

# ROADWORKS SPECIFICATION

R23 SUBGRADE ZONE

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**REVISION REGISTER**

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	R23.1	Clause reworded		
	R23.2-R23.5	New clauses added		
	R23.6	Replaces previous R23.2 clause, clause reworded		
	R23.7	Replaces previous R23.3 clause, clause reworded		
	R23.8	Replaces previous R23.4-R23.6 clauses, clauses reworded		
	R23.9	Replaces previous R23.7 clause, clause reworded		
	R23.10	Replaces previous R23.8 clause, clause reworded		
	R23.11	New clause added		
	R23.A,B&C	New appendices added		

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### R23.1 SCOPE

This specification sets out the requirements for the subgrade zone in excavations and on embankments. It applies to new roadwork construction and to works on existing road pavements where the works involve the exposure of, or the construction of, the subgrade zone and pavement.

The provisions of this specification cover:

- the quality requirements of imported materials used to construct the subgrade zone on embankments, and in cut and the exposed subgrade under an existing road pavement where excavation and replacement of the subgrade is judged to be required
- methods of assessment of the condition and compliance of exposed subgrade zone materials in cut and below existing pavements, including the representative Insitu CBR and proof rolling procedures
- construction of the subgrade zone including remedial treatments for exposed subgrade zones in cut, compaction, dimensions and shape tolerances
- evidence of compliance
- measurement and payment
- hold points.

### R23.2 OBJECTIVE

The objective is to provide a subgrade zone that meets or exceeds the requirements of the pavement design to assist in achieving a stable, durable pavement.

### R23.3 REFERENCES AND STANDARDS

Subgrade construction shall be compatible with the provisions of all DIER standard specifications for Design, Construction and Maintenance in particular:

- G1 - General Provision
- G2 - Contract Management Plan
- G3 - Traffic Management
- G4 - Compaction Assessment
- G6 - Production of Aggregate and Rock Products
- G9 - Product Quality
- G8 - Construction Survey
- R22 - Earthworks

Subgrade construction shall also be compatible with a number of Australian Standards and Austroads Guides:

#### *Australian Standards*

- AS 1348 – Road and Traffic Engineering – Glossary of Terms
- AS 1289.6 – Methods for Testing Soils for Engineering Purposes.

#### *Austroads Guide to Pavement Technology*

- Part 2 – Pavement Structural Design
- Part 4 – Pavement Materials
- Part 4I – Earthworks Materials
- Part 5 – Pavement Evaluation and Treatment Design.

### R23.4 DEFINITIONS

Further to the documents referred to in *Clause R23.3 References and Standards* the following definitions shall apply:

*Formation* - the surface of the finished earthworks, excluding cut and fill batters.

*Note: the location of the formation relative to the subgrade is different for pavements constructed in cut and fill.*

*Subgrade* – the trimmed or prepared portion of the formation on which the pavement is constructed.

*Subgrade Zone* – In a cutting, the subgrade zone is the layer 200 mm below the formation. In a fill, the subgrade zone is the nominal 200mm layer above the formation. Refer to Figure R23.1.

