AS3798 – 2007 GUIDELINES ON EARTHWORKS FOR COMMERCIAL AND RESIDENTIAL DEVELOPMENTS – RECENT REVISION

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ABSTRACT

The paper presents an outline of the recent revisions to AS 3798 – Guidelines on earthworks for commercial and residential developments.

1 INTRODUCTION

AS 3798 – Guidelines on earthworks for commercial and residential developments – was first released in 1990. This was followed by a "roadshow" wherein Standards Australia sponsored an afternoon of presentations in most capital cities; these were well attended and, partly, led to the early adoption of the standard by many practising civil engineers. The Standard was revised in 1996 to account for many changes in AS 1289 – Method of testing soils for engineering purposes. More recently the third edition was released in February 2007. It is the authors' opinion that the Standard has been a useful document and aged well, both revisions introduced only minor changes. This paper provides a commentary on the changes introduced in the latest revision of AS 3798.

Unfortunately, most professional's contact with the Standard appears limited to Table 5.1 – Minimum relative compaction – with the advanced professional referring to Table 8.1 – Frequency of testing – in their black periods. This is a shame as these two tables, while important, are only a minor part of the Standard. It is hoped that this paper will make a wider group of professionals conversant with more of the Standard.

The authors are respectively a member and the chairman of the Standards Australia committee responsible for drafting the Standard and have been so since the committee was form in the 1980s.

2 GENERAL

The objective of the Standard has not changed and is given in the Preface as *"to provide guidance to those responsible for or involved in the design, specification and control testing of earthworks for commercial and residential developments."* The Preface continues and makes the point that the Standard is a guideline and an informative document only. This is far too often overlooked by both engineers and lawyers.

The Preface states that the Standard will be referenced by the Building Code of Australia (BCA) 2008. Notwithstanding this the Standard contains no instances of "shall" and only one "must", in Section 7.3 *"It must be appreciated ..."*.

Section 1.1 – Scope – has been enlarged and now states that the Standard:

- "*is not intended to be sufficient for medium or high density residential development without due consideration by a suitably qualified professional."*
- excludes pavements, major roadworks and water-retaining structures,
- limits fill depth to which the standard is applicable to 5 m.

It may be adopted for such works on advice from a suitably qualified (geotechnical for over 5 m) professional.

Definitions have been added or modified:

- Cohesive soils may include well-graded granular materials such as crushed rock.
- Compaction and consolidation are defined.

- A "lot" is defined as *"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."* This definition is fundamental to the testing and acceptance of work completed using a performance specification (ie specified relative compaction). It was the experience of the committee that even though the "not one to fail" criterion had been in the Standard since its inception it was not universally applied or understood. The Standard has been revised to firm up this position.

Designated personnel are expanded in Section 1.3 to include *"the geotechnical professional"* and the geotechnical testing authority (GTA) has become either a GTA or a GITA (geotechnical inspection and testing authority)! If you can wait, further details are provided in Sections 7 and 8 of the Standard.

Section 2 – Investigation, planning and design – is virtually unchanged. Factor (g) Drainage has been extended to advise *"the placement of fill or construction of cuts may impact the flow of subsurface water and may lead to localised instability. Special provisions may be necessary to account for the potential effect of the works in this situation."*. At Factor (v) "geotextiles" have become "geosynthetics" and Factor (z) potential acid sulfate soils has been added.

Section 3 – Documentation – has only minor editorial changes. It now notes that materials to be removed from site may require classification. Construction records have been extended to include records of test rolling, if undertaken, and sources of fill in various zones, where applicable.

The authors note that, although not new, the Standard states *"the functional requirements of the design should be documented in the specification and drawings for the earthworks project."* It is our experience that many designers appear to consider that a statement that "work should be in accordance with AS3798" often with contradictory compaction requirements is a satisfactory specification for any and all earthworks. This is not the case.

3 MATERIALS

Section 4 – Materials – has only minor revisions. The section on pavement materials has been deleted as it is now out of scope.

Section 4.1 acknowledges that the Standard applies to imported material as well as material from cut to fill operations. Further it explicitly comments that the usual form of specification only indirectly considers the properties most relevant to earthworks, ie shrink-swell and stiffness.

Section 4.2 notes that material sourced on site are likely to be known to the designer and thus may allow a more relaxed approach than for imported materials.

In Section 4.3 – Unsuitable materials – fill containing wood, metal, plastic, boulders or other deleterious materials is considered to be unsuitable if those materials are *"in sufficient proportions to affect the required performance of the fill"*. While this may have been considered by many to be implied in the previous edition, it is now clearly stated.

The authors note that the first paragraph of the next section should be at the end of Section 4.3.

