# Minerals Planning Guidance 5: Stability in surface mineral workings and tips

## Contents

PPG 14 set out the broad planning and technical issues in respect of development on unstable land and PPG 14 Annex 1 developed these with particular reference to the problems caused by landslides and unstable slopes. This MPG aims to apply that guidance with particular reference to stability in quarries, surface mines and associated tips and related structures and should be read in conjunction with it. The problems are reviewed and the responsibilities of the different parties are briefly examined.

**This guidance advises that:**

- mineral planning authorities need to consider stability in relation to surface mineral workings and tips;

- local planning authorities need to consider stability in relation to development in, on or near abandoned surface mineral workings and tips; and that

- policies should outline the consideration which will be given to stability issues in considering mineral development and other development in, on or near to mineral workings and tips;

- consideration of apparently unrelated issues may require consideration of the potential effects on the stability of excavated or tipped slopes;

- where appropriate, planning applications and restoration/landscaping schemes should be accompanied by a design report prepared by a competent person which demonstrates that the perimeter slopes and any internal slopes remaining after restoration will remain stable.

Appendices outline good practice in the design, assessment and inspection of:

- excavated slopes; and

- tips and related structures

## Introduction

1. The Environment White Paper ("This Common Inheritance" Cm 1200, September 1990) identified the maintenance of a physically safe environment as one of the priorities the planning system should take into account to ensure that proper precautions are taken against the risks posed by physical hazards. PPG 14 clearly established instability as a material planning consideration in so far as it affects land use and development; PPG 14 Annex 1 advised on the particular considerations which may be needed with respect to landslides.

2. Instability at active mineral workings disrupts mineral extraction, it may affect land beyond the quarry boundary and it may threaten the safety of people in and around the quarry. It may also be a cause of delays and additional costs in quarry reclamation schemes. Once active quarrying has ceased, there may remain a risk to third parties as well as to any development within or near a quarry or on or adjacent to a tip or lagoon. Instability problems may interfere with the effective restoration of sites to beneficial after-use appropriate to and compatible with the surroundings. The beneficial and sustainable extraction of minerals, therefore, requires particular attention to stability matters.

## Purpose and Coverage of this Guidance

3. The purpose of this guidance is to advise local authorities, landowners, mineral operators and other developers on the exercise of planning control with respect to stability in surface mineral workings and tips and on good practice in the design, assessment and inspection of excavated slopes and tips. It is complementary to and should be read in conjunction with PPG 14 (*Development on unstable land*) and PPG 14 Annex 1 (*Landslides and planning*) and to the Quarries Regulations 1999 and associated Approved Code of Practice. It is intended to ensure that:

- the operation and restoration of surface mineral workings is not detrimentally affected by instability;
- instability does not impact on neighbouring land;
- on cessation of active working, surface mineral workings are left in a safe and stable condition;
- development in, on or near disused and abandoned workings takes due account of potential instability.

4. This guidance covers the stability of surface mineral workings subject to current planning applications, to review of conditions and to continuing conditions requiring agreement of schemes of restoration and after-care. It covers excavation faces and tips as defined in the Quarries Regulations 1999, including spoil heaps, tailings dams and lagoons, soil or overburden storage mounds used as amenity banks or stored in readiness for landscaping and restoration works, mineral stockpiles and quarry backfill. Instability due to underground mining (subsidence) is not covered but the principles apply equally to surface tips and related structures arising from such mining. They are also of wider relevance to other development involving excavated slopes and tipping and to the stability assessment of natural cliff faces with the potential to affect land use and development.

## Instability in Surface Mineral Workings and Tips

5. Surface mineral workings involve the excavation of faces and tipping of material to create slopes, which are stable enough in the short term to allow working/back-filling to take place within the time required to enable the mineral to be excavated by machinery and transported for processing and use. As such, they are not unstable. However, longer-term instability and uncontrolled instability in the short term may cause problems to the operation, restoration and after-use of mineral workings and it may affect land outside the quarry boundary.

6. The potential for stability issues to be of increasing importance arises from a number of developments in the minerals industry. Economies of scale and the growing importance of environmental constraints have led to a concentration of mineral working on existing sites. Workings may, as a result, extend closer to existing site boundaries and there is a trend towards deeper quarries to maximise the recovery of the reserve. The need to maximise production in quarries and to minimise the overall stripping ratio in surface mines requires operators to work to the steepest feasible overall slopes. The extension of workings both laterally and in depth results in greater quantities of mineral waste or overburden. Mineral processing may produce a discard which is inherently less stable, eg because it is finer-grained or contains more water. Site constraints may then result in land availability for disposal being reduced, leading to greater potential for instability. Back-filling of workings with material excavated or with mineral processing or imported waste (including landfill) may result in differential settlement or impedance of groundwater flows as well as possibly causing contamination. All these factors lead to the possibility of instability, which may affect neighbouring land and development. Pressure to develop near to or in quarries increases the extent of development at risk by encroachment onto areas that may be affected by instability and may in itself lead to instability of what would otherwise be stable slopes.

7. The causes and types of instability are varied but there are basically three situations, which are described in Appendix A:

- excavated slopes
- tips and related structures
- quarry back-fill

*Excavated slopes*

8. Between 1969 and 1989, approximately 2,200 reported accidents resulted in personal injury in British quarries, of which about 110 were the result of "falls of ground". Two thirds of these were from quarry faces, predominantly from rock quarries but also including a number from sand and gravel workings. Whilst some of these involved collapse of the excavated face with up to over 10,000 tonnes of material involved, two thirds of those in rock quarries resulted from isolated rockfalls weighing in some instances only a few kilograms and most falling from a height of 20m or less. Movement or fracture of excavated slopes in quarries with the potential to kill someone or adversely affect neighbouring property are classified as dangerous occurrences but I practice they are often not reported; it is reasonable, however, to assume a similar distribution by type of slope failure and rockfall. Over this 20-year period, several public roads and footpaths have been closed following collapses extending outside quarry limits; major services have required diversions; and on two occasions emergency measures were necessary to support railway tracks due to ground movements generated by quarrying; the breaching of the banks of the River Aire by an opencast coal working in 1989 also had a significant impact. A number of factories in abandoned quarries

have experienced problems with rockfall; in places, housing in or close to quarries has been threatened as a result of ground movements caused by retreating slopes.

*Tips and related structures*

9. Of the 110 "falls of ground" accidents, one third resulted from falls from mineral stockpiles, usually during reclaim of mineral for processing or sale, but none have been attributed to the collapse of a spoil heap or lagoon. Tip instability is, therefore, not a major source of accidents in British quarries; since the Aberfan disaster in 1966, the coal mining industry has had a similarly good record with only two accidents, both of which followed excavation of the toe of a previously stable closed tip. Nevertheless, there have been, on average, about 4 reportable dangerous occurrences per year involving insecure quarry tips and about 5 per year involving coal mine tips. Several of these could have resulted in personal injury, since they tend to involve large volumes of material (50 of 74 occurrences in quarries involved over 1,000 cubic metres and 2 over 100,000 cubic metres). 1 in 3 resulted in damage to property and 1 in 5 to disturbance to land or property beyond the curtilage of the mine or quarry. Collapsing tips have blocked roads, railways and rivers, they have damaged neighbouring buildings and vehicles and they have disrupted electricity and water supplies. Failures have also damaged mobile and fixed quarry plant, blocked and severely disrupted haul roads; in some cases, they have required the complete redesign of tipping operations. Failure of lagoons (18 of the 74 occurrences) was twice as likely to result in damage to property as that of spoil heaps, probably because lagoon contents tend to flow faster and for much greater distances, allowing less time for preventive or remedial measures. Concern has also been expressed about the potential failure of tips not associated with mining or quarrying, such as the sewage sludge lagoon, which breached and partially blocked the River Colne in West Yorkshire in 1992.

