGRAPHS (with descriptions, date, and reference numbers as given on the site plan)
REKOD FOTOGRAF-FOTOGRAF (disertakan dengan deskripsi, tarikh and no.rujukan seperti yang ditunjukkan di dalam pelan tapak)

Note:
Nota

1 **Add additional record sheets for photographs as necessary.**
Sila gunakan helaian rekod tambahan untuk fotograf-fotograf jika perlu.

2 **For removal of loose rocks from rock face or clearing debris from defence measures, e.g. check dam, the estimated colume of debris removed should be recorded.**
Jikalau batuan longgar perlu dibersihkan daripada permukaan batu atau sampah perlu dibersihkan daripada struktur penahanan, isipada batuan atau sampah yang dibersihkan perlu direkodkan.

3 **Record photographs should show in detail areas where maintenance works are required and signs of distress observed.**
Fotograf-fotograf hendaklah menunjukkan kawasan di mana kerja penyenggaraan diperlukan dan tanda-tanda kegagalan diperhatikan.

4 **Record photographs before and after the execution of maintenance works should be taken from the same vantage points.**
Fotograf-fotograf sebelum dan selepas kerja penyenggaraan dilakukan hendaklah diambil daripada sudut pandangan yang sama.

APPENDIX C – EXAMPLE OF TERM OF REFERENCE FOR ENGINEER INSPECTIONS FOR MAINTENANCE FOR PRIVATE SLOPES

EXAMPLE OF TERM OF REFERENCE FOR ENGINEER INSPECTIONS FOR MAINTENANCE

1. Objective of the Assignment

The objective of this Assignment is to carry out an Engineer Inspection for Maintenance, including the preparation of an Engineer Inspection Report and the preparation/updating* of a Maintenance Manual, and, if required, the design, management and supervision of works, for slope/retaining structure* number _____, the location and extent of which are shown on the attached plan.

2. Description of the Assignment

The Assignment shall consist of the following items of work:

(a) to assess the state of maintenance and condition of the slope/retaining structure*,

(b) to establish if Stability Assessments of the slope/retaining structure* have previously been carried out and, if so, to carry out a review of these previous Stability Assessments,

(c) to determine whether a Stability Assessment and/or preventive maintenance or urgent repair works or access provision are necessary,

(d) to recommend, arrange, supervise and certify the satisfactory completion of any necessary works*, and

(e) to prepare/update* the maintenance documentation and recommend improvement for the maintenance process.

The review of previous Stability Assessments required in (b) above is not intended to certify or endorse any part or the whole of the previous Stability Assessments. It only aims to identify whether the previous Stability Assessments contains any obvious deficiencies in engineering approach or assumptions in the light of current local geotechnical engineering practice and safety standards, any monitoring records indicating deficiency in the design assumptions, and to judge whether the stability of the slope/retaining structure would be affected by any visible changes in conditions identified during the site inspection.

3. Deliverables

The Engineer shall submit _____ copies of the Engineer Inspection Report covering the tasks listed in Section 4 below and enclosing the Records of Engineer Inspection for Maintenance /and _____ copies of the Maintenance Manual to the Employer.

4. Services to be Provided by the Engineer

This Assignment shall be carried out by a professionally-qualified geotechnical/civil engineer in Malaysia. Where necessary geological input shall be obtained from a qualified geologist registered with Institute Geology Malaysia. As the inspecting engineer, the geotechnical/civil engineer shall prepare and sign the Records of Engineer Inspection for Maintenance. The geotechnical/civil engineer shall also prepare and sign the Engineer Inspection Report.

Part 1 - Information Collection

(a) Starting from the sample checklist in Appendix H of Cerun 1, prepare a checklist for the agreement of the Employer indicating the types of documents to be collected under this Assignment.

(b) Collect available documentary information pertaining to the slope/retaining structure* and the nearby areas which could have implications on its stability.

Part 2 - Site Inspection

(a) Carry out an inspection of the slope/retaining structure* and the nearby areas and prepare Records of Engineer Inspection for Maintenance according to the Indicative Record Sheets given in Appendix F of Cerun 1. In particular,

(i) evaluate the adequacy of access to the slope/retaining structure for maintenance inspections taking into account the requirements of safety regulations and provide recommendations in accordance with Part 4(b) below,

(ii) identify visually any discrepancies between the records of previous engineer inspections for maintenance, maintenance manuals, the works as constructed, actual site conditions and the plans in the Stability Assessment Reports, design reports, drawings or as-built records,

(iii) identify all visible changes including landslides, unauthorised constructions, formation of unauthorised cultivation areas, appearance of tension cracks, or other signs of distress, that have taken place at or in the vicinity of the slope/retaining structure*, in particular any changes since the last Stability Assessment and Engineer Inspection, which could have implications on its stability, and to judge whether these might be significant,

(iv) identify the presence of buried and exposed water-carrying services (including any ducting systems housing the services) and unauthorised services, on or in the vicinity of the slope/retaining structure* (including relevant areas outside the lot boundary), both visually and with reference to the record plans for the services,

(v) check for signs of leakage of any exposed and buried water-carrying services (including any ducting systems housing the services) and identify the source of any leaky water-carrying services where possible and provide recommendations in accordance with part 4(c) below,

(vi) look for and consider the implications of problems that are not explicitly included in the list of maintenance for man-made items, and bring to the attention of the Employer any immediate and obvious danger noted and provide recommendations in accordance with Part 4(d) below, and

(vii) reassessment of geology, geological structure and ground water at site where applicable.

Part 3 - Assessment

Based on the tasks of Parts 1 and 2 above, carry out the following tasks:

(a) Evaluate the relevance and completeness of all information collected with reference to the checklist agreed by the Employer (see Part 1(a)). Determine whether Stability Assessments covering parts or the entirety of the slope/retaining structure* have previously been carried out. If so, review the previous Stability Assessment reports to check whether the engineering approach used, the assumptions and the conclusions made in these reports are reasonable in the light of current practice and safety standards.

(b) Re-assess the consequence-to-life category, as in Appendix 1A, of the slope/retaining structure*, as set out in the standards and guidance documents promulgated by Cawangan Kejuruteraan Cerun, JKR.

(c) Check that Routine Maintenance Inspections and the recommendations for routine maintenance works have been carried out and documented satisfactorily.

(d) Check that Regular Checks of Buried Water-carrying Services (including any ducting systems housing the services) and/or Regular Monitoring of Special Measures (if required) and the recommendations arising from the checks have been carried out and documented satisfactorily.

(e) Assess the adequacy of routine maintenance works and supplement the list of basic maintenance works items, as necessary.

(f) Re-assess the required frequency of Routine Maintenance Inspections, Engineer Inspections for Maintenance, and Regular Checks of Buried Water-carrying Services (including any ducting systems housing the services).

Part 4 - Recommendations

(a) Recommend any necessary preventive maintenance works.

(b) Based on the task of Part 2(a)(i), recommend any necessary access to be provided for maintenance inspections and works.

