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Name of Organisation: YARRA TRAMS
Name of Project: TRAM TRACK CONSTRUCTION
Name of Document: SPECIFICATION
Document Version: 1.5
Project Number: SF99137.0
1. INTRODUCTION

1.1 Purpose

This is a specification for the construction of tram tracks. Only the following components and/or methods are included in this specification:

- 41 kg/m & 60 kg/m tram rail.
- Rail joints (aluminothermic welds, Kirby type arc welds, fishplates with swage lock fastenings or fishbolts)
- Ballast track construction including destressing and tamping operations
- Timber sleepers with dogspikes or gauge-lock clips.
- Concrete sleepers with resilient clips.
- Concrete track construction

1.2 Scope

This specification is to be used by Yarra Trams and any Contractors for the construction of any tramway tracks.

This specification sets down requirements as applicable for:

- Preparation Works.
- Site Clearance.
- Earthworks.
- Drainage.
- Ballast.
- Concrete.
- Track Components.
- Rail Joints.
- Track Construction.
- Bonding.
- Completion of Works.

For works that include Autopoints (Hanning & Kahl) works, refer to TS94/007 Yarra Trams – Auto Pnts v1.0.

1.3 Responsibilities

It is the responsibility of the Contractor to complete all works as specified in this specification.

*HP* The Contractor must review the Scope of Works in conjunction with Yarra Trams for design and construct contract. Options such as resilient tracks (rubber boot), grass track etc must be resolved by Yarra Trams.

It is the responsibility of the Superintendent to ensure that all works are carried out in compliance with this specification.
1.4 Records

The Contractor shall provide the Superintendent with all records as specified. Records shall also be provided of any works which do not conform to this specification or the drawings provided.

1.5 Referenced Documents

The Works shall in general be carried out in accordance with the standard drawings, specifications and codes of practice specifically noted in this specification or on the drawings.

Where Australian, British, or American standard specifications, rules, or codes of practice are referred to, such reference shall always be taken to include the latest issues, together with the latest amendments and supplements. It shall be the Contractor’s responsibility to ascertain the existence of such amendments and supplements.

Reference may be made to the following documents:

**Australian Standards:**
- AS 1085.1 Railway Permanent Way Material, Steel Rails
- AS 1085.2 Railway Permanent Way Material, Fishplates
- AS 1085.3 Railway Permanent Way Material, Sleeper Plates
- AS 1085.4 Railway Permanent Way Material, Fishbolts and Nuts
- AS 1085.7 Railway Permanent Way Material, Spring Washers
- AS 1085.8 Railway Permanent Way Material, Dogspikes
- AS 1085.10 Railway Permanent Way Material, Rail Anchors
- AS 1085.13 Railway Permanent Way Material, Spring Fastening Spikes for Sleeper Plates
- AS 1085.14 Railway Permanent Way Material, Prestressed Concrete Sleepers
- AS 1085.15 Railway Permanent Way Material, Aluminothermic Rail Welding
- AS 1141 Methods for Sampling and Testing Aggregate
- AS 1152 Test Sieves
- AS 1252 High Strength Steel Bolts with associated Nuts and Washers for Structural Engineering
- AS 1289 Methods of Testing Soils for Engineering Purposes- (Part 1) Soil Compaction and Density Tests
- AS 1742 Manual of Uniform Traffic Control Devices
- AS 1743 Road Signs - Specifications
- AS 1744 Standard Alphabets for Road Signs
- AS 3500.3 Stormwater Drainage
- AS 3818.2 Rail Track Sleepers, Lead or Crossing Timbers and Bridge Transoms from Eastern Australian Hardwoods
- AS 4058 Precast Concrete Pipes
TRAM TRACK CONSTRUCTION
SPECIFICATION

- AS 4100 Steel Structures
- B 157 High Strength Steel Bolts with associated Nuts and Washers for Structural Engineering (Inch Series)

PTC Documents:
- TM 35 Joining of Rails by Aluminoothermic Welding
- TM 36 Joining of Rails by Flash Butt Welding
- TM 37 Control Cooling of Flash Butt Welds for 60 kg AS head hardened rails
- TS 96002 Joining of Rails by Arc Welding (Kirby Joint)
- WI DRAFT Installation Instruction - Cembre Electric Track Connector No. AR60N
- TS 94/007 Construction of Autopoints
- CEC 3/87 Instructions relating to the laying, Welding, Destressing and Maintenance of Welded Rail Track
- ENG-TE- STD-2101 Track Technical Definitions
- Investigation into Simultaneous Dual Track Reconstruction

The above documents marked N/A are generally not applicable to most construction works and are not provided with the tram track construction specification. These documents shall be provided or made available upon request.

Drawings Attached to Specification:

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The above drawings are generally not applicable to most construction works and are not provided with the construction specification. These drawings shall be provided or made available upon request.
1.6 Definitions

Contractor: Contractor shall include tenderer, manufacturer and service supplier.

Principal: Principal shall mean Yarra Trams.

Public Transport Corporation: Public Transport Corporation (PTC) documents, including drawings, are referred to in this document. The PTC documents shall be utilised unless superseded by Yarra Trams documents.

Superintendent: Superintendent shall mean the Principal’s representative. The term shall include any appointed representative of the Superintendent.

Technical Definitions: Refer to document ENG-TE-STD-2101, Track Technical Definitions. Definitions are also provided within the relevant sections of this specification.
2. GENERAL CLAUSES

2.1 Hold Points

Hold points are identified by the letters HP in the left margin and by bold text print or arise from non-conformances.

Text which is bold but not identified by the letters HP in the left margin is not a hold point. These are specified obligations on the Contractor requiring the review or approval of the Superintendent. They are bold for ease of identification.

Refer also to AS 4300-1995 Metrolink Version 2 clause 31A.1 Hold Points.

2.2 Damage caused by the Work

The Contractor shall immediately notify the Superintendent if any of his work causes damage to the Principal's property (adjacent trackwork or to any overhead structures, fittings or cables) or any third party property.

Refer also to AS 4300-1995 Metrolink Version 2 clause 16.2 Reinstatement.

2.3 Materials and Workmanship


2.3.1 Alternatives

The use of alternative designs and/or materials may be considered if it can be demonstrated that the alternative is equivalent to or better than the specified and that it complies with all Clauses of Section 1.5 of this Specification.

The alternative design shall not necessitate the use of additional tools other than that expected to be used for the fitting specified.

Request for such approval shall be submitted to the Superintendent in writing together with supporting evidence of the benefits of the alternative.

No alteration in design or material shall be implemented unless approved by the Superintendent in writing.

2.3.2 Designs by the Contractor

Apart from the Drawings supplied, the Contractor shall prepare at his own expense all other drawings (Contractor's shop drawings) which are required for the completion of the Contract. Such Contractor's shop drawings shall conform in all respects with the sizes and dimensions of the Principal's Engineering Drawings, to the satisfaction and approval of the Superintendent. Contractor's shop drawings shall show all details, sizes, dimensions, etc.
The Contractor shall submit, for the written approval of the Superintendent, 2 prints of each Contractor's shop drawings, prior to commencing any work detailed on those drawings. Ten working days shall be allowed for approval of Contractors drawings.

Any material ordered or works done by the Contractor before his drawings or any amendments thereto have been approved shall be at the Contractor's risk.

The Contractor shall bear full responsibility for the accuracy, correctness and practicability of all details shown on the Contractor's shop drawings used in the work, and their general approval by the Superintendent shall not relieve the Contractor of this responsibility.

1.4 Safety

Refer to AS 4300-1995 Metrolink Version 2 clause 15 Protection of People and Property.

2.4.1 Track Occupation and Safeworking

The Contractor shall provide and place protective barriers and all signs necessary for the safety of the public, motor traffic, workmen and trams in accordance with VicRoads and other road authority's requirements.

For any works to be carried out while trams are still running, the Contractor’s attention is drawn to drawing P.15556 for clearances from the tram tracks.

2.4.2 Dead Line Work

Most construction work shall be undertaken under dead line conditions. This means that power has been removed from the overhead trolley wire network, automatic points as well as other components that may need to be worked on.

No connection to the existing electrical system shall be made without the express and written approval of the Superintendent.

2.4.3 Protection from Tram Traffic

A flagman shall be provided who is equipped with a whistle or equivalent device. The flagman will activate the device such that adequate time is given to workmen to clear the site safely prior to the tram arriving.

The Contractor, his employees and sub-contractors shall not remain, nor shall any vehicle, plant or object be permitted to be placed within 1.5 metres of the rail of any tram track with tram traffic on it, without approval of the Superintendent.
The stability of existing tram tracks must not be prejudiced by the operations of the Contractor, and the Contractor and his employees shall obey absolutely all instruction given by the Superintendent in order to maintain stability.

The Contractor shall carry out all works on, or adjacent to the tram tracks in such a manner as not to cause interference to the view of any tram driver or crew of any traffic signals.

2.4.4 Traffic Management


Advance warning signs, which state as a minimum, must be placed on all approaches to the works area, as approved by VicRoads:

```
Tramway Works Ahead .......... Road
Between .......... and .......... Streets
Long Delays Expected - Use Alternative Route
```

VicRoads and relevant Councils shall approve the location, number and layout of these signs. The signs shall be erected no later than 7 days prior to the commencement of works.

All signs should be legible from a minimum distance of 100 metres and are to be in accordance with the Australian Standards Numbers AS1742 (Manual of Uniform Traffic Control Devices), AS1743 (Road Signs) and AS1744 (Standard Alphabets for Road Signs). They are to be clean, in good condition and must be erected in a firm upright position.

The Contractor shall obtain VicRoads approvals and forward them together with a layout plan showing all proposed traffic control measures to the Superintendent at least seven (7) days prior to work taking place. The Contractor shall allow at least 6 weeks to obtain VicRoads approvals for traffic control measures.

Unless otherwise specified, the Contractor shall also arrange at his expense, notices to be placed in daily and local newspapers advising the general public of road closures. Such notices shall include details of locations of road closures, suggested alternative routes and detours and hours of closures.

The implied satisfaction of the Superintendent with any protection measures employed by the Contractor or requested by the Superintendent shall in no way relieve the Contractor of the responsibility for the provisions of this
Clause. The Contractor shall provide extra plant, signs and material necessary to deal with any emergencies.

2.5 Survey works

The contractor shall undertake a site survey to enable confirmation of the relative values of the control points provided by the Superintendent, and to enable the set out for the construction of the tramway track to an accuracy of +/- 3 mm.

The Superintendent shall provide the Contractor with drawings and sufficient survey information in order to set out the works, ie. Bench Marks, control points (at least one control point for every 200 metres of trackwork) and drawings for the proposed contract works.

Track alignments shall be established from coordinates and bearings supplied on design drawings. Any discrepancies between new and existing alignments at the extents of works shall be reported to the Supervisor for clarification.

The Contractor shall ensure that chainages are marked out on site at 10 m intervals and at tangent points.

The Contractor shall be required to confirm all relative values and report any discrepancies of the Reduced Level and coordinates of such points which shall be provided by the Superintendent.

The Contractor shall ensure that all levels and cross sections shown on the drawings are a true representation of actual ground conditions.

The Principal will not consider claims based on alleged variations between indicated and actual ground levels.

The Contractor shall, as soon as practicable and before commencing any work under the Contract including work provided by the Superintendent, check all dimensions and measurements and satisfy himself that they are correct for the specified purpose and that they conform to the requirements of the Contract.

If the Contractor discovers any error he shall immediately notify the Superintendent and request rectification thereof.