*Back-fill in surface mineral workings*

10. Settlement of back-fill in surface mineral workings continues indefinitely, albeit at a decreasing rate depending on the material deposited, the method of placement, total thickness, applied load and, most importantly, drainage conditions. Differential settlement on back-filled ground may result in the disruption of drainage measures, possibly with consequential effects on the type and rate of settlement and on the stability of associated slopes. The subsequent use of back-filled quarries for built development is, therefore, a complex issue. Layered compaction of back-filled areas will reduce later settlement but will not eliminate it entirely. Particular problems may arise with variations in water level and with variations in the thickness of back-fill, or at the transition from back-fill to virgin ground.

## Responsibilities for Stability of Surface Mineral Workings and Tips

11. The primary responsibility for the safety and stability of a surface mineral working is that of the operator, defined in the Quarries Regulations 1999 as "the person in overall control of the working of the quarry". Under these Regulations a quarry may be taken as including any excavation or system of excavations made for the purpose of, or in connection with, the getting of minerals not being a mine, borehole or well. It thus includes all surface mineral workings whether these are described as quarries or surface mines. Tips for the time being used in connection or conjunction with the operation of a quarry are deemed to form part of the quarry. A tip is defined in the Regulations as an accumulation or deposit if any substance at a quarry, including but not limited to overburden dumps, back-fill, spoil heaps, stockpiles and lagoons. Surface mineral workings are subject to the provisions of the Health and Safety at Work etc Act 1974 and the Quarries Regulations 1999. Enforcement is through the quarry inspectors of the Field Operations Division of the Health and Safety Executive (HSE). On the cessation of working and following restoration, responsibility reverts to the landowner and any subsequent developer/employer who operates part or all of the quarry as a place of work. Tips associated with underground mineral workings are subject to the provisions of the Mines and Quarries (Tips) Act 1969 and the Mines and Quarries (Tips) Regulations 1971. A tip is defined under this legislation as an accumulation or deposit of refuse from a mine; temporary storage mounds for topsoil, subsoil and mineral stockpiles are thus excluded from this definition. Enforcement of the tips legislation is through HM Inspectorate of Mines of the HSE. Part II of the Mines and Quarries (Tips) Act 1969 is concerned with the prevention of public danger from disused quarry and mine tips not associated with an active mineral working. Enforcement in respect of these Part II tips is by local authorities, rather than the HSE.

12. Under the Quarries Regulations 1999, the operator has a general duty to ensure the safety of excavations and tips. They are required to be designed, constructed, operated and maintained so as to ensure that instability or movement, which is likely to give risk to the health and safety of any person, is avoided. Requirements for inspection of working places and faces and for action in the event of perceived danger are specified in the Regulations. Reporting of accidents and dangerous occurrences is explained in the Approved Code of Practice *Health and safety at quarries.* All proposed and existing excavations or tips need to be appraised at appropriate intervals to determine whether they constitute a significant hazard. Where a significant hazard exists, the Regulations require that a geotechnical assessment be carried out, at least every two years, to identify and assess all the factors liable to affect the stability and safety of a proposed or existing excavation or tip. The Regulations also require that the operator shall ensure that in the event of abandonment of or ceasing of operations at a quarry, it is left in a safe condition. For tips associated with underground mines, similar duties are imposed on mine owners under the Mines and Quarries (Tips) Act 1969. The Mines and Quarries (Tips) Regulations 1971 specify the requirements for design of tips, supervision of tipping operations, inspection of tips and the reporting of defects and dangerous occurrences.

13. Surface mineral working and tipping operations constitute development and therefore require permission under the Town and Country Planning Acts. As indicated in PPG 14, stability is a material planning consideration in so far as it affects land use but the planning system should not seek to duplicate controls that are the statutory responsibility of other bodies. The risks to health and safety of people are thus properly considered under health and safety legislation. However, where any instability may threaten land outside of the boundaries of the mineral working or tip, it may not necessarily threaten the health and safety of people though it could affect neighbouring land use. The MPA then has a duty to consider the potential effects on land use in the public interest and where necessary to consult adjoining landowners and other third-party interests.

14. The principal reasons for ensuring the stability of excavated slopes and of tips and related structures and the relevant responsibilities and interests of different parties can be summarised as being:

- To minimise the risk of accidents to the workforce and others who may be affected by uncontrolled falls of ground or other ground movements; this is the responsibility of the operator and of major concern to HSE;
- to minimise financial losses caused by slope failures and related ground movements; this is a principal concern of the operator;
- to minimise the loss through ground movements of screens or baffles with consequent adverse environmental effects, which such features were erected to counter; this is of concern to the mineral planning authority as well as the industry;
- to ensure the safety of any existing or concurrently permitted use of land above or below an excavated slope or tip during and after the conclusion of active quarrying or tipping; this is of interest and concern to all parties but especially to neighbouring land owners and owners of third-party services adjacent to the quarry;
- to permit the optimum recovery of a mineral within the context of the geological, geotechnical, environmental, planning and economic constraints that apply; this is the prime objective of the operator and is also of concern to the mineral planning authority.

## Planning Control

### Development plans

15. PPG 14 (paragraphs 25-30) outlines the approach that local planning authorities should follow in dealing with land instability issues in general. PPG 14 Annex 1 (paragraphs 21-26; appendix 1A) outlines the specific requirements in respect of landsliding including the assessment of landslide hazard and the possible need for a stability report. MPG 12 (paragraphs 61-73 and Appendices D and E) outlines the requirements for consideration of mine openings in development plans and emphasises the importance of advice and information on mined ground.

16. When preparing minerals local plans, MPAs will need to consider the extent to which specific policies should be included to cover tip- and quarry-slope stability or whether this issue should be covered by supplementary guidance. This consideration should take account of the factors which might trigger particular concerns about stability, such as proximity to built development or infrastructure; knowledge of previous instability problems; the criteria to be used to define stand-off distances or clearances between quarry slopes or tips and the site boundary or third-party structures; and the requirement for final slopes and restoration to be compatible with stable slopes. It would be useful to indicate the consultations that will be undertaken in respect of third-party structures and the information required as a basis for consultation and decision.

17. In addition, policies in district-wide local plans should seek to ensure that land use is appropriate when considering development above or below abandoned quarry slopes and on or near to disused tips or back-filled workings. In particular, attention should be given to the possible need for stand-offs to protect neighbouring land or structures and/or for slope stabilisation measures. Where development is being proposed on back-filled workings, consideration will be needed of both the planning and Building Regulations requirements in respect of stability, as well as of the possibility of contamination arising imported waste. Further advice on developing contaminated land is given in PPG 23 *Planning and pollution control.* It may be appropriate in some cases to identify former quarried areas in the local plan or in supplementary planning guidance as possible physical constraints, which may not prevent development but which need to be addressed when considering development. Any development planning briefs prepared for such sites should ensure that the issues of slope stability, differential settlement of quarry backfill and the likelihood of contamination and migration of contamination from the site are properly addressed.