(c) Based on the task of Part 2(a)(v), recommend any necessary immediate detailed leakage check, regular checks, repair and re-routing of the services. Where leaking water-carrying services are found, advise the services' owners

and appropriate authorities for actions. Update the Maintenance Manual to include a provision to initiate an additional Engineer Inspection for Maintenance whenever anomalies due to leaking services are observed.

(d) Based on the work of Part 2(a)(iii) & (vi), recommend any necessary emergency measures (e.g. cordoning off works), urgent repair or investigations.

(e) Advise whether a Stability Assessment of the slope/retaining structure* is needed taking into consideration the results of the tasks in Parts 2 and 3 and the results of the previous Stability Assessment(s), if any.

Part 5 - Reporting

(a) Prepare an Engineer Inspection Report covering the above tasks and enclosing the Records of Engineer Inspection for Maintenance for submission to the Employer.

(b) Explain the findings and recommendations of the Engineer Inspection to the Employer, in particular whether Stability Assessment or works are required to be carried out, with justifications and cost estimates including any site supervision costs, and answering any queries.

Part 6 - Preparation/Updating* of the Maintenance Manual

(a) Prepare/update* the Maintenance Manual to include all relevant information extracted from the previous Stability Assessment(s), and the desk study, records and details of any previous landslides and subsequent repair works, and site inspection(s) under this Assignment, with traceability to all source documents used.

(b) Prepare/update* the Maintenance Manual to include a statement of landscape design highlighting the rationale for the choice of the landscape items for the slope/retaining structure.

Part 7 - Design, Management and Supervision of Works (Optional Items)

(a) Prepare specifications and plans for the necessary routine and preventive maintenance works, urgent repair, and access provision based on the tasks of Part 4(a), (b) & (d) above.

(b) Recommend the requirements of a construction design review for the works in Part 7(a) above.

(c) Obtain or arrange to obtain all statutory approvals (e.g. from Local Authorities) and agreements from any parties, as appropriate, required for the execution of the necessary remedial works.

(d) Seek approval/agreement from the relevant authorities (e.g. Public Works Department, Police, and District Lands Offices) and any affected parties (e.g.

utility companies), if necessary, for the execution of the items of works on the slopes/retaining structures.

(e) Prepare the table tender document, call tender, and provide recommendations for the Employer to appoint the most suitable Contractor to undertake the works.

(f) Undertake supervision of the items of works and all contract administration. Check whether the works have been carried out in accordance with the works contract requirements and if so certify payment for works that are satisfactorily completed.

(g) Carry out any necessary construction design reviews and liaise with the Contractor and the Employer as necessary.

(h) Prepare and certify the as-built drawing and/or construction records, including any design reviews carried out, and update the Maintenance Manual to document the works done, based on site inspections and the as-built records of the works. Submit relevant documents to statutory authorities certifying the completion of works.

5. Programmed of Implementation

The due date for the commencement of the Assignment shall be _____.

The due date(s) for the completion of Parts 1 to 6 of Section 4 of the Assignment, including the submission of Record of Engineer Inspection for Maintenance and any relevant documents and reports, shall be _____.

6. Standards and Specifications

The Engineer shall adopt such technical and design standards and specifications as are applicable to and in current use by Cawangan Kejuruteraan Cerun JKR or, if non-existent, international Codes of Practice and Specifications.

7. Information Provided by the Employer

All available information held by the Employer and relevant to the Assignment will be provided to the Engineer.

Notes:

(1) Deleted if not applicable.

(2) The agreement should be priced on the basis of all the tasks included in Parts 1 to 6 of Section 4 only. The fee for the tasks in Part 7 of Section 4, if found necessary, should be negotiated separately.

(3) The programmed for the tasks in Part 7 of Section 4 should be agreed after completion of the tasks in Parts 1 to 6 of Section 4.

APPENDIX D – SCOPE OF SERVICES FOR ENGINEER INSPECTIONS FOR MAINTENANCE FOR GOVERNMENT SLOPES

1. General

The following section outlines the scope of works to be carried out in the Engineer Inspections for Maintenance and other provisions for procuring additional information for the effective management of slope maintenance programmed.

2. Services to be Provided by the Engineer undertaking Engineer Inspections for Maintenance for Government Slopes

Part 1 - Information Collection

(a) Information on a particular slope can be obtained from relevant agencies, such as JKR headquarters, local authorities and water related agencies.

Part 2 - Site Inspection

(a) Carry out an inspection of the slopes and retaining structures and the nearby areas, and prepare Records of Engineer Inspections for Maintenance based on the Indicative Record Sheets given in Appendix F of Cerun 1. In particular,

(i) evaluate the adequacy of access to the slopes and retaining structures for maintenance inspections taking into account the requirements of safety regulations and provide recommendations in accordance with Part 4(b) below,

(ii) identify visually any discrepancies between the records of previous Engineer Inspections for Maintenance, maintenance manuals, the as-constructed works, actual site conditions and the plans in the stability assessment reports, design reports, drawings or as-built records, if any,

(iii) identify all visible changes including landslides, unauthorised constructions, formation of unauthorised cultivation areas, appearance of tension cracks, or other signs of distress, that have taken place at or in the vicinity of a slope or retaining structure, in particular any changes since the last stability assessment and Engineer Inspection, which could have implications on its stability, and to judge whether these might be significant,

(iv) identify the presence of buried and exposed water-carrying services, (including any ducting systems housing the services) and unauthorised services, on or in the vicinity of the slopes and retaining structures (including relevant areas outside the lot boundary), both visually and with reference to the record plans for the services,

(v) check for signs of leakage of any exposed and buried water-carrying services (including any ducting systems housing the services) and identify the source of any leaking water-carrying services where possible and provide recommendations in accordance with Part 4(c) below, and

(vi) look for and consider the implications of problems that are not explicitly included in the list of maintenance for man-made items, and bring to the

attention of the relevant authority any immediate and obvious danger noted and provide recommendations in accordance with Part 4(d) below.

(b) Where directed by the relevant authority, make arrangements for gaining access to any part of a slope or retaining structure and the nearby areas to be inspected including liaison with all relevant parties and authorities, the application of any necessary permits, general vegetation clearance for access and the provision of the necessary equipment and consumable for inspecting the slope safely.

(c) Collect or update relevant data used to determine the priority ranking of follow-up actions for slopes and retaining structures, including stability assessments, preventive maintenance works or upgrading works.

(d) Collect data for registration for any unregistered slopes or retaining structures found within the project/allocation boundary, and for which the relevant authority has the obligation to maintain. In the event of an unregistered slope or retaining structure locating in the vicinity of the project/allocation boundary or the venue of inspection and whose maintenance responsibility is not clear, collect the basic information of the unregistered slope or retaining structure including its location, the height and gradient of the slope or retaining structure and record photographs.