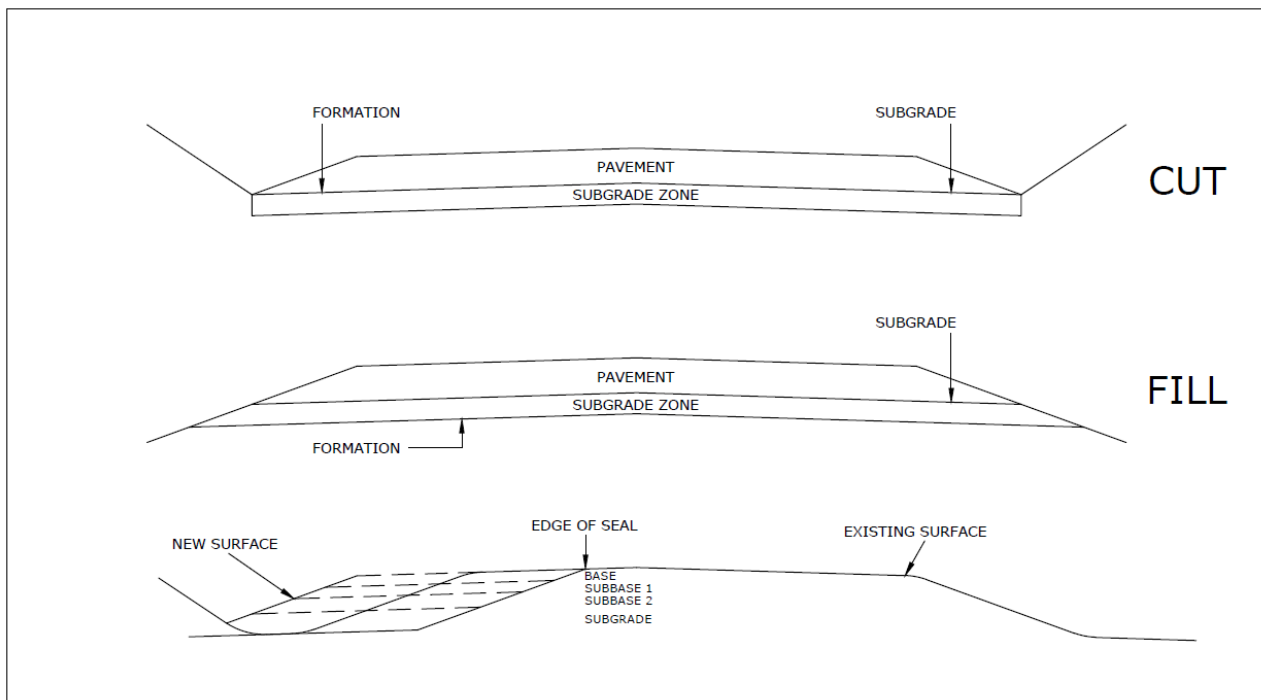
*Unsuitable material* – material that is soft, excessively wet, unstable or otherwise not suitable for the specified purpose.

*Lot* - a uniform piece of work brought to completion at the same time, using identical materials and construction practices. Cuts and fills shall not be included in the same lot.

*Representative CBR*- A value determined in accordance with this specification which is used to assess compliance with this specification.

*Rock* – as detailed in *Standard Specification Clause R22.8.2 Classification of Material to be Excavated*.

**Figure R23.1 – Typical Subgrade Zone and Pavement Widening**



## R23.5 CONTRACT MANAGEMENT PLAN

Further to *Standard Specification G2 Contract Management Plan*, the Contractor's Contract Management Plan (CMP) shall include:

- details of the equipment, rolling and inspection procedures to be used for proof rolling
- cross references between lot numbers allocated and the unique product number.

## R23.6 MATERIALS

### R23.6.1 General

Materials for the subgrade zone shall:

- be free of unsuitable materials, vegetative and other deleterious matter
- have an assigned California Bearing Ratio (CBR) not less than that required by the Project Specification.

### **R23.6.2 Compliance Of Materials And Representative CBR**

Unless specified elsewhere in this specification, compliance of materials and the Representative CBR will be based on the soaked CBR determined by laboratory test *AS 1289.6.1.1*. The CBR test shall be performed on samples compacted to a Dry Density Ratio of 100% (standard compaction) at a moisture content within  $\pm 10\%$  of Optimum Moisture Content (OMC) and after a 4 day soak.

Laboratory testing shall be undertaken at the rate of 1 test for every 1000m<sup>2</sup> of subgrade.

Material passing the 53mm sieve but retained on the 19mm sieve may be replaced by material passing the 19mm sieve but retained on the 4.75mm sieve, provided that the amount replaced on a dry weight basis, shall not exceed:

- the amount passing the 53mm sieve but retained on the 19mm sieve
- 25% of the portion passing the 19mm sieve.