### Development control

*Applications for mineral workings and review of old mineral permissions*

18. General guidance for the handling of individual applications on actual or potentially unstable land is contained in PPG 14 (paragraphs 31-45) and specifically in respect to landslides in PPG 14 Annex 1 (paragraphs 27-31; appendix 1B) and to mine entries and underground mine openings in MPG 12 (paragraphs 34-60). The importance of early discussions between the applicant and the MPA and of appropriate consultation cannot be over-emphasised. It is particularly important to ensure that the stability of quarry and tip slopes is considered in relation to a number of issues, which may not appear to be directly related (paragraphs 19, 20 below). It is particularly important that there should be good

consultation with the HSE to ensure that there is no conflict between planning conditions and the statutory requirements of the Quarry Regulations.

19. In order to reduce the potential for a mineral operation to have adverse environmental effects, it is sometimes necessary to specify the direction of working, eg to reduce the period and extent of visual impact or to reduce the effects of noise and/or dust on nearby communities. In doing so consideration should be given to the possible adverse effects on the stability of excavated slopes of working in a manner which might not be the optimum from the geotechnical standpoint.

20. Landscaping and restoration proposals should be consistent with the production and maintenance of safe and stable slopes. The stability of amenity bunds has been a problem in some quarries and they need to be carefully designed and constructed. Particular care is needed when attempting to simulate or replicate natural slope features in the locality, which have resulted from and continue to be affected by natural processes of instability. At many sites, the progressive nature of extraction and restoration provides an inherent link between the working and restoration faces. It may, therefore, be necessary for the MPA to specify the slopes of those faces and benches to ensure that acceptable restoration slopes can be achieved with the materials available and that they are suitable for appropriate planting with the necessary access for maintenance. In other cases, however, most internal slopes and benches will not directly link to the restoration proposals and it would be inappropriate for the MPA to specify those slopes in planning conditions.

21. To make reasonable assessments of mineral reserves and resources, assumptions have to be made regarding stable ultimate slope angles. The deeper a deposit and the thicker the overburden, the more critical this assumption becomes. Similarly, the calculation of stand-off distances for the approach of quarrying to neighbouring land or structures or for the approach of development to active and abandoned quarries and tips requires an assessment of the stability of both excavated and tipped slopes. Whilst there are some statutory or empirical stand-off distances used, eg under the Pipelines Act 1962 or by BG Transco in relation to their legal easements, the width of a safety corridor around a service or structure will depend on the depths of working, the nature and style of tipping and the prevailing ground conditions. Since each site has unique ground conditions, it is not feasible to prescribe a comprehensive system of stand-offs or clearances; the closeness of approach to neighbouring land or structures and the need for consultation with third-party interests should be determined, therefore, on a site-specific basis. In practice, such stand-offs are often determined for other environmental reasons (eg to minimise the effects of noise, dust or visual impact) in the case of new quarries or the approach of development to active workings. The requirements for stable slopes are generally encompassed within the stand-offs specified for those reasons.

22. While the internal working slopes of quarries and tips are principally matters of concern to the operator and the HSE rather than for the MPA, the final perimeter slopes and restoration proposals have land-use implications, which need to be considered by the MPA. In order to do so it will need to be provided by the operator with an assessment and design of perimeter slopes and any internal slopes remaining after restoration to enable any potential for adverse effects due to instability to be minimised. The options available for excavated slopes are:

- to design the final slopes before submitting a planning application;

- to complete design after the granting of planning permission as part of the preparation of a restoration/landscaping scheme for the ultimate slopes which is to be agreed before excavation commences; or
- to complete design after excavation has commenced but before the final working faces have been formed at the site perimeter.

23. If the design is completed before a planning application is submitted, the ultimate limits of excavation or tipping/back-fill and final long-term slope details are established with certainty at the outset. This allows full consideration of the potential impacts by all consultees as well as by the MPA. However, it does have earlier cost implications for operators in terms of investigation and design expenditure being incurred before permission is assured. Submission of a landscaping/restoration scheme after permission is granted but before excavation starts would avoid any possibility of abortive expenditure but would give less certainty at the time of application. In addition, an initial investigation can only give so much information and the details of geological structures at any site will become clearer as excavation progresses. Under the Quarries Regulations 1999, operators are required to review their appraisals/assessments during the life of a working and modify slope design in the light of new information. Slope design would thus benefit from observations on the stability of actual slopes. However, there are drawbacks for the operator in that initial layout and development of internal slopes may not benefit from previous design work and for consultees in that they will not have a proper basis for assessing the potential effects of the excavation on their interests.

24. The consideration of slope stability that is needed at the time of application will vary between mineral workings depending on a number of factors, eg depth of working; the nature of materials excavated; the life of the working; and the nature of restoration proposals and, thus the length of time slopes are expected to be in place. Early consideration of quarry and tip slope stability in pre-application discussions will enable the requirements and their timing to be determined in the light of individual circumstances. Consideration could be on a two-stage basis, similar to that detailed in the Quarries Regulations 1999. Applications for new workings should be accompanied by an appraisal of slope stability issues based on existing information, which aims to:

- identify any potential hazard to people and property and assess its significance;
- establish the basis for reserve calculation;
- identify any features which could adversely affect the stability of the working to enable basic quarry design to be undertaken.

25. For some mineral workings, such as relatively short-term operations, which are progressively restored by back-filling, this may be sufficient, since excavated and tipped slopes, which will be exposed for a short period only, can be designed to an acceptably low level of risk. Deeper longer-term workings, in which significant slopes will remain at the end of working may need a more detailed assessment of stability issues as part of the landscaping and restoration plan; this will generally follow the grant of planning permission and take advantage of knowledge gained during operations. In carrying out a review of old mineral permissions, a similar approach is recommended. In this case, however, there will generally be greater certainty as to the geological conditions arising from existing information than with a new working. Where built development is the proposed after-use for back-filled workings, MPAs should impose conditions to secure appropriate deposition

and compaction to allow that development to proceed without the need for further ground treatment.

26. Appraisals and assessments of excavated and tip slope stability should be carried out for the operator by a competent person, as defined in the Quarries Regulations 1999. The MPA is entitled to rely on such appraisals and assessments in considering the impact of stability on land use. The MPA should ensure that any changes to the applicantsí proposed method of working, which may be desirable for other reasons, are appraised and assessed by that competent person. Guidelines to good practice in the design, assessment and inspection of excavated slopes and tips are given in Appendices B and C. These are not intended to be prescriptive but they give an indication of the essential features and factors involved in the consideration of slope stability in surface mineral workings and tips. As such they will provide a basis for discussion with the applicant and for any necessary consultations, eg with neighbouring landowners and the HSE.