Part 3 - Assessment

Based on the tasks of Parts 1 and 2 above, carry out the following tasks for each slope or retaining structure:

(a) Evaluate the relevance and completeness of all information collected with reference to the checklist agreed by the relevant authority (see Part 1). Determine whether stability assessments covering parts or the entire slope or retaining structure have previously been carried out. If so, review the previous stability assessment reports to check whether the engineering approach used, the assumptions and the conclusions made in these reports are reasonable in the light of current practice and safety standards.

(b) Re-assess the consequence-to-life category of the slope or retaining structure, as in Appendix 1A.

(c) Check that Routine Maintenance Inspections and the recommendations for routine maintenance works have been carried out and documented satisfactorily.

(d) Check that Regular Checks of Buried Water-carrying Services (including any ducting systems housing the services) and/or Regular Monitoring of Special Measures (if required) and the recommendations arising from the checks have been carried out and documented satisfactorily.

(e) Assess the adequacy of routine maintenance works and supplement the list of basic maintenance works items, as necessary.

(f) Re-assess the required frequency of Routine Maintenance Inspections, Engineer Inspections for Maintenance, and Regular Checks of Buried Water-carrying Services (including any ducting systems housing the services).

(g) Provide to Cawangan Kejuruteraan Cerun JKR any updated details including any changes in the slope or retaining structure boundary and data.

Part 4 - Recommendations

(a) Recommend any necessary preventive maintenance works.

(b) Based on the task of Part 2(a)(i), recommend any necessary access to be provided for maintenance inspections and works.

(c) Based on the task of Part 2(a)(v), recommend any necessary immediate detailed leakage check, regular checks, repair and re-routing of the services. Where leaking water-carrying services are found, advise the services' owner and appropriate authorities for actions. Update the maintenance manual to include a provision to initiate any additional Engineer Inspection for Maintenance necessary due to the leaking services.

(d) Based on the work of Part 2(a)(iii) & (vi), recommend any necessary emergency measures (e.g. cordoning off works), urgent repair or investigations.

(e) Advise whether a stability assessment of a slope or retaining structure is needed taking into consideration the results of the tasks in Parts 2 and 3 and the results of the previous stability assessments, if any.

(f) If a stability assessment of a slope or retaining structure is considered necessary in Part 4(e), advise the relevant authority to take necessary measures to reduce the potential consequence of failure instead of carrying out a stability assessment.

(g) Based on the data collected in Part 2(c), advise the relevant authority a ranking list for carrying out stability assessment, preventive maintenance works or upgrading works for the slopes and retaining structures, based on a suitable prioritising scheme approved by Cawangan Kejuruteraan Cerun JKR. The ranking list should take into account the consequence-to-life category of the slopes and retaining structures and any possible action under the JKR preventive measures programmed.

(h) Based on data collected in Part 2(d) above, register any unregistered slopes or retaining structures identified within the project/allocation boundary, which the Employer is responsible for their maintenance according to the guidelines and standards produced by Cawangan Kejuruteraan Cerun JKR. In case the unregistered slope or retaining structure lies in the vicinity of the project/allocation boundary or the venue of inspection or where its maintenance responsibility is not certain, provide the basic information to facilitate the registration by Cawangan Kejuruteraan Cerun JKR.

Part 5 - Reporting

(a) Prepare an Engineer Inspection Report covering the above tasks and enclosing the Records of Engineer Inspection for Maintenance for submission to the relevant authority.

(b) Explain the findings and recommendations of the Engineer Inspection to the relevant authority, in particular whether stability assessment or works are required to be carried out, with justifications and cost estimates including any site supervision costs, and answer any queries.

(c) Prepare the records of Engineer Inspection for Maintenance and Maintenance Manual in electronic format conforming to the database specification produced by Cawangan Kejuruteraan Cerun JKR.

Part 6 - Preparation or Updating of Maintenance Manuals

(a) Prepare or update the maintenance manual for each slope or retaining structure to include all relevant information extracted from the previous stability assessments, and the desk study, records and details of any previous landslides and subsequent repair works, and action status and priority of the slope or retaining structure in JKR preventive measures programmed and site inspection(s) under this Assignment, with traceability to all source of documents used.

(b) Prepare or update the maintenance manual for each slope or retaining structure to include a statement of landscape design, highlighting the rationale for the choice of the landscape items to the slope or retaining structure.

Part 7 - Design of Works (Optional Items)

(a) Compile a list of slopes/retaining structures together with the necessary routine and preventive maintenance works, urgent repair and access provision based on all the tasks of Parts 4(a), (b) and (d) above. Where directed by the relevant authority, prepare specifications and plans for the items of works on the slopes/retaining structures selected from the list by the relevant authority to a standard that can be used directly in the relevant authority's works contract.

(b) Recommend the requirements of construction design review for the works in Part 7(a) above.

APPENDIX E – EXAMPLE OF TERM OF REFERENCE FOR STABILITY ASSESSMENTS FOR PRIVATE SLOPES OR RETAINING STRUCTURES

EXAMPLE TERM OF REFERENCE FOR STABILITY ASSESSMENTS

1. Objectives of the Assignment

The objectives of the Assignment are:

(a) to determine whether the geotechnical standard of the slope/retaining structure* meets the requirements stipulated in the current standards used by Public Works Department or Geotechnical Manual for Slope (1984) produced by GEO Hong Kong, whichever is applicable, and

(b) to recommend /and arrange, supervise and certify satisfactory completion of* any necessary ground investigation and upgrading works.

2. Deliverables

The Engineer shall submit _____ copies of the Stability Assessment Report and _____ copies of the Maintenance Manual to the Employer.

3. Services to be Provided by the Engineer

This Assignment shall be carried out by a professionally-qualified geotechnical/civil engineer in Malaysia Where necessary geological input shall be obtained from a qualified geologist registered with Institute Geology Malaysia. The Engineer shall carry out the following tasks for slope/retaining structure* number _____, the location and extent of which are shown in the attached plan.

Part 1 - Basic Items

(a) Review the Engineer Inspection for Maintenance reports pertaining to the slope/retaining structure* and the nearby areas which could have implications on its stability.

(b) Where considered necessary, recommend, arrange and supervise ground investigation, monitoring and identification of buried services that could affect the stability of the slope/retaining structure*.

(c) Assess the geotechnical standard of the slope/retaining structure* with respect to the requirements stipulated in the current standard used by the Public Works Department or Geotechnical Manual for Slopes (1984).

(d) Provide recommendations on any necessary upgrading works.

(e) Prepare/update* the Maintenance Manual.

Part 2 - Design, Management and Supervision of Works (Optional Items)

(a) Prepare specifications and plans for the necessary upgrading works based on the tasks of Part 1 above.

(b) Recommend the requirements of a construction design review for the works in Part 2(a) above.

(c) Obtain or arrange to obtain all statutory approval (e.g. from Local Authorities) and agreement from any parties, as appropriate, required for the execution of the necessary remedial works.

(d) Seek approval or agreement from the relevant authorities (e.g. Public Works Department, Police, and District Lands Offices) and any affected parties (e.g. utility companies), if necessary, for the execution of the items of works on the slope/retaining structure*.

(e) Prepare the table tender document, invite tenders, and make recommendations for the Employer to appoint the most suitable Contractor to undertake the works.