There are minor edits to Section 4.4 – Suitable materials. It is still the position that most naturally occurring soils and weathered rock can be used to form a structural fill. Two new materials have been added to those that may require special consideration – potential acid sulfate soils and materials that cannot be tested to demonstrate compliance with the specification. This later group reflects the frequent problem in many designs that (i) quote AS 3798 and (ii), say, a minimum relative compaction of 98% and (iii) allow material with greater than 20% retained on the 37.5 mm sieve. In as much as this is a specification it is internally contradictory and has led to, or been significant in, many disputes. Changing (iii) to require less than 20% retained on the 37.5 mm sieve can be very costly for little, if any, benefit but not doing so means there is no performance criterion as all the test methods in the Standard require this.

The authors point out that, in their opinion, designers should not specify material properties, eg plasticity, grading or CBR requirements, unless the property is required to achieve the design objective. Once such properties are specified several non-trivial contingent issues need to be addressed. As materials change during compaction, such tests can often only meaningfully be undertaken on the compacted material and have a relatively long "turn around" time. While not the only problem raised this has the potential to seriously impact on the earthworks schedule, again often for little benefit. Other problems frequently encountered include that the frequency (and even method) of such testing is often

not specified or if it is it is usual for it to be considerably less than one test per lot. Thus, when there is a single failure, it is rarely clear to what area/material it actually applies. It is difficult to see how such tests can be used as unambiguous acceptance criteria.

In particular some designers specify a "maximum particle size", often 100 or 200 mm, the authors consider this to be poor practice unless there is a particular performance requirement. The authors note the following issues:

- If relative compaction is used to control density then there should be less than 20% retained on the 37.5 mm sieve (or other requirement if alternate testing is specified) and it is difficult to see that oversize could present a problem. A common exception is in the near surface layers of a fill where there can be a perception, sometimes well based, that large clasts can cause difficulties in excavation for footings and service trenches.
- AS 1289.1.1 contains minimum sub-sample masses. These extend to a nominal maximum size of particle present of 150 mm for which the sample is 125 kg (it is 70 kg for a 100 mm nominal maximum size). Thus the test requires very large samples and hence will often be undertaken on a very infrequent basis (it at all). Further if the maximum size is specified as say two thirds of the layer thickness and the layer is 300 mm maximum thickness then there is no method in AS 1289 (or AS 1141) to control sampling.
- Often "maximum size" is not defined.
    - It is often asserted that maximum size is that of a particle that passes a sieve of the nominated size. This raises two issues, firstly as discussed in the previous point, that there is no test method above 150 mm and secondly that a sieve measures the intermediate dimension of a particle, ie a 100 mm diameter pipe passes through a 150 mm sieve.
    - The clearest definition is along the lines of "maximum dimension in any direction", while clear this cannot be established other than by physical measurement (eg by calipers). Thus compliance can only be proven by removing and measuring every single particle in the works. Non-compliance can be proven by finding a single non-complying particle.
- Contractors will sometimes attempt to comply with such a specification by "screening" the material but this commonly involves "grizzlies" or bar screens. This only controls the minor dimension of a particle, ie a 100 mm thick concrete slab can pass through a 150 mm grizzly.
- When testing is completed it will often be at a tenth or less of the frequency of the density testing. When a single test fails it is not clear to what material it refers (unless tied to say a "superlot") and it might well be asserted that it applies to several days work now buried under several more recent days work.
- It is important for the superintendent to be pragmatic, especially if there is a maximum size specification. In the authors' opinion it would not be out of order to accept the occasional "plum" in the fill.
- Finally all of the above is fertile ground for disputes for little, if any, benefit..

4 COMPACTION CRITERIA

There are many changes to Section 5 – Compaction criteria – but these are generally to clarify matters that previously may not have been clear. The criteria are still on a "no value to be less than" (properly "not one to fail") and are provided on the basis of historical data that have been found to deliver acceptable performance. The Standard does not provide guidance on statistical acceptance criteria. Several paragraphs in Section 5.1 have been moved to other parts of the Standard but not deleted. While strongly endorsing the "not one to fail" acceptance criterion, the authors note that such a criterion requires a rational contractor to undertake the absolute minimum frequency of testing as any additional tests do not increase the likelihood of acceptance but do increase the likelihood of rejection.

Section 5.2 – Compaction of soils – and Table 5.1 – Minimum relative compaction – applies to soils that contain less than 20% by mass of particles coarser than 37.5 mm after field compaction. Changes to Table 5.1 and its notes include:

- Pavement base and sub-base courses have been deleted, thus all references to density ratio are for standard compactive effort.
- Minimum density indices for cohesionless soils have been increased by 5%.
- Hilf density ratio is included in Note 1.
- Note 4 recommends that the designer, in association with a geotechnical professional, assess the load carrying capacity and expected deformations.
- DCP testing is included in Note 6.