Materials with more than 20% retained on the 37.5mm sieve are not required to be tested by the soaked CBR test method. The Representative CBR shall be estimated from *Table R23.1 – Subgrade Zone - Representative CBR Values*.

**Table R23.1 – Subgrade Zone - Representative CBR Values**

Property			Assigned CBR
% passing 2.36 mm sieve	% passing 19 mm sieve	Liquid limit	
>35	< 70	<55	8
<35	< 70	<55	10
< 10	< 40	No requirement	15

The Representative CBR of materials complying with Subbase 2 of *Standard Specification R40 Pavement Base and Subbase* is 15.

### **R23.6.3 Imported Materials for Subgrade Zone**

The following applies to materials imported onto the project from an external source or from a source within the project. Materials not complying with this specification shall not be imported.

The maximum particle size of imported material after breakdown in place shall not exceed 100 mm.

The Representative soaked CBR of imported materials shall equal or exceed the minimum CBR defined in the project specification. If not defined in the project specification or elsewhere in this specification, the soaked CBR shall be equal to or exceed 5%.

Imported materials with the following properties shall be accepted as having a soaked CBR of 5%, when:

- the product of the PI and % passing the 0.425mm sieve is less than or equals 1200, provided that the PI does not exceed 30 and the percentage passing the 0.075mm sieve does not exceed 40%
- the material is classified under the Unified Classification Scheme as SW, GW, SP, GP, SM, GM (refer *Appendix R23.C*).

Prior to the use of an imported material, the Contractor shall provide the Superintendent with:

- a report on the source of the material
- where the material is from an external source, evidence of the necessary permits and licences, in accordance with *Standard Specification G1 General Provisions Clause G1.6*

- test results as evidence of its likely compliance. All tests from the intended source shall be provided
- a reference sample
- an inspection and test plan covering the intended source. The Contractor must give due account of the likely variation in the composition of materials from the intended source
- the intended destination/location, lot number and chainage, of the imported material.

Where the evidence of compliance is based on laboratory measured soaked CBRs, the Representative soaked CBR shall be the minimum of three (3) tests.

The Superintendent, if not satisfied with the evidence of likely compliance and/or is of the opinion that the inspection and test plan will not ensure a complying product, may reject the source or define an alternative and/or enhanced inspection and test regime.

The Contractor shall keep up-to-date records of the results of all tests from each source. The recording of test results shall be completed within 3 working days of the completion of each test.

Any non-compliance shall be reported to the Superintendent within 24 hours of the completion of the testing.

#### **R23.6.4 Subgrade Zone in Excavation and Low Embankment**

In addition to the provisions of R23.6.1, the subgrade zone shall not include material in which the product of the Plastic Index and percentage passing the 0.425mm sieve exceeds 1800, unless approved by the Superintendent.

### **R23.7 FIELD ASSESSMENT OF SUBGRADE ZONES IN EXCAVATION**

#### **R23.7.1 General**

The following applies to subgrade zones in excavations and low embankments or below existing pavements and shoulders on which a new pavement is to be constructed.

*Note:*

*The purpose of these assessment procedures is to determine if the material at formation level complies with the specification and, in the event of non-compliance the nature and extent of remediation requirements.*

The results of the testing, including the location and extent of any non-compliance, shall be provided to the Superintendent within 24 hours of the completion of the testing. Non-compliance will include Representative Insitu CBRs less than the specified value and the occurrence of deformation and springing during proof rolling. Locations shall be defined in terms of the Contract chainage (nearest 10m) and offset (nearest 1.0m).

#### **R23.7.2 Assessment of Insitu Material by Penetrometer**

In-situ field assessment shall be undertaken using either the Farnell Penetrometer (in accordance with *Appendix R23.A*) or Dynamic Cone Penetrometer (DCP) (in accordance with *AS 1289.6.3.2* and *Appendix R23.B*). In the event of a disparity between the Farnell and DCP test data, the Farnell data shall apply.

In-situ field testing shall be undertaken at the rate of 1 for every 200 m<sup>2</sup> of subgrade.