(f) Undertake supervision of the items of works and all contract administration. Check whether the works have been carried out in accordance with the works contract requirements and if so certify payment for the works that are satisfactorily completed.

(g) Carry out any necessary construction design reviews and liaise with the Contractor and the Employer as necessary.

(h) Prepare and certify the as-built drawing and/or construction records, including any design reviews carried out, and update the Maintenance Manual to document the works done, based on a site inspection and the as-built records of the works. Submit relevant documents to statutory authorities certifying the completion of works.

4. Programmed of Implementation

The due date for the commencement of the Assignment shall be _____.

The due date(s) for the completion of Part 1 of the Assignment, including the submission of Stability Assessment Report and any relevant documents and reports, shall be _____, working to a programmed agreed with the Employer within _____ weeks of the commencement of the Assignment.

5. Standards and Specifications

The Engineer shall adopt such technical and design standards and specifications as are applicable to and in current use by Cawangan Kejuruteraan Cerun, JKR, or, if non-existent, international Codes of Practice and Specifications.

6. Information Provided by the Employer

All available information held by the Employer and relevant to the Assignment will be provided to the Engineer.

Notes:

(1) * denotes item to be deleted if not applicable.

(2) The agreement should be priced on the basis of all the tasks included in Part 1 of Section 3 only. The fee for the tasks in Part 2 of Section 3, if found necessary, should be negotiated separately.

(3) The programmed for the tasks in Part 2 of Section 3 should be agreed after completion of the tasks in Part 1.

APPENDIX F – INDICATIVE RECORD SHEETS FOR ENGINEER INSPECTIONS FOR MAINTENANCE

RECORD OF ROUTINE MAINTENANCE INSPECTION **SHEET 1 OF 10** Rekod Pemeriksaan Rutin Untuk Penyeggaraan Cerun	
SLOPE / STRUCTURE WALL REFERENCE NO. No. Rujukan Cerun / Struktur Penahan	
Date of Inspection: Tarikh pemeriksaan:	
Date of Last Engineer Inspection for Maintenance: Tarikh pemeriksaan terakhir oleh Jurutera:	
Due Date of Next Engineer Inspection for Maintenance: Tarikh kerja Penyenggaraan seterusnya oleh Jurutera:	
Weather Condition at Time of Inspection: Keadaan cuaca semasa pemeriksaan:	
Map Coordinates: Koordinates Peta:	**Date of Construction:** Tarikh Pembinaan:
Easting: Timur:	**Northing:** Utara:

REVIEW OF ROUTINE MAINTENANCE
(Ulasan Penyenggaraan Rutin)

- **Have routine maintenance works been satisfactory carried out?** Yes/Partially/No
  (Give details if answer is Partially)
  Adakah kerja-kerja penyenggaraan rutin teleh dijalankan dengan memuaskan? Ya/Sebahagian/Tidak
  (Jelaskan jika sebahagian)
  .....
  .....
- **Are the maintenance record sheets used adequate?** Yes/No
  Adakah borang rekod penyenggaraan mencukupi? Ya/Tidak
- **Have adequate maintenance records been kept?** Yes/No
  Adakah rekod penyenggaraan yang dikumpulkan mencukupi? Ya/Tidak
- **Is there adequate access to the slope or retaining structure for Maintenance Inspection?** Yes/No
  Adakah laluan ke cerun/tembok panahan sesuai untuk Pemeriksaan Penyenggaraan? Ya/Tidak
- **Has the full extent of the slope or retaining structure to be inspected and maintained been established?** Yes/No
  (i.e. check against lease document issued by the Lands Department?)
  Adakah luas kawasan cerun/struktur penahan telah diperiksa dan disenggara sepenuhnya? Ya/Tidak
  (iaitu, semak dokumen pajakan yangdikeluarkan oleh pihak Pejabat Tanah?)
- **Has the documentation for the inspection and maintenance of slopes and retaining structures been validated**? Yes/No
  Adakah keseluruhan cerun atau struktur penahan yang akan diperiksa dan disenggara telah dikenalpasti dari segi kesahihan dokumennya? Ya/Tidak

OTHER OBSERVATIONS
Pemerhatian-Pemerhatian Lain

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 2 OF 10** Rekod Pemeriksaan Jurutera Untuk Penyenggaraan		
SLOPE / RETAINING STRUCTURE REFERENCE NO. No. Rujukan Cerun / Struktur Penahan.		
CONDITION OF SOIL Keadaan Cerun Tanah		
Items to be checked Perkara yang perlu disemak	**Condition** Keadaan	**Works Needed** Kerja Diperlukan
Impermeable surface cover **Yes/No** (Penutupan permukaan tak telap air) Ya/Tidak	**Good/Fair/Poor** Baik/Sederhana/Tidak Baik	
Weepholes **Yes/No** Lubang Leleh Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
Vegetated surface **Yes/No** Pemukaan bertumbuhan Ya/Tidak	**Good/Fair/Poor** Bersih/Sederana/Tidak Baik	
Drainage channels **Yes/No** Saluran Perparitan Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
	No/Moderate/Severe Cracking Tidak/Sederhana/Retakan Teruk	
Sumps and silt traps **Yes/No** Takungan dan perangkap kelodak Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
	No/Moderate/Severe Cracking Tidak/Sederhana/Retakan Teruk	
Associated culverts & natural drainage lines **Yes/No** Pembetung dan jajaran parit semulajadi yang berkaitan Ya/Tidak	**Clear/Partly blocked/Blocked** (Bersih/Sebahagian tersumbat/Sumbat)	
Stabilisation Measures **Yes/No** Tindakan Kestabilan Ya/Tidak	**Good/Fair/Poor** (Baik/Sederhana/Tidak Baik)	
Others **(Specify)** Lain-lain (Jelaskan)		
Questions to be asked Soalan yang perlu dipertimbangkan	**Remarks** Catatan	**Works Needed** Kerja Diperlukan
Any recent slope failure? **Yes/No** Adakah sebarang kegagalan cerun terkini? Ya/Tidak	**Record any of these anomalies since the last inspection and note any recurrence of the same problem. If yes to any of these questions, give details of the observations and implications of the problems (continue on separate sheets if necessary.** Rekodkan sebarang perubahan sejak permeriksaan terakhir dan catatkan jikalau masalah yang sama berulang. Jukalau ya, sila nyatakan butiran kepada permerhatian dan akibatnya	
Any recent erosion? **Yes/No** Adakah sebarang hakisan terkini? Ya/Tidak		
Any recent movements? **Yes/No** Adakah sebarang pergerakan terkini? Ya/Tidak		
Any tension cracks at the crest? **Yes/No** Adakah sebarang retak tegangan dipuncak? Ya/Tidak		
Any recent seepage **Yes/No** Adakah sebarang resapan air tanah terkini? Ya/Tidak		
Any other signs of distress? **Yes/No** **(Please specify)** Adakah sebarang tanda kegagalan terkini Ya/Tidak (Sila nyatakan)		
COMMENTS (continue on separate sheets if needed) Ulasan (Sambung di kertas berasingan jika perlu)		

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 3 OF 10**
Rekod Pemeriksaan Jurutera Untuk Penyenggaraan

SLOPE / RETAINING STRUCTURE REFERENCE NO
No. Rujukan Cerun/Struktur Penahan.

