PART 2

EARTHWORKS AND FOUNDATIONS

PART 2: EARTHWORKS AND FOUNDATIONS

201 SCOPE

201.1 This Part of this Code of Practice sets out the recommendations for the carrying out of earthworks or preparation for foundations, or both, including:

(i) The excavation and filling of land to form new contours;

(ii) The assessment and protection of slope stability;

(iii) The suitability of both natural and filled ground for the founding of roads, buildings, services and other works;

(iv) The control of erosion and siltations during and after earthworks.

201.2 Because of the wide range of soil types, physical conditions and environmental factors which apply in different areas it is not often possible to lay down precise requirements which will be subject in particular instances to the judgement of the Engineer, owner's representative or soils engineer.

202 GENERAL

202.1 Choice of final landform is dependent on many factors which may be specific to the subdivision or development. These include:

(i) Relation with surrounding landscape;

(ii) Size;

(iii) Roading pattern;

(iv) Preservation of natural features;

(v) Stability;

(vi) Damage by flood or other natural occurrences such as erosion by sea, river, or surface stormwater run-off.

202.2 The New Zealand Standard Code of Practice for earthfill for residential development (NZS 4431) provides a means of compliance with local authority bylaw requirements for earthfills.

Provision is made in this standard for certification of suitability of land for subdivision and development to meet the requirements of this Standard. This requirement is independent of the requirements under the Building Act 1991. Reference is made to the desirability of using local material which may provide a satisfactory foundation in particular circumstances.

Attention is drawn to the Water and Soil Division (Ministry of Works and Development) publication:

(i) Urban Land Development - Water and Soil Management Publication 3.

202.3 Consultation with Environment Waikato should be undertaken to review the need for further consents that may be required for vegetation clearance, earthworks and land disturbance.

203 TECHNICAL RESPONSIBILITIES

203.1 Where any land development or subdivision involves the carrying out of bulk earthworks, the assessment of slope stability, or the detailed evaluation of the suitability of natural ground for the foundations of buildings, roads, services or other works, then a soil engineer should be appointed by the developer to carry out the following instructions:

(i) Prior to detailed planning of any development to undertake a site inspection and such investigations of subsurface conditions as may be required.

(ii) Before work commences to review the drawings and specifications defining the earthworks proposed, and submit a written report to the Engineer on foundation and stability aspects and any proposed departures from this Code and associated standards.

(iii) Before work commences and during construction to determine the extent of further specialist soils engineering services required (including investigation and geological work).

(iv) Before and during construction to determine the methods and frequency of construction control tests to be carried out, determine the reliability of the testing, and to evaluate the significance to test results and field inspection reports in assessing the quality of the finished work.

(v) During construction to provide regular inspection (while a daily visit might be regarded as reasonable on earthwork construction on minor projects, inspection on a nearly full time basis is often necessary).

(vi) On completion to submit a written report to the Engineer attesting to the compliance of the earthworks with the specifications, and as to the suitability of the subdivision for building construction.

203.2 The owner's representative may act as the soils engineer if he possesses suitable qualifications and experience.

203.3 The construction control testing should be carried out by a competent person, or, preferably, under the control of the soils engineer, and with Testing Laboratory Registration Council (Telarc) registration in all relevant tests.

204 SITE INVESTIGATIONS

204.1 Preliminary Site Evaluation

204.1.1 Prior to any detailed planning or design, the owner's representative or soils engineer, as applicable, should undertake a preliminary evaluation of the general nature and character of the site in sufficient detail to determine the likely requirements for earthworks or the need for further investigations into the suitability of foundation conditions, or both, and the stability of the natural ground. The preliminary evaluations should be carried out in the context of the total surrounds of the site, and should not be influenced by details of land tenure, territorial or other boundary considerations. In simple cases a visual appraisal may be sufficient, but in other cases depending on the nature of the project, its locality, the scale of development proposed and individual site characteristics, particular attention may need to be given to the following matters which should

normally be considered prior to preparing a proposal for subdivision or development.

(i) Drainage. It is important to identify the existing natural drainage pattern of any area and to locate the natural springs or seepage.

(ii) Where any natural drainage paths are interfered with or altered by earthworks then appropriate measures should be taken to ensure that sufficient adequate alternative drainage facilities are provided.

Slope Stability. Some natural slopes exist in a state of only marginal stability and relatively minor works such as trenching, excavation for road or building platforms, removal of scrub and vegetation, or the erection of buildings, can lead to failure. Signs of instability include cracked or hummocky surfaces, crescent shaped depressions, crooked fences, trees or power poles leaning uphill or downhill, uneven surfaces, swamps or wet ground in elevated positions, plants such as rushes growing on a slope and water seeping from the ground.