Failure of the Contractor to so check such dimensions or measurements or to inform the Superintendent of an error in due time before incurring any associated expense or delay, shall prohibit the Contractor from claiming for any additional expenses or extension of time arising from such error.
If the Contractor commences any work in relation to the Contract, the Contractor shall be deemed to have accepted all such details as being entirely workable, practicable and appropriate for the intended purpose.

The Contractor shall make good at his own expense any defect due to a discrepancy which has not been brought to the notice of the Superintendent for clarification.

2.6 Permits and Approvals for Works

The Contractor shall provide at least six weeks written notice to the Superintendent of intention to commence any works included in this contract. No works shall be undertaken without specific and written approval from the Superintendent assuring that power has been removed from the overhead trolley wire network, automatic points, and any other components which may need to be worked on.

Refer also to AS 4300-1995 Metrolink Version 2 clause 14.7 Permits.

2.7 Lighting

The Contractor shall provide any necessary temporary lighting between sunset and sunrise.

Refer also to AS 4300-1995 Metrolink Version 2 clause 15 Protection of People and Property.

2.8 Tram, Bus and Vehicle Loops

The excavation of track may lead to the removal of tram, bus and/or vehicle detectors. The Contractor shall arrange through VicRoads, temporary signal detectors that will facilitate the safe and efficient movement of trams, buses and vehicles through the construction area.

The Contractor shall supply details of these measures to the Superintendent for approval at least one week prior to the commencement of work.

On completion of the works all detectors are to be reinstated to the requirements of VicRoads and the Superintendent.

2.9 Relocation of Services

The Contractor shall conduct a survey of underground services and assets prior to commencing work to:
- ensure the safety of personnel,
- maintain the integrity of existing underground services and assets,
- determine if any services or assets need altering or relocating so that the works can proceed.
The Contractor shall inform the Superintendent as soon as he becomes aware of the need to alter or relocate any services and shall advise the Superintendent of details of the proposed alteration or relocation. The time of alteration of any such services will be dependent on the requirements of the Authorities concerned and it shall be the Contractor's responsibility to organise his works program accordingly.

All costs of alteration or relocation of services will be borne by the Contractor unless otherwise stated.

2.10 Temporary Works

Any temporary works provided by the Contractor shall be adequate for the purpose and shall be properly designed and constructed for the load which they will be required to carry.

All aspects of the design of any temporary structures required to support constructional loads shall comply with the current Australian Standard, Specifications and Codes where such exist, or, in their absence, with British or American Standard Specifications and Codes of Practice.

Any temporary or additional works provided by the Contractor shall be adequate for the purpose and shall be properly designed and constructed for the load which they will be required to carry.

Details of any temporary or additional works proposed by the Contractor shall be forwarded to the Superintendent for approval at least 7 days before intended works.

Any approval of the temporary works by the Superintendent shall not relieve the Contractor of any of his responsibilities for work under the Contract.

2.11 Plant and Equipment


Maintenance records of all plant and equipment shall be available for inspection by the Superintendent prior to use and at any other time whilst work is in progress. Prior to use of any electrical equipment or appliance on the works the particular item shall be presented to the Superintendent for inspection. The Contractor shall maintain in his site office a register of such items, including the date and Superintendent's signature confirming such inspection.

The use of explosives or explosive powered devices by the Contractor, shall be subject to the prior approval of the Superintendent.
The use of mobile plant and equipment near tracks and overhead shall conform with the procedures and guidelines outlined in the Contract Documentation and in accordance with Electrical Operating Rules and Regulations.

2.12 Standsite and Storage Sidings

The provision of off-tracking standsites and storage sidings for track machinery shall be the responsibility of the Contractor.

**HP** The Superintendent shall approve the location of standsites and temporary storage sidings.

*Refer also to AS 4300-1995 Metrolink Version 2 clause 27 Site.*
3. SITE CLEARANCE

3.1 Description

Site clearance comprises removal and disposal of:
- Trackwork including rails, timbers, ballast and concrete;
- Trees, brush, stumps, logs and other vegetation;
- Refuse and obstructions such as old foundations, poles, drains, fences and disused structures;
- Turf and topsoil;
- Fouled formation material.

3.2 Survey Marks

During site clearance, the Contractor shall take care not to disturb any survey marks.

3.3 Area of Work

Clearing shall be carried out over the entire length of the work as shown on the Drawings.

The width to be cleared for a new embankment or cutting, shall comprise the whole width as indicated on the drawings, with a further horizontal distance of 1 metre from the toe of the proposed embankment.

Where drains are to be constructed, site clearance shall be continued to the outer edge of the drains.

3.4 Clearance of Trees and Obstructions

All of the surface within the specified area shall be completely cleared of all obstructions. Trees shall be felled within the area to be cleared in such manner as to avoid damage to any facility and any vegetation outside this area.

Where possible, trees that cannot be felled without danger to traffic or damage to other trees, shrubs, structures or property shall be cut in sections from the top down. Tree branches extending over the cleared area and which hang within 6 metres of the finished formation level shall be cut off and removed from site.

The Contractor shall be responsible for obtaining all permits or authorisations required for the removal of trees or other vegetation.

3.5 Stripping of Topsoil

After removal of all above ground obstructions, the topsoil shall be stripped to a minimum depth of 150 mm. This stripping shall remove all traces of grass, weeds, roots and other unacceptable matter.
The entire specified area shall be grubbed free of stumps, roots and other perishable matter, to a depth of not less than 300 mm below the stripped surface level. All such grubbed areas shall be refilled with suitable material, compacted to the same extent as the surrounding area.

1.6 Temporary Bridging Cables for existing Track Work

By removing both tracks for simultaneous track construction or construction of special works, the main and most direct electrical path for the return of traction current may be removed. This may result in an unsafe work site with some risk to the general public and the workers, especially those handling rail. To maintain electrical continuity under these circumstances temporary bridging cables may be required.

Prior to commencing work, each location shall be investigated for the presence of assets that require special attention and solutions, such as automatic sectionalising switches and substation negative connections to the rail.

All work shall be conducted under ‘power off’ conditions where the overhead power is isolated above the track being worked on.

Temporary bridging cables shall be installed in accordance with Drawings No. E14-668-YT, E14-669-YT and E14-670-YT and as directed by the Superintendent.

3.7 Removal of existing Trackwork

Trackwork in ballast shall be unfastened from timbers and dismantled into sets of rails, points, crossings, guard rails, closure rails etc.

Trackwork in concrete shall be removed by breaking the concrete, cutting the rails and carting from site.

Unnecessary cutting of rail shall be avoided. Platework shall be unfastened and removed from timbers. Bolts and screws shall be unscrewed wherever possible. Material shall be unfastened and handled in a manner, which is not detrimental to components, rail, trackwork or structures.

All surplus trackwork, unless otherwise specified, shall remain the property of the Principal.

3.8 Removal and Disposal of Materials

All material shall be disposed of before embankment or cutting construction commences. No accumulation of flammable material shall be permitted to remain on the tramway reserve. The cleared site shall be left in a neat and tidy condition.
All material removed in clearing shall be either:

(a) Removal from Site
Material removed from the site for disposal shall be moved to a site conforming to all statutory requirements.

It shall be the Contractor's responsibility to locate a site and to arrange with and obtain permission from the Authorities controlling disposal of material at that location.

(b) Disposal by Burning
Where burning is proposed, the Contractor shall obtain all applicable permits and shall meet all the requirements of Authorities having jurisdiction over the work.

   HP  Before commencing any burning operation, the Contractor shall submit all permits to the Superintendent for review.

(c) Disposal on the Principal's Land
Where approved by the Superintendent, surplus, reusable trackwork and/or debris from site clearance may be disposed of on the Principal’s property, under conditions specified by the Superintendent.
4. EARTHWORKS

4.1 General

For the whole distance specified, the tramway track shall be formed, compacted, graded, boxed, trimmed and drained as shown on TS1401-YT and/or TS1403 and detail design drawings, as applicable.

The work includes filling and cutting to the required heights and widths, and construction of drains, side drains and sub-surface drains, where existing drains are affected by the works.

Where new track is to be constructed on existing formation, excavation shall be carried out down to the new formation level. The Contractor shall carry out all work necessary to ensure that this formation meets all the standards specified for formation construction.

4.2 Construction - General

The Contractor shall perform his work in such a manner as not to harm the undisturbed condition of the underlaying or adjacent soils or damage filling or prevent the proper placement of fill. Should any existing soil structures be damaged or disturbed due to lack of precaution on the part of the Contractor and such damage or disturbance may, in the opinion of the Superintendent, preclude the utilisation of the site as planned, the Contractor shall make good such damage or disturbance. The cost of any consequent repairs or modifications will be deemed to be included in the Contract Sum.

During the progress of the works, the Contractor shall maintain the surface of all fills in such a condition that all parts are well drained at all times. The Contractor shall employ such equipment and shall manage the earthworks in such a way as to ensure that:

- materials are maintained in a condition suitable for their intended use,
- the earthworks are kept well drained,
- the trimming and final grading of surfaces is completed as work proceeds,
- no damage is caused to existing services, drainage and other works within or at the perimeter of the excavated area,
- damage to or contamination of excavated surface by construction equipment is avoided,
- all work is executed in a safe, neat and workmanlike manner.

4.3 Definitions

Formation is the finished surface on which the track is laid after completion of earthworks, including the sub-ballast course but excluding any cut or fill batters.
Ballast is the crushed rock supporting the sleepers and forming part of the track. Requirements for ballast are covered in other Parts of this Specification.

Sub-ballast is the trimmed and graded crushed rock or similar material forming the portion of the formation on which the ballast is laid.

Batter is the uniform side slope of a cut or fill.

Fill is the material used for filling the earthworks up to design surface level as indicated on the Drawings, but not including sub-ballast material.

Track consists of rails, sleepers, fastenings and ballast laid on the formation in continuity to line and grade.

4.4 Diverting Water and De-watering, Ground Water

The Contractor shall carry out all work necessary to divert surface water and to keep trenches and other excavations free of water. If so directed by the Superintendent, the Contractor shall carry out diversion works before commencing excavation.

The Contractor, at his sole expense, shall make good any work or material damaged by water.

The Contractor shall make full allowance for any ground water that might be encountered during construction and no extras will be paid to the Contractor on the grounds that he failed to allow sufficiently for presence of such water.

The Contractor must carry out and perform at his expense all pumping of any kind and his price must in every case include the cost of such pumping and for keeping the works free from water no matter whence derived, by temporary drainage, pumping, bailing, or other means. The Contractor shall provide all sumps, sub-drains, pipes, drains, channels, temporary pumping plant, etc. and must re-fill with approved materials any spaces left by the removal of any such works or otherwise deal with them as directed by the Superintendent.

4.5 Tolerances

All earthworks shall be finished to even and uniform surfaces which shall conform to the lines, levels and cross-falls shown on the Drawings, within tolerances specified below:

a) Formation Level The finished surface level of the completed formation shall not vary more than 25 mm above or below the
levels shown on the drawings. No point in the general surface shall vary more than 12 mm either from a 3 metre straight edge laid parallel to the centreline of the formation or from a template placed at right angles to the centreline.

b) Formation Width

Finished formation widths shall not vary more than - 0 mm, + 50 mm from dimensions shown on the Drawings.

c) Batter Slopes

For embankments, the angle of the batters shall not be steeper than 2.0 horizontal to 1.0 vertical.

For excavations, the angle shall not be steeper than 2.0 horizontal to 1.0 vertical.

d) Cross Fall

The cross fall for the surface of the new formation shall be 1 in 60 to the outside of tracks or 1 in 30 towards the sub-surface drain in the centre of tracks or as shown on detail design drawings if applicable.