CONDITION OF RETAINING STRUCTURE
Keadaan Struktur Penahan

Items to be checked (Perkara yang perlu disemak)		**Condition** (Keadaan)	**Works Needed** (Kerja Diperlukan)
Weephole Lubang Leleh	**Yes/No** Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
Mortar joints/pointing Sambungan/Pepenjuru mortar	**(Yes/No)** Ya/Tidak	**Good/Fair/Poor** Baik/Sederhana/Tidak Baik	
Drainage channels Saluran Parit	**Yes/No** Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Sumbat	
		No/Moderate/Severe Cracking Tidak/Sederhana/Retakan Teruk	
Outlets of drainpipes Alur keluar saliran paip	**Yes/No** Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
Concrete Facing) Permukaan konkrit	**Yes/No** Ya/Tidak	**Good/Fair/Poor** Baik/Sederhana/Tidak Baik	
Others Lain-lain	**Specify** Jelaskan		
Questions to be asked (Soalan yang perlu ditanya)		**Catatan** (Remarks)	**Works Needed** (Kerja Diperlukan)
Any recent wall settlement? (Adakah sebarang enapan terkini pada tembok?)	**Yes/No** Ya/Tidak	**Record any of these anomalies since the last inspection and note any recurrence of the same problem. If yes to any of these questions, give details of the observations and implications of the problems (continue on separate sheets if necessary)** Rekodkan sebarang perubahan sejak permeriksaan terakhir dan catatkan jikalau masalah yang sama berulang. Jikalau ya, sila nyatakan butiran kepada pemerhatian dan akibatnya (sambung di helain yang lain sekiranya perlu)	
Any recent wall cracking? (Adakah sebarang rekahan terkini pada tembok)	**Yes/No** Ya/Tidak		
Any recent wall tilting? (Adakah sebarang kecondongan terkini pada tembok?)	**Yes/No** Ya/Tidak		
Any recent wall bulging? (Adakah sebarang penggelembungan terkini pada tembok?)	**Yes/No** Ya/Tidak		
Any recent seepage? (Adakah sebarang resapan air tanah terkini?)	**Yes/No** Ya/Tidak		
Any other signs of distress? **(Please specify)** Adakah sebarang tanda-tanda kegagalan terkini? (Sila nyatakan)	**Yes/No** Ya/Tidak		

COMMENTS (continue on separate sheets if needed
Ulasan (sambung di kertas berasingan jika perlu)

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 4 OF 10** Rekod Pemeriksaan Jurutera Untuk Penyenggaraan		
SLOPE / RETAINING STRUCTURE REFERENCE NO No. Rujukan Cerun / Struktur Penahan.		
CONDITION OF ROCK SLOPE Keadaan Cerun Batu		
Items to be checked Perkaran yang perlu disemak	**Condition** Keadaan	**Works Needed** Kerja Diperlukan
Impermeable surface cover **Yes/No** Penutupan permukaan tak telap air Ya/Tidak	**Good/Fair/Poor** Baik/Sederhana/Tidak Baik	
Weephole **Yes/No** Lubang Leleh Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
Drainage channels **Yes/No** Saluran Parit Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
	No/Moderate/Severe Cracking Tidak/Sederhana/Retakan Teruk	
Sumps and silt traps **Yes/No** Lubang perangkap dan perangkap pasir Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
	No/Moderate/Severe Cracking Tidak/Sederhana/Retakan Teruk	
Associated culverts & natural drainage lines **Yes/No** Pembetung dan jajaran parit semulajadi yang Ya/Tidak	**Clear/Partly blocked/Blocked** Bersih/Sebahagian tersumbat/Tersumbat	
Stabilization measures & protection (Please specify) **Yes/No** Tindakan Kestabilan dan Penahan (Sila nyatakan) Ya/Tidak	**Good/Fair/Poor** Baik/Sederhana/Tidak Baik	
Others (Specify) Lain-lain (Jelaskan)		
Questions to be asked Soalan yang perlu dipertimbangkan	**Remarks** Catatan	**Works Needed** Kerja Diperlukan
Any recent rockfall? **Yes/No** Adakah sebarang runtuhan batu terkini? Ya/Tidak	**Record any of these anomalies since the last inspection and note any recurrence of the same problem. If yes to any of these questions, give details of the observations and implications of the problems (continue on separate sheets if necessary).** Rekodkan sebarang perubahan sejak permeriksaan terakhir dan catatkan jikalau masalah yang sama berulang. Jikalau ya, sila nyatakan butiran kepada pemerhatian dan akibatnya (gunakan helaian lain sekiranya perlu).	
Any loose blocks on slope?) **Yes/No** Adakah sebarang blok longgar pada cerun? Ya/Tidak		
Any loose wedges on slope? **Yes/No** Adakah sebarang baji longgar pada cerun? Ya/Tidak		
Any badly fractured zone? **Yes/No** Adakah sebarang zon retakan yang ketara? Ya/Tidak		
Any open joints at the crest? **Yes/No** Adakah sebarang sambungan terbuka di puncak? Ya/Tidak		
Any recent seepage? **Yes/No** (Adakah sebarang resapan air tanah terkini?) Ya/Tidak		
Any other signs of disability? **Yes/No** **(Please specify)** Adakah sebarang tanda tidak stabil? Ya/Tidak (Sila nyatakan)		
COMMENT (continue on separate sheets if needed) Komen (sambung di kertas berasingan jika perlu)		

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 5 OF 10**
Rekod Pemeriksaan Jurutera Untuk Penyenggaraan

SLOPE / RETAINING STRUCTURE REFERENCE NO
No. Rujukan Cerun / Struktur Penahan.

BURRIED WATER-CARRYING SERVICES (including ducting systems and conduits)
Perkhidmatan Saluran Pembawa-Air Dibawah Tanah (Termasuk system saluran dan konduit)

- **Will Service adversely affect the slope or retaining structure in event of leakage?** **Yes/No**
  Adakah paip perkhidmatan yang lemah akan mengakibatkan kerosakan kepada cerun atau Struktur Penahan jika berlaku kebocoran? (Ya/Tidak)
- **Has there been any change to service since last Engineer Inspection for Maintenance?** **Yes/No**
  Adakah penggantian dibuat pada peralatan sejak Pemeriksaan Penyenggaraan yang terakhir oleh Jurutera? (Ya/Tidak)
- **Are there signs of water leakage from services?** **Yes/No**
  Adakah tanda kebocoran air daripada paip perkhidmatan? (Ya/Tidak)
- **Do any services need immediate leakage testing?** **Yes/No**
  Adakah paip perkhidmatan memerlukan ujian pembocoran yang serta merta? (Ya/Tidak)
- **Is re-routing of services necessary and practicable?** **Yes/No**
  Adakah perlu dan praktikal jika paip perkhidmatan diubah ke laluan lain? (Ya/Tidak)
- **Do any services require regular checks? (If yes, recommend frequency)** **Yes/No**
  Adakah sebarang paip perkhidmatan memerlukan permeriksaan yang lebih kerap? Sekiranya ya, cadangkan kekerapan (Ya/Tidak)

