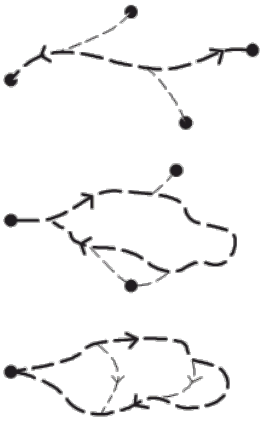
5.3 Tracks

5.3.1 Siting and alignment



Track form
Departure and destination points will define each end of the track. Its shape will be influenced by the form below.

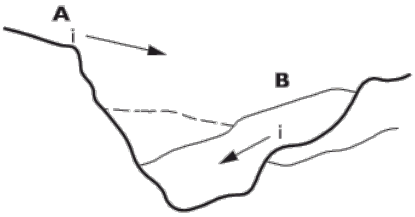
Linear form can be used for both long-distance routes and for short links between related facilities such as parking and swimming areas. Added spurs provide access to features off the main route.

Single loop is preferable to give diversity where a return through different terrrain to the starting point is possible. There is also less wear on the track surface.

Connected loop increases choice of distance travelled and features encountered.

The final plan for a track system can be a combination of the above basic types. Note that simple layouts are easy to follow whereas more complicated systems require very clear track marking and maps to avoid confusing users.

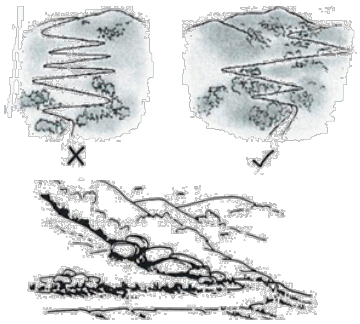
Panorama and features
Aesthetic factors are an integral ingredient of the walking track experience and the success of a track design can be measured by the *quality* of the experience gained.



The design aim should be able to create visual stimulation and exposure to a *variety* of spatial experiences.

The surveyor should seek to permit large-scale vistas (A) so that walkers can orient themselves and understand the geological processes that shaped the landscape. Closer views (B) will enable focus upon details of natural interest.

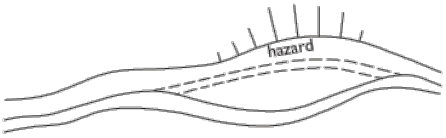
Interpretive opportunities
There are usually intepretive aspects related to track location with the aim of motivating users to develop awareness and understanding of the country they are moving through. There should be liaison between track surveyors and those involved in interpretation at an early stage.



Switchback using natural feature as turning point

Switchbacks
Regular switchbacks can be monotonous, unsightly and encourage shortcutting at corners. It is better to select a more natural line, using obstacles such as boulders or trees at corners.

Proximity of hazards
Alignment should have regard for the implication of hazards adjoining tracks. Where possible the requirement for barriers (as determined by the track classification and height calculations for the hazard) could be avoided by the redirection of alignments away from hazards.



Drainage
Design tracks with consideration for adequate drainage to prevent surface and base course failure.

5.3.2 Standard profiles

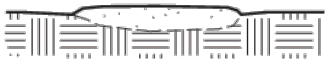
Flat terrain

- The existing ground surface should not be disturbed unnecessarily in order to obtain a base for the track.
- If drainage is needed, track base should be built up rather than cut in.

Built up

Sideslopes

- On sideslopes, benching (cut and fill) of the track formation will be necessary.
- Stable or mineral soils allow the use of the cut soil for 'fill' on the downslope side of the track. This material if stabilised can form the outer part of the track tread.
- However in unstable or peat soils the fill may not be suitable for load bearing, and the track must be on cut only.



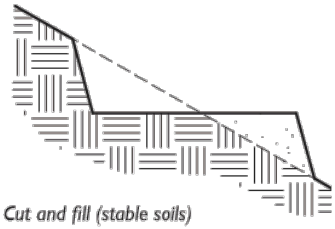
Refurbish eroding track

Cut and fill batter angles

The two primary objectives in sloping batters are to control erosion by establishing slopes that are more nearly natural, thus enabling vegetation to grow on the cut and fill surface, and to reduce the possibility of damage to the track from water saturated batters collapsing.

The slopes of cuttings and embankments are usually made as steep as the material will allow without slipping. While past experience and local example are the best indicators, the following table offers a guide to the maximum slopes that can be considered for varying soil types.

The angle of repose is the greatest angle at which the soil will stand without slippage.