4.6 Excavation - General

Extreme care shall be taken when excavating near bonds connected to electrical assets or negative feeder cables.

Excavated material that complies with the Specification for filling material may be stockpiled and used as filling.

Excavation operations for the track formation shall be conducted so that material outside the limit of the batters will not be disturbed. All slips and falls of insecure masses of material outside the specified batters due to lack of care on the part of the Contractor shall be removed by the Contractor at his own expense.

Unless otherwise specified or directed by the Superintendent, the excavation in cut to fill zones shall be continued, in the form of transverse benching, across the cut/fill interface for a distance sufficient to ensure that a minimum thickness of fill of 600 mm is achieved across the full width of the formation. Such distance shall not exceed 30 m on each side of the interface.

All bonds excavated during track repair or earthworks shall be reinstated as per relevant Standard Drawing.

**HP**

No blasting shall be undertaken without written permission from both the relevant statutory authorities and the Superintendent.
4.7 Excavation of Soft or Unsuitable Material

Soft areas identified by the Superintendent shall be removed and replaced with approved fill and compacted in accordance with the Specification. On completion, the areas shall be subject to a further test rolling.

Payment for excavation and removal of unsuitable material identified by the Superintendent shall be made at the applicable "Rates for Variations" or as stated otherwise. Payment will be made for the volume certified by the Superintendent, measured as solid volume of excavated and compacted replacement fill.

If in the opinion of the Superintendent the material has become unsuitable due to the Contractor's negligence or use of inappropriate methods, no additional payment will be made for this work.

4.8 Excavation of Rock

Rock shall be defined as natural material, either continuous or in the form of boulders which cannot readily be removed by the normal use of hand tools or mechanical earth moving equipment, but first has to be broken by means of pneumatic tools, explosion or special rock breaking equipment. Extra payment for rock excavation shall be made at the applicable rate in the "Rates for Variations". Payment will be made for the volume certified by the Superintendent, measured as solid volume prior to removal. It shall be the responsibility of the Contractor to make all necessary arrangements for the removal of rock.

4.9 Excavation of Contaminated Material

Contaminated material shall be disposed of as per regulations. There shall be no additional payment for the disposal of contaminated material.

4.10 Disposal of Surplus Material

Any excavated material, not required or acceptable for use as fill, and all other waste material shall be removed to a site of disposal conforming with all statutory requirements.

It shall be the Contractor's responsibility to locate a site and to arrange with and obtain permission from the Authorities controlling disposal of spoil material at that location.

When approved by the Superintendent, surplus excavated material may be disposed of on the Principal’s land by widening embankments, or as otherwise directed.
4.11  Fill – Test Rolling

After site clearance and before commencing any backfilling, the whole of the area on which fill is to be placed shall be test rolled to detect any soft spots.

Test rolling shall comprise one pass of a 5 tonne smooth wheel roller.

*HP*  The Contractor shall arrange for the Superintendent to be present at test rolling.

4.12  Fill - Procedures

Embankment construction shall include the preparation of all surfaces upon which the fill is to be placed, the purchase and supply of materials, the placing, spreading and compaction of the fill and the disposal of any unsuitable material.

*HP*  No material shall be borrowed from Principal’s land unless agreed to by the Superintendent.

The formation shall be constructed in layers of uniform thickness not exceeding 200 mm loose and each layer shall be compacted as specified.

Filling over and around pipes and culverts shall be placed in such a manner that will avoid unbalanced loading and that will not cause movement or place any undue load on the structure. Such filling shall be compacted in horizontal layers not exceeding 150 mm loose thickness and shall be thoroughly compacted by hand controlled power driven tampers. The level of filling on either side of such structure shall at no time differ by more than 300 mm. This method of filling shall be carried out for a distance from the structures of at least one and one half times the height of such structures.

4.13  Fill – approved Material

Filling shall consist of material free from material exceeding 150 mm in the largest dimension, clay lumps, logs, stumps, sod, weeds or other perishable matter. All such filling shall have a liquid limit not greater than 40 and the product of the liquid limit and the percentage passing the 425 micron sieve shall not exceed 1800.

Non-cohesive filling with a plasticity index of less than 6 shall only be used with the written approval of the Superintendent, and in accordance with such conditions as may be required to protect the filling from erosion.

*HP*  Prior to placement in fills, and then at intervals of not less than once each five day’s production, the Contractor shall submit to the Superintendent for review test results of proposed fill materials.
4.14 Fill - Benching

Where fill is to be placed against an existing fill, surfaces on or against which the fill is to be placed which have a slope steeper than 4 horizontally to 1 vertically shall, unless otherwise specified or directed by the Superintendent, be cut progressively in the form of benches over the full area to be covered by new fill.

The width of each bench shall be such as to permit safe and effective operation of plant but shall be not less than 1 m.

Each bench shall be sloped inwards at a slope not flatter than 10 horizontally to 1 vertically. Each bench shall be filled with compacted material or the bank reinstated at the end of each day so that the distance from the toe of any bench or batter shall not be any closer than \((2.0 + 1.5H)\) to the existing track centre (where \(H\) is the height below rail level).

The new fill shall be placed and compacted in layers as specified until the surface reaches the top of the vertical face of each bench, and then a new bench shall be cut; this process shall continue for the full height of the fill.

4.15 Sub-Ballast – Approved Material

Sub-ballast material shall be basaltic fine crushed rock or equivalent material complying with this Specification and approved by the Superintendent.

**HP** The Superintendent shall approve the source quarry for sub-ballast material.

Sub-ballast material shall have a Plasticity Index not greater than 20. No roots, sod or other deleterious matter shall be contained in the sub-ballast.

Grading shall conform to that shown in the following Grading Table.

<table>
<thead>
<tr>
<th>SIEVE SIZE AS (mm)</th>
<th>% PASSING (By Mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.5</td>
<td>100</td>
</tr>
<tr>
<td>19.0</td>
<td>95 - 100</td>
</tr>
<tr>
<td>9.5</td>
<td>60 - 80</td>
</tr>
<tr>
<td>2.36</td>
<td>25 - 40</td>
</tr>
<tr>
<td>1.18</td>
<td>15 - 32</td>
</tr>
<tr>
<td>0.15</td>
<td>4 - 12</td>
</tr>
</tbody>
</table>

**HP** The Tenderer shall submit a 25 kg sample of the proposed sub-ballast material, together with sieve analysis test results, prior to commencement of the sub-ballast placement, for review by the Superintendent.
The sub-ballast shall be compacted in accordance with the requirements specified for filling.

Sub-ballast shall be provided to a uniform compacted depth of 150 mm.

Sub-ballast may be placed in one layer.

4.16 Crushed Rock Base Course

4.16.1 Material
Crushed rock pavement material shall be 20 mm nominal size Class 2 crushed rock or 20 mm recycled concrete material complying with the requirements of VicRoads Standard Specification.

4.16.2 Construction - General
The Contractor shall perform his work in such a manner as not to harm the undisturbed condition of the underlaying or adjacent soils or damage the material or prevent the proper placement of the base course. Should any existing soil structures be damaged or disturbed due to lack of precaution on the part of the Contractor and such damage or disturbance may, in the opinion of the Superintendent, preclude the utilisation of the site as planned, the Contractor shall make good such damage or disturbance. The cost of any consequent repairs or modifications will be deemed to be included in the Contract Sum.

During the progress of the works, the Contractor shall maintain the surface of base course in such a condition that all parts are well drained at all times.

The Contractor shall employ such equipment and shall manage the base course in such a way as to ensure that:

- materials are maintained in a condition suitable for their intended use,
- the base course is kept well drained,
- the trimming and final grading of surfaces is completed as work proceeds,
- no damage is caused to existing services, drainage and other works within or at the perimeter of the excavated area,
- damage to or contamination of excavated surface by construction equipment is avoided,
- all work is executed in a safe, neat and workmanlike manner.

4.16.3 Spreading
The pavement material shall be spread in even and equal layers more than 60 mm but not exceeding 120 mm in compacted thickness.

Pavement material shall be spread by means that minimise segregation. Care shall be taken to prevent segregation of pavement material into fine and
coarse components. Where segregation does occur, the material shall be replaced at the Contractor's expense.

Each layer shall be spread and compacted before the next layer is spread.

4.16.4 Compaction
The Contractor shall have sufficient plant on the job during spreading operation to compact the crushed rock as it is being spread.

Compaction of each layer shall commence immediately after spreading. Where necessary, the Contractor shall water the spread material to maintain the moisture content of the material to within one percent of the Modified or Vibratory optimum moisture content as appropriate.

Surface irregularities, deficiencies in level and high areas shall be rectified by scarifying, adding or removing material as necessary, reshaping and re-compacting except that rectification more than three hours after mixing shall be by replacing material.

Each layer of material shall be separately compacted to a density of not less than 95 percent Modified Relative Compaction.

4.16.5 Tolerances
Pavement courses consisting of one or more layers of the same material shall be finished to a reasonably smooth and uniform surface and shall conform to the lines, grades, thicknesses and cross-sections shown within the following limits:

The top of each pavement course shall not vary from the specified level by more than 10 mm.

The thickness of the crushed rock course shall be not less than specified.

No point on the top course of the pavement shall deviate from a 3 metre straight edge by more than 10 mm nor at a rate of more than 20 mm per metre.

4.16.6 Acceptance Testing
Approval and acceptance of the crushed rock layers shall be based on the results of a program of proof rolling and testing submitted to and approved by the Superintendent. The submission shall provide for the division of each layer into portions of 500 m² area maximum. A minimum of one field density test shall be taken from a representative point in each portion.

The costs of tests, including testing of previously rejected portions, will be deemed to be included in the Contract Sum.

All testing shall be carried out in accordance with AS 1289.
Where the dry density ratio is less than that specified then the portion will be rejected. The Contractor shall rectify any rejected portions, at the Contractor's expense.

1.17 Compaction – Procedures

Compaction of earthworks shall include the compaction of all fill material (including sub-ballast material) to the standards specified.

All compaction shall be carried out using rollers approved by the Superintendent.

Construction equipment and traffic shall not be allowed on the formation or sub-ballast while it is in a wet condition. Material that has become excessively wet shall be dried or removed from the site and replaced by material of suitable moisture content.

Compaction of fill material shall be achieved by a minimum of 10 passes of an approved roller. The speed of all passes of rollers shall not exceed 5 km/h.

Compaction of earthworks shall be carried out at a moisture content appropriate to the compacting equipment being used and between 85% - 125% of the optimum moisture content found in the compaction test.

Compaction of the fill is not to proceed if the fill is in a wet condition.

The fill is not to be watered unless specifically agreed by the Superintendent and then only within the limits of the area defined.

4.18 Compaction – Proof Rolling

Fill layers and excavated formation shall be compacted so that they are capable of withstanding, without visible deformation or springing, proof rolling with either:

(a) a smooth wheeled roller of mass not less than 12 tonne and with a load intensity on the rear wheels of not less than 6 tonne per metre of width; or

(b) a pneumatic tyred roller having tyres inflated to 700 kPa and being loaded to not less than 4.5 tonne per tyre.

Proof rolling shall be carried out by the Contractor, in the presence of the Superintendent, prior to placing the next layer of fill material.
The final layer should be proof rolled immediately following completion of compaction. If proof rolled at some later date, the entire surface shall be watered and given not less than eight coverages of the proving roller before the proof rolling commences.

4.19 Compaction – Soil Tests

The Contractor shall carry out soil tests at a minimum frequency of one day's production.