If 'Yes' in any of the above items, give details of observations and/or recommendations
Jika ada di antara perkara-perkara di atas adalah 'Ya', berikan permerhatian yang terperinci dan cadangan-cadangan;

Others
Lain-lain

GENERAL COMMENTS
Komen-Komen Umum

- **Has Stability Assessment/upgrade works* been carried out?** **Yes/No**
  Adakah Penilaian Kestabilan/Kerja-kerja menaiktaraf* telah dijalankan? (Ya/Tidak)
- **Has the stability of the slope/retaining structure*previously been assessed to be adequate** **Yes/No**
  Adakah Penilaian Kestabilan bagi cerun/Struktur Penahan lepas telah memadai? (Ya/Tidak)
- **Are the engineering approach used, the assumptions and conclusions made in the previous Stability Assessment report reasonable in light of the current practice and safety standards? (If No, Give details)** **Yes/No**
  Adakah pendekatan kejuruteraan yang digunakan, anggapan dan kesimpulan yang telah dibuat di dalam laporan Penilaian Kestabilan munasabah dari segi praktis terkini dan piawaian keselamatan? (jika tidak, jelaskan) (Ya/Tidak)
- **Is there any change that has taken place, which could have reduced the stability of the slope/retaining structure since the last Stability Assessment/upgrading works*? (If yes, give details of observations)** **Yes/No**
  Adakah sebarang perubahan yang berlaku, akan melemahkan kestabilan cerun/struktur penahan semenjak Penilaian Kestabilan/Kerja-kerja menaiktaraf* yang lalu? (Jika ya, jelaskan pemerhatian) (Ya/Tidak)
- **Has the consequence-to-life category of the slope/retaining structure changed?** **Yes/No**
  (If yes, from _____to _____and update slope record for facilities type affected)
  Adakah kategori akibat-keatas-nyawa cerun/Struktur Penahan berubah? (Ya/Tidak)
  (Jika ada, dari _____ke_____ dan kemaskinikan rekod cerun bagi kemudahan yang terlibat)
- **Is the frequency of Routine Maintenance Inspection satisfactory? If no, recommend new frequency** **Yes/No**
  Adakah kekerapan bagi Pemeriksaan Penyenggaraan Rutin memuaskan? (Jika tidak, cadangkan kekrapan baru) (Ya/Tidak)
- **Is the frequency of Engineer Inspection for Maintenance satisfactory? (If no, recommend new frequency)** **Yes/No**
  Adakah frekuensi bagi Pemeriksaan Penyenggaraan oleh Jurutera memuaskan? (Jika tidak, cadangkan frekuensi baru) (Ya/Tidak)
- **Has RegularCcheck of Burried Water-carrying Services been carried out?** **Yes/No**
  Adakah pemeriksaan kerap bagi Perkhidmatan Saluran Air dan Pembentung di Bawah Tanah telah dijalankan? (Ya/Tidak)
- **Has Regular Monitoring of Special Measures (if required) been carried out?** **Yes/No**
  Adakah Pemantauan yang kerap bagi Tindakan Khusus (jika ada) telah dijalankan dengan memuaskan? (Ya/Tidak)
- **Have recommendations from past Engineer Inspection been carried out?** **Yes/No**
  Adakah cadangan-cadangan daripada Pemeriksaan Jurutera yang lepas telah dibuat? (Ya/Tidak)
- **Are surface drains adequate in size and proper in layout? (If no, consider recommending Preventive Maintenance Works)** **Yes/No**
  Adakah saiz permukaan parit memadai dan jajarannya sempurna? (Jika tidak, pertimbangkan cadangan Kerja-kerja Penyenggaraan Pencegahan) (Ya/Tidak)

Others
Lain-lain

*** delete where appropriate.**
* potong mana-mana yang tidak berkenaan.

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 6 OF 10**
Rekod Pemeriksaan Jurutera Untuk Penyenggaraan

SLOPE / RETAINING STRUCTURE REFERENCE NO
No. Rujukan Cerun / Struktur Penahan

RECOMMENDATION OF ROUTINE MAINTENANCE WORKS
(Show location and nature of proposed works on a plan)
Cadangan Kerja-Kerja Penyenggaraan Rutin
(Tunjukkan lokasi dan cadangan kerja-kerja di atas pelan)

RECOMMENDATION OF PREVENTIVE MAINTENANCE WORKS
(Show location and nature of proposed works on a plan)
Cadangan Kerja-Kerja Penyenggaraan Pencegahan
(Tunjuk lokasi dan cadangan kerja-kerja di atas pelan)

OVERALL STATE OF SLOPE MAINTENANCE:
(Penjelasan Keselurushan Penyenggaraan Cerun:)

- **Any major defects in surface protection?** **Yes/No**
  Adakah terdapat kerosakan yang serious pada permukaan perlindungan? (Ya/Tidak)
- **Any major defects in surface drainage system?** **Yes/No**
  Adakah terdapat kerosakan yang serius pada sistem perparitan permukaan? (Ya/Tidak)
- **Any major defects in subsurface drainage system?** **Yes/No**
  Adakah terdapat kerosakan yang serius pada system perparitan sub-permukaan? (Ya/Tidak)
- **Any major leakage of water-carrying services?** **Yes/No**
  Adakah terdapat kebocoran perkhidmatan saluran-air dan pembentung? (Ya/Tidak)
- **Any major defects in special measures?** **Yes/No**
  Adakah terdapat kerosakan yang serius dalam tindakan-tindakan khusus? (Ya/Tidak)

Others
(Lain-lain)

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 7 OF 10**
Rekod Pemeriksaan Jurutera Untuk Penyenggaraan

SLOPE / RETAINING STRUCTURE REFERENCE No
No. Rujukan Cerun / Struktur Penahan.

OTHER RECOMMENDATIONS
(e.g. where there is concern on the health of the trees and presence of decaying or dying trees, advice from specialist such as horticulturist may be recommended)

Lain-Lain Cadangan
(cth: mana-mana yang berkait dengan kesihatan pokok-pokok dan terdapat pokok-pokok yang telah reput, nasihat daripada pakar adalah diperlukan)

- **Freguency of Routine maintenance Inspections:**
  Kekerapan Pemeriksaan Penyenggaraan Rutin:
- **Frequency of Engineer Inspection for Maintenance:**
  Kekerapan Pemeriksaan Penyenggaraan oleh Jurutera:
- **Freguency of Regular Checks of Buried Water-Carrying Service:**
  Kekerapan Pemeriksaan Lazim pada Perkhidmatan Saluran-Air Bawah Tanah:

Name of Inspecting Engineer :
Nama Jurutera yang Memeriksa

---

of (organization)
daripada(organisasi)

Qualification of Inspecting Engineer (e.g. PE)
Kelayakan Jurutera Pemeriksa (contoh P.E.):

Signature
Tandatangan

Date
Tarikh

Received by (Name of Client)
Diterima oleh (Nama Pelanggan):

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of (organization)
daripada (organisasi)

Signature
Tandatangan

Date
Tarikh

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 8 OF 10**
Rekod Pemeriksaan Jurutera Untuk Penyenggaraan

SLOPE / RETAINING STRUCTURE REFERENCE NO
No. Rujukan Cerun / Struktur Penahan.