Along with several comments from the previous Section 5.1, the Standard recommends that *"advice from a geotechnical professional should be taken in relation to relative compaction and placement moisture contents."*

Section 5.3 – Placement moisture content – is a new section that adds to advice previously in Section 5.1. This section contains almost mandatory wording *"for potentially reactive or moisture-sensitive soils it will be necessary to specify a range of moisture content ..."*. It does not say (but probably should as in Section 4.1) that this is more important near the surface than at depth. The Standard now suggests that control may be by moisture variation or a percentage of the standard optimum moisture content.

Section 5.4 – Coarse material – suggests that a method specification may be adopted for such materials. The authors note that the RTA (NSW) has test methods that allow for more than 20% retained on the 37.5 mm sieve.

Section 5.5 – Test rolling – has replaced the acceptance criterion of *"capable of withstanding test rolling without excessive deflection"* to *"without visible deformation or springing"*. *"Excessive deformation"* was not defined in the Standard and thus was left to the GTA, but the GTA could not know what was in the designer's mind. The revised criterion is observer dependent but if there is any doubt *"the opinion of the designer should be sought."* The plant for test rolling has been revised and is now generally larger than recommended previously.

Unprocessed waste materials are distinguished where previously waste materials were discussed. This reflects the increased use of recycled concrete, etc, in work as a high quality material. There are minor changes to the wording regarding trench backfilling.

Reference is made to impact rolling.

5 CONSTRUCTION

There are many minor editorial changes to Section 6 – Construction.

In Section 6.1 – Site preparation:

- Topsoil has become "topsoil and severely root-affected soils" with regard to site stripping.
- The depth of foundation preparation has been reduced from 200 mm to 150 mm.
- A section on off-site disposal has been added.

Although often replaced by boiler plate text on drawing, Section 6.2 – Fill construction – still recommends *"the thickness of each fill layer should be appropriate to the equipment to be used and test procedures to be adopted"*. This is now followed by some specific advice on layer thickness.

Following the discussion in the earlier section on materials, the word "generally" has been added to *"the maximum particle size of any rocks or other lumps within the layer, after compaction, generally should not exceed two-thirds of the compacted layer thickness"*. The authors note that it was impossible to prove compliance with the previous wording (save by complete removal and measurement of the fill) and was relatively easy to prove non-compliance. This was a serious matter as there is no practical way to ensure that any fill material absolutely complies with the previous wording. The revised wording avoids this issue. A possible option is to specify that particle should protrude from the layer after compaction; such a clause allows for ready compliance testing with Level 1 control and achieves a workable grading (especially if there is less than 20% retained on the 37.5 mm sieve).

Fill compaction has been revised to reflect lot testing and compliance with the specification rather than density test result below a specified level. Fill against structures has been revised to include fill in trenches.

6 METHODS OF TESTING

Section 7 – Methods of testing – has been revised to reflect the renumbering of some of the AS 1289 tests since 1996. Comments on cement modified material have been deleted as they applied primarily to pavement materials. Section 7.4 has been revised to reflect AS 1289 requirement for a one to one reference density and no longer permits relaxation of this.

Section 7.5 allows for different test procedures. Section 7.7 requires that samples for reference density testing be prepared in accordance with AS 1289.1.1, there are other minor editorial changes.

7 INSPECTION AND TESTING

Section 8 – Inspection and testing – has been revised to include the previous Section 8 and Appendix B. There has been a tendency for some GTAs to concentrate on density testing and to a lesser extent on subgrade stripping; often little attention has been paid to any other requirements of the specification. The authors' common experience is that often the GTA does not even have a full copy of the specification and drawings.

There are now only two levels of control. It is recommended that both a GITA or a GTA be independent, with the expectation that this independence will be increased by the engagement being by the owner or engineer rather than the contractor.

Under Level 1 inspection and testing, the Standard has been revised to emphasise that the GTA, now the GITA, should be inspecting as well as testing in order to be able to provide an opinion on the compliance of the works with the specification and drawings. In the past, it has been the case that often such an opinion was not requested with the initial brief and was not required as part of a Level 1 control. It is now the default position. The GITA is responsible for ensuring that the inspection and testing is sufficient to be able to express such an opinion.

Under Level 2 the GTA will carry out sampling and testing and report results thereof.

Section 8.7 – Frequency of testing – has been revised to clarify the logic and restates the "not one to fail" philosophy.

8 APPENDICES

Appendices have been revised. Appendix A – Referenced documents – has been updated. Appendix B moved to Section 8. Minor revisions to what are now Appendices B and C. Appendix D modified to reflect a textbook rather than proprietary equipment supplier source.