(iii) Foundation Stability. A study of the general topography of the site and its surroundings may indicate areas which have previously been built up as a result of natural ground movement or by the deliberate placing of fill material. Unless such fill has been placed and compacted under proper control, long term differential settlement could occur causing damage to superimposed structures, roads, services or other subdivision works.

Note: The District contains a number of areas where 'tomos' have developed. These may affect the suitability of a site for development and consequently these will require identification and addressing as part of any development proposal.

204.2 Specialist Services

204.2.1 Where a soils engineer has been appointed as recommended in section 203 then prior to or at the time of submission of an application or subdivision or development he should submit to Council a written report setting out the particulars of any investigations carried out including details of contours, natural features and modifications proposed thereto; and shall furnish to Council a statement of professional opinion as to the suitability of the land for subdivision with details of any special conditions that should be imposed. A suitable format for this statement of opinion is included as Appendix A.

205 PLANNING AND DESIGN

205.1 Landform

205.1.1 The final choice of landform should represent the most desirable compromise between the factors referred to above and the preservation of natural features and the natural quality of the landscape including the retention of natural watercourses.

The choice of suitable landform is dependent on many factors which may be specific to a particular site. In general, unnecessary earthworks should

be avoided but considerations which may justify the carrying out of earthworks include:

(i) The minimisation of the possibility of damage to property occurring through ground movement in the form of slips, subsidence, creep, erosion of settlement.

(ii) The minimisation of the possibility of damage to property occurring through flooding, or surface water run-off.

(iii) The development of a more desirable roading pattern with improved accessibility to and within the site and the creation of a better sense of orientation and identity of the area as a whole.

(iv) The efficiency of overall land utilisation including the quality of individual sites and amenity areas around buildings, the economics of providing engineering services, and the standard of roading and on-site vehicular access.

(v) The need to create suitably graded areas for playing fields and other community facilities.

(vi) The enhancement of the general environmental character of the area by softening the landscape or by artificially creating or emphasizing landforms of visual significance particularly on flat sites or on areas devoid of landscape features, or preservation of some specifically significant feature.

205.2 Soil Investigations

205.2.1 Where appropriate the general nature and shape of the ground should be studied and particular note taken of:

(i) The geological nature and distribution of soils and rock;

(ii) Existing and proposed drainage conditions and the likely effects on ground water;

(iii) Previous history of ground movements in similar soils in the area; and

(iv) Performance of comparable cuts and fills (if any) in adjacent areas.

205.2.2 Soil data should be obtained for areas which:

(i) Are intended to form in situ bases for fills;

(ii) Are intended to yield material for construction of fills; and

(iii) Are intended to be exposed as permanent batters.

205.2.3 Sufficient borings, probings or open cuts should be made:

(i) Classify the soil strata by field and visual methods;

(ii) Evaluate the likely extent and variation in depths of the principal soil types, and

(iii) Relating subsequent soil test properties to relevant strata over the site.

The test data appropriate in different areas shall be determined by the soils engineer.

205.3 Stability Criteria

205.3.1 Settlement. The most important factor in ensuring satisfactory performance of stable fills is the limiting of post-construction differential settlements. The design and construction of fills should be such that these settlements are kept within acceptable limits.

The weight of residential buildings of one-storey and two-storey construction not requiring specific design, in terms of NZS 3604, is unlikely to produce significant settlement of fill constructed in accordance with this Code. Local filling placed close to a house during or after construction, for example, for a patio, will produce much larger stress increases which may induce differential settlement of the house.

Bearing Capacity. The strength of the ground resisting general shear failure (and resulting gross deformation) under the footings of a house is a local phenomenon distinct from settlement. Fill constructed to minimize settlement in accordance with this Code will have adequate shear strength.

It should be noted, however, that despite careful construction there may be localised soft areas in the upper layers of fill within the zone of influence of small foundations. Should the routine foundations inspection by the building or the local authority during construction suggest, or should the Engineer suspect, that localised soft areas are present, then tests should be made to determine the required treatment of the fill material, or of the foundations. These tests should extend to a depth as agreed with the Group Manager Asset Management and may include shear strength tests, field load tests or dynamic penetrometer tests or other recognised soil strength tests.

Note: The developer should refer to the Natural Hazards Register contained in Volume 4 of the District Plan.