*Applications for development on or near abandoned tips and quarries*

27. Where development is proposed in or near the slopes of abandoned quarries or tips, local planning authorities should seek information from applicants in respect of stability reports prepared by a competent person. The layout of such development will need to be considered in relation to the stability of nearby slopes and the necessity for and feasibility of any necessary stabilisation measures. Development on back-filled workings and tips will also need to consider the potential effects of differential consolidation of the fill/tip material as well as any potential effects on slope stability. The detailed resolution in terms of specific foundation measures or ground treatment is, however, a matter for the building regulations. Further guidance is given in PPG 14 *Development on unstable land* and in PPG 14 Annex 1 *Landslides and planning*; advice on the consideration of potential contamination of such sites is given in PPG 23 *Planning and pollution control.*

## Conclusions

28. The Secretary of State looks to all local planning authorities and to mineral operators and other developers to implement the advice in this guidance note. This will help to ensure that proper consideration is given to the risk to public safety and the environment due to ground movements during and after surface minerals extraction.

## Appendix A. Instability in Surface Mineral Workings and Tips

A1. Surface mineral workings are developed in a variety of geological and geotechnical settings. These range from shallow workings in unconsolidated superficial deposits (sand, sand and gravel) to deep workings in both hard rocks (igneous and metamorphic rocks, sandstones, limestones) and in weaker layered minerals (coal, clays and shales); deeper workings are often overlain by shallow superficial deposits. There has been a tendency over the years towards deeper working arising from technological change, rationalisation of the industry and increasing environmental constraints. While slope failures in quarries are responsible for only a small number of notifiable accidents, deeper workings increase the potential for large rock slope movements.

A2. The causes and types of instability in surface mineral workings and tips are varied but there are essentially three situations, excavated slopes, tips and back-fill in surface mineral workings. The factors influencing instability and the types of failure that occur are described below. Guidelines on good practice in the design assessment and inspection of excavated quarry faces and tips are contained in Appendices B and C.

*Excavated slopes*

A3. Figure A1 schematically presents a number of situations, which illustrate the factors which may influence the stability of quarry faces or which may indicate potential instability. Many of these situations will not arise in the modern well managed quarry operation and, indeed, some of them would be contrary to the requirements of present health and safety legislation. Such situations could have arisen in the past, however, and there may be abandoned quarries where they still exist. Appendix B outlines the need for inspections of both active and disused quarry faces to identify any occurrence of these situations and for the design and assessment of quarry faces to take account of these factors.

A4. The main factors affecting the stability of quarry slopes can be summarised as:

- the location and properties of structural discontinuities (eg bedding planes, joints, faults etc), their orientation with respect to the slope and to other discontinuities within the slope, resistance to movement along them, their persistence and spacing and the ease with which water can penetrate, accumulate or flow along them;
- the properties of intact rock and soil materials, including the physical properties of different minerals and their bonding one to another, variations in properties in different directions, moisture content, weathering characteristics and intact material strength;
- groundwater conditions, particularly the build-up of water pressures, which reduces the force resisting sliding between blocks in the rock mass and enhances the disturbing forces separating blocks; and
- operational or external factors, such as slope geometry, loading of slopes, vibrations and other engineering activities (eg old underground workings, drainage works, boreholes, back-filled areas).

A5. The main types of slope failure affecting excavated quarry slopes are:

- translational failures, with sliding at the forward edge on a single surface, or wedge failures, with sliding along two or more intersecting discontinuities; translational failures may occur on any rock slope with adversely oriented planar discontinuities which dip into the excavation, critical factors being unfavourable face orientation, undercutting of critical discontinuities, high water pressures and daylighting of (ie intersection of the quarry face by) critical discontinuities;

- rotational and curvilinear failures, where rock-mass behaviour is not dominated by major structural features but by the intact shear strength of the rock mass due to the relationship between block size and slope dimensions, in heavily fractured or disturbed ground or in low strength materials; they may occur in high faces in weak rocks or in thick superficial cover deposits (overburden), critical factors being loading of the crest of the slope, the excavation process itself and high water pressures;

- toppling failures involving non-sliding elements rotating about some fixed axes, where the centre of gravity of blocks lie in front of the face, the base is too shallow for sliding to occur and steeply inclined discontinuities are sufficiently open to allow movement; they may occur in steeply excavated rock faces with highly inclined discontinuities which act as release planes, critical factors being over-steep faces, over-blasting, high water pressures in rear discontinuities and closely spaced discontinuities dipping steeply into the face;

- rockfall, involving often isolated blocks detached from the face by sliding or toppling, by undercutting of larger blocks, loosened by blasting or forced out after freeze-thaw weathering or by high water pressures following heavy rainfall; rockfall commonly precedes a large-scale collapse and it may also follow slope failure; long-continued rockfall, especially in soft rocks, can give rise to substantial regression of the slope crest without any large-scale collapse; it may occur in most steeply excavated rock slopes with individual blocks or small volumes of material based on unfavourably inclined surfaces, critical factors being over-steep faces leading to undercutting of individual blocks, degradation of ground due to weathering, high water pressures, freeze-thaw weathering cycle and poorly designed blasting;

- void collapse affecting the ground surface alone or triggering other forms of slope failure; it may occur in rock slopes constructed in previously mined ground or in ground with natural voids, critical factors being increased permeability promoting weathering and decreasing rock strength and initial deformation leading to other modes of failure

*Tips*

A6. Figure A2 schematically presents a number of situations illustrating the factors influencing tip instability and which may indicate potential instability. As with the face illustration in Figure A1, most of these do not arise in well managed quarry operation but inspections, tip design and assessment should take account of these factors as described in the good practice guidance in Appendix C.

A7. The main factors influencing the stability of tip slopes are:

- properties of material within and beneath tips, including particle size and voids, moisture content, permeability, shear strength and pore water pressure;

- method of construction and structure of tips, eg whether end-dumped, layer-placed or heaped tips, or single- or multi-stage construction lagoons;

- surface and groundwater conditions, since water in a tip can modify the strength of materials, increase weight and provide additional disturbing forces, reduce effective shear strength by generating hydraulic uplift and cause surface erosion;

- foundation and site conditions, such as the relationships with existing ground slopes and those at the junction between bedrock and superficial deposits (rockhead), presence of weak materials, spring lines and subjacent features such as services, mine workings or natural cavities;

- operational or external factors such as the effects of vibrations from plant operations or blasting, damage to drainage measures and, particularly, the removal of material from the toe of a tip through erosion by livestock or burrowing animals or, more commonly, by direct excavation for operational reasons.

A8. The main types of slope failure affecting tip slopes are:

- rotational and curvilinear failures which may involve the tip and its foundations, critical factors being over-steep faces in weak materials, weak planar surface at tip/foundation interface, weak foundation materials and high pore pressures due to water infiltration into tip, or rapid rise in lagoon level;
- translational surface sliding in granular materials tipped at or above their angle of repose, critical factors being loss of cohesion as the surface dries, reduction of strength due to water or weathering and removal of toe by erosion or for operational reasons;
- biplanar failures involving the formation of an upper active wedge which displaces a lower passive wedge ahead of it, critical factors being weak material at formation level, insufficient loading at toe of slope and high water levels within spoil;

**Figure A1. Schematic drawing showing factors influencing the stability of quarry faces and indicating potential instability.**

**Figure A2. Schematic drawing showing the factors influencing tip stability and indicating potential instability.**

These figures are made available in *Adobe Acrobat* format for downloading.
The *Adobe Acrobat Reader* can be freely downloaded.