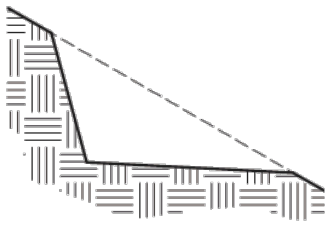
Cut and fill (stable soils)

Batter stabilisation

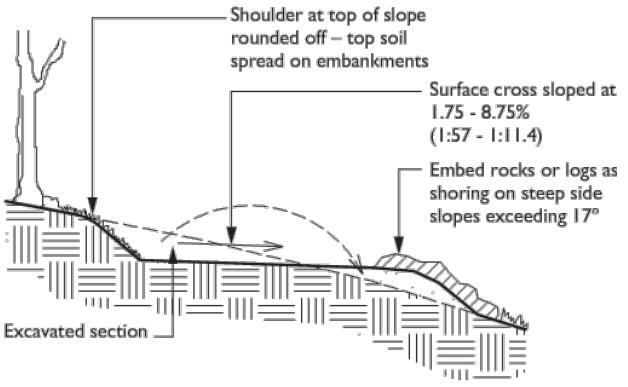
On embankments where erosion is likely to be a problem, plant growth should be encouraged by spreading topsoil and humus.

Shoulders at the top of the excavation should be rounded off to prevent soil from sliding onto the track. Boulders, logs and other debris that might fall onto the track should also be removed. Disturb plants at the top of cut slopes and at the base of embankments as little as possible. Neatly trim exposed roots flush with the soil surface. Do not bury tree bases in fill batters as this may suffocate and cause death of the tree.

Where thorough compaction of fill material is not possible, additional material should be applied once natural settlement has occurred.



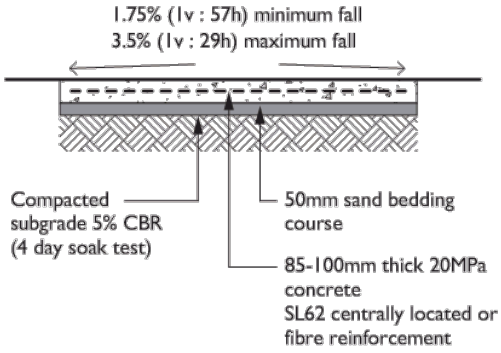
Cut only (unstable soils)



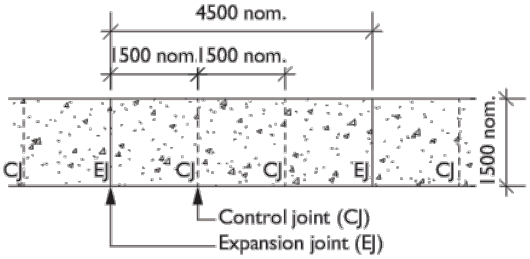
Weight and angle of repose for different soil types

Material	*Condition*	*Angle of repose (° from horizon)*
Sand	dry	30
Gravel	dry	35
	wet	30
Clay	dry	40-45
	wet	33
Loam	dry, loose	40
	dry, firm	45
	moist	45
	saturated	25
Shale / compact	gravelly soil	53-63
Rock		75-90

5.3.3 Concrete

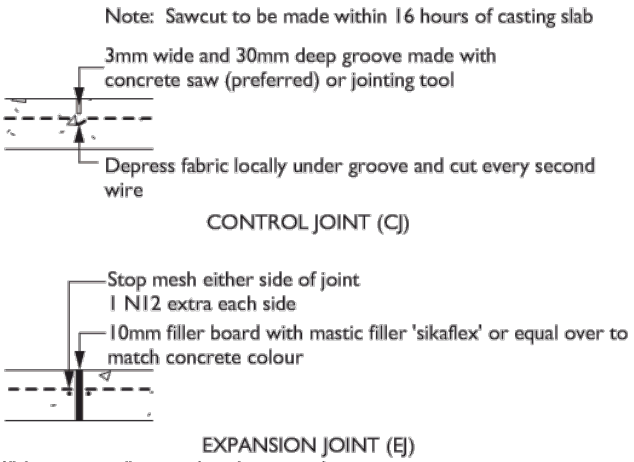


Typical section



The distance between concrete joints varies, generally depending on the width of the path. As a general rule aim to make squares with concrete joints, with every third joint being an expansion joint and all in between joints being control joints
Eg. For a 1500mm wide concrete path (shown above – joints should be at 1500 nom. centres. Therefore each expansion joint is 4500mm apart.

Typical plan – jointing example



All dimensions in millimetres unless otherwise noted

Location
Suitable for Class 1-2 tracks, generally high-use tracks adjoining park focal points such as visitor centres, lookouts, etc