RECORDS OF INFORMATION SEARCH (A list of the documents identified and reviewed, with comments on the contents date and places each is obtained)
Rekod Maklumat (Satu senarai dokumen yang telah dikenalpasti dan diulas bersama dengan komen-komen berkenaan isi-isi kandungan, tarikh dan tempat ia diperolehi)

Note
Add additional record sheets for photographs as necessary
Nota:
Sila gunakan helain rekod tambahan untuk fotograf jika perlu

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 9 OF 10**
Rekod Pemeriksaan Jurutera Untuk Penyenggaraan

SLOPE / RETAINING STRUCTURE REFERENCE NO
No. Rujukan Cerun / Struktur Penahan

SITE PLAN (Reference numbers should be assigned to location of man-made items for which maintenance works are required. The corresponding reference numbers should be quoted in the photographic record.)
Pelan Tapak (Nombor rujukan pada lokasi struktur buatan manuasia yang memerlukan kerja penyenggaraan hendaklah diberikan. Nombor rujukan yang sama harus digunakan bagi rekod bergambar.)

Note:
Add additional record sheets for photographs as necessary
Nota:
Sila gunakan helaian tambahan untuk fotograf jika perlu

RECORD OF ENGINEER INSPECTION FOR MAINTENANCE **SHEET 10 OF 10** Rekod Pemeriksaan Jurutera Untuk Penyenggaraan
SLOPE / RETAINING STRUCTURE REFERENCE NO No. Rujukan Cerun / Struktur Penahan.
PHOTOGRAPHS RECORD (With descriptions, date and reference number as given on the site plan) Rekod Fotograf (disertakan dengan perihalan, tarikh dan no rujukan seperti yang ditunjukkan di atas pelan tapak)
Note: **Add additional record sheets for photographs as necessary** **(Record photographs should be taken from the same vantage points as the last inspection)** Nota: Sila gunakan helain tambahan untuk fotograf jika perlu (Rekod fotograf perlu diambil pada sudut yang sama seperti pemeriksaan yang sebelumnya)

APPENDIX G – INDICATIVE FORMAT FOR MAINTENANCE MANUAL FOR NATURAL TERRAIN HAZARD MITIGATION MEASURES

MAINTENANCE MANUAL FOR NATURAL TERRAIN **SHEET 1 OF 4**
Buku Panduan Penyenggaraan Bagi Lereng Semulajadi
HAZARD MITIGATION MEASURES
Tindakan-Tindakan Pengurangan Bahaya

MITIGATION MEASURES REFERENCE NO
No. Rujukan Tindakan Pengurangan

LOCATION OF MITIGATION MEASURES
Lokasi Tindakan Pengurangan

MAP COORDINATES Koordinat Peta				**Date of Construction** Tarikh Pembinaan:
Easting Timur		**Northing:** Utara		

Purpose of Mitigation Measures (e.g. hazards being mitigated against, hazard locations and design volumes, and facilities to be protected) Tujuan Tindakan Pengurangan(Contoh: bahaya yang dikurangkan, lokasi bahaya dan isipadu rekabentuk dan kemudahan yang ingin dilindungi)

TECHNICAL INFORMATION (continue on separate sheets if necessary)
Maklumat Teknikal (Sambung dengan helaian yang lain sekiranya perlu)

Stabilisation Measures (1) Tindakan-Tindakan Penstabilan (1)

☐ **Boulder Buttresses** Sagang Batu tongkol
Total No. of Buttresses Jumlah Sagang _____

☐ **Soil Nail** Paku Tanah
Total No. of Soil Nail Jumlah Paku Tanah _____
Maximum Length of Soil Nails (m) Panjang Maksimum Paku Tanah (m) _____

☐ **Harizontal Drains** Saliran mengufuk
Total No. of Horizontal Drains Jumlah Saliran Mengufuks _____
Maximum Length of Harizontal Drains (m) Panjang Maksimum Saliran Mengufuk (m) _____

Others:
Lain-lain _____

Protective Measures (1) Tindakan-Tindakan Perlindungan (1)

Types of Measures: Check Dam/Earth Bund/Boulder Fence/Others
Jenis Tindakan: Empangan Penyekat/Di atas tanah/Pagar Batu Tongkol
Typical Dimension : **(e.g. length maximum height)**
Dimensi-dimensi Tipikal**:** (contoh: panjang, ketinggian maksimum) _____
Others:
Lain-lain: _____

MAINTENANCE REQUIREMENTS Keperluan Penyenggaraan

Frequency of Routine Maintenance Inspection:
Kekerapan Pemeriksaan Penyenggaraan Rutin: _____

Man-made items for Maintenance:
Barangan buatan manusia yang perlu diselanggara: _____

Guidelines on seeking geotechnical Civil/Engineer's advice:
Garis Panduan untuk mendapat khidmat nasihat jurutera Geoteknik/Civil: _____

INFORMATION PROVIDER Pemberi Maklumat

Records prepared by: Rekod disediakan oleh: _____ **Firm:** Firma: _____

Signature: Tandatangan: _____ **Date:** Tarikh: _____

Note **(1) Use a separate Sheet 1 for each type of protective measure. Different types of stabilization measures (e.g. butteresses and soil nails) in the same location can be considered as a group for record purpose.** (Gunakan borang yang lain bagi setiap tindakan perlindungan. Jenis tindakan penstabilan yang berlainan (seperti; sagang dan paku tanah) dilokasi yang sama boleh dianggap sebagai satu kumpulan untuk tujuan rekod.)