The adequacy of subgrade compaction and proposed pavement depth for road works shall be confirmed by tests on the finished subgrade. This requirement is compulsory for new roads to be vested in Council.

205.3.3 Shrinkage and Expansion. Because some clay soils are likely to undergo shrinkage and swelling when subjected to seasonal changes in water content, special examination of welling and shrinkage characteristics should be made in the case of highly plastic soils.

Where applicable, the need for a foundation depth or design to minimise these effects, particularly for continuous brittle walls, should be noted in the completion report and statement of the soils engineer (refer 207.2)

205.3.4 Slope Stability. In most cases, it is unnecessary or impracticable to measure quantitatively the factor of safety of a slope against shear failure. Maximum slopes of cuts and fills may be determined by the soils engineer from experience and from observation of slopes in the vicinity which have a long-standing history of stability, are of similar height to the proposed slope and are of apparently similar geological formation.

Where necessary or a precedent is not available, a special soils engineer investigation should be carried out by the soils engineer to determine acceptable limits to cut and fill slopes. In assessing slope stability account should be taken of possible future changes in ground water level or other conditions. Where a fill may be required to act under extreme conditions as a detention dam, investigation should include the ability of the fill to act as a detention dam and upstream effect of the fill.

See also 401.

205.4 Quality of Filling Material

The majority of soils, other than organic material, are potentially suitable for fillings under controlled conditions. However, the Group Manager Asset Management retains the right to disallow the use of unsuitable fill material.

205.5 Compaction Standards for Fill Material

205.5.1 As described in NZS 4431, the standard of compaction should be measured in terms of one of the following:

(i) Relative Compaction. That is, the ratio of the field dry density of fill to the maximum (laboratory) dry density expressed as a percentage. Unless otherwise required by the soils engineer, fill should be compacted to at least 95% relative compaction, in terms of the standard method of compaction.

(ii) Air Voids and Shear Strength. Used for cohesive soils, where specific test methods and criteria should be determined by the soils engineer, who may, for example, require air voids to be less than 10% and shear strength to be not less than 50 kPa on completion of construction.

(iii) Relative Density. That is, the field dry density expressed in terms of maximum minimum densities established by laboratory test (used for cohesionless soils). The specific minimum value should be determined by the soils engineer who may, for example, require a minimum relative density of 80%.

See NZS 4431.

(iv) Field Relative Compaction (Field Proctor Test). This is the ratio of the density of the compacted fill material at its in situ moisture content, relative to the density of the same material at the same moisture content after standard compaction (Proctor compaction) in terms of Test 14 of NZS 4402. (This method gives a quick determination of the actual field compactive effort being applied, relative to Proctor compaction, without need for drying in the testing procedure, and this may be adequate control provided the material is close to optimum moisture content.)

205.6 Erosion Control

205.6.1 Subdivision or development should be carried out in such a manner as to restrict soil erosion to acceptable levels. This can be achieved by adopting sound design and construction procedures.

205.6.2 Diversions of natural water and the discharge of water containing silt arising from subdivision or development works are subject to either a land use, water or discharge permit in terms of the Resource Management Act 1991. Where the Regional Council has issued a general authorisation, that is - for the diversion or discharge of water or water containing sediment associated with subdivision or development, the subdividing owner's representative shall comply with the conditions of such authorisation including notification to the Regional Council if required. Where water is to be diverted from one catchment to another, the effect on that catchment should be investigated, and where necessary approvals shall be obtained from the respective authorities or owners, or both.

205.6.3 Without prejudice to the conditions of any Resource Consent the following practices should be adopted in the planning and design of land subdivision or development projects involving earthworks:

(i) Large projects should be programmed for construction in self-contained stages which can be largely completed within one earthworks season. Where possible, the upper part of a catchment should be developed first.

(ii) Where possible, the permanent storm-water system should be designed so it can be constructed at an early stage in the project and be used to collect run-off from the site during construction in conjunction with silt control measures.

(iii) The specifications should require the use of construction procedures which minimise concentration of run-off and excessive velocities, which could otherwise result in erosion.

(iv) Silt retention ponds should be constructed and maintained in all earthworks projects where they are feasible and necessary.

(v) Graded "V" drains (also called contour drains) should be used to divert run-off water from non-construction areas past site-works or to divert run-off from exposed areas into silt retention ponds and reduce overland flow distances on bar surfaces. Such drains should have a maximum slope of 1 in 30 and a maximum design velocity of flow 2m/s.

(vi) Cut and fill areas should be re-topsoiled and sown as soon as possible after earthworks and drainage works.