Figures A1 and A2 (*Adobe Acrobat 302kb*)

- liquefaction and flow slides involving fine-grained, saturated, granular material which rapidly loses much of its shear strength due to sudden disturbance such as rotational failure, subsidence or vibrations; this is a particularly common failure mode within lagoon materials following the breaching of a retaining bank; flow slides can rapidly travel significant distances (10-20 times the height of the tip) and may cause substantial damage, critical factors being poor compaction and/or saturation of tips and lagoons including substantial volumes of sand- or silt-sized material;
- piping failures, cavitation collapse and mud runs where water washes out fine material as it seeps through a structure, where voids have been left or have been created in a tip (eg by piping, collapsed culverts, burrowing animals or as a result of tip fires) or where water flows down or out of a tip carrying loose material and eroding gullies; critical factors are the rate of flow of water through a tip structure, poor compaction or accessibility to burrowing animals and poor drainage, exposure of weak materials within the tip surface and over-dumping on peat; and
- settlement and heave involving variations in level of the tip or the toe of a slope are not important modes of failure in themselves but, since differential movements are common, they can have important consequences for surface and subsurface drainage and hence on other types of failure; they may also be an indication of some other form of failure.

*Back-fill in surface mineral workings*

A9. While it is being placed, or if a final void is left unfilled, overburden or waste material which is being used to backfill quarries and surface mines can be subject to the same types of failure as tips and related structures. Critical factors include:

- adverse gradients on the quarry floor, ie the quarry floor being inclined away from the toe of the backfill;
- high water levels in the backfill; and

- the presence of weak materials on the quarry floor.

A.10. Once it is in place, however, the principal problems are likely to arise through differential settlement of the backfill material, due to:

- variability in fill;
- variation in depth of fill;
- non-uniform load distribution; or
- non-uniform inundation.

Differential settlement does not occur just across the edge of the excavation but it can also result from filling of a sloping quarry floor or over a buried highwall.

A11. The settlement of fill materials results from the mechanisms of compaction and consolidation. Primary settlement occurs as a result of imposed loads. Creep settlement is thought to be due to a gradual reduction in void space in fill materials under self-weight or imposed loading. Both types of settlement are time-dependent, reducing with time. Collapse settlement is due to reduction in the strength of fill materials when they become saturated. It can occur suddenly at any time depending on the occurrence of contributing factors. It commonly occurs where water levels rise within the backfill but it may also result from subsidence or surcharge loading. It may be particularly severe when the backfill has been placed with no compaction. The filling of quarries with imported waste material by landfill may require particular consideration of the potential effects of differential settlement as the material deposited degrades, as well as the potential for leachate and/or landfill gas generation.

A12.The guidelines in Appendix C are intended to refer to back-fill in surface minerals workings, which are defined as tips under the Quarries Regulations 1999.

## Appendix B. Guidelines on the Design, Assessment and Inspection of Excavated Quarry Slopes

B1. The proper design of excavated quarry slopes is the responsibility of the quarry operator and must comply with statutory requirements under the Health and Safety at Work etc Act 1974 and the Quarries Regulations 1999. While the internal working faces will generally not have significant land-use implications and are essentially matters for the operator and HSE, the stability of final perimeter slopes can have land-use implications, particularly where important facilities and services are located near to the final slopes of the excavation. Such facilities and services include third-party buildings and neighbouring land, railways, roads and footpaths, pipelines, power lines, canals, rivers and reservoirs, areas of established amenity, archaeological or scientific interest and areas of public access. In such cases it may be necessary for the minerals planning authority to request from the applicant an appraisal or more detailed assessment, which details the consideration that has been given to the stability of excavated slopes. Where instability occurs or is expected, an assessment will be needed of the actual risks and of potential remedial or preventive measures. Regular inspection of working places is required by statute. A prudent developer should also carry out inspections and assessments of abandoned quarry slopes when development is proposed above or below them.

B2. These guidelines were prepared as part of Department of the Environment research on the stability and hydrogeology of excavated slopes in quarries (Geoffrey Walton Practice, 1988). They are intended to apply to quarries and opencast workings in bedrock minerals and are also relevant to excavated slopes at mineral workings in superficial or re-deposited materials. They outline design procedures identifying the steps that should be followed when designing, assessing and inspecting quarry slopes. As such, they are not intended to be prescriptive but they do illustrate good practice in considering excavated slopes. They are not alternative measures to those required by statute, as set out in the Quarries Regulations 1999 and the Approved Code of Practice (*Health and safety at quarries.*) but they give further detail on what constitutes good practice. They should be regarded as illustrating the standards to be employed by prudent quarry management to fulfil their statutory duties and to provide the information required by a minerals planning authority to enable it to determine a planning application or to approve a restoration/landscaping scheme for the final quarry faces.

### Design of Excavated Quarry Slopes

B3. This section refers to excavated slopes at new quarries and extensions to existing quarries, either laterally or in depth. Careful design procedures are always required but particularly when any slope is planned to approach a third-party structure. It is not possible to establish critical distances of approach to third-party structures, which are generally applicable, or to specify standard slope angles. Designing a slope to ensure no adverse impact of instability on adjacent land requires consideration of:

- rock and soil materials;
- geological structure;
- groundwater conditions behind the excavated slope;
- depth of excavation;
- benching system employed; and

- periods for which the face will be exposed.

B4. Ideally, excavated slopes should be designed having regard to all the geotechnical constraints listed above; investigation and design should be carried out by a competent person. In some cases, the competent person may determine on the basis of an initial appraisal that the geological structure is such that the likelihood of failure is negligible and that a fully detailed assessment is not necessary. In other cases, features such as clay bands within strong rocks or high water pressures behind or beneath the quarry slopes may influence ground stability at substantial distances beyond the limits of excavation; in such cases, the existence of a significant hazard to land and property will necessitate a full assessment of slope stability issues.

**Information to be collected**

B5. The design of excavated slopes and their potential effects on third-party property requires the collection of data on the site of the excavation and any contiguous land that might be affected by it. This data should be collected by means of survey, tests, boreholes or groundwater assessments on a range of relevant items as listed below. Use should always be made of information from previous investigations. It may not be necessary to collect and report all the information listed provided that a reason is given for any omissions. The decision on what is required to check the stability of proposed slopes and to design stable slopes is a matter for the competent person.

*A. Existing features*

i. location of all services and features which may need to be protected;

ii. location of abandoned services that might jeopardise slope stability;

iii. location of active and abandoned mine and quarry workings, including back-filled workings;

iv. location of all natural drainage features including springs, seepages and watercourses;

v. configuration of existing natural and excavated slopes in analogous settings in the neighbourhood, including any existing instability.

*B. Geology: Superficial materials*

i. thickness, nature and properties and base levels of superficial materials and their variability;

ii. groundwater levels within superficial deposits;

iii. location and details of any boreholes, trial pits or exposures used to investigate superficial materials;

iv. details of pertinent laboratory tests;

*C. Geology: Bedrock materials*

i. thickness, nature and properties of different rock types and their relative positions and the depths and nature of weathering;

ii. orientation and character of pertinent structural features (eg bedding, cleavage, faults, joints and other discontinuities);

iii. presence of significant aquifers and groundwater levels and pressures therein;

iv. location and details or any boreholes or exposures used to investigate bedrock and groundwater characteristics;

v. details of any pertinent laboratory tests.