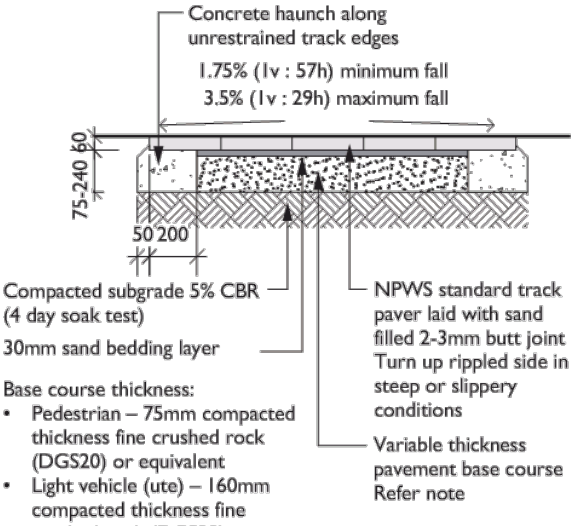
See also *5.3.1 Siting and alignment*

Principles
- Hard-wearing path with long life expectancy and low ongoing maintenance requirements
- Suitable for wheelchair use
- Consider visibility from adjoining areas – if critically viewed and likely to be of visual impact, consider asphalt

Technical
- Concrete and reinforcement in accordance with Australian Standards
- Monitor joints to avoid settlement causing deflections greater than 5mm

Finishes
Range of approved finishes – refer *10.2.8 Concrete* for details:
- Exposed aggregate by light 'washing' or 'honing' of concrete surface
- Broom finish (tooled edges followed by broom finish over top)
- Grey oxide added to any of the above finishes

5.3.4 Paver

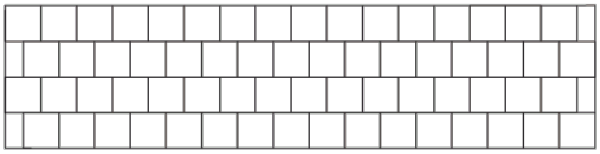


Base course thickness:

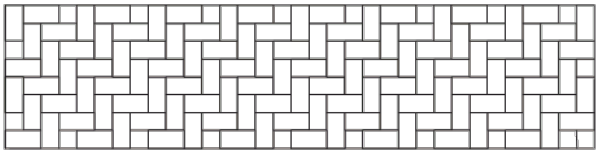
- Pedestrian – 75mm compacted thickness fine crushed rock (DGS20) or equivalent
- Light vehicle (ute) – 160mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Heavy vehicle (single axle) – 240mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Site-specific engineering advice required in areas of problem soil condition, steep grades, etc

Typical section

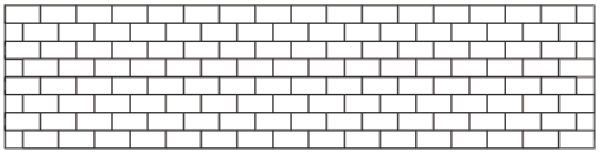
Typical laying patterns



300x300 stretcher bond pattern



300x150 herringbone pattern



300x150 stretcher bond pattern

All dimensions in millimetres unless otherwise noted

Location
Suitable for Class 1-2 tracks

See also *5.3.1 Siting and alignment*

Principles

- Standard size paver that is easily tranportable and can be laid in a curved alignment
- Concrete paver with dark grey colour to blend with a range of natural settings
- A custom made paver with rippled surface has been made previously for NPWS to provide extra grip in slippery condtions
- Smooth surface shall be compliant with class V of AS / NZS 4586 and provide adequate slop resistance for gradients up to 1:14 in general applications (ie not damp)
- Clay brick pavers commonly used in domestic landscapes are not to be used due to the need to promote an image identifiable from other open space managers, the limited colour range, and potential to lose slip resistance over time.

Technical

Paver colour
- Dark grey / charcoal colour

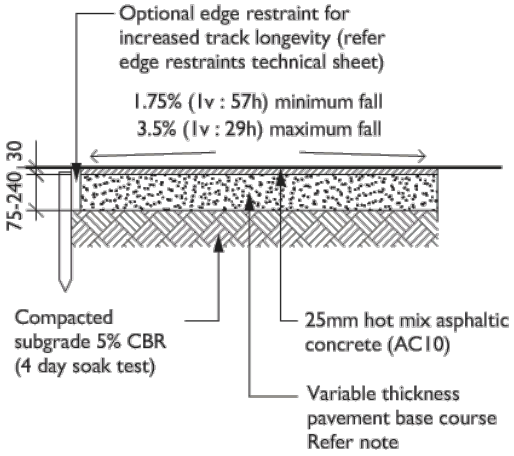
Paver size
- 300x300x60mm or
- 300x150x60mm

Rippled finish
- Optional custom rippled surface on top face

Base course
- Fine crushed rock
- Recycled concrete or brick

Maintenance
- Monitor joints to avoid settlement / deflections greater than 5mm

5.3.5 Asphalt



Base course thickness:

- Pedestrian – 75mm compacted thickness fine crushed rock (DGS20) or equivalent
- Light vehicle (ute) – 160mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Heavy vehicle (single axle) – 240mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Site-specific engineering advice required in areas of problem soil condition, steep grades, etc