**HP** The Contractor shall provide the test results to the Superintendent for review immediately on completion of each test.

All compaction standards shall be measured according to AS 1289 as follows:

- Standard Compaction AS 1289 5.1.1
- Modified Compaction AS 1289 5.2.1

The following compaction standards shall be achieved:

(a) Embankments more than 3 m high, remainder of formation and stripped area - 95% modified.
(b) Formation within 600 mm of finished surface 95% modified.
(c) Sub-ballast. - 95% modified.
(d) Embankments less than 3 m high, remainder of formation and stripped surface 95% standard.

4.20 Compaction - Plant

Sufficient rollers shall be provided, of suitable types, to compact the stripped surface and the courses of fill material in accordance with this Specification. Drawn type rollers shall be provided with a tractor having sufficient weight and power to pull the roller at a satisfactory speed under actual working conditions.

(a) Smooth wheel power rollers shall have a mass of not less than 10 tonne and shall provide a load under the rear wheels of not less than 6250 kg per lineal metre of width.

Smooth wheel drawn rollers and grid rollers shall provide load not less than 6250 kg per lineal metre of rolling width.

(b) Tamping Rollers shall consist of metal rollers or drums studded with tamping feet which project not less than 180 mm from the face of the drum.
The tamping feet should be arranged in circumferential rows so that the clear distance between the outer ends of adjacent feet is not less than 150 mm or more than 300 mm in the rows and not more than 300 mm between the rows. Spaced bars shall properly cleanse the space between circumferential rows.

The effective cross sectional areas of each tamping foot measured shall be not less than 4500 mm$^2$ and shall be not more than that which will provide a minimum load in each tamping foot of 176 tonne/m$^2$ of cross sectional area. This load per tamping foot shall be determined by dividing the total mass of the roller by the maximum number of feet in a row parallel to, or approximately parallel to, the axis of the roller.

Rollers with feet, which are excessively worn, shall not be used.

(c) Pneumatic Tyred Rollers tyre pressures shall be not less than 500 kPa and the load per tyre shall be not less than 2270 kg. Double axle type rollers shall have the rear tyres staggered in relation to the front tyres.

(d) Vibrating Smooth Drum Rollers shall have a total mass of not less than 4 tonne and shall have a static load on the vibrating roller of not less than 2250 kg per lineal metre of roller width. Also, the ratio of the centrifugal force produced by the rotating mass to the mass of the vibrating roller shall be not less than one.

(e) Vibrating Tamping Rollers shall be drawn rollers not less than 4.5 tonne mass and shall comply with the requirements for tamping rollers except that the cross-sectional area of each tamping foot shall be such that the mass of the roller divided by the total cross-sectional area of all of the feet on the roller shall be not less than 4360 kg per m$^2$.

4.21 Use of Geofabrics

The use of geofabric under compacted fill or sub-ballast is to be adopted only when extremely poor subgrade conditions prevail, that is where the CBR value is 10 or less.

The Superintendent shall approve the locations, types and amounts of geofabrics to be used.

Where it is evident that proper compaction and/or drainage of the stripped area cannot be achieved or where excavation of soft or unsuitable material cannot be effected, a suitable geofabric is to be used.

For record purposes an “as constructed” plan of any area where Geofabric is used showing the extent and type of Geofabric is to be prepared by the Contractor and submitted to the Superintendent.
Payment for use of geofabrics in accordance with the Superintendent's instructions will be made at the applicable "Rates for Variations".
5. DRAINAGE

5.1 General

This section covers the drainage works including the construction of table drains, catch drains, drainage channels, sub-soil drains, reinforced concrete pipe and box drains and end walls, trench drains, dish drains and pits.

Throughout the entire period of works the Contractor shall provide a drainage system such that at all the times water is drained directly off and kept away from all formations, roads and work areas to the satisfaction of the Superintendent.

Drainage shall be provided at changes of longitudinal grade from negative to positive ie. low points, and at other locations as shown on the design plans. All drainage works shall be in accordance with the drawings.

Along track where the bottom of ballast is below natural surface level, and where there are no side drains, then a sub-surface drain shall be constructed between the tracks.

Sub-surface drains shall be constructed under the track margins as shown on TS1401-YT, TS1406-YT, or TS1407-YT or in accordance with the Statutory Authorities requirements.

Track drainage covers and frames shall be fabricated by the Contractor, in accordance with Drawings No. TS1301, TS1302 and TS1303 subject to the approval of the Superintendent.

Track drainage pits and pipework shall be constructed as shown Drawings No. TS1304-YT and TS1305, subject to the approval of the Superintendent.

The above drawings refer only 60 kg/m grooved tram rail and adjustments to the drainage frame are required to suit 41 kg/m T-head tram rail.

The road motor box pit for automatic points shall be drained separately to the normal switch drainage and care shall be taken to ensure that water cannot flow into the road motor box pit. This drain must be at least 800 mm below road level.

Drainage shall be connected either to existing Principal’s, VicRoads or the Local Authority’s storm water drainage system using either UPVC pipe or reinforced concrete pipes or an alternative as approved by the relevant authority. Minimum pipe size shall be 150 mm.

Any drainage junctions where the angle of flow is greater than 90 degrees, the Contractor shall construct a junction pit of sufficient size (min. 450 mm x 300 mm) and at sufficient depth to ensure that water flows correctly and that there is sufficient access for cleaning purposes.
The Contractor shall make the drainage workable to the drainage authority’s connection point and to advise if the drainage system is not workable.

All trenches shall be backfilled and compacted in accordance with VicRoads Standard Specification for Roadworks and Bridgeworks, July, 1992, and to the satisfaction of the Superintendent.

5.2 Scope of Excavation for Drainage

The scope of excavation for drainage includes excavation for culverts, open drains, subsurface drains and regrading of existing open drains.

All excavation for drainage shall be made to the lines, grades and forms shown on the drawings and plans or as directed by the Superintendent. Precautions shall be taken by the Contractor to ensure that all excavations are rendered secure and safe and comply with all statutory regulations.

5.3 Sub-Surface Drains

Pavement drains are generally provided along the line between an existing pavement and a new pavement (ie track slab) where pavement depths or permeabilities could create a moisture trap.

Special reference is to be made to VicRoads Design Guidelines Section 7.5 1997.

Sub-surface drainage shall be wrapped in geotextile to prevent siltation.

Sketch TS1403 shows a typical ballast track cross section with sub-surface drainage.

Sketch TS1401-YT shows a typical concrete track cross section with sub-surface drainage.

5.4 Installation of Drainage Pipes

The bedding of all pipes shall be in accordance with AS.3500.3-1990 and be sand complying with the following:

a) Max. particle size of 5 mm.
b) Not more than 5% by weight passing the 75 micron AS 1152 sieve.
c) Free from organic impurities.
d) Consisting of hard durable particle.
e) Well graded.

A 15 kg sample and the results of a grading analysis shall be provided to the Superintendent for approval prior to use.
All UPVC joints shall be effected utilising the 'male' 'female' ends. The ends to be joined shall be thoroughly cleaned using an approved solvent. The ends, both male and female shall then be coated with an approved adhesive and the joint then be completed.

The solvent and adhesive used shall comply with all current Occupational Health and Safety requirements to the satisfaction of the Superintendent.

All reinforced concrete pipes shall be flush jointed Class 4 and, unless shown otherwise on the drawings, shall conform to the requirements of the current edition of the Australian Standard AS 4058.

All pipes shall be laid true to line and grade with the female end (where it exists) upstream. Joints between pipes shall be kept tightly closed. Mortared joints shall be caulked with a compound of two parts fine sand and one part cement, well tamped into the joints.

All surrounding back fill material shall be crushed rock and compacted in accordance with clause 4.15.

In concrete construction, a reinforcing mesh, F82, shall be placed in the concrete, over any pipes, and up to 2 m from the pipes, at a depth between the pipe and the foot of the rail with at least 50 mm concrete cover and a minimum clearance of 50 mm to the foot of the rail.

5.5 Tolerance of Culverts

The alignment of all pipes shall not vary more than 25 mm from the design alignment. The invert level of culverts shall be subject to the following tolerances:

Invert level +0 mm to -25 mm tolerance.

5.6 Precautions during Construction

Construction equipment shall not be driven over a pipe until at least 600 mm thickness of filling has been placed over pipe culverts unless approved by the Superintendent. For heavy equipment the thickness of fillings shall be such that the induced stresses in the pipe are less than the allowable design stress. The Contractor shall satisfy the Superintendent with calculations if requested, that such stresses are not being exceeded with the Contractors proposed equipment and construction methods.
6. TRACK CONSTRUCTION - GENERAL

6.1 Rails

6.1.1 General
New rail will generally be supplied but in some cases serviceable rail will be supplied in lengths with flame cut rail ends.

6.1.2 Handling and Removal
Rail shall not be handled in any manner which is detrimental to the rail, trackwork, trackwork components or structures. Damage caused by improper handling shall be rectified at the Contractor's expense. Unnecessary cutting of rail for removal shall be avoided.

6.1.3 Laying
Serviceable rail shall be laid such that the worn face (former running edge) is utilised as the running edge of the relayed track unless otherwise specified by the Superintendent. If rail is required to be transposed, the rail head and/or welds may require regrinding to conform to true rail head profile.

All rails shall be straight and true prior to laying. Any crippled, deformed or damaged rail shall not be used.

The bottom of the rail, the sleeper plate and the bearing surface of the sleeper, as applicable, shall be clean before the rail is laid.

On timber sleepered track, all rail shall be supported on sleeper plates except at turnouts, where plating shall conform to relevant drawings.

6.1.4 Cutting
The Contractor shall avoid any unnecessary cutting of rails.

Cutting of rail shall be carried out to ensure conformance to detailed specifications for rail end condition (cutting), proximity of welds (minimum closure lengths), head matching (joint alignment) and requirement for square or staggered joints (position of joints).

Rails shall only be cut with an approved rail saw or friction saw. Flame cutting of running rail is prohibited.

As supplied rail ends shall be re-sawn if the condition does not comply with the tolerance. Flame cut rail ends shall be re-sawn a minimum distance of 25 mm from the flame cut.

Cuts shall be square to the rail within a tolerance of 2.0 mm over the width and/or height of the rail.
Cutting compound should be used for cooling and lubrication when a rail saw is used. Cutting compound shall not be used with friction saws.

6.1.5 Drilling
When necessary to provide holes in the rail web, such holes shall be made only by drilling. Drills shall be sharp and cutting compound should be used for cooling and lubrication.

All holes shall be drilled and chamfered utilising a suitable template for the relevant rail section. Holes shall be parallel throughout their depth, clean and square with the web. No burrs or projections shall be left and the rails shall not be damaged.

Holes for fishplate shall be as shown on drawing TS1206.

Holes shall be 27 mm diameter for 25.4 mm swage lock fastenings. All holes on the same rail end shall be the same diameter. Hole diameter tolerances shall be ± 1.0 mm. All holes shall have 1 mm chamfers at both ends.

Where 6 hole fishplates are used, three holes shall be drilled in each rail end unless otherwise specified. For 4 hole fishplates, two holes shall be drilled in each rail end.

No two holes shall be closer than 127 mm centres.

Incorrectly drilled holes shall be cut out.

Hole positions at rail ends and turnouts shall conform to dimensions specified and shall be within horizontal and vertical tolerances of ± 1.0 mm.

6.1.6 Minimum Closure Lengths
In jointed ballasted track, the minimum rail length shall be 6.0 metres.

In CWR ballasted track, the minimum rail length shall be 3.0 metres.