*D. Proposed works*

i. proposed slope configurations, including positions and elevations of toe and crest of final slope and positions, elevations and widths of benches within the slope;

ii. position of any proposed surface or sub-surface drainage measures;

iii. location of any proposed surcharge structures such as amenity/baffle banks or spoil dumps which may affect stability;

iv. siting of any lagoons or settlement ponds.

**Plans and cross-sections**

B6. A design report for excavated slopes should be fully illustrated with plans and cross-sections, which summarise the information that has been collected and used in the slope design. In particular, a plan of the proposed slope should be prepared at a scale of not less than 1:2,500 with accurate cross-sections at a scale of not less than 1:1,250 along the line of maximum gradient of the slope and at intervals along the slope of 250m or less as appropriate to the scale of the undertaking and the geological and geotechnical setting. The scale of the cross-sections should enable the thickness, position and character of materials behind the slope to be shown as well as the groundwater assumptions used in any stability analyses. The plan should cover the site of the excavation and any contiguous land that might be affected by it and should show all existing features and the proposed works, together with surface contours and the OS National Grid. Additional plans or overlays may be used to present pertinent geological and structural features relevant to superficial and bedrock materials.

**Slope design**

B7. The information collected and the plans and cross-sections should be appraised by the competent person in respect of potential mechanisms by which the slope might fail and analyses of those mechanisms to assess the risk of failure or the level of safety. Analyses of slopes near third-party property should conform to current good geotechnical practice and be appropriate to the quality of information and the risks involved. The factors of safety or risk of failure used in slope design should conform to those used in civil engineering.

B8. In reporting his appraisal, the competent person should specify:

- potential modes of failure which it is reasonable to consider;
- pertinent conditions and material properties and groundwater assumptions used in any stability analyses;
- methods of analysis used to assess the stability of the proposed slope or the reasons analyses are not necessary;
- findings and implications of any stability analyses, including the long-term security of the slope where appropriate.

B9. Where analyses are undertaken to determine a slope configuration rather than to confirm the stability of proposals, the competent person should also specify for bedrock and superficial materials if necessary:

- maximum overall slope from the crest to the most critical point of approach on the excavated slope;
- maximum slope height appropriate to overall slope angle;
- safe distance of approach to the site boundary/any structure and the overall safety of the slope;
- proposed distance of approach; and
- other relevant matters (eg precautions to be employed, type or rate of excavation, benching system to be employed, direction of advance of excavation, design life of structure).

B10. Any design report submitted as an appraisal or assessment of stability issues with a planning application, with a restoration/landscaping scheme or as part of the review of an old mineral permission under the Environment Act 1995, should be prepared by the competent person. It should include the findings of the investigations (paragraph B5), the plans and cross-sections (paragraph B6) and the appraisal of the proposed slopes (paragraphs B8, and B9 if appropriate).

**Assessment of Exisiting Slopes**

B11. An assessment of existing slopes will be needed if a collapse has occurred or is threatened, or in any other situation where the competent person considers such an assessment to be appropriate. This should examine the security of existing slopes in both active and abandoned quarries to determine the level of risk and the need for preventive or remedial measures. An assessment of stability will also be required when development is proposed above or below abandoned quarry slopes or other excavated faces.

**Information to be collected**

B12. In principle, the investigations necessary to assess the stability of existing slopes are identical to those for proposed slopes. In practice, if unacceptable ground movements are threatened a more rapid investigation and reporting of recommendations may be required. For slopes in abandoned quarries where there is no immediate urgency due to actual or apprehended ground movement, information should be collected by means of survey, tests, boreholes etc on existing features/services and on the geology of superficial and bedrock materials in the same way as for proposed slopes.

*A. Existing information*

Any pertinent records should be examined (eg reports from previous investigations); these may include data on:

- superficial and bedrock materials, including groundwater conditions;
- existing features/services on or near the slope;
- plans and cross-sections;
- any slope investigation or design details;
- age of slope and history of performance, including information on any previous slope failures.

*B. Investigations*

Without taking undue personal risks, the slope should be inspected by a competent person in accordance with paragraphs B15-17 below and information obtained on the following:

- slope configuration, ie an accurate survey including the overall geometry with alignment, elevation and width of any benches and the inclination of individual sections of the slope and the ground behind the slope;
- location and extent of any distress in the slope including items noted in paragraph 16 below;
- thickness and character of superficial materials;
- position and character of bedrock materials, particularly the location of weak, heavily broken or deeply weathered rocks or engineering soils;
- position, inclination and character of any structural features such as bedding planes, faults joints etc likely to influence stability;
- position of surface seepages of groundwater and any areas where exposed faces are damp/dry; and
- location and condition of any engineering works likely to be important, eg exposed mine workings/subsidence damage, buried services, surcharging structures, surface drainage measures behind the slope.

**Assessment**

B13. The information obtained should be presented in an illustrated report, using photographs where necessary, and should be used to prepare an accurate plan and cross-sections as required. The competent person should then assess:

- the most likely mode of slope failure that might occur;
- the actual mode of slope failure that is in progress;
- the extent and size of likely ground movements both behind and in front of the excavated slope; and
- means by which ground movements and/or rockfall may be avoided, arrested, restricted and/or further investigated

B14. The best methods of analysis should be employed appropriate to the information available and the perceived risks to people and structures. In reporting the assessment, the competent person should identify the methods of stability analysis employed or the reason why such analysis was not necessary. The report should include observations on the safety of any proposed engineering works above, on or below the excavated slope. It should be noted that rockfall (uncontrolled collapse from the face of less than $10m^3$ of material) is generally only a hazard to people and structures beneath the quarry face. Depending on its nature and scale, a slope failure may put at risk both those within and outside a quarry and either above or below the face.

**Inspection**

B15. The Quarries Regulations 1999 require inspection of faces above places of work or roadway before work starts or re-starts. More detailed inspections may be carried out from time to time, particularly following any actual or potential incident of instability. The faces of abandoned quarries should also be inspected by the owner or occupier as part of the assessment following an incident or preceding development above or below the face. Many features to be found in excavated rock slopes may indicate incipient rock fall or slope failure. Inspection should concentrate on identifying those features (Fig A1), on recording visible changes and on noting circumstances which were not anticipated and which may be significant in terms of safety. Inspections should be carried out only by those with sufficient knowledge training and experience; inspection reports should be reviewed promptly and assessed by the competent person.

B16. The inspection report should be illustrated where necessary with plans, diagrams and photographs and it should note the date and time of inspection, the date of the previous inspection, the location and time since excavation of the bench/slope and current and antecedent weather. It should note in particular any recent or active rockfall or slope failure with details of the location, size or extent and materials involved; any unexpected geological conditions since the previous inspection; and other changes in slope conditions or features of note. The presence or absence of the features illustrated in Fig A1 and listed below should be noted with appropriate details on location, extent and materials involved:

- lowering of ground surface or cracking at or behind the crest of the slope/bench;
- water running over the crest or entering cracks behind the crest of the slope/bench;
- new accumulations of water behind the crest or at the toe of the slope/bench;
- additional loading of ground behind the crest of the slope/bench;
- bulging of face or displacement across discontinuities;
- open structural features inclined out of or steeply into the face;
- loose material on or water issuing from the face;
- irregularities in gradient or plan of the face;
- ground movements or water issuing at or in front of the toe of the slope/bench;
- indications of silting, impending or partial blockage, recent overflowing, bank erosion or inflow into superficial or bedrock deposits in water courses/lagoons behind the slope crest.