Typical section

Location
Suitable for Class 1-2 tracks

See also *5.3.1 Siting and alignment*

Principles

- Smooth surface for wheelchair access
- Bitumen seal reduces erosion of the track surface and pavement failure due to water ingress
- Asphalt can be supplied as hot mix and installed by contractors
- Cold mix generally not recommended as a track surface due to high maintenance requirements
- Small sections can be repaired by preparing and placing and compacting asphalt (cold mix)
- Leaching of bitumen emulsion in sensitive areas may affect plant life

Technical

Wearing surface

- Hot mix asphaltic concrete (AC10)

Base course

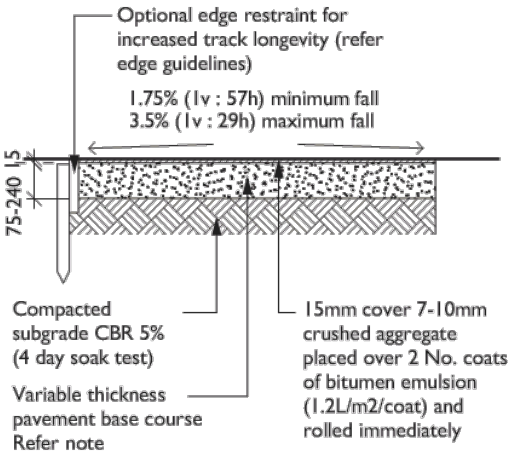
- Fine crushed rock
- Recycled concrete or brick

Edging (optional)

- Stone
- Concrete
- Timber

All dimensions in millimetres unless otherwise noted

5.3.6 Bitumen seal



Base course thickness:
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- Light vehicle (ute) – 160mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Heavy vehicle (single axle) – 240mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Site-specific engineering advice required in areas of problem soil condition, steep grades, etc

Typical section

Location
Suitable for Class 2-3 tracks

See also *5.3.1 Siting and alignment*

Principles
- Bitumen seal reduces erosion and pavement failure due to water ingress
- Bitumen can be supplied hot sprayed by contractors or installed in cold emulsion form by experienced staff
- Small sections can be repaired by preparing the base and applying emulsion and aggregate
- Aggregate can be difficult to walk on in bare feet (eg. beach access) and can be slippery on grades when loose
- Leaching of bitumen emulsion in sensitive areas may effect plant life

Technical

Bitumen
- Refer materials information sheets / 11.10 Bitumen

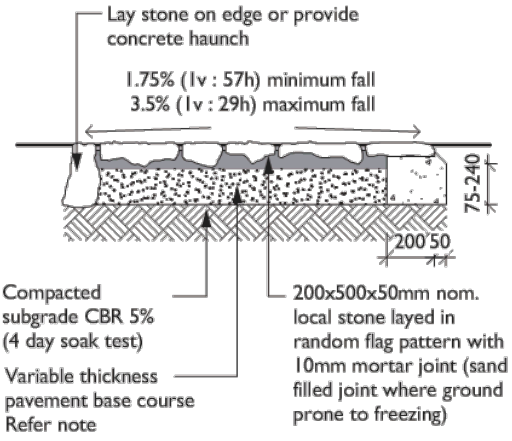
Wearing surface
Crushed aggregate (locally occurring required):
- Blue metal (commonly used)
- Limestone
- Dolomite
- Quartz
- Granite
- Sandstone
- River gravel

Base course
- Fine crushed rock
- Recycled concrete or brick

Edging (optional)
- Stone
- Timber

All dimensions in millimetres unless otherwise noted

5.3.7 Stone



Base course thickness:

- Pedestrian – 75mm compacted thickness fine crushed rock (DGS20) or equivalent
- Light vehicle (ute) – 160mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Heavy vehicle (single axle) – 240mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Site-specific engineering advice required in areas of problem soil condition, steep grades, etc

Typical section

Location

Suitable for Class 3 track, generally for stabilising highly erodible track sections (not for the whole length of track) in the majority of park areas or for longer sections in alpine areas

See also *5.3.1 Siting and alignment*

Principles

- Hard-wearing pavement surface
- Low-maintenance requirements
- Blends well with natural settings when local stone is used
- Not impacted by freezing or snow drifts (avoid mortar joints)
- Heavy and can be difficult to transport
- Bush rock should not be used as it is important fauna habitat

Technical

Stone

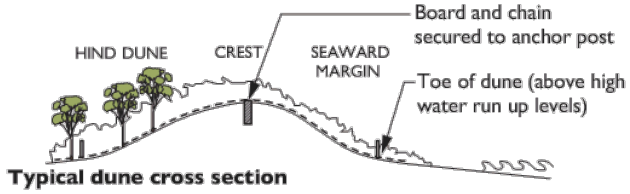
- Local stone preferred
- Select stone that is structurally sound with no cracks or obvious flaws