In concreted track, the minimum rail length shall be 2.0 metres.

The above minimum rail lengths apply in normal straight and curved track. Shorter lengths may be specified on drawings for track junctions.

6.1.7 Inspection
Any obvious defects in the rail, e.g. cracks, cripples or serious deformations, as determined by the Superintendent, shall be cut out and replaced at the Contractor's expense. Welds shall be cut out if proximity does not comply with minimum closure length requirements.
1.2 Rail Joints

6.2.1 General
Rail joints can be either:
- Flash butt welds
- Aluminothermic welds
- Fishplates with swage lock fastenings
- Fishplates with fishbolts
- Kirby joints.

Rails of like size shall be joined using either flash butt or aluminothermic welds, unless otherwise specified or approved by the Superintendent.

Rails joined by flash butt or aluminothermic welds are considered as continuously welded rail (CWR). CWR in ballast must be tensed to prevent buckling of rails. CWR in concrete does not need tensing as the concrete prevents any buckling.

Rails of different sizes shall be joined with approved aluminothermic welds or with junction fishplates. Junction fishplates shall be shaped to suit the different profiles and fastened with swage lock fastenings.

Rails shall be joined to manganese castings with fishplates and swage lock fastenings.

Manganese castings shall be joined to each other with fishplates and swage lock fastenings.

Care shall be taken to ensure that the top and running edge of both rails match up at each joint. Any misalignment of rail heads caused by the existing rail being worn shall be rectified by grinding or building up the worn rail to line level and gauge using the appropriate weld material creating a 1 in 25 ramp.

Fishplates with fishbolts shall only be used for temporary joints.

Kirby type welded joints shall not be used without the approval of the Superintendent.

Kirby joints are considered to be of an inadequate strength to be used in tensed track.

Any Kirby joint approved by the Superintendent for permanent installation in tensed ballast track, shall be protected against movement. Protection shall be by anchoring, for 40 m on each side of the joint, or by burying the track in concrete, for a minimum of 5 m on each side of the joint.
Situations where the use of permanent Kirby type joints may be approved are:
- Joints in concrete track
- Joining of dissimilar rail sections
- Joining of rails to castings if the castings are constructed in an unsuitable manner for fishplating
- Joining of manganese castings

6.2.2 Position of Joints
Joints shall be square across the track in straight track and at a change of rail section unless authorised otherwise by the Superintendent. Maximum skew at square joints shall be 65 mm.

Curved track may have staggered joints and the stagger shall be squared up with the first joints into the straights. Curved track of less than 325 m radius shall have staggered joints in accordance with detail design plans for the particular location.

Unless authorised by the Superintendent, no joint shall be located within 3.0 m of the approach of rigid track construction, ie concrete track construction or direct fixation on bridges.

6.2.3 Flash Butt Welds
Flash butt welded joints shall be constructed in accordance with Specification TM 36 - Joining of Rails by Flash Butt Welding.

Flash butt welds and adjacent heat effected areas of head hardened rails shall be treated to ensure equivalent surface hardness and hardness profile to the primary rail as specified in AS 1085.11 clause 11.5 or as otherwise specified. The Contractor shall provide details of the heat treatment process for approval by the Superintendent. Head hardened 60 kg AS (T head) rails may be treated in accordance with Specification TM 37. This process may need to be modified to suit other rail profiles and/or chemical compositions.

6.2.4 Aluminothermic Welds
Aluminothermic welded joints shall be constructed in accordance with Specification TM 35 - Joining of Rails by Aluminothermic Welding.

6.2.5 Kirby Type Joints
Kirby type joints shall be constructed in accordance with Specification TS 96002 - Joining of Rails by Arc Welding (Kirby Joint).

6.2.6 Fishplates - General
Fishplates shall match the relevant rail section and shall conform to AS 1085.2. 6 hole fishplates shall be used for all new trackworks.

Junction fishplates shall be utilised to join rails of differing sizes. Junction fishplates shall be designed to match the relevant rail sections taking into
account rail wear at each location. Care in design shall be taken to ensure the head and running edge line up correctly.

Fishplates shall be installed in pairs comprising similar plates.

Fishplates shall be fitted such that there is no gap between the rail ends.

Fishplates shall be fitted correct side up so that the corresponding fishing faces of fishplates and rails are in contact, i.e. 1:3 top of fishplate to 1:3 underside of rail head. The correct tightening sequence is:

<table>
<thead>
<tr>
<th>FISHPLATES, 6 hole</th>
<th>JUNCTION FISHPLATES, 6 hole</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 4 1 2 3 6</td>
<td>3 2 1 4 5 6</td>
</tr>
</tbody>
</table>

Heavier Rail Lighter Rail

The fishing faces of rails and fishplates shall not be painted or lubricated.

6.2.7 Joint Alignment – Fishplated Joints

No step or abrupt variation in alignment is permitted.

When a straight edge 1 metre long is laid on the top surface of the rails symmetrically about the joint, any deviation between the straight edge and the rails shall not exceed 1.0 mm at the end of the straight edge for a convex variation or 0.5 mm at the joint for a concave variation after lifting, tamping and lining.

When a straight edge 1 metre long is held against the running edge sides of the rails, symmetrically about the joint, 8 mm below the running surface of the rail, any deviation between the straight edge and the rails shall not exceed 1.0 mm at the end of the straight edge for a convex variation or 0.5 mm at the joint for a concave variation. Any joint, which does not comply with the alignment specification, shall be corrected or cut out.

6.2.8 Fishplates with Swage Lock Fastenings

Swage lock fastenings shall comply with the intentions of AS 1252 and AS 1511.

Fastenings shall be 25.4 mm diameter unless otherwise specified. All collars shall be flanged type. All washers shall be round, flat, 25.4 mm diameter, high strength structural steel washers and comply with AS 1252 and B 157 (inch series for dimensions).

Swage lock fastenings shall be installed:
- in one direction with bolt heads on gauge side and collars on field side of track,
- strictly in accordance with the manufacturer's current specifications,
- in accordance with Drawing No. TS1206.
Washers may be used to adjust the grip length of each fastening. A maximum of 4 washers shall be used on each fastening and these shall be equally distributed under the head and collar of the fastening. A washer shall be utilised over all oval holes and where a hole is greater than 27 mm diameter.

The head and collar seating of swage lock fastenings shall be within 1 degree under the head and 3 degrees under the collar of normal to the axis of the fastening, unless otherwise specified by the Superintendent.

Temporary bolts shall be installed and tightened for initial assembly. Bolts shall then be replaced individually with swage lock fastenings, generally commencing in the centre of the assembly, alternating in each direction towards the ends.

Threaded swage lock fastenings shall only be used where standard bolts and/or the puller cannot be utilised. Threaded swage lock fastenings shall be assembled with a washer under the nut. Installation shall be such that a minimum of 1 and a maximum of 3 full threads shall protrude beyond the nut. A high strength anaerobic retaining compound (Loctite 262 or approved equivalent) shall be utilised on the thread. The thread shall be clean and dry and the retaining compound applied strictly in accordance with the manufacturer's specifications. A cleaning agent as approved by the retaining compound manufacturer shall be used if required.

All sharp edges shall be ground off the protruding ends of swage lock fastenings after installation.

6.2.9 Fishplates with Fishbolts – Temporary Joints
Fishbolts and nuts shall be M24 heat treated and comply with AS 1085.4.

Washers shall be M27 x 12 x 12 mm spring washers and comply with AS 1085.7.

The correct torque levels for heat treated M24 fishbolts are 450 Nm to 500 Nm.

Fishbolt threads shall not be lubricated.

Temporary joints shall be replaced with the final joint within ten working days. If the final joint is fishplates with swage lock fastenings then all 3 holes for the temporary joint shall be drilled as detailed on Drawing No. TS1206. If the final joint is an aluminothermic welded joint then the holes for the temporary joint shall be only the 2nd and 3rd holes from the end as detailed on Drawing No. TS1206.
6.3 Alignment, Level and Cant

The trackwork, including points and crossings, shall conform to the alignment, levels and cant as shown on the detail design drawings.

6.4 Curved Trackwork

Rails for curved trackwork, i.e. radius less than 325 m, shall be head hardened and pre-bent. For conventional rail (41 kg/m) a pre-bent check plate shall be fitted to rail prior to installation.

Extra, 25 mm diameter, tie bar holes may need to be drilled in the web of the rails so that tie bars can be fitted correctly (perpendicularly) between the rails.

6.5 Special Works

Special Work is any trackwork which must be pre-fabricated (ie bent or assembled) before it can be constructed on site. This includes all switches, crossings and any trackwork which needs pre-bending.

Trackwork for junctions and crossovers shall be pre-fabricated into modules. Typical modules are turnouts, diamonds and H crossings.

Rails for crossingwork shall be head hardened. A pre-bent check plate shall be fitted to Tee head rails prior to installation.

A turnout module consists of a pair of switches (including drainage boxes and all working components), 1 crossing, and connecting rails. A turnout module weighs approximately 2 tonnes.

A diamond module consists of 4 crossings and 4 closure rails. A diamond module weighs approximately 1 tonne.

A H-crossing module consists of 16 crossings and 8 closure rails. A H-crossing module weighs approximately 4 tonnes.

The modules and separate rails shall be welded together on site using the appropriate methods as specified.

All points and crossings shall be seated on the appropriate sleeper plates and shall be firmly fastened down onto sleepers by the specified fastenings.

Points and crossings shall be laid in the general plane of the trackwork, unless otherwise specified.
6.5.1 Points
6.5.1.1 Major Components
The major components of a set of points include
- Switch Housings
- Switches (also referred to as the blades or tongues)
- Inter-Connecting Box
- Sump Box:

The above are pre-assembled along with any operating mechanism for the control of switch movement.

The sump to the points assembly shall be drained in accordance with design plans to suit site conditions.

Points operating equipment shall be fitted and adjusted to operate correctly.

_For additional works for Autopoints refer to YARRA TRAMS – AUTO PNTS V1.3_

6.5.1.2 Lubrication
Bearing surfaces shall be thoroughly cleaned to remove all scale, rust, grease, moisture and other contaminants prior to application of switch plate lubricant. A non-flammable solvent may be used for degreasing, if necessary.

6.5.2 Crossings
Crossings shall be fixed with all legs in true alignment as intended.

6.5.3 Check Rails and Plates
Where Tee head rails are used at special works, or curves up to 325 m, the guard rails or check plates shall be fitted in accordance with the following table:

<table>
<thead>
<tr>
<th>CURVE RADIUS / TURNOUT</th>
<th>CHECK REQUIREMENT</th>
<th>HIGH LEG CHECK</th>
<th>LOW LEG CHECK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FLANGE GAP</td>
<td>HEIGHT AT RAIL HEAD</td>
</tr>
<tr>
<td>Curve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 100 m R</td>
<td>Both Rails</td>
<td>30 mm</td>
<td>-2.4 mm</td>
</tr>
<tr>
<td>100 to 325 m R</td>
<td>Low Leg Rail</td>
<td>30 mm</td>
<td>-2.4 mm</td>
</tr>
<tr>
<td>Greater than 325 m R</td>
<td>Not Required</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Turnout, Opposite V Crossing

|                     | Both Rails |                |                |            |                     |
|---------------------|------------|----------------|----------------|            |                     |
| Zero Superelevation | 30 mm      | -2.4 mm        | 26 mm          | +3.6 mm    |                     |
| With Superelevation | 26 mm      | +3.6 mm        | 26 mm          | +3.6 mm    |                     |
Check Plate details and construction shall comply with Drawings No. YTS1102, YTS1103 and YTS1208.