(vii) The batter faces of cuts and fills should be protected as soon as possible after construction by grassing, hydroseeding, tree planting, or other suitable surfacing.

205.7 Provision for Permanent Services

205.7.1 Where settlement is expected to occur, all service pipes installed within or under earth filling shall be designed and constructed to ensure adequate capacity, strength and water-tightness to withstand the loads due to settlement and to prevent leakage into the fill.

205.7.2 Where surface water could cause erosion of batters or internal instability through soakage in the soil, open interceptor drains should be constructed in permanent materials, and benches in batter faces should be sloped back and graded longitudinally to reduce spillage of storm-water over the

batter. Water from stormwater systems should be prevented from flowing into a fill or into natural ground near the toe or sides of a fill and no storm-water soak pits should be constructed in a fill whereby the stability of the fill might be impaired.

205.7.3 All drains required permanently to protect the stability of fillings or to prevent flooding and erosion should be clearly identified as such on "as-built" drawings.

206 CONSTRUCTION PROCEDURES

206.1 Specifications

206.1.1 Before any earthworks are commenced, areas of cut and fill should be clearly defined. Where necessary, sufficient fencing or barriers should be provided around trees or other features to be protected. All site activities including clearing, storage, cutting and filling should be kept away from the root zone of trees (best defined as the extent of the canopy). Adequate provision should also be made for the control of erosion, surface water run-off and siltation.

206.1.2 The normal necessary specifications are to be prepared to control the earthwork construction as follows:

(i) All rubbish, vegetation and debris should be removed from earthworks areas prior to the commencement of topsoil stripping. Areas on which fill is to be placed, or from which cut is to be removed, and haul roads should be stripped of all topsoil and such unsuitable soft or organic material as determined by the soils engineer. Special care should be taken to ensure that organic materials and areas of old uncompacted filling are not overlooked through being overlaid by other soils.

(ii) Stripping should be carried out as a specific operation with areas being stripped in large enough increments to ensure that there is an adequate margin of stripped ground beyond any current cutting or filling operation. Particular care should be taken to ensure that overspill is not left in an uncompacted state anywhere on the site, when constructing temporary haul roads.

(iii) All stripped material should be deposited in temporary stockpiles or permanent dumps, in locations where there is no possibility of the material being unintentionally covered by, or incorporated into, structural fills.

(iv) Where a fill abuts against sloping ground, benches should be cut into the ground to prevent the development of a continuous surface of low shear strength.

(v) Previous drains or similar subsoil seepage control systems should be installed (as necessary) to lead seepage away from all springs and potential areas of ground water under or adjacent to fills in order to -

a. Prevent saturation of the fill before construction of the fill is complete;

b. Prevent internal ground water pressures which would detrimentally reduce shear strengths.

(vi) Subsoil drains should discharge via flexible jointed pipes to an outlet approved by the Engineer, preferably a stable watercourse or a piped storm-water system. The position of all subsoil drains should be recorded on the "as-built' plan.

(vii) The stripped ground surface should be prepared and then inspected by the soils engineer before any fill is placed thereon.

206.2 Fill Construction

206.2.1 The quality of fill material and required control testing should be determined and specified before the placing of fill commences. Fill should be placed in a systematic and uniform manner with near horizontal layers of uniform thickness (less than 225mm) of material being deposited and compacted progressively across the fill area.

206.2.2 Before any loose layer of fill is compacted, the water content should be suitable for the compaction required and as uniform as possible. Any compacted layer which has deteriorated after an interruption in the earthmoving operation, should be rectified before further material is placed over it.

206.2.3 Fill batter faces should be compacted as a separate operation, or alternatively, overfilled and cut back.

206.2.4 Where testing shows the compaction achieved in the field to be below the specified minimum, all material represented by the test should be further compacted or removed as necessary.

206.3 Temporary Drainage and Erosion Control

206.3.1 During the construction period, measures should be taken to prevent excessive water-logging of surface materials yet to be excavated or compacted or both, and to prevent fill material from being eroded and redeposited at lower levels. Such measures should include:

(i) The surfaces of fills and cuts should be graded to prevent ponding.

(ii) Temporary drains should be constructed at the toe of steep slopes to intercept surface run-off and to lead drainage away to a suitable watercourse or pipe storm-water system.

(iii) Surface water should be prevented from discharging over batter faces by drains formed to intercept surface run-off and discharge via stable channels or pipes, preferably into stable watercourses or piped storm-water systems.

(iv) The upper surface of fills should be compacted with rubber tyres or smooth wheeled plant when rain is impending, or when the site is to be left unattended.