Base course

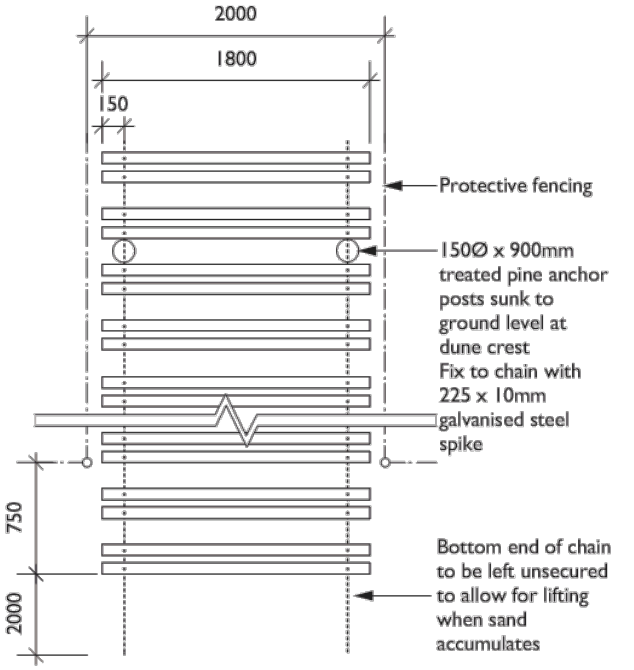
- Fine crushed rock
- Recycled concrete or brick

All dimensions in millimetres unless otherwise noted

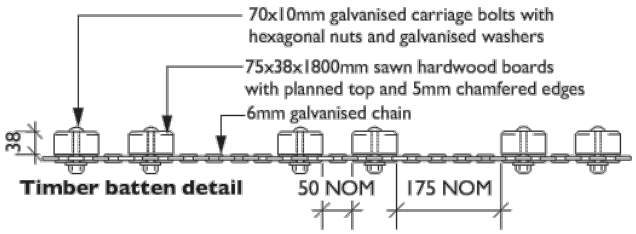
5.3.8 Board and chain



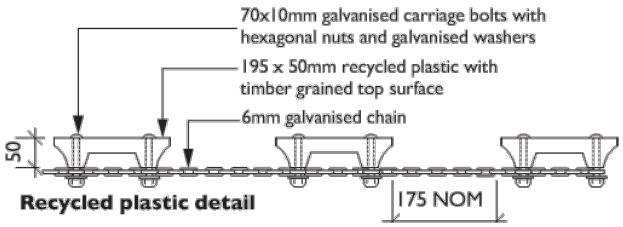
Typical dune cross section



Typical plan



Timber batten detail



Recycled plastic detail

All dimensions in millimetres unless otherwise noted

Location

Suitable for Class 3 tracks, generally used to cross sand dunes, especially where subjected to intense use

See also *5.3.1 Siting and alignment*

Principles

- Provides environmental protection in dynamic coastal conditions such as sandy soil and erosion prone slopes
- Designed to adjust to the changing dune profile
- Hind dune areas with gentle gradients need not have board and chain access ways – mulch track may be sufficient
- Works best as a trafficable surface with sand filled up to the top of the boards and good revegetation on both sides
- Can be installed to 1 (v) in 4 (h) maximum slopes – if dune is steeper than steps or switchbacks are required
- Install with dune fence to both edges
- Designed for pedestrian use and occasional service-vehicle access
- Range of potential board spacing patterns – pattern shown balances cost and speed of construction with comfort, and can be easily raised if sand begins to bury it
- Use of anchor posts is optional depending on dune dynamics and degree of sand movement

Technical

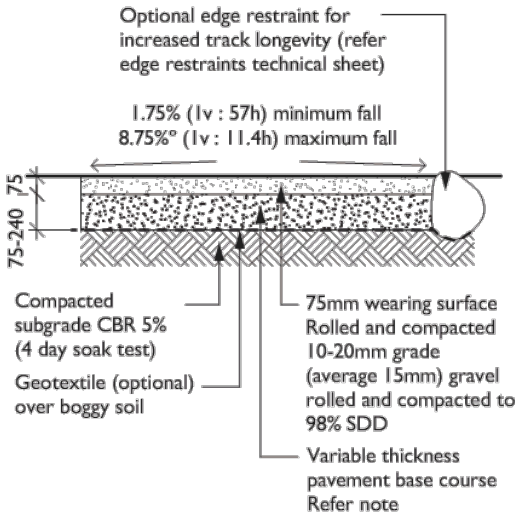
Battens

- Heavy duty galvanised steel chain
- HW Timber battens or recycled HDPE based plastic lumber with 'W' cross section as available from REPLAS or approved equivalent
- Softwood generally not preferred as it often warps leaving potentially dangerous protrusions

Maintenance

- Regular inspection recommended
- Raise when covered by sand and replace boards as necessary

5.3.9 Gravel



Base course thickness:
- Pedestrian – 75mm compacted thickness fine crushed rock (DGS20) or equivalent
- Light vehicle (ute) – 160mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Heavy vehicle (single axle) – 240mm compacted thickness fine crushed rock (DGS20) or equivalent (80% confidence)
- Site-specific engineering advice required in areas of problem soil condition, steep grades, etc

Typical section

Using geotextile

Geotextile is a non-woven polyester semi-permeable membrane cloth that separates the gravel surfacing material (or fill) from the soft soil below.