The ends of Check Plates which are elevated above rail level shall be ramped 6 mm by 250 mm length at the ends.

Check Plate material shall be:-

<table>
<thead>
<tr>
<th>CURVE</th>
<th>CHECK PLATE MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Leg, Up to 100 m Radius and Opposite V Crossings</td>
<td>AS 3597 Grade 700, Bisalloy 80 or equivalent</td>
</tr>
<tr>
<td>All other situations</td>
<td>AS 1443 Grade K1042, fully killed</td>
</tr>
</tbody>
</table>

6.5.4 Closure Rails
Closure rails shall be cut and laid in such a manner that no gaps are provided at joints.

6.6 Gauge of Trackwork
Track gauge shall be measured between the running edges of the rails at points 8 mm below the running surface and must take into account any rail head metal flow.

Track gauge for straight track shall be 1435 mm.
Guard rail gauge shall be 1390 mm.

Gauge shall be modified as follows:
- Straight and curved track (except turnouts) laid neat to gauge
- Straight track through Diamonds & H Crossings 5 mm tight
- Turnouts, (turnout move) opposite V Crossings 3 mm wide
- Turnouts, (through move), opposite V Crossings where superelevation is applied 3 mm wide
6.7 Track Geometry Tolerances

Track shall be constructed to the tolerances shown in the following table:-

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centreline location</td>
<td>± 3 mm</td>
</tr>
<tr>
<td>Level</td>
<td>± 3 mm</td>
</tr>
<tr>
<td>Gauge (open track)</td>
<td>+ 3, - 0 mm</td>
</tr>
<tr>
<td>Gauge, Turnouts (opposite crossings)</td>
<td>+ 2, - 0 mm</td>
</tr>
<tr>
<td>Gauge, Diamonds and ‘H’ Crossings</td>
<td>+ 2, - 0 mm</td>
</tr>
<tr>
<td>Guard rail (Check) flangeway</td>
<td>+ 1, - 0 mm</td>
</tr>
<tr>
<td>Line measured over a 10 m chord</td>
<td>± 3 mm</td>
</tr>
<tr>
<td>Twist (3.5 m chord)</td>
<td>± 2 mm</td>
</tr>
<tr>
<td>Cant</td>
<td>± 3 mm</td>
</tr>
<tr>
<td>Top (10 m chord)</td>
<td>± 3 mm</td>
</tr>
<tr>
<td>Sleeper spacing</td>
<td>± 25 mm</td>
</tr>
</tbody>
</table>

Cant shall be applied uniformly over the full length of transitions.

6.8 Bonds

6.8.1 General

In order to ensure continuity of the electric circuit as well as minimising the electrolysis effects, bonds shall be installed on the rails.

**Extreme care shall be taken when excavating near bonds connected to electrical assets or negative feeder cables.**

All rail connections in concrete track construction shall be welded to the foot of the rail as per detail ‘A’ of Drawing No. E14-558-YT.

Long bonds in concrete track construction shall be encased in concrete, with 100 mm cover in all directions, in a trench beneath the edge of the crushed rock base course and with orange cable marker tape between the concrete and the crushed rock base course.

All rail connections in ballast track construction must be achieved using the 'Cembre AR' series of connectors. For 41 kg/m rail the 'Cembre AR60N' electric track connector shall be used. For installation instructions of 'Cembre' rail connectors refer to works instruction WI DRAFT.

All bonds in ballast track construction shall be installed after tamping of track because tamping will damage any previously installed bonds. All bonds, other than rail joint bonds, shall be protected by a minimum of 300 mm ballast.
Bonds shall conform to Drawing No. E14-501-YT or equivalent, approved by the Superintendent.

Locations of all bond connections to rail shall be marked on the top of the head of the rail on opposite side to the running edge. Each mark shall consist of 3 straight cuts (known as 'crow's foot') coming to a point at the edge of the rail head - each cut to be 20 mm long x 2 mm wide x 2 mm deep.

6.8.2 Rail Joint Bonding
Whenever two rails are joined by fishplates, a short electrical bond, Drawing No. E14-501-YT Reference E14-501-YT/300, shall be provided to ensure electrical continuity of the joint.

6.8.3 Track and Rail Bonding
Track and rail bonds shall be installed at 150 m intervals. On conventional fixed overhead, these bonds should be installed at approximately every fifth pole.

All bonds excavated during track repair or earthworks shall be reinstated as per Drawing No. E14-558-YT.

If any stretch of track over 150 m is found to be without any track and rail bonds then the Superintendent's advice shall be sought whether additional bonding is required.

6.8.4 Pillar Box Bonding
All pillar boxes shall be bonded as per Drawing No. E14-704-YT.

6.8.5 Long Bonding
At special works such as H-crossings, junctions, crossovers and turnouts, bonding shall take place around the special works. The connections shall be made to bridge the straight tracks past either side of the special works.

A bare copper conductor of 400 mm² shall be used to form the long bond that bonds around the special works. The centre of two rail bonds are attached by the 'Wheeze' process at each end of the 400 mm² conductor to form four legs at each end.

Long bonding shall not be placed in the region of automatic track circuits.

Typical long bonding drawings are:-
- H-crossing E14-603-YT
- Crossover E14-559-YT
- Junction E14-560
- Turnout E14-586-YT
6.8.6 Pole Bonding
A pole bond shall be installed at 300 m intervals. On conventional fixed overhead, these bonds should be installed at approximately every 10th pole.

A pole bond shall also be installed on every tram overhead pole which has electrical equipment mounted on it (such as: - Aerial Switches, Automatic Sectionalizing Switches and Surge Diveters).

Locations of poles carrying electrical equipment are to be obtained from the Superintendent. If no pole bond is found connected to the track at any of these locations then the Superintendent shall be notified.

A pole with a surge diverter (special case of electrical equipment) shall have the surge diverter attached to the rail with 120 mm² cable and shall be installed as per Drawing No. E14-644-YT, except that the cable to the surge diverter must extend all the way to the surge diverter and not stop 300 mm above ground level.

If a pole with electrical equipment on it is a wooden pole then it shall not be bonded.

All pole bonds shall be 120 mm² cable and shall be installed as per Drawing No. E14-644-YT.

All pole bonds excavated during track repair or earthworks shall be reinstated using a cad welded terminal.

If any stretch of track over 300 m is found to be without any pole bond then the Superintendent's advice shall be sought whether additional bonding is required.

Electrical equipment which needs a pole bond includes Auto-sectionalising switches, Aerial switches and Surge diverters.

6.8.7 Negative Feeders
Substation negative cables shall be attached to the rail with 400 mm² cable and shall be installed as per Drawing No. E14-643-YT.

6.8.8 Testing and Reinstatement of Existing Pole Bonds
Where in the process of carrying out track repairs, pole bonds are located or excavated, they shall be tested following the procedure below.

For poles that carry sectionalising switches the pole bond cable shall not be disconnected unless the sectionalising switch is isolated and the permission of the Superintendent has been obtained.
The pole bond conductor shall be disconnected at the pole and the resistance of the conductor between the pole terminal lug and the rail connection shall be measured.

The test shall be conducted by a qualified electrical trades person or qualified Technical Officer.

The Superintendent shall approve the equipment as well as the method utilised to perform the test.

The results of the bond testing shall be submitted in writing to the Superintendent.

The location, pole number, original cable resistance reading, final pole bond resistance reading after reinstatement shall be included in the test results.

Depending on the test results obtained one of the following procedures shall be undertaken.

The cable shall also be visually inspected for damage to conductors along its length and adjacent to the rail connections. If any conductors are damaged, the cable shall be replaced.

If the cable resistance exceeds 0.1 Ohm, then:

- If the pole carries underground feeder cables, an aerial switch or a sectionalising switch then a new 120 mm² double insulated conductor shall be run between the pole and the rail as per Drawing No. E14-644-YT.

  On completion of the cable installation the resistance between the pole and the rail shall be retested and shall not exceed 0.1 Ohm.

- If the pole carries a surge diverter then two new 120 mm² double insulated cables shall be run between the pole and the rail as per Drawing No. E14-644-YT, except that the cable to the surge diverter must extend all the way to the surge diverter and not stop 300 mm above ground level.

  On completion of the cable installation the resistance between the pole and the rail and the surge diverter earth cable and the rail shall be retested and shall not exceed 0.1 Ohm.

- If the pole does not carry underground feeder cables, an aerial switch, a sectionalising switch or a surge diverter the Superintendent's advice shall be sought whether to replace the pole bond cable or not.

  If the bond cable is to be replaced it shall be done as per Drawing No. E14-644-YT.
On completion of the cable installation the resistance between the pole and the rail shall be retested and shall not exceed 0.1 Ohm.

If the bond cable is not to be replaced, then it shall be disconnected from the pole cut at or below ground level. At the track end the cable shall be cut as far away as possible from the rail and be abandoned.

If the cable resistance does not exceed 0.1 Ohm then:
- The cable bond connections shall be reinstated at the rail and the pole as per drawing No. E14-644-YT.

On completion of the cable installation the resistance between the pole and the rail shall be retested and shall not exceed 0.1 Ohm.
7. TRACK CONSTRUCTION IN BALLAST

7.1 Ballast

7.1.1 Placement and Compaction of Ballast

Track construction shall not be carried out over any length of formation until the formation has been checked and approved by the Superintendent.

Following acceptance of the completed formation and prior to laying sleepers, the Contractor shall place, grade and compact one or more layers of ballast to a total minimum depth of 150 mm.

Compaction shall be by a smooth wheeled vibrating roller as specified for earthworks.

The compaction plant shall be subject to approval by the Superintendent.

The Superintendent shall inspect completed work prior to placement of sleepers.

Track construction shall be carried out after the initial 150 mm layer of ballast has been compacted.

After track construction and prior to tamping, cribs and shoulders are to be filled to top of sleeper with extra ballast.

The depth of ballast following tamping shall be 200 mm from top of sub ballast to bottom of sleepers.

7.1.2 Ballast General Requirements

The whole of the material supplied shall be basalt or other rock of similar properties as approved by the Superintendent, and shall be clean, free from clay, dirt and other deleterious matter or weathered pieces of rock and free of dust.

The Superintendent shall review the source material prior to ballast production commencing.

In the event of a Contractor tendering to supply a material, the source rock of which is other than basalt, the Superintendent may arrange additional inspections, tests and evaluations so that appropriate test values can be set to ensure that the rock is acceptable.
7.1.3 Testing: General
The Contractor shall test the ballast for conformity with this specification. Testing shall consist of two parts:

a) Testing for full conformity in a NATA registered laboratory.

f) On-site testing for particle size and shape.

7.1.4 Mechanical Properties
Material supplied shall be capable of complying with the requirements specified in AS 1141 - Methods of Sampling and Testing Aggregates.

Friable particles shall not be present in the material supplied in excess of 0.3% by weight when tested in accordance with Part 32 of AS 1141.

Bulk density expressed on a dry basis shall not be less than 2600 kg/m³ when tested in accordance with Part 6 of AS 1141.

When tested in accordance with the method described in Part 23 of AS 1141: Los Angeles Value, the percentage of wear shall not exceed 30%.

The crushing value, when tested in accordance with Part 21 of AS 1141, shall not exceed 30%.

When the material is tested in accordance with Part 14 of AS 1141 the percentage of mis-shaped particles at 2:1 ratio shall not exceed 30%.

