

Australian Standard[®]

Guidelines on earthworks for commercial and residential developments



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 - Australian Building Codes Board
 - Australian Geomechanics Society
 - Institute of Public Works Engineering Australia
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 - University of New South Wales
-

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Guidelines on earthworks for commercial and residential developments

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PREFACE

This Standard was prepared by the Standards Australia Committee CE-027, Earthworks, to supersede AS 3798—1996.

This Standard incorporates Amendment No. 1 (August 2008). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of this Standard is to provide guidance to those responsible for or involved in the design, specification, supervision and control testing of earthworks for commercial and residential developments.

This Standard is a guideline, which is an informative document only.

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STANDARDS AUSTRALIA

Australian Standard

Guidelines on earthworks for commercial and residential developments

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard provides guidance on the specification, execution, and control testing of earthworks and associated site preparation works for commercial and residential developments. This Standard does not in itself constitute a specification for earthworks and the specifier should consider the applicability of these guidelines to the project under consideration.

The Standard is not intended to be used for pavements, major roadworks, or water-retaining structures. Such works require special consideration.

Residential developments in the context of this Standard are intended to include single lot development up to broad acre subdivisional development for detached or semi-detached housing. The Standard is not intended to be sufficient for medium- or high-density residential development without due consideration by a suitably qualified professional.

Historically, previous editions of this Standard have been used to assist in the specification and execution of earthworks beyond the intended scope of the document. Whilst with due consideration some aspects of this Standard may be applicable to such works, designers and specification writers should be aware the guidance given herein may not be applicable. In such circumstances, appropriate advice should be sought from a suitably qualified professional before adopting this Standard.

Where the depth of filling required for works to which this Standard would otherwise be applicable exceeds 5 m, advice from a geotechnical professional should be sought.

1.2 TERMS AND DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.2.1 Cohesionless soil

Poorly graded sand and gravel mixture, generally with less than 5% fines (i.e., particles finer than 75 μm diameter), which is non-plastic and which does not exhibit a well-defined moisture-density relationship when tested in accordance with AS 1289.5.1.1 or AS 1289.5.2.1.

1.2.2 Cohesive soil

Material that has a well-defined moisture-density relationship when tested in accordance with AS 1289.5.1.1 or AS 1289.5.2.1.

NOTE: This may include well-graded granular materials such as crushed rock.

1.2.3 Collapsing soil

Soil that may suffer a significant decrease in volume under load or when it becomes nearly saturated, which may have existed in this metastable state for a long period.

1.2.4 Compaction

The process whereby the density of a soil mass is increased by mechanical, usually dynamic, means. This typically involves tamping, rolling, impact or vibration, or a combination of these processes. This process results in a relocation of the soil particles and in the expulsion of air from the soil mass, usually without significantly altering the amount of water in the soil.

1.2.5 Consolidation

The process by which water, and sometimes air, is expelled from a soil mass over time due to the action of an imposed static stress and causes settlement.

NOTE: The terms compaction and consolidation are not interchangeable and consolidation should not be referred to in earthworks specifications.

1.2.6 Dispersive soil

Soil that has the ability to pass rapidly into suspension in the presence of water.

1.2.7 Foundation

The earth material immediately underlying and supporting any engineering structure; thus, the foundation for a fill is the stripped surface and a fill itself can be a foundation for a building.

1.2.8 Lot

A lot is an area of work that is essentially homogeneous in relation to material type and moisture condition, rolling response and compaction technique, and which has been used for the assessment of the relative compaction of an area of work.

1.2.9 Pavement material

Material that is used in the construction of pavements.

NOTE: Pavement material is generally granular and often manufactured from hard rock sources (e.g., crushed rock).

1.2.10 Reactive soil

Clay soil, for which a change in moisture content results in a sufficient change in volume to affect the engineering performance of any structure in contact with it.

1.2.11 Relative compaction

- 1 For cohesive soils, the dry density ratio determined in accordance with AS 1289.5.4.1, or the Hilt density ratio determined in accordance with AS 1289.5.7.1.
- 2 For cohesionless soils, the density index determined in accordance with AS 1289.5.6.1.

1.2.12 Rockfill

Fill composed almost exclusively of fragments of broken rock. It generally consists of a large portion of gravel and larger sized fragments, and may contain large open voids.

1.2.13 Structural fill

Any fill that will be (or may be), required to support structures or associated pavements, or for which engineering properties are to be controlled. Sometimes referred to as controlled or engineered fill.

1.2.14 Subgrade

The earth material on which it is proposed to construct a pavement. This is often taken as being to a depth of 300 mm below the level from which the formal pavement is constructed.