Geotextile material can be easily placed directly on a weakly structured soil surface to create an initial base layer to improve track stability.

The cloth acts to allow free movement of water but inhibits the downward movement of gravel into the boggy soil below. Consequently hard setting gravel can be laid directly over geotextile on soft clay soils, however adequate drainage must first be provided.

Installation of geotextile onto ground as base layer in track construction allows for removal of track at a later date without disturbance to the site soil below. This is particularly useful for archaeological sites.

Location

Suitable for Class 3-5 tracks

See also *5.3.1 Siting and alignment*

Principles

- Blends well with natural environment
- Use of locally occurring gravel preferred
- Can be susceptible to erosion from surface water especially on tracks with longitudinal gradients steeper than 1vertical to 8 horizontal
- Can be stabilised with additives to improve longevity
- Track surface should be compacted and profiled to minimise surface depressions and ponding
- Integrate turnpiking of alignment where appropriate to more effectively manage drainage to steeply sloping sites

Technical

Gravel

Gravel to be well graded material of nominal size range as listed and of uniform colour including:
- Crushed rock
- Decomposed granite
- Shell grit

Edging
- Stone
- Rock
- Timber edge (200x38mm)

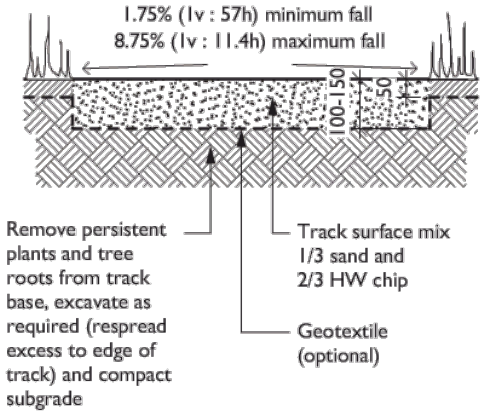
Geotextile (optional)
- A24 BIDIM geotextile (or equal) for most general applications – consider heavier fabric for sharp irregular sub base or base course (over 50mm ø)

Base course
- Fine crushed rock
- Recycled concrete or brick

Stabilisation of wearing surface (optional)
- Variety of stabilisation mixes can be added – refer 5.3.12 Lime stabilisation and 5.3.13 Cement stabilisation

All dimensions in millimetres unless otherwise noted

5.3.10 Mulch and woodchip



Typical section

Location
Suitable for class **3-5** tracks that are lightly trafficked

See also *5.3.1 Siting and alignment*

Principles
- Relatively cost-effective and simple to construct
- Especially good for forest settings and sand dunes where sand drift is not occurring and where track grade is relatively level (otherwise board and chain preferred)
- Blends very well with natural settings
- Allows specific routes to be easily decommissioned (closed)
- Provide dune fence to track edges when used to cross sand dunes – refer *Barriers and fencing / 8.4.4 Dune fence*

Technical
Mulch
- Leaf litter mulch collected from the park; or
- 20mm nom. HW chip for greater material durability

Geotextile
- A24 BIDIM geotextile (or equal) for most general applications – consider heavier fabric for sharp irregular sub-base or base course (over 50mm ø)

Using geotextile
Geotextile is a non-woven polyester semi-permeable membrane cloth that separates the gravel surfacing material (or fill) from the soft soil below.

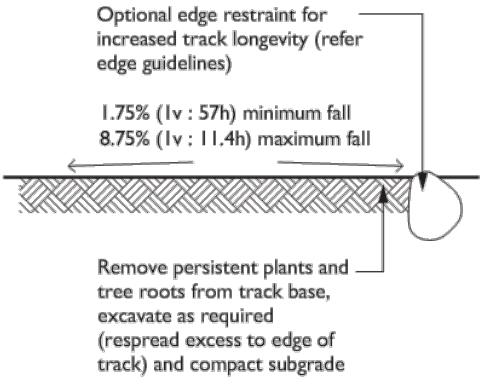
Geotextile material can be easily placed directly on a weakly structured soil surface to create an initial base layer to improve track stability.

The cloth acts to allow free movement of water but inhibits the downward movement of gravel into the boggy soil below. Consequently hard setting gravel can be laid directly over geotextile on soft clay soils, however adequate drainage must first be provided.

Installation of geotextile onto ground as base layer in track construction allows for removal of track at a later date without disturbance to the site soil below. This is particularly useful for archaeological sites.