<table>
<thead>
<tr>
<th>SIEVE SIZE AS (mm)</th>
<th>% PASSING BY MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>63.0</td>
<td>100</td>
</tr>
<tr>
<td>53.0</td>
<td>90 - 100</td>
</tr>
<tr>
<td>37.5</td>
<td>35 - 70</td>
</tr>
<tr>
<td>26.5</td>
<td>0 - 15</td>
</tr>
<tr>
<td>13.2</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

7.1.5 Testing for Full Conformity
The Contractor shall be responsible for extracting, transporting and testing samples of ballast for conformity with the Specification. One such sample shall be taken from the first 100 m³ of ballast produced.

The ballast sample shall be tested in a NATA registered laboratory for conformity to the Specification.

Should the sample not meet the requirements of the Specification, an additional sample shall be provided for further testing.
Ballast production shall not continue beyond the first 100 m³ until the Superintendent has reviewed and approved the test results.

7.1.6 Testing On-Site
The Contractor shall be responsible for extracting and testing on-site samples of ballast for conformity with the particle size and shape requirements of the Specification. The Contractor shall maintain on site all equipment and personnel necessary for conducting such tests.

The proportion of mis-shaped particles, as measured with proportional callipers, shall be tested at least once every week when ballast is being delivered.

Particle size distribution shall be measured daily, and at least once from every 1000 m³ of ballast produced.

7.1.7 Reporting of Test Results
The results of all testing shall be kept by the Contractor and copies shall be forwarded to the Superintendent within 24 hours of receipt. All data recorded and calculations made in the process of deriving test results are to be kept and provided to the Superintendent upon request.

All samples shall be consecutively numbered, and the sample number shall be recorded on all test results.

7.1.8 Acceptance or Rejection of Ballast
The Superintendent may reject ballast failing the tests as detailed in this Specification.

The Superintendent, after rejecting ballast, may direct a halt in production so that rectification or remedial works can take place. All downtime, mobilisation of new or additional equipment, trial crushing and testing for acceptance as a result of such downtime shall be at the Contractor's expense.

Production shall resume upon satisfactory completion of trial crushing and testing, and the approval of the Superintendent.

Trial crushing shall mean the supply of 50 m³ of ballast stockpiled independently of the main stockpile. That 50 m³ shall be sampled and tested for conformity to this Specification.

7.1.9 Avoidance of Segregation
At all times during production, transport, stockpiling and placement, the Contractor shall ensure that ballast is handled in ways which minimise segregation of different sized stones.

The Superintendent may reject ballast that has become excessively segregated.
1.2 Sleepers

7.2.1 General
Concrete sleepers shall be used for all open track in ballast.

Timber sleepers shall be used for turnouts and junctions where suitable concrete sleepers are not available.

Two timber sleepers with dogspikes shall also be used at fishplated joints (one either side of the joint) because other fixing methods foul the fishplated joints. Dogspikes may need to be reversed to prevent fouling the fishplated joint.

7.2.2 Handling and Storage
Sleepers shall be handled and moved into position in such a way as to avoid damage or bruising. Sleepers shall not be subjected to blows from a hammer or any other tool or appliance. The use of picks or hoe tines to pull timber sleepers into position is not permitted.

Sleepers shall be stored and stacked in a manner which will prevent warping and twisting of timber sleepers, or damage to Pandrol shoulders in concrete sleepers.

The Contractor shall inspect sleepers, provided by the Superintendent, for quality prior to installation. Claims for condition of sleepers received will not be accepted unless notified within 48 hours of delivery.

The Superintendent shall inspect sleepers provided by the Contractor, but this does not relieve the Contractor of responsibility for conformance.

7.2.3 Aligning
Sleepers shall be laid central to the track and at right angles to the centreline of the track unless otherwise specified. Timber sleepers for turnouts shall be aligned on one end as specified on drawings.

7.2.4 Spacing
Sleeper spacing shall be at the following centres:
- Open track - 685 mm ± 25 mm. Minimum 1460 sleepers per km.
- Mechanical joints utilising bar type fishplates - 460 mm ± 5 mm.
- Turnouts - as specified on relevant drawings, with a general tolerance ± 10 mm.
- Tolerance for position of fixed sleepers ± 5 mm.
Sleeper spacing shall be adjusted to ensure that:
- welded joints are suspended centrally between sleepers (spaced at 685 mm)
- fishplated joints shall be suspended centrally between sleepers (spaced at 460 mm).

7.2.5 Laying
Timber sleepers shall be laid heart side down.

All sleepers shall be lifted, lined and tamped after installation and fastening of rails.

7.2.6 Concrete Sleepers
Concrete sleepers for open track shall conform to Technical Specification TM 38 - Tramway Prestressed Concrete Sleepers.

7.2.7 Timber Sleepers
Timber sleepers shall comply with A53818.2, Rail Track Sleepers, Lead or Crossing Timbers and Bridge Transoms from Eastern Australian Hardwoods.

Timber sleepers, if specified for open track shall be 2600 x 250 x 125 and shall be cut from red gum or better as per PTC contract ‘Supply of Timber Railway Sleepers’.

Timber sleepers for turnouts shall be 250 x 150 with lengths as specified on layout drawings and shall be sawn from red gum as per PTC contract ‘Supply and Delivery of Sawn Red Gum Timbers’.

Where the sleeper plate is being relocated or installed on a serviceable sleeper, the bearing area may be uneven due to cutting by the plate or rail. Such uneven surfaces shall be adzed to provide a flat and level bearing surface for the sleeper plate.

Holes for dogspikes (19 mm) and/or Pandrol gauge-lock clips (16 mm) shall be bored with an auger or drill at right angles to the bearing face of the sleeper and through the full depth of the sleeper. Holes may be pre-bored utilising suitable templates which ensure correct final track gauge.

Holes for the two inside and the two outside dogspikes on each sleeper shall be on opposite sides of the centre of sleepers (other than at joints) on straight track. Refer to Standard Plan F474C for further details.

On curves of 500 m radius or less, spike holes shall provide for two dogspikes on the out side of the outer rail.

At rail joints, spike holes shall be bored in accordance with Standard Plan F474C and Plan 940-58.
In existing track situations where dogspikes are loose in spike holes, new holes may be cross bored otherwise sleeper plates or sleepers shall be relocated and new holes bored. New holes shall be bored in serviceable sleepers. The minimum width of sound wood shall be 25 mm between spike holes and 40 mm between a spike hole and edge of sleeper.

Spike holes from which a spike has been removed shall not be reused. Existing holes in sleepers shall be plugged if under plates or rail or at the minimum separating distance for spike holes. Pegs shall be 20 mm square KD hardwood of similar length to sleeper depth.

### 7.3 Fastenings

#### 7.3.1 General
Rail fastenings can be either:
- Dogspikes with sleeper plates.
- Gauge-lock clips with sleeper plates.
- Resilient rail clips.

Dogspikes with sleeper plates shall be used with timber sleepers to refasten existing trackwork.

Gauge-lock clips with sleeper plates shall be used with timber sleepers on new trackwork.

Resilient rail clips shall be used with concrete sleepers on new trackwork.

#### 7.3.2 Dogspikes with Sleeper Plates
Dogspikes shall be 19 mm and in accordance with AS 1085.8.

New or released serviceable dogspikes can be used. Dogspikes which are not deformed, excessively corroded and have a minimum diagonal dimension of 23 mm are considered serviceable.

Dogspikes shall have a length of 150 mm on plated track.

The two inside and the two outside dogspikes shall be located on opposite sides of the centre of sleepers (other than at joints).

On straight track two dogspikes shall be used for each rail. On curves of 500m radius or less, an additional dogspike shall be installed on the out side of the outer rail.

The arrangement of dogspikes shall be in accordance with Standard Plan F474C and Plan 940-58.

Double shoulder, level base, sleeper plates, generally to AS 1085.3, shall be used with dogspikes.
Level base sleeper plates shall be used at turnouts in accordance with relevant layout drawings.

Sleeper plates shall be placed centrally about the longitudinal axis of the sleepers and squared so that the side of the plate sits parallel with the rail foot.

7.3.3 Gauge-Lock Clips with Sleeper Plates
Gauge-lock clip fastenings (Pandrol or equivalent as approved by the Superintendent) shall be used on all new trackwork. All fastenings shall be installed in accordance with manufacturer’s specifications.

Flat sleeper plates shall be used with gauge-lock clips - refer Pandrol Drawing PMP41060.

Level base sleeper plates shall be used at turnouts in accordance with relevant layout drawings.

Sleeper plates shall be placed centrally about the longitudinal axis of the sleepers and squared so that the side of the plate sits parallel with the rail foot - refer Pandrol Drawing TSA105165.

7.3.4 Resilient Rail Clips for use with Concrete Sleepers
The rail fastening system shall consist of the following Pandrol components:
- Resilient Rail Clips E 1821
- Rail Foot Insulator IN 55088
- Rail Pad HDPE 7.5 mm thick RP 65263.

The components shall be installed strictly in accordance with manufacturer’s instructions as specified in 'Pandrol Installation Manual'.

A Panpuller, or equivalent, shall be used for installing or removing the clips - use of a hammer or the like shall not be permitted.

7.3.5 Anchoring
Rail anchors shall be utilised to control rail creep and maintain individual rail lengths in an adjusted or destressed condition at a rail temperature of 38°C.

Rail anchors shall be used on dogspiked track as specified in CEC 3/87.

Rail anchors shall not be used with gauge lock or resilient fastenings except near any Kirby joints, or where the end of works is not fixed in concrete or suitably anchored. Road crossings not in concrete are not considered fixed. In these instances an anchor block as specified on Drawing No. TM217 shall be used.

Rail anchors may only be used on the rails for which they were manufactured and shall be correctly fitted to the rail flange in accordance with
manufacturer's instructions. Anchors shall have a firm bearing against the face of the sleeper and shall be perpendicular (at right angles) to the rail. Care shall be exercised to ensure that anchors are not over or under driven or mechanically damaged during application. Any damaged anchors shall be replaced. Rail anchors shall not be fitted at welds.

Anchors that are more than 10 mm from the face of the sleeper must be removed and re-applied. Anchors within 10 mm may be tapped lightly at each end until firmly bearing against the sleeper. A final tap on the nib end may be required to ensure that the anchor is locked in and not overdriven.

On completion of laying and adjusting, the rail shall be anchored to standard in accordance with Standard Plans MF523C and MF524C.

Establishment of creep monuments is not the responsibility of the Contractor. The Superintendent shall nominate and approve the location and type of creep monument.

7.4 Track Adjustment

With continuously welded rail (CWR - rails joined with flash butt, aluminothermic welds or swage lock fastenings) the track must be adjusted (tensed) in accordance with CEC 3/87.

Allowance must be made for expansion and contraction of rail to control stress. The required adjustment depends on rail temperature at time of laying and/or adjusting the rail lengths. Rail temperature at the time of laying or adjusting shall be measured with an approved type of thermometer. The thermometer shall be placed on the shady side of the rail web, protected from the influence of wind, and shall be read when the temperature has stabilised.

In hot weather, it may be necessary to anchor the track temporarily to avoid expansion while the next section is laid or adjusted. This will prevent creep affecting the designed adjustment.

Each rail length shall be adjusted in accordance with the rail adjustment table and shall be anchored to standard pattern in accordance with Standard Plan MF523C or MF524C, depending on rail length.

**HP** A record of location, rail length installed, rail temperature and adjustment shall be prepared and a copy provided to the Superintendent prior to welding commencing. The Contractor shall provide a sample record sheet for approval.
7.5 Marking Tangent Points and Cant Values

Tangent Points shall be stencilled in white paint on the outside of the low leg rail web reading from the Melbourne end of a curve as follows:
- T.S. (tangent-spiral) at the beginning of the transition.
- S.C. (spiral-curve) at the end of the transition/start of the circular curve.
- C.S. (curve-spiral) at the end of the circular curve/beginning of the transition.
- S.T. (spiral-tangent) at the end of the transition.