The testing, whenever practical, shall be undertaken when the cut level is in the order of 100mm above formation level and extended to at least 100mm below the subgrade zone.

In the event that the Representative Insitu CBR is less than 50% of the mean of all the tests within the lot, the Superintendent may determine further testing within the region of the representative test result.

**R23.7.3 Assessment of Insitu Material by Proof Rolling**

Where material is judged to be unsuitable for assessment by a penetrometer in accordance with *Appendices R23.A and R23.B* the following shall apply.

The Contractor shall notify the Superintendent within 24 hours of the exposure of the subgrade zone. As a prerequisite to making a direction as to the required treatment of the subgrade zone, the Superintendent may direct that proof rolling of the subgrade be undertaken.

Plant for use in proof rolling procedures shall comply with the following requirements:

**Option 1**

- the rear tyres of static smooth steel wheeled rollers of more than 12,000kg operating mass
- pneumatic tyred roller of 15,000kg operating mass.

**Option 2**

- 10 yard truck with rear double axle fully loaded weight 24,000kg (12,000kg unloaded)
- water cart with rear double axle fully loaded weight 24,000kg.

The surface of the subgrade shall be watered and given a minimum of three passes with the proof roller prior to commencement of proof rolling.

Proof rolling shall be conducted immediately following completion of compaction. The Contractor shall give the Superintendent at least 24 hours notice prior to this proof rolling.

The Superintendent shall determine if the material is acceptable, based primarily on the requirement that there is not an unreasonable amount of visual deformation.

**R23.8 CONSTRUCTION****R23.8.1 General**

Subgrade zones within cuts and below existing pavements that fail to comply with the requirements of this specification may be required to be remediated in accordance with the requirements of this clause.

Imported materials shall be placed in accordance with the requirements of this clause.

**R23.8.2 Excavation in Materials other than Rock**

The Superintendent may direct remediation of the subgrade zone not complying with this specification or where:

- the Representative Insitu CBR is less than the specified value;
- the subgrade deforms excessively under proof rolling.

Remediation may include but not be limited to:

- excavation and replacement to a nominated depth with a complying material;
- re-compaction to 100% Dry Density Ratio (standard compaction) and between 80 to 110% of Optimum Moisture Content (OMC);
- loosening of the surface to a depth determined by the Superintendent, drying to OMC or below and re-compaction to 100% dry density ratio (standard compaction);
- Insitu stabilisation;
- geotextile reinforcement, or geogrid reinforcement or both;
- increase in pavement depth;
- drainage blanket.

Prior to giving direction concerning remediation, the Superintendent may direct a recalculation of the Representative CBR based on the formula  $CBR = \text{Cone Index} / 20$ . Refer *Appendix R23.A Note 3*.



**R23.8.3 Excavation in Rock**

Excavation in rock in the subgrade zone shall be in accordance with *Standard Specification R22 Earthworks Cause R22.3.1 (ii) and (iii)*.

**R23.8.4 Low Embankments**

Where the design formation level is less than 200 mm above the foundation of the embankment in areas other than rock, the material shall be excavated to 200mm below the design formation level. The subgrade zone shall then be constructed.

**R23.8.5 Compaction of Imported Materials**

Materials shall be compacted to a characteristic Dry Density ratio of 100% (standard compaction) with a moisture content that facilitates compaction in the range between 80 to 110% of OMC.

**R23.8.6 Protection of the Prepared Subgrade Zone**

The subgrade zone shall be maintained in a manner that avoids the ponding of water on its surface. The moisture content of clay subgrades, in cut and under existing pavements, shall be maintained at close to the moisture condition prior to exposure, except when the original moisture content exceeds 110% of OMC, (Standard Compaction). In this event, the Superintendent may direct that the subgrade zone shall be allowed to dry to OMC or below, or direct that a remediation treatment of the kind described in R23.8.2 be undertaken.