All dimensions in millimetres unless otherwise noted

5.3.11 Natural surface



Typical section

Location
Suitable for Class 4-5 tracks

See also *5.3.1 Siting and alignment*

Principles
- Least costly and simplest form of track construction
- With adequate drainage this will often be adequate to carry normal intermittent foot traffic
- If the natural soil is deemed unsuitable due to structural weakness or unacceptable slipperiness, etc, then some form of surfacing will be required
- Existing soil profile can be stabilised (optional)

Technical
Track surface
- Natural soil found in-situ

Edging
Should be minimal, but can be provided to minimise erosion:
- Timber
- Rock

Stabilisation of wearing surface (optional)
- Variety of stabilisation mixes can be added – refer *5.3.12 Lime stabilisation* and *5.3.13 Cement stabilisation*

All dimensions in millimetres unless otherwise noted

5.3.12 Lime stabilisation

Soils fall into two broad categories: clays, for which lime is the most suitable additive, or sands for which cement is preferable. Lime-treated soil can be reworked whereas cement-treated soil cannot.

It should be noted that the use of stabilisers can change a soil's natural acidity and affect plant growth in sensitive environments.

Lime hardening of clay soils is a common method of strengthening foundation soils in road building. Clay soils, when proved suitable, can be stabilised and hardened using hydrated or quicklime.

Hydrated lime is most widely used, as quicklime is a caustic and corrosive material with a risk of severe burns to staff. For occupational and public safety reasons the use of quick lime should not be permitted. Even when working with hydrated lime, prolonged exposure of the skin can result in irritation and rashes.

Soil type	***Content***	***Bags/cu metres***
Sands, fine crushed rock	Not recommended	–
Well graded clay gravel	~3%	1
Sandy clay	~5%	2
Silty clay	2%-4%	0.75-1.5
Heavy clay	3%-8%	1-3
Organic soils	Not recommended	–

Suggested lime content for stabilisation
(Hydrated lime as % of dry weight of soil)

A simple test for soil types is that if a sample can be rolled into a 'worm' in the palm of the hand and doesn't break then it can be classified as a clay soil where being considered in large quantities. Clay soils should be tested at a soils laboratory to establish suitability for lime technique.

Short track sections (say 25 metres) should be dusted and rotary hoed into moist but not wet clay soil. A resultant mixture should be moist enough to ball in the hand but not wet. Lime should be thoroughly and evenly mixed through the full material depth. A windless, rainfree day should be chosen.

After rotary hoeing, surface may be graveled to 50mm depth, compacted with plate vibrator and then surface gravelled and rolled.

5.3.13 Cement stabilisation

Soils fall into two broad categories: clays, for which lime is the most suitable additive, or sands for which cement is preferable. Lime treated soil can be reworked whereas cement treated soil cannot.

It should be noted that the use of stabilisers can change the soil's natural acidity and impact plant growth in sensitive environments.

Cement-stabilised tracks require little maintenance and can be long lasting. This method of stabilisation enhances strength and resistance to water softening and is widely used for road works. It can also be used for walking track base/surface stabilisation purposes.

The technique involves breaking up the soil, adding the cement, usually by spreading on the surface of the loose soil thoroughly, mixing the cement in and then lightly watering and compacting. When the cement hydrates, the soil is stabilised and will be stronger and more resistant to water. Cement may also be added to wet sandy soils, in which it is spread and cured without machine compaction.

The addition of even small quantities of cement, up to 2%, will modify the properties of the soil, whereas large amounts will radically alter the soil. A clean gravel with 5% to 10% cement will produce a lean concrete. Avoid making a weak concrete as this can be brittle and subject to cracking.

The percentage of cement added will vary with soil type (refer table below).

Soil type	***Cement (%)***	***Bags/cu metre***
Fine crushed rock	0.5-2	0.25-0.5
Sandy clay gravels	2-4	0.75-1.5
Well graded sand	2-4	0.75-1.5
Poorly graded sand	4-6*	1.5-2
Sandy clay	4-6	1.5-2
Silty clay	6-8	
Heavy clay	**	
Organic soils	10-15**	3-5

Cement contents for various soil types

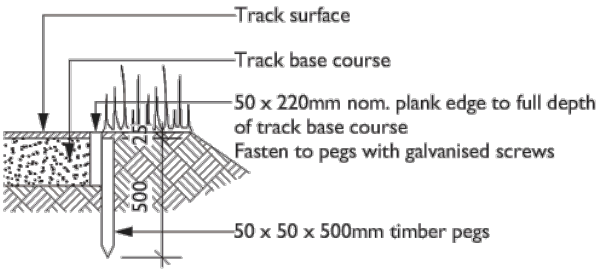
* Cement segregation may occur.