Cant values shall be stencilled on the inside of the high leg rail web or check plate, at each 10 mm increment through the transitions.

7.6 Tamping of Track

7.6.1 General
The Contractor shall lift or lower the track as necessary and accurately pack to correct line, level and cant. The track shall be held at true level and the ballast tamped without disturbing this level.

Mechanical tampers shall pack the ballast so that every rail in points and crossings and plain track is packed. Around crossings and elsewhere where standard tamping tools will not fit between rails, special equipment is to be used to hand pack the ballast.

7.6.2 Plant and Equipment
The Superintendent shall approve the plant and equipment to be used for tamping, compacting or regulating ballast before use.

During the course of the work, all plant and equipment shall be maintained to the satisfaction of the Superintendent.

Tamping equipment shall be capable of being adjusted to ensure satisfactory tine penetration below the underside of sleepers for differing rail sections and sleeper thicknesses. Tamping tines shall not be excessively worn.

Track construction equipment, including tamping equipment, shall be limited to the following:
- Dynamic axle load: 22 tonnes
- Static axle load: 17 tonnes
- Speed of travel: 20 kph

The Contractor shall meet costs for transport of plant and equipment to the site for use on the Contract, and away from the site at the end of the Contract, including any railway protection or operating costs.

7.6.3 Tamping Operations
For each lift on all work, two passes of the tamping machine shall be applied to each sleeper being tamped.
The Contractor shall ensure that 2 tamping tools always work opposite each other on the same sleeper or timber. Ballast shall be thoroughly consolidated to a distance of 400 mm along each side of the centre line of each rail and under the full width of the sleeper.

7.6.4 Regulation of Ballast
After tamping, the ballast shall be regulated and trimmed to the profiles shown on the Drawings.

The cribs and shoulders of the ballast shall be vibration compacted by a suitable method. As far as possible the Contractor shall ensure that this work is done immediately after tamping and lining operations.

Upon completion of compaction, the ballast profile shall be restored to that shown on the Drawings including, if necessary, the placement of additional ballast.

*HP* The Superintendent prior to work commencing shall approve the method and procedure for crib and shoulder compaction.
8. EMBEDDED TRACK IN CONCRETE

8.1 Types of Embedded Track

There are two types of Embedded track construction in concrete.

8.1.1 Conventional
The rail and fastenings are embedded in a continuous single pour slab.

8.1.2 Rubber Boot
The rail and fastenings, incorporating rubber boot, are embedded in a continuous single pour slab.

8.2 Concrete – General

The concrete mix for embedded track for both conventional and rubber boot shall be as follows.

Where there is need to run tram traffic within 14 days or less, a Special 50 Mpa concrete shall be provided. This shall satisfy strength requirements as outlined in the following table.

<table>
<thead>
<tr>
<th>Concrete Type</th>
<th>Age</th>
<th>Compressive Strength (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special 50</td>
<td>5 hours</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>7 days</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>28 days</td>
<td>50</td>
</tr>
</tbody>
</table>

Note that Special 50 plus accelerator needs to be considered if trams are to use the track 5 hours after the last pour within the track (the 4 foot). Less time may be approved by the superintendent for concrete pour in the centre of the two tracks (the 6 foot).

No motor traffic shall be allowed on to the concrete until a minimum strength of 14 Mpa has been achieved. Approval from the Superintendent shall be sought prior to allowing traffic on to the concrete.

Where tram traffic is not expected to be run for at least 28 days, the Superintendent may permit the use of concrete that achieves a minimum compressive strength of 32 Mpa at 28 days.

8.3 Standards and Materials for Concrete

The manufacture and supply of concrete shall comply with the requirements of AS 1379 and the standards referred to in Clause 1.2 of AS 1379.

Cement used shall be general purpose Portland cement Type GP complying with AS3972. Minimum cement contents shall be 460 kg/m3 for Special 50 mix and 360 kg/m3 for 32 Mpa mix.
Fine and coarse aggregate for concrete shall comply with AS 2758.1

Coarse aggregate shall have nominal size of 20 mm.

Concrete slump shall be a maximum of 75 mm determined from a slump test in accordance with AS1012.3 unless otherwise approved in writing by the Superintendent.

8.4 Tie Bars

Tie bars shall conform to Drawing No. TS1101 and Australian Standard AS 1302 or equivalent approved by the Superintendent.

Tie bars shall be placed at the minimum rate of five (5) per full rail length (approximately every 3 metres for straight track and at 1.5 metres spacing for curved track). Tie bars are not to be placed in the fish plate holes near the ends of the rails.

The tie bars shall be adjusted and tightened to keep the rails to gauge.

The larger 22 mm tie bars shall be used for junctions or for curves with radius less than 325 metres. 18 mm tie bars are to be used for straight track or curves with radius greater than 325 metres.

Tie bars to be used in junctions and crossovers shall be fabricated to suit the particular location in the junction or crossover.

8.5 Rail Supports

Rail shall supported on either standard tramway concrete sleepers or concrete blocks of minimum size 200mm x 200mm x 100mm to achieve line and level. The Superintendent shall approve the material and shape of packers.

Packers shall be placed under the rail at regular intervals as well as under each end of switches and under the centre of each crossing and other locations as deemed necessary by the Superintendent. Refer to Drawing No. TS1401-YT, TS1406-YT and TS1407-YT.

8.6 Preparation for Concrete Placing

The Contractor shall place the concrete around each of the tracks before placing the concrete between the tracks. Each part shall be poured as a monolithic section in one continuous operation unless otherwise directed and/or approved by the Superintendent.

Tram movements and schedules shall govern placement of concrete.
The placement of any concrete around each of the tracks shall not commence until the consent to proceed is obtained from the Superintendent.

No concrete shall be poured until dimensions, levels and alignments of all formwork, reinforcement and dowels, rail levels and alignments, rail joint welding, track bonding and track drainage have been checked by the Superintendent. The Contractor is to advise the Superintendent of his intention to pour concrete, two (2) clear working days prior to the pour, or later as approved by the Superintendent.

Concrete shall not be placed later than five (5) hours prior to the resumption of tram services.

The sub-base shall be dampened and concrete shall be deposited on the dampened sub-base in such a manner as to minimise segregation and rehandling. The placing shall be rapid and continuous between planned construction joints, and it shall be distributed so that when consolidated and finished, the slab thickness, surface shape and levels shown will be achieved at all locations.

Dowels shall be used where concrete pours stop and restart if concrete is hard.

The contractor shall take particular care that no concrete enters the working compartments of the switches.

The Contractor shall ensure that there is a minimum of 125 mm under the foot of the rail for the placement of new concrete. If this cannot be achieved, then F82 reinforcement shall be placed under the foot of the rail with at least 50 mm coverage. Where the track is being laid on a concrete foundation slab, such as a bridge deck, the reinforcement mesh may be omitted. Approval from the Superintendent shall be obtained for the construction method.

8.6.1 General
Concrete shall be manufactured, transported and, handled, in accordance with the requirements of AS 3600 and with the additional requirements specified herein.

Unless otherwise approved, concrete used in the works shall be ready-mixed concrete manufactured, supplied and delivered in accordance with AS 1379. Ready-mixed concrete shall be delivered to the site in trucks of the revolving drum type and the use of non-agitating delivery equipment will not be permitted.

At least 14 days prior to the commencement of the works, the Contractor shall notify the Superintendent of the name of the proposed Concrete Supplier the location of the ready-mixed concrete plant and the mix design.
No concrete shall be supplied unless and until the Superintendent has approved of that Supplier, Plant and mix design.

The Superintendent reserves the right to withhold or withdraw his approval of any Supplier or Plant if not satisfied that adequate quantities of concrete complying with the requirements of this Specification can or are being produced.

In the event of the Superintendent directing that Supplier be other than that indicated in the Schedule, any variations in price, above or below the rate indicated in the Schedule of information for the supply of ready-mixed concrete material, shall be to the Principal's account.

Prior to the discharge of concrete at the site, the mixer or agitator shall be operated at mixing speed for a minimum period of one minute or until the concrete achieves the required uniformity.

Notwithstanding the provisions of AS 1379, all concrete shall be completely discharged in position in the forms within 60 minutes of the introduction of the mixing water to the mix.

The concrete shall be placed and compacted within 20 minutes after discharge from the mixer.

There shall be no addition of water or any other material to the concrete at the site without the approval of the Superintendent.

The working surfaces of platforms and conveying equipment shall be cleaned of all foreign material and set concrete immediately prior to commencement of each continuous placing run.

Prior to and during the placing of concrete, the formwork and the space to be occupied by the fresh concrete, and all embedded items, including reinforcement, shall be maintained in a clean condition, free of mud, oil and other deleterious materials. All debris shall be removed from places to be filled with concrete.

Concrete shall be handled from the supply truck to the place of final deposit as rapidly as possible by methods that shall prevent the separation, segregation, or loss of ingredients. It shall be deposited as nearly as possible in its final position in order to prevent rehandling or flowing. Dropping the concrete a greater height than 1.2 metres will not be permitted.

If an interval between placing of any two consecutive loads of concrete should occur in which the concrete commences to harden, the concrete shall be removed from under the rail and a transverse construction joint shall be made as specified.
No concrete which has partially hardened or has been contaminated by foreign materials shall be deposited in the work. Concrete shall not be retempered.

8.6.2 Reinforcement
At track junctions, steel reinforcement fabric shall be placed within each track, as well as in between the two tracks at track junctions. The fabric shall be F82 sheets, unless otherwise shown on drawings or approved by the Superintendent.

The reinforcement shall be laid on the tie bars and/or approved supports and shall be securely held in its correct position during the concrete placing operation and until the concrete has hardened.

Steel reinforcement shall comply with the requirements of AS 1302, AS 1303, AS 1304, AS 3600.

Welding, including tack welding, of hard-drawn steel wire reinforced fabric shall not be permitted.

Any welding of hot-rolled steel reinforced bars, if permitted by the Superintendent, shall be in accordance with Australian Standard AS 1554, Part 3, Welding of Reinforced Steel, and including all preheated requirements specified therein.

All reinforcement when placed shall be free from grease, tar, oil, paint, mud, loose mill scale, loose or thick rust, etc., and shall present a clean surface.

Reinforcing fabric sheets shall be handled so that they remain free from distortion. They shall be lapped so that the two outermost wires of one sheet of fabric overlap the two outermost wires of the sheet being lapped. Lapped portions shall be tied with wire at a maximum spacing of 500 mm.

Reinforcement shall be terminated 75 to 80 mm from dowelled contraction joints. Reinforcement shall terminate at least 40 mm and not more than 80 mm from longitudinal construction joints, or pavement edges.

Reinforcement bars shall be bent by machine or other approved means producing a gradual and even bend. Bars shall be bent cold. After being bent and straightened, steel reinforcing bars shall not be re-bent within 500 mm of the previous bend.

At corners and bends in main reinforcement, the internal radii of bends shall be not less than five times the diameter of bar unless detailed otherwise on the drawings.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the progress of the concreting will not be permitted.
The Superintendent shall approve placement and fastening of reinforcement before any concrete is deposited.

8.6.3 Dowels
All dowels shall be one-piece, straight, plain round steel bars complying with the requirements of AS 1302, and of the sizes shown on the appropriate drawing detail. They shall be cut to length prior to delivery to the