**R23.8.7 Levels and Tolerances**

The thickness of the subgrade zone, measured at any point, shall not be less than 180mm. The surface of the constructed subgrade zone which is the formation level, shall lie within +0 and -60 mm of the formation level as shown on the drawings. If not shown, the surface shall be parallel to the pavement surface level.

The surface at any point shall not lie more than 20 mm below a 3m straightedge laid in any direction.

The batters in the subgrade zone shall be a continuation of those in the earthworks and constructed to the same tolerances.

**R23.8.8 Testing for Compaction and Compaction Moisture Content**

Prepared subgrade zones in materials other than those classified as rock shall be tested for compaction and moisture content in accordance with *Standard Specification G4 Compaction Assessment*.

**R23.8.9 Non-Complying Material and Work**

The Superintendent may deem that materials exposed in the subgrade zone of cuts and below existing pavements are unsuitable based on their composition and/or Insitu condition and may direct that the material undergo remedial treatment as defined in *Clause R23.8.2* or direct that other remediation be undertaken.

In the event that a test result or visual evidence indicates a reduction in the quality of an imported material, whereby the imported material may no longer comply, the Contractor shall stop production of that material and submit non-conformance and corrective action reports. The report shall identify where the non-complying material has been placed within the subgrade zone and shall include recommendations for rectification of the non-complying material.

Where non-compliance occurs in imported materials or is deemed by the Superintendent to have been caused by the use of inappropriate construction methods or inadequate protection of the subgrade, the cost of remediation shall be at the Contractor's expense.

### R23.9 EVIDENCE OF COMPLIANCE AND RECORDS

Further to *Standard Specification G1 General Conditions Clause G1.7 Records*, the Contractor shall keep records of:

- location of lot boundaries, determined by changes in subgrade materials, cut and fill and treatment method;
- the nature of subgrade treatment in cuts and where used, the method of proving the subgrade by either Insitu CBR tests or by proof rolling;
- the source of any imported material used within a particular lot;
- results of laboratory and field test results for each lot.

Test results shall include:

- particle size distribution, Atterberg Limits and the Plastic Index x percentage passing the 0.425mm sieve and /or whichever is appropriate, Laboratory Soaked CBR test results including maximum density and OMC of imported materials;
- field compaction test results as defined in *Standard Specification G4 Compaction Assessment, Clause G4.6.3*;
- Insitu CBR test results as defined in *Appendices R23.A and R23.B*;
- the location of zones within each lot where non-compliance occurred in the Insitu CBR tests and/or in the proof rolling.

The above records shall be made available for inspection by the Superintendent on request and shall be included with the Completed Works Reports.

The Contractor shall submit subgrade Insitu CBR, compaction and subgrade surface level results to the Superintendent with the Hold Point release request.

### R23.10 MEASUREMENT AND PAYMENT

Further to *Standard Specification G1 General Provisions Clause G1.18.2*, when field measurement of subgrade zone preparation is undertaken payment shall be for the compacted in-place volume to a depth of 200mm below formation level within the design parameters at the relevant Schedule of Rates items.

There shall be no payment for re-instatement of over excavation, or areas of unsatisfactory materials or work methods.

Payment for low embankments excavation and placement of fill shall be at the relevant Schedule of Rates items.

The Contractor shall be responsible for any damage to the prepared subgrade surface caused by traffic, weather, flooding and other agents. Where damage occurs the Contractor shall reinstate the subgrade to the specified condition at no cost to the Principal.

The cost of laboratory and in-situ testing and proof rolling is deemed to be included in the rate for scheduled item number 2.04.

### R23.11 HOLD POINTS

The following hold points have been identified in this specification:

Clause Ref	Description	Nominated work not to proceed	Evidence of Compliance
R23.6	Materials for subgrade zone	Placement of material in subgrade zone	Test results
R23.7	Assessment of insitu material	Excavation of insitu material	Penetrometer results or proof rolling
R23.8	Top of subgrade	Placement of pavement material	Test results

No pavement material shall be placed on prepared subgrade until the Hold Points are released by the Superintendent.