MAINTENANCE MANUAL FOR NATURAL TERRAIN Buku Panduan Penyenggaraan Bagi Lereng Semulajadi **HAZARD MITIGATION MEASURES** Tindakan-Tindakan Mengurangkan Bahaya	**SHEET 2 OF 4**
MITIGATION MEASURES REFERENCE NO. No. Rujukan Tindakan Pengurangan	
LOCATION PLAN AND SITE PLAN (with scale and indication on access) Pelan Lokasi Dan Pelan Tapak (dengan skala dan menunjukkan laluan masuk)	

MAINTENANCE MANUAL FOR NATURAL TERRAIN **SHEET 3 OF 4**
Buku Panduan Penyenggaraan Bagi Lereng Semulajadi
HAZARD MITIGATION MEASURES
Tindakan Mengurangkan Bahaya

MITIGATION MEASURES REFERENCE NO.
No. Rujukan Tindakan Pengurangan

PLAN/SECTIONS OF THE MITIGATION MEASURES TO BE MAINTAINED
Pelan/Keratan-Keratan Rentas Bagi Tindakan-Tindakan Pengurangan Yang Perlu Diselenggarakan

Notes: All dimensions are in millimeters and all levels are in meters
Nota: Semua dimensi dalam millimeter dan semua area dalam meter

MAINTENANCE MANUAL FOR NATURAL TERRAIN **SHEET 4 OF 4**
Buku Panduan Penyenggaraan Bagi Lereng Semulajadi
HAZARD MITIGATION MEASURES
Tindakan Mengurangkan Bahaya

MITIGATION MEASURES REFERENCE NO.)
No. Rujukan Tindakan Pengurangan

RECORD PHOTOGRAPHS (with descriptions and date; and with the vantage points indicated on the plans)
Fotograf-fotograf Rekod (dengan perihalan dan tarikh; dan sudut-sudut fotograf diambil ditunjukkan di atas pelan)

Notes: Add additional record sheets for photographs as necessary
Nota: Tambah helaian rekod untuk fotograf sekiranya perlu

APPENDIX H – SAMPLE CHECK LIST FOR INFORMATION SEARCH WHEN CONDUCTING ENGINEER INSPECTIONS FOR MAINTENANCE

SAMPLE CHECKLIST FOR INFORMATION SEARCH

General

- Relevant information held by the Employer and the maintenance personnel

Technical Background

- Cawangan Kejuruteraan Cerun, JKR or Local Authorities
  - Slope Information System (e.g. slope records, landslide incidents)
  - Landslide Preventive Measures Information System
  - Reports of detailed study of slopes/retaining structures
  - Landslide incident reports
  - Project files
  - Slope files

Relevant Checking Files

- Local Authorities
  - Private development files

Buried and Exposed Services

- Public Works Department
- Water Supplies Department
- Drainage and Irrigation Department (JPS)
- Malaysian Highway Authority (LLM)
- Housing Department
- Sewerage Services Department (JPP)
- Relevant utilities departments

APPENDIX I – CONSEQUENCE-TO-LIFE CATEGORY

Typical Examples of Facilities Affected by Landslides in Each Consequence-to-Life Category

Facilities	Consequence-To-life Category
Heavily Used buildings E.g. residential building, commercial office, store and shop, hotel, factory, school, power station, ambulance depot, market, hospital, polyclinic, clinic, welfare centre	1
Other Infrastructures E.g. cottage, licensed and squatter area, bus shelter, railway platform and other sheltered public waiting area, dangerous good storage site (e.g. petrol stations), road with very heavy vehicular or pedestrian traffic density	
Lightly Used Buildings E.g. indoor car park, building within barracks, abattoir, incinerator, indoor games' sport hall, sewage treatment plant, refuse transfer station, church, temple, monastery, civic centre, manned substation.	
Other Infrastructures E.g. major infrastructure facility (e.g. railway, LRT, flyover, subway, tunnel portal, service reservoir), construction site (if future use not certain), road with heavy vehicular of pedestrian traffic density	2
Heavily used open space and public waiting area E.g. heavily used playground, open car park, heavily used sitting out area, horticulture garden, road with moderate vehicular or pedestrian traffic density	
Lightly used open-air recreation area E.g. e.g. district open space, lightly used playground , cemetery, columbarium, non-dangerous goods storage site, road with low vehicular or pedestrian traffic density	3
Remote area E.g. country park, undeveloped green belt, abandoned quarry, road with very low vehicular or pedestrian traffic density	

Note: The consequence-to-life category refers to situation where the facilities are located within the expected travel distance of landslide debris. Any indirect consequences should also be taken into consideration, e.g. debris falling into a watercourse can travel long distance and affect other facilities.

GLOSSARY OF TERMS

GLOSSARY OF TERMS

Catalogue of Slopes
The Catalogue of Slopes contains information on all sizeable man-made slopes and retaining structures on any Government Project within Malaysia. The Catalogue is maintained by Cawangan Kejuruteraan Cerun JKR.

Consequence-to-life Category
A system that is used by Cawangan Kejuruteraan Cerun JKR (adopted from Hong Kong) to classify a slope or retaining structure into one of several categories according to the severity of consequence in terms of loss of life should the slope or retaining structure fail. (Refer to Appendix I)

Disturbed Terrain Feature
Disturbed terrain features contain repairs to landslide scars or comprise a series of composite cut and fill slopes where the ground surface has been disturbed, the natural slope gradient is greater than 15° and although the individual slopes do not meet the height criteria for registration, the total height does meet the criteria for registration in the Catalogue of Slopes. They generally cover situations where extensive modifications have been made to the ground surface, such as repairs to landslide scars, cemeteries, cleared squatter land and agricultural terraces (existing or now abandoned).

Engineer Inspection for Maintenance
Maintenance inspection by a professionally qualified geotechnical/civil engineer to assess the state of maintenance and condition of a slope or retaining structure to ascertain the need for detailed investigation, Stability Assessment and improvement works.

Improvement Works
A collective term to mean preventive maintenance works and upgrading works.

Maintenance Manual
A document containing details of maintenance requirements of a slope or retaining structure.

Maintenance Works
Works carried out to maintain slopes or retaining structures in good condition, and to avoid deterioration.

Monitoring Schedule
A document providing detailed requirements of Regular Monitoring of Special Measures, including frequency of monitoring, requirement of personnel, 'alert levels' for monitoring results, contingency plans, etc.

Prescriptive Measures
Pre-determined, experience-based and suitably conservative modules of works prescribed to a slope or retaining structure to improve its stability or reduce the risk of failure, without detailed ground investigation and design analysis. These generally involve conventional and conservative details in design, and attention to specifications and control of materials, workmanship, protection and maintenance procedures.

Preventive Maintenance
Works. Works of preventive nature to reduce the rate of deterioration of a slope or retaining structure, comprising the provision of simple, standardised and suitably conservative modules of works.

Regular Monitoring of Special Measures
Monitoring of special measures (e.g. prestressed ground anchors, designed horizontal drains) which are critical to the continued stability of the slope or retaining structure.

Routine Maintenance Inspection
Maintenance inspection of slopes or retaining structures that is carried out by any responsible person, including property management staff or maintenance staff, to establish the need of basic maintenance works for man-made items.

Routine Maintenance Works
Basic maintenance works, such as clearance of accumulated debris from drainage channels, repair of cracked slope surface cover, etc, carried out routinely to slopes and retaining structures.

Stability Assessment
An investigation or a study that is carried out for the purpose of assessing the stability of a slope or retaining structure to determine whether it meets the current geotechnical standard.

Upgrading Works
Works carried out to upgrade sub-standard slopes or retaining structures to the requirements to the current geotechnical standards promulgated by Cawangan Kejuruteraan Cerun JKR, a good example is given in the Geotechnical Manual for Slopes (GCO, 1984).

Public Works Department Malaysia