B17. This information should then be incorporated into the assessment of the slope face described in paragraphs B13-14 above, particularly in respect of any face that has suffered or is likely to suffer from instability and/or where development is proposed above or beneath the face.

## Appendix C: Guidelines on the Design, Assessment and Inspection of Tips

C1. The proper design of tips, as defined in the Quarries Regulations 1999, is the responsibility of the quarry (or mine) owner. It must comply with statutory requirements under the Health and Safety at Work etc Act 1974 and the Quarries Regulations 1999 (and the Mines and Quarries (Tips) Act 1969 and associated regulations). The requirements for inspection, appraisal and geotechnical assessment of quarry tips are set out in the Quarries Regulations 1999 and the Approved Code of Practice. Design, reporting and inspection procedures for tips associated with mines are set out in the Mines and Quarries (Tips) Regulations 1971. Individual operators often have their own checklists for the several types of inspection required. If instability occurs, informed assessments are needed of the actual risks and to consider appropriate emergency measures or remedial treatment. Inspection and assessments may also be necessary when development is proposed on or near to tips.

C2. These guidelines were prepared as part of DOE research on the stability of quarry tips and backfill (Geoffrey Walton Practice, 1991). They are intended to apply to tips as defined in the Quarries Regulations 1999. They are also relevant to tips arising from underground mining activities or from other industrial development. They seek to identify the steps to be followed and the type of data to be collected when designing, assessing or inspecting tips and related structures. As with the quarry face guidelines in Appendix B, they are not alternative measures to those required by statute but they illustrate good practice in meeting those requirements. They should be seen as assisting in the general aim of constructing and maintaining secure tips, especially where safety of third-party land and structures beyond the perimeter of the site is an issue.

### Design of Tips

C3. This section refers to tips on new sites or at existing operations. Careful design procedures are always required but particularly when soil, waste and water-retaining structures are sited near third-party property and wherever underground mine workings and solution cavities or other natural or man-made caverns are known to lie in the vicinity of excavated or embankment lagoons. The extent of detailed design required depends on:

- materials used in construction;
- foundation materials and structure, both natural and artificial;
- groundwater conditions;
- surface water management;
- proposed geometry and life of the structure; and
- proximity to property and services.

### Information to be collected

C4. The design of a tip requires the collection by means of surveys, boreholes, tests and review of appropriate records for the following items pertinent to stability and safety. It may not be practicable to collect all the information listed, provided that a reason is given by the competent person for any omissions. However, certain information must be collected in respect of classified tips to satisfy statutory requirements.

*A. Existing features/services*

i. topographic survey of the site and nearby ground which might be affected by or affect the proposed tip, contoured at not greater than 2.0m vertical interval;

ii. location of all active and abandoned services and facilities beneath, on and above the proposed site and adjacent land which may need to be protected or that might jeopardise the security of the structure;

iii. location of both active and abandoned mines and quarry workings, including the position of shafts, adits and underground working galleries or levels, quarry benches and faces and the limits of previously back-filled quarries and other existing tips;

iv. location of all natural or artificial watercourse, springs, seepages, ponds, waterlogged and peaty areas, any sinks, caves or hollows receiving surface water and indications of changes in groundwater levels;

v. location of any surface features resulting from ground instability, including active, dormant or former landslipping or related ground movements and subsidence fissures, crown holes or hollows.

*B. Geology: superficial materials*

i. thickness, nature and properties and base levels of superficial materials, both natural and placed, and their variability;

ii. details of water levels and variations in levels in superficial materials;

iii. location and details of any boreholes, trial pits or exposed surfaces used to investigate superficial materials;

iv. details of pertinent laboratory tests; and

v. other relevant information appropriate to the behaviour of superficial materials as a foundation for structures or when excavated or stockpiled.

*C. Geology: bedrock materials*

i. thickness, nature and properties (including variations) of different rock types and pertinent structural features and weathering zones to depths appropriate to the intended structure;

ii. presence of aquifers with details water levels and variations in levelincluding artesian or sub-artesian pressures at depths within the bedrock appropriate to intended structure;

iii. location and details of any boreholes or excavations used to investigate bedrock and groundwater conditions;

iv. details of any pertinent laboratory tests; and

v. other relevant information appropriate to the behaviour of bedrock as a foundation material or when excavated or stockpiled.

*D. Proposed works*

i. nature (including grading, moisture contents, etc) of materials used in construction;

ii. internal structure, including proposed layering, thickness of layers, drainage blankets, disposition of different materials within the structure including surface treatment;

iii. geometry and surface limits (within area covered) of proposed structure, including inclination of ground covered, proposed side slopes (contours) and heights at all stages of construction, position and size of benches, widths and heights of embankments or other retaining walls, total quantities of solid materials and impounded liquids with or without wastes in suspension, areas of impounded water, freeboard heights;

iv. proposed surface and subsurface drainage arrangements, means of collecting surface water drainage and measures to control water pressures or levels within, beneath or behind structures. For impounded liquids with or without wastes in suspension, details of inflow and outflow arrangements (including emergency measures) and details of excavated or spoil slopes adjacent to structures;

v. proposed ground preparation or foundation treatment including details of types and thicknesses of materials to be removed prior to construction, and details of proposed formation levels and gradients and related provisions for drainage;

vi. rates of construction by reference to metres raised per year and quantities deposited weekly, annually and in total and methods of placement of solid spoil including proposed compaction procedures; and

vii. nature and extent of supervision and inspections during construction and actions to be taken in the event of perceived danger or dangerous occurrences.

### Plans and cross-sections

C5. Plans of the proposed tip or related structure should be prepared at a scale of not less than 1:2,500 together with accurate cross-sections at a scale of not less than 1:1,250. They should cover the site of the tip or related structure and any contiguous land, which might be affected by the proposed tip and should show, where appropriate:

i. surface contours at not greater than 2m vertical interval and the location of all existing features/services;

ii. inferred contours (not greater than 5m vertical interval) on base of superficial deposits, on identified strata (or details of dip and direction of dip of bedrock strata, and of groundwater levels (or recorded range);

iii. positions of faults and inferred boundaries between different bedrock materials;

iv. positions of zones of tensile or compressive strain resulting from underground mining and/or any suspected voids or caverns beneath the site;

v. positions of all boreholes , trial pits etc;

vi. positions of cross-sections; and

vii. details of proposed structure indicating the items set out under proposed works above.

C6. Cross-sections should be prepared incorporating the information listed above and showing variations in thickness and character of superficial and bedrock materials relevant to stability. They should correspond to the line of maximum overall gradient of the proposed structure and also be parallel to the line of maximum overall gradient of the foundation surface and/or of any relevant horizon in material beneath the foundation. The positioning and spacing of cross-sections should allow for the highest and most critical points of the structure to be assessed for use when appropriate in subsequent stability analyses. Cross-sections of any fluid-retaining structures should also show inlet and outlet levels, normal operating water levels and emergency outlet/diversion arrangements.