## **APPENDIX R23.A – ESTIMATE OF THE INSITU CBR USING A FARNELL CONE PENETROMETER**

### **R23.A.1 Scope**

The following describes a method of measuring the Insitu CBR of cohesive fine grained soils using a Farnell Penetrometer. The testing, whenever practical, shall be undertaken when the cut level is in the order of 100mm above formation level and extended to at least 100mm below the subgrade zone.

The Farnell Penetrometer is a proprietary device. It includes a head fitted with driving handles and two rotating scales and steel cones. The CBR cone is the smaller of the two cones. The cones are pushed into the ground via the handles and scaled connecting rods. The reaction of the cone to the soil is measured on the rotating scales within the head. The two scales read Cone Index (CI) and CBR.

The method is limited to CBR's of less than 15. It is not appropriate for cohesionless soils or soils containing significant gravel and stone.

### **R23.A.2 Equipment**

- Farnell Penetrometer head. (Note 1)
- Extension rods
- CBR Cone (30° Cone, not less than 12.5mm diameter) (Note 1)
- Spanner tools
- Recording Sheets

### **R23.A.3 Method**

1. Assemble the instrument, ensuring that the correct (the smaller) cone is selected. Check the connection of the cone to the rod. Check zero on the CBR scale and adjust if required by turning the screw under rubber sleeve with an appropriate Allen Key.
2. Push the penetrometer steadily into the ground at a rate of approximately 10mm per second. Be careful not to bend the rod or to change the direction of thrust. The penetration depth should not exceed 600mm.
3. Record the cumulative penetration (mm) and the average reading on the CBR scale to the nearest 0.5 over each 50 or 75mm of penetration (Note 2).
4. Calculate the average CBR recorded within the subgrade zone at each test site.

### **R23.A.4 Representative Insitu CBR**

The Representative insitu CBR for the subgrade zone is the lowest average CBR recorded within the particular lot, determined in accordance with *Step 4 of R23.A.3*.

### **R23.A.5 Report**

The report shall include:

- The reading interval (50 or 75mm) of the penetrometer rod.
- Table of the measured Insitu CBR at each test interval and the average CBR within the subgrade zone for each test site within the particular lot, including the chainage and offset;
- Representative Insitu CBR;
- The mean of all the test results, calculated in accordance with *Step 4 of R23.A.3*.

*Notes:*

1. *The penetrometer shall have a valid calibration, not more than 2 years old. The load deflection relationship for the CI scale shall be within the range, of 0.95 to 1.05 of Load = CI x 0.225.*

*The Farnell kit contains a template to check the diameter of the cone. The cone should not fit through the hole. The diameter should not exceed 12.7mm. The point should be sharp and not noticeably rounded. The sides of the cone should not be scored.*

- 2. The rods will normally have markings at 75mm. Some are marked at 50mm. Either interval is satisfactory but has to be recorded. The calculation of average values will be based on 3 or 4 readings with the 50mm interval and 2 readings with the 75mm intervals*
- 3. Studies (Black WPM-TRRL Report 901 " The Strength of Clay Subgrades: Its Measurement by a Penetrometer") have indicated that the best estimate of the Insitu CBR is obtained by dividing the Cone Index Scale (CI) by 20. It is recognised that readings based on the CBR scale, below a scale reading of CBR=7, will generally underestimate the Insitu CBR. This inbuilt conservatism is generally acceptable to the Superintendent.*

## APPENDIX R23.B – ESTIMATE OF INSITU CBR WITH A 9 KG DYNAMIC CONE PENETROMETER

### R23.B.1 Scope

The following describes a method of estimating the Insitu CBR of cohesive fine grained soils using a 9 kg dynamic cone penetrometer. The test method follows AS1289.6.3.2 "Soil Strength and Consolidation Tests – Determination of the penetrometer resistance of a soil-9 kg dynamic cone penetrometer test".

The testing, whenever practical, shall be undertaken when the cut level is in the order of 100mm above formation level and extended to at least 100mm below the subgrade zone.