1.2.15 Topsoil

A surficial soil containing some organic matter, usually darker than the underlying soils.

1.3 DESIGNATION OF PERSONNEL

For the purpose of this Standard, the following terms are relevant:

- (a) *The owner*—sometimes referred to as the proprietor or the principal.
- (b) *The designer*.
- (c) *The geotechnical professional*—a person suitably qualified and experienced in geotechnical principles as applied to earthworks.
- (d) *The superintendent*—the principal's authorized person, sometimes referred to as the engineer or the architect.
- (e) *The constructor*—sometimes referred to as the contractor or the builder.
- (f) *The geotechnical inspection and testing authority (GITA)*—an organization that should be used for the inspection and testing as detailed in Section 7 and Section 8.
- (g) *The geotechnical testing authority (GTA)*—an organization that should be used for the testing as detailed in Section 7 and Section 8.

SECTION 2 INVESTIGATION, PLANNING AND DESIGN

The investigation, planning and design for projects involving earthworks require the designer give consideration to those factors that may affect the works. Before site works are commenced, some or all of the following details may need to be taken into account:

- (a) *Approvals* The precise terms of approval of the project by relevant authorities, including local government and heritage, planning and environmental protection agencies, can influence the execution of the works.

The necessity to obtain approvals will extend to off-site locations, such as borrow areas and haul routes.

- (b) *Services* Inspections, in conjunction with the relevant authority where necessary, to locate existing and proposed public utility services, which may be affected by or affect the works. Written requirements, in respect of such services, should be obtained from each relevant authority.

- (c) *Adjoining property* Examination to assess whether there is a potential for damage due to vibration, excavation, filling, noise, run-off, dust or other effects of the earthworks, and liaison with the adjoining owners.

- (d) *Regulations* Working hours on site, warning signs, fencing or security requirements and emanations from the site including dust, water, silt, noise or smoke, are controlled by regulations. These regulations are in addition to the civil rights of adjoining owners and the public.

- (e) *Preservation items* Surveys necessary to identify and locate aboriginal or historic relics, heritage items or rare flora or fauna, which may require preservation or relocation.

- (f) *Rehabilitation* Rehabilitation of areas affected by construction activities such as borrow pits, stockpiles, excavated or fill batters, spoil disposal areas, haul routes, stormwater control, camp, office and workshop sites, should be included in the drawings and specifications so that materials such as topsoil, mulched native vegetation (which can contain useful seedstock and nutrients) and bulk fill materials used for rehabilitation are identified and preserved for re-use. Rehabilitation works should be completed before the constructor vacates the site.

- (g) *Drainage* Temporary or permanent diversion of permanent or ephemeral watercourses prior to or during construction of the earthworks and associated works may affect the quantity or quality, or both, of the stormwater run-off. Therefore, special provisions may be necessary to minimize the effects and to protect the legal rights of adjacent and downstream landowners. Failure in providing for such provisions could lead to litigation and delay in completion of the earthworks project.

Approval from the relevant authorities should be obtained prior to either the placement of fill on flood-prone lands or construction of drainage structures, i.e., culverts in natural watercourses.

The placement of fill or construction of cuts may impact the flow of subsurface water and may lead to localized instability. Special provisions may be necessary to account for the potential effect of the works in this situation.

- (h) *Erosion and siltation* Protection of the earthworks from erosion, both during construction and after construction, needs to be taken into account. Run-off from the works, and areas affected by the works, may be subject to special provisions (see Item (g) above).

- (i) *Sloping ground* Special precautions where the earthworks are constructed on sloping ground include—
 - (i) benching of the surface of the natural ground to assist in the placing of the fill and to key the fill to the foundation soil;
 - (ii) berms or benches above, within, or at the foot of cuts to intercept stormwater run-off or detritus; and
 - (iii) special works.
- (j) *Slope stability* The basis for the assessment of the short- and long-term stabilities of natural slopes, cut-face slopes and fill slopes is—

- (i) local experience with similar materials under similar conditions; or
- (ii) geotechnical investigation and analysis.

Each stability assessment needs to take into account any existing slopes, proposed undercut and surcharge of the slopes and the effect of water seepage on the slopes. Each slope should be selected with regard to the required access, including maintenance, e.g., mowing.

- (k) *Zoning* Zones for fill may be designated by specific locations and levels within the earthworks. The bases for the selection of fill within zones are—

- (i) easily compacted fill near existing structures, to minimize the compactive effort and consequent risk of damage;
- (ii) granular fill in areas that may become wet during compaction;
- (iii) fill containing large fragments, i.e., rock or building rubble, not within the top 600 mm or at greater depth if trenches are to be constructed for footings or services, or piers or piles have to penetrate the fill; and
- (iv) saline fill not within the top 600 mm where vegetation may be established.