## Design

C7. The information collected and the plans and cross-sections should be appraised by a competent person in respect of potential mechanisms, by which the tip or related structure could fail, and analyses of those mechanisms to assess the risk of failure or the level of safety. Analyses of structures, especially those near third-party property, should conform to current good practice and be appropriate to the quality of information available and the risks involved. The factors of safety or risk of failure used in design should conform to those used in civil engineering.

C8. In reporting his appraisal, the competent person should specify:

- potential modes of failure which it is reasonable to consider;
- pertinent conditions and material properties and groundwater and drainage assumptions used or assumed in any stability analyses;
- methods of analysis, or the reasoning used to assess the security of the proposed structure; and
- findings and implications of any analysis or assessment, including the long-term security of the proposed structure.

C9. Where analyses are undertaken to determine the configuration of the structure, rather than to confirm the viability of proposals, the competent person should also specify for tips and for embankments retaining liquid or solid waste:

- maximum overall slope from the crest to the toe of the structure;
- maximum slope height appropriate to overall slope, given the most adverse foundation gradient anticipated;
- safe distance of approach of any excavations to the toe of the structure; and
- other relevant matters (eg width of embankments at crest level, foundation preparation, rates of construction, provision of internal and external drainage measures, maximum gradients for inner slope of embankment, acceptable ground vibrations, maximum level of retained liquids, security of slopes above impounded water etc).

C10. The design report submitted with a planning application, a notification of proposals for works permitted by the GPDO 1995, a restoration/landscaping scheme or as part of the review of old mineral permissions should be prepared by the competent person. It should include the findings of the investigations (paragraph C4), the plans and cross-sections (paragraphs C5-6) and the appraisal of the proposed structure (paragraphs C8, and C9 if appropriate).

## Assessment of Existing Tips

C11. The Quarries Regulations 1999 require the operator to prepare and implement a scheme of inspection of all parts of the quarry, including quarry tips, and the Advisory Code of Practice and guidance includes a model checklist and report form for inspection reports. The Mines and Quarries (Tips) Regulations 1971 lay down minimum inspection frequencies and reporting procedures for all tips associated with active mines and quarries and reporting requirements in the event of a dangerous occurrence. There may also be a requirement for assessment of a tip or related structure where a competent person considers it to be necessary, eg prior to tip reworking or when development is proposed near the toe or on top of such a structure.

**Information to be collected**

C12. In principle, the investigations necessary to assess the stability of an existing tip are identical to those for proposed tips. In practice, especially if unacceptable ground movements threaten, less time may be available for an assessment of security and a more rapid inspection, investigation and reporting procedure is required. The guidelines below are intended to assist all interested parties in the systematic inspection of tips and related structures; notification and investigation procedures should always conform to statutory requirements.

*A. Existing information*

Any pertinent records (eg reports from previous investigations) should be examined for data on:

- existing features/services near, on or beneath the structure;
- superficial and bedrock materials, including groundwater conditions;
- details of any ground investigation or design report, including, where relevant, all records required to be kept by legislation;
- construction details, locations and types of tipped materials;
- plans and cross-sections;
- age of the structure and history of the development of the structure and its performance; and
- recent rainfall records.

*B. Investigations*

Without undue risk, the structure should be inspected by a competent person in accordance with paragraphs C15-17 below and information obtained on the following:

- geometry of the structure (by accurate survey, if necessary using targetless survey techniques where safety precludes access) including alignment, elevation and widths of any benches, drainage arrangements and inclination of individual sections of slope;
- materials used in construction;
- location and size/extent of any distress in the structure including items noted in paragraph 16 below, eg tension cracks, bulging etc;
- character and inclination of foundation materials;
- position of surface seepages of water;
- performance of drainage arrangements on, in or beneath the structure; and
- location of any engineering works likely to be important, eg mine workings, buried services, surcharging structures.

**Assessment**

C13. The ormation obtained should be presented in an illustrated report, using photographs where appropriate, and should be used to prepare an accurate plan and cross-sections as required. The competent person should assess:

- the most likely mode of failure that might occur;

- any mode of failure that is in progress;
- the extent and size of likely movements, discharge of fluids etc; and
- means by which movements etc may be avoided, arrested, restricted and/or further investigated.

C14. The best methods of analysis should be employed appropriate to the information available and the perceived risk. In reporting the assessment, the competent person should note the methods of analysis or reasoning employed or why an analysis was not necessary. The report should include observations on the safety of any proposed engineering works above, on or below the tip or related structure.

**Inspection and Reporting**

C15. The Quarries Regulations 1999 require operators to operate a scheme for the systematic inspection of all parts of a quarry. Inspections of all active and closed tips at appropriate intervals are also required by the Mines and Quarries (Tips) Regulations 1971. Careful inspection of tips and related structures may reveal features associated with incipient movements or failure. Inspections should concentrate on identifying those features (Figure A2), on recording visible changes, confirming that construction is proceeding according to the tipping rules and noting circumstances that were not predicted and which may be significant in terms of safety.

C16. The inspection report should be illustrated where necessary with plans, diagrams and photographs. It should note the date and time of inspection, the date of any previous inspection, the structure inspected, its age and stage of construction and current and antecedent weather. It should note in particular any recent or active slope failure/movements with details of the location, size or extent and materials involved, any unexpected conditions since the previous inspection and other changes in slope conditions or features of note. The presence or absence of the features illustrated in Figure A2 and listed below should be noted with appropriate details on location, extent and materials involved:

- lowering or settlement of surface or cracking at or behind the crest of the structure;
- water running over crest or entering cracks behind the crest of the structure;
- new accumulations of water behind the crest or at the toe of the structure;
- surcharging of ground behind the crest of the structure;
- bulging or settlement of slope face;
- loose material eroding or being washed out of or water issuing from slope face;
- irregularities or changes in gradient or plan of the slope face;
- indications of blocked drainage blankets;
- ground movements or water issuing at or in front of the slope toe;
- excavations at or near the toe of the structure;
- indications of silting, impending or partial blockage, recent overflowing, bank erosion or inflow into superficial or bedrock deposits in water courses near the structure;
- adverse drainage from access roads;

- indications of burning, fumes, smoke or steam;
- indications of recent ground movements due to mining, solution cavities or landsliding;
- construction varying from plan; and/or
- instruments recording movements or rises in water levels or damaged.

C18.Additional observations for water-retaining structures confining water with or without waste in suspension (or weak but solid materials) should note particularly any abnormal flows of water in or near the structure or unaccountable changes in flow in water courses, drains and culverts and any indications of recent increases or falls in water or sediment level. The presence or absence of the following should be noted:

- wave erosion inside embankment;
- impedance of inflow, outflow or storm flow;
- freeboard less than minimum required;
- signs of damage due to burrowing animals or cattle; and
- escape of materials in suspension or solution.

C19. This information should then be incorporated into the assessment of the structure described in paragraphs C13-14 above, particularly where any structure has suffered or is likely to suffer from instability and/or where development is proposed above, on or below the structure. A record should be made of all proposed remedial works whether or not failure has occurred or is assessed as being likely to arise.

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