### R23.B.2 Apparatus

As per AS1289.6.3.2.

### R23.B.3 Procedure

Generally as per AS1289.6.3.2 with the following explanations.

1. Record the cumulative penetration (mm) after every second fall of the hammer until;
  - i. The cone has penetrated to at least 100mm below the subgrade zone, or
  - ii. After 20 falls of the hammer when in the event that the cone has not penetrated to 100mm below the subgrade zone.
2. Calculate the penetration (mm) per hammer fall for each of the reading sets of R23.B.3.1.
3. Determine the insitu CBR for each of the reading sets using *Table R23.B.1* and record.

**Table R23.B.1 – Estimation of Insitu CBR**

Penetration (mm) fall	CBR
>90	<2
60-90	2
50-59	3
40-49	4
30-39	5
25-29	7
15-24	10
<15	>10

4. Determine the lowest CBR, averaged over any 150mm depth interval, or thereabouts, within the subgrade zone (Note 1).

### R23.B.4 Representative CBR

The Representative Insitu CBR for the subgrade zone is the lowest average CBR recorded within the particular lot, determined in accordance with *Step 4 of R23.B.3*.

### R23.B.5 Report

The report shall include:

- Table of the number of hammer falls, penetration (mm) and estimated CBR for each test site within the particular lot, including the chainage and offset;
- Representative Insitu CBR;
- The mean of all the test results, calculated in accordance with *Step 4 of R23.B.3*.

#### Notes:

*The estimate should be derived from the whole number of blows to produce approximately 150mm of penetration. The depth interval may range between 100 and 200mm.*

**APPENDIX R23.C – UNIFIED SOIL CLASSIFICATION SYSTEM**

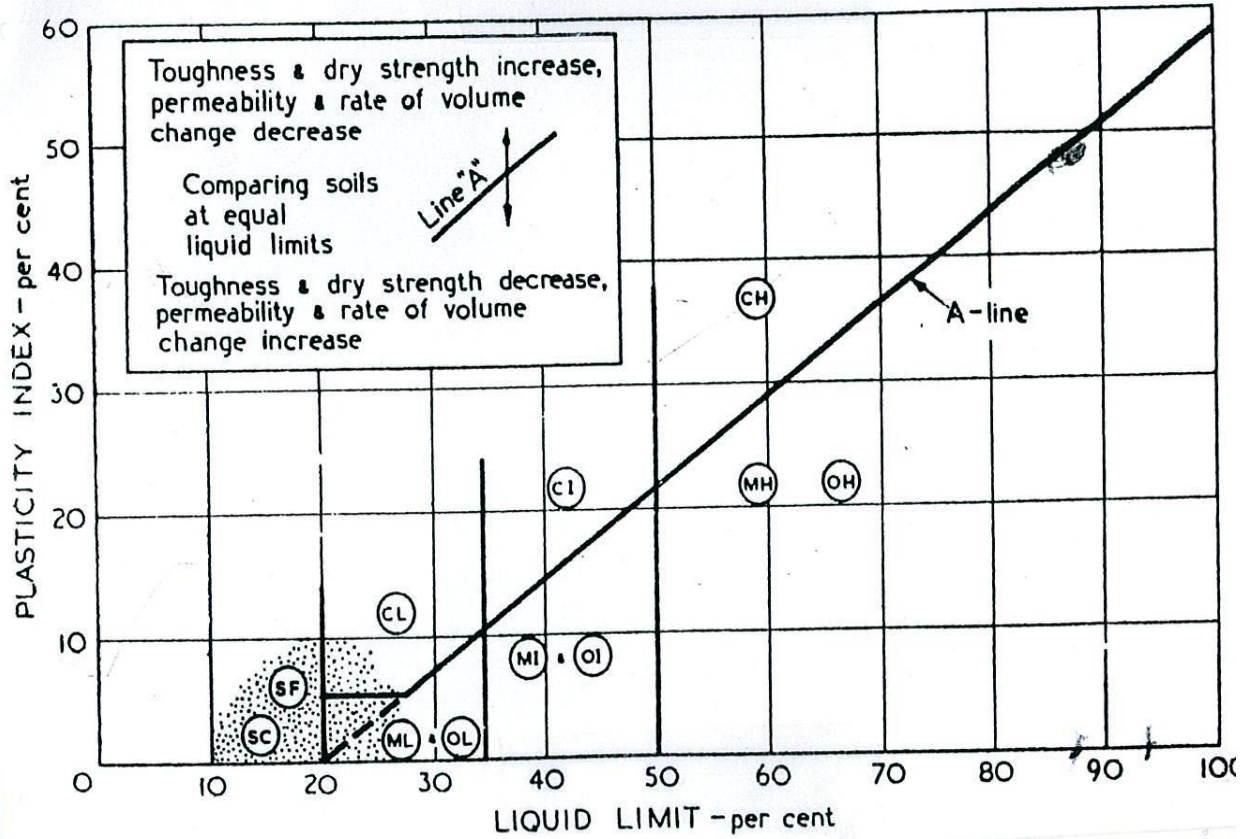
The following is a simplified outline of the Unified Soil Classification system for the portion of material that pass the 63mm sieve. It provides the framework of the system and describes the principal characteristics of the major groups.