- (l) *Soft or compressible foundation soils* Soft or compressible soils do not form a good foundation on which to place and compact fills, and may need to be excavated.

Alternatively, fill (which is readily compactable) may be placed in the lower levels of the earthworks immediately above such soils. Geosynthetics or some other ground improvement techniques may also be considered (see Item (v)).

To minimize displacement of such soils during construction, the earthworks should be programmed to avoid unnecessary loading of the foundation, e.g., appropriate routing of fill haulage equipment or stage construction.

The calculation of quantities needs to take into account the effect of compression of the foundation soils.

- (m) *Reactive soils* The moisture content of reactive soils after compaction of fills should approximate the estimated long-term moisture content, which may be about the same as the moisture content for the undisturbed reactive soils at or about the depth of seasonal influence.
- (n) *Low density or potentially collapsing soils* Low density or potentially collapsing soils lose volume when compacted in or beneath the earthworks. Calculation of quantities needs to take into account the effect of compression of the fill or foundation, or both.
- (o) *Existing filled ground* Existing filled ground, for which the conditions of the placement are not adequately documented as described in Clause 3.4, should not be assumed to be either of the standard of compaction or of the composition adequate to support fill or any other loads.

Site investigations, which may include test pits, test bores, test rolling (see Clause 5.5), or other methods, are necessary to assess the degree of compaction and composition of the existing filled ground. Analysis of the results obtained from these investigations will allow an assessment of the adequacy of the existing filled ground or the extent of remedial works that may be required. Such remedial works could include complete removal.

- (p) *Non-potable water* The suitability of non-potable water for increasing the moisture content of fill should be evaluated by field and laboratory trials. Saline waters should not be used—
 - (i) in the upper layers of fill, beneath either bituminous sealed pavements or areas where vegetation may be established; and
 - (ii) in fill where steel is buried.
- (q) *Trenches* Excavations for trenches require special consideration for support. Relevant authorities place limitations on the maximum depth to which trenches may be excavated without shoring.
- (r) *Compaction moisture content* The optimum moisture content determined by laboratory methods is only a guide for field construction, as the optimum moisture content for compaction under field conditions will depend on the material type, equipment used, the layer thickness and the nature of the foundation. In general, the heavier the compaction effort or the thinner the layer, the lower the optimum moisture content. Increased compaction effort may cause the soil to approach saturation and higher densities may not result.
- (s) *Surcharging of slopes* Cut face and fill slopes, sides of trenches and slopes supported by retaining walls should not be loaded, e.g., by construction equipment, materials, soil and the like, unless the assessment of the slope stability (see Item (j)) included an allowance for particular load(s).
- (t) *Calculation of quantities* In calculating quantities of fill, the following should be taken into account:
 - (i) Volume changes due to excavation, spreading and compaction.

NOTE: The degree of volume change is dependent on the type and geological origin of the material and required relative compaction. It can be assessed as part of the site investigation, using field density tests and laboratory compaction tests.
 - (ii) Compression of the foundation (see Items (l) and (n)).
- (u) *Physical separation of dissimilar materials* Filters, comprising material of selected particle size distribution and geosynthetics (see Item (v)), may be used to avoid the mixing of materials after placement. Filters and geosynthetics are used to avoid—
 - (i) soft materials being forced into voids of granular material; or
 - (ii) erosion of fine material into adjacent granular material.
- (v) *Geosynthetics* Proprietary products are available with particular properties suitable to act as a filter, drainage layer and/or physical separator to allow water flow whilst avoiding migration of soil particles or as a tensile reinforcement layer. Such materials may be construction expedients, or may form part of the permanent earthworks. Geosynthetics should be carefully chosen for the intended purpose and have an adequate service life under the intended conditions.
- (w) *Vibration* Construction activities, particularly those using equipment such as compactors or blasting, may cause vibrations that could damage nearby structures, either directly (due to the vibration transmitted to the structure) or indirectly (for example, by causing settlement of the foundations).

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- (x) *Contamination* Any known or suspected ground or groundwater contamination should be investigated. Relevant authorities have set limits on the quantity of contaminants permitted in ground, in various applications. Removal of contaminated soil from the site is likely to require special consideration, such as classification. Similarly, allowing contaminated soil to be imported or to remain on site may require approval from the relevant authority. The impact of any investigation on planned earthworks, including safety and environmental aspects, should be considered.
- (y) *Retaining walls* The compaction of fill against retaining walls may induce higher pressures than adopted in the design. The nature of the fill to be used, the specified level of compaction, and the type of compaction equipment to be used, should be assessed in selecting design fill loads on retaining walls.
- (z) *Potential acid sulfate soils* In certain areas, particularly in coastal marine deposit areas, the presence of considerable amounts of iron sulfates is possible. Disturbing or exposing these soils to air may cause the formation of sulfuric acid. Excavation and movement of such soils are subject to strict environmental controls that normally expect chemical treatment to avoid contamination of streams and drains. Consultation with the relevant environmental authority is required prior to the excavation or use of such soils.

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NOTE: For sampling and investigation of soil for iron sulfate content, see AS 4482.1.

SECTION 3 DOCUMENTATION

3.1 GENERAL

This Section includes details of the documentation for the design and construction of an earthworks project.

3.2 INVESTIGATION AND PLANNING

Investigations for the planning of earthworks for use by the designer, the constructor and other interested parties should include the following:

- (a) Outline of the need for, and objectives of, the project.
- (b) Site investigation of the project and any associated sites, covering, where applicable, the—
 - (i) condition of the site(s) including—
 - (A) present uses, i.e., buildings and vegetation; and
 - (B) evidence of past uses, i.e., demolition, filling and vegetation;
 - (ii) foundation and subgrade materials;
 - (iii) special areas due to groundwater, seepage, rock, reactive and collapsing soils;
 - (iv) available fill materials and, where applicable, details of the overburden;
 - (v) suitability of the fill materials for the intended purposes;
 - (vi) classification of materials to be removed off site;
 - (vii) availability of suitable pavement materials;
 - (viii) quantity and quality of the available water; and
 - (ix) suitability of water for the placement of the fill.
- (c) Where applicable, an outline of other plans that have been considered in the investigation. This should include the points discussed in Section 2.
- (d) The quality assurance requirements for the project.

3.3 DESIGN AND SPECIFICATION

The functional requirements of the design should be documented in the specification and drawings for the earthworks project. This documentation should be sufficiently complete to allow the constructor to unambiguously carry out the works, and for the superintendent (and the geotechnical inspection and testing authority, as necessary) to be able to interpret the design and administer the contract.

Such documentation will typically include (or have consciously excluded), the following, as well as any other matters that may be of particular importance to the particular project:

- (a) Adequate specification and drawings to allow the proper pricing, planning, execution and supervision of the works. Plans, sections and elevations should clearly show areas of earthworks, identifying areas requiring specific treatments. Particularly on larger projects, the specification and drawings should adequately define the following:
 - (i) The areas in which spoil may be dumped or stockpiled.
 - (ii) Restrictions on clearing and stripping.
 - (iii) Drainage requirements during and after construction.

- (iv) Criteria for selection of materials for placement in various parts of the fill and for material to be excluded from fill. Material descriptions should be clear, unambiguous and in accordance with AS 1726.
 - (v) Criteria for standard of surface trim of completed earthworks.
 - (vi) Details of tests, including minimum frequency, to be carried out for testing to ensure the fill complies with the specified criteria.
 - (vii) The scope of the commission to be given to the geotechnical inspection and testing authority (see Clause 1.3).
 - (viii) Either the methods to be used for construction or the requirements to be met by test in the finished project. It is generally unwise to mix performance and method specifications. Where a performance specification is adopted, restrictions on methods should be limited to those absolutely necessary (for example, to limit the risk of damage to nearby structures).
- (b) Site investigation information, including that given in Clause 3.2(b), together with details of, and provision for, access to any further relevant information for the purpose of design or construction planning. Selective provision of available site investigation data can give rise to serious problems, either engineering or legal, or both, and should not be done without due consideration of the issues involved. An overview of the issues is given in a monograph on this subject.*
- (c) Any other relevant information in the possession of the designer.

3.4 CONSTRUCTION

Adequate records need to be kept during construction, including conditions encountered, works as executed, testing and any alterations to the specification and drawings. As a minimum, these records should show the following:

- (a) The areas in which fill is placed.
- (b) Levels after stripping.
- (c) Location of any trees or large shrubs that may have been removed.
- (d) Materials exposed after stripping and the criteria upon which the decision to cease stripping was made.
- (e) Levels after completion of the filling.
- (f) Details of test rolling, if undertaken.
- (g) Types of fill material in various zones.
- (h) Sources of fill material in various zones, where applicable.
- (i) Location and level of each compliance test, together with test results. Where a test is a retest of a lot that was previously rejected, this should be stated.
- (j) Action taken where testing indicated that the specified criteria had not been met.

Any areas in which the fill material or compaction is to be of a lesser standard or a greater standard than elsewhere on the site should be clearly identified.

*Guidelines for the provision of geotechnical information in construction contracts, Canberra, The Institution of Engineers, Australia, 1987