(v) The completed battered surfaces of fills should be compacted with sheepsfoot or similar non-smooth compaction plant to reduce run-off velocities.

(vi) Silt traps and retention ponds should be constructed where they are feasible and necessary. These should be cleaned out, as required to ensure that adequate silt storage is maintained.

(vii) Temporary barriers or fences choked with brush, sacking or the like, should be used to reduce flow velocities and to trap silt.

(viii) Section of natural ground should be left unstripped to act as grass (or other vegetation) filters for run-off from adjacent areas.

(ix) All earthwork areas should be retopsoiled and grassed or hydroseeded as soon as possible after completion of the earthworks and drainage works.

206.4 Inspection and Quality Control

206.4.1 The soils engineer should provide an adequate level of inspection and testing, in order to enable him to evaluate properly the general quality of the finished work, and to enable him to furnish a report as to the compliance of the work with the specifications. This is not to be construed as a guarantee or warranty but rather a record of his professional opinion based on reasonable care.

206.4.2 Visual inspection should be made by the soils engineer or a competent inspector acting on his behalf at the following times:

(i) After any part of the existing ground has been finally stripped and prepared and before the placing of any fill on that ground.

(ii) After any drain has been installed and before the drain is covered by fill.

(iii) At such other times as the soils engineer considers necessary to enable him to assess the general standard of earthworks and to reasonably satisfy himself that -

a. Fill is not placed over soft or organic material;

b. All areas of existing ground showing seepage or potential seepage emission have relief drains provided;

c. Compaction operations are systematic, the water content of fill material appears on visual inspection to be suitable and the degree of compaction appears to be consistently satisfactory.

206.4.3 During the construction of earth fills some or all of the following quantitative control test should be made on the fill material:

(i) Tests to determine whether the water content is suitable;

(ii) In situ density tests to determine whether the degree of compaction is up to the specified minimum;

(iii) Where appropriate tests to determine the maximum dry density for the soil tested in each in situ field density test;

(iv) Such other tests as may be specified by the soils engineer for control testing of fills or particular soil types, providing that the soil property tested shall be related to in situ density or water content of the fill by a laboratory investigation. Such tests include shear

strength tests, cone penetrometer tests, and other Proctor needle tests.

206.4.4 Once the filling work is progressing as a steady operation with uniform construction methods, and provided that -

(i) Adequate construction effort is being maintained;

(ii) Adequate visual inspection is being maintained;

(iii) The specification requirements are being met.

Then minimum frequency of control testing shall generally be one in situ density test (or equivalent) for each 2000m3 or 1.0m lift of fill. Testing shall be more frequent than specified above, under any of the following circumstances:

a. During the first 4000m3 of filling carried out on the project.

b. On the final layer of not less than 1.0m depth.

c. When soil type or conditions are variable.

d. When the soils engineer or his inspector is in any doubt about the adequacy of construction methods or soil properties.

e. When a decision to reject work based on the judgement of the soils engineer or his inspector is disputed, and;

f. When relatively small quantities of fill are concentrated in localised areas or placed discontinuously over a long period of time.

206.4.5 The locations of tests should be decided by the soils engineer or his inspector, who should select them so as to test material likely to be furthest from the specified quality. In addition, a proportion of tests should be taken at random locations to check the average standard being obtained.

206.4.6 All field and laboratory test data should be recorded in a systematic manner that will allow the results to be identified and allow the calculations to be checked at a later date, if necessary. All control test results should have recorded the time, date, location and elevation. Test results relating to sections of fill that have been subsequently removed or reworked and recompacted should be noted accordingly.

207 FINAL DOCUMENTATION

207.1 "As-Built" Drawings

207.1.1 On completion of the earthworks an "as-built" plan should be prepared showing the extent and depth of fill in the form of lines joining all points of equal depth of fill at vertical intervals of for example, 500mm or 1m as appropriate. The "as-built" plans should also record the position, type and size of all subsoil drains, and their outlets. The plans should also show areas of filling of low density and any fill areas which the soils engineer considers do not comply with this Standard.

207.2 Soils Engineer's Report

207.2.1 On completion of construction, the soils engineer should furnish for the engineer a report describing the extent of the inspection and the results of testing together with a statement of professional opinion as to the compliance of the filled ground to the specification, the suitability of filled ground for specified types of building construction, and where applicable, the suitability of original ground for specified types of building construction.

An acceptable format for this statement of opinion is included as Appendix B. An alternative format is given in Appendix B of NZS 4431.

See also 202.2