Major Divisions		Minor Divisions	Group Symbols	Typical Names & Properties
<b>Coarse Grained Soils</b> >50% of the soil is retained on the 0.075mm sieve	Gravels: >50% of the coarse fraction is retained on the 2.36mm sieve	Coarse: 20-60mm Medium: 6-20mm Fine: 2-6mm	GW	Well graded gravels has wide range of particle sizes with substantial amount of intermediate sizes; low fines, will not bind together.
			GP	Poorly graded gravels, one size or a range of sizes with missing intermediate sizes; not enough fines to bind coarse particles together.
			GM	Silty gravels with excess of non plastic fines.
			GC	Clayey gravel with excess plastic fines sufficient to bind together, medium to high dry strengths
	Sands: > 50% of the coarse fraction passes the 2.36mm sieve	Coarse: 0.6-2.0mm Medium: 0.2-0.6mm Fine: 0.06-0.2mm	SW	Well graded gravelly sand has wide range of particle size with substantial amount of intermediate sizes, low fines, will not bind together.
			SP	Poorly graded sand uniform one size or range with missing intermediate sizes not enough fines to bind coarse particles
			SM	Silty sand with low, dry strength non plastic fines.
SC			Clayey sand with plastic fines sufficient to bind and medium to high dry strengths.	
<b>Fine Grained Soils</b> >50% of the soil passes the 0.075mm sieve	Silts and Clays: With LL < 50% (Suffix: L or I is based on Atterberg Limits) (refer to chart)	M – Silt C – Clay O – Organic	ML	Inorganic silts and very fine sands, rock flour or clayey fine silts with low (L) plasticity
			CL-CI	Inorganic clays of low (L) to intermediate (I) plasticity; gravelly clays, sand clays and silty clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and Clay: with LL > 50% (Suffix: H is based on Atterberg Limits) (refer to chart)	M – Silt C – Clay O – Organic	MH	Inorganic silts, micaceous or diatomaceous earths, fine sandy silts. The red volcanic soils of North Tasmania, classify as MH
			CH	Inorganic clays of high plasticity. They include expansive soils, cracking clays
			OH	Organic clays of medium to high plasticity, organic silts
Highly Organic Soil			Pt	Peat and other highly organic soil

**Notes:**

1. Applies to materials passing 63mm sieve, cobbles (60 – 200mm) and boulders (>200mm) not included.
2. The term coarse fraction refers to material retained on the 0.075mm sieve. The fine fraction refers to material passing this sieve.
3. Note that Atterberg limits are performed on materials passing the 0.425mm sieve.
4. Soils possessing characteristic of two groups are designated by a combination of group symbols.

5. The A-Line in the attached chart determines if a soil is classified a silt (below) or clay (above).







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