** Not recommended for heavy clay. Clay forms pockets which dissolve and cause collapse in overall structure.

Construction notes:

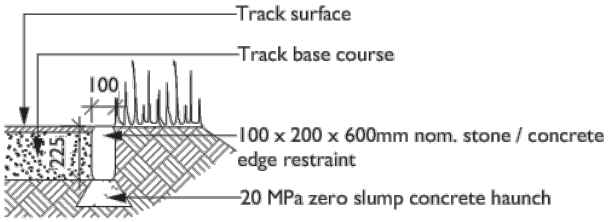
- Cement can be added to a sandy gravel soil for use as capping over a firm base course. Minimum water can either be added in the mixing process or if gravel is naturally moist it can be sprinkled over track surface during compaction.
- Cement should be evenly mixed through to the full depth of material. The resultant material should be moist enough to ball in the hand but not wet.
- A plate vibrator can be used for compaction of a 'dry' mix if a firm foundation has been prepared. If not a hand tamping tool is needed.
- The sandy gravel/cement mix is laid on the prepared base and lightly crowned to a minimum depth of 60mm.
- Avoid spillage of weak cement mix onto vegetation.

5.3.14 Edge restraints



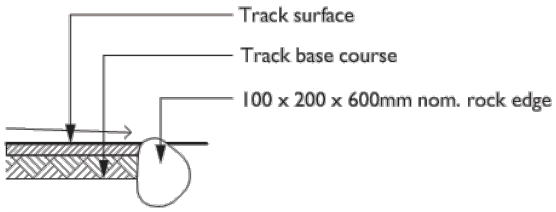
Timber edge

Environmental Conditions	1	2	3	4	5
	6	7	8	9	



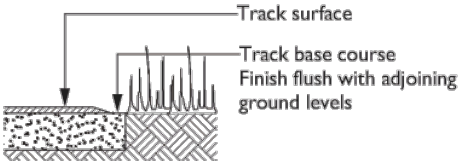
Stone / concrete edge

Environmental Conditions	1	2	3	4	5
	6	7	8	9	



Rock edge

Environmental Conditions	1	2	3	4	5
	6	7	8	9	



No edging

Location
Track classes 1- 4 on asphalt, two coat seal, gravel and natural soil tracks

Principles
- Hard edges retain track surface and base course to improve longevity and reduce maintenance requirements
- Deeper edges are more effective for long-term stability
- Note that tracks without edging are generally cheaper to construct
- Avoid formalised edges to track surfaces running downslope which could channel / drainage and cause erosion

Technical
Stone/rock edge
- Use of locally occurring stone types preferred
- Bush rock not to be used due to key threatening process

Timber edge
- Class 1-2 hardwood (untreated) or
- Preservative treated softwood for inground use (H4 Hazard level)
- A recycled plastic edge may be used in place of timber where extremely hot temperatures are not expected

Track class	*Edging type*
1-2	Stone, concrete, timber
3	Rock
4	Rock (where required)
5	None

All dimensions in millimetres unless otherwise noted

5.3.15 Ramps

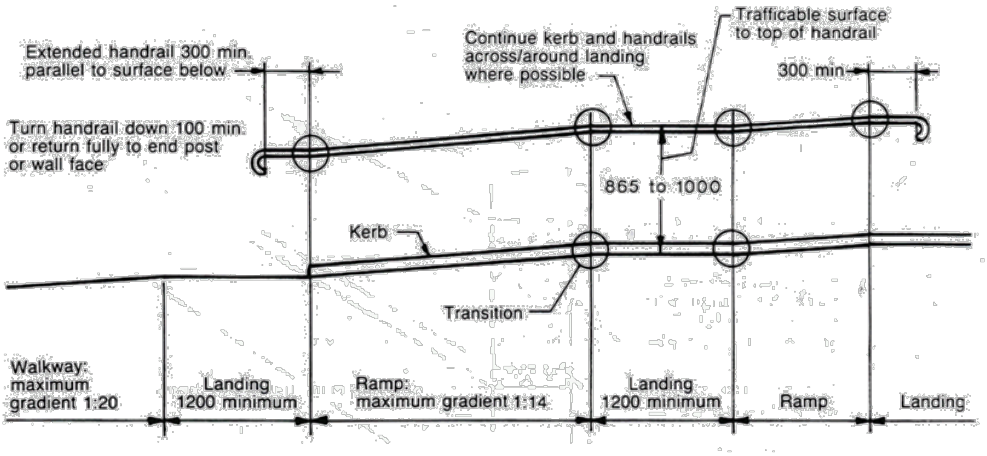
AS1428.1: Design for access and mobility – general requirements

Ramps should be used to provide universal access on class 1 tracks in accordance with *AS1428 Design for access and mobility* as summarised below:

Ramps
- 1:14 maximum gradient with a landing (1200mm min) every 9m
- Handrails on both sides (constant height 865-1000mm above ramp) with 1000mm minimum width between handrails
- Kerb or rail to both sides

Walkways
- 1:33 gradient – landing every 25m
- 1:20 gradient – landing every 15m
- No handrails required for walkways

Note:
- Landings not required for walkways with gradients flatter than 1:33



Ramp design
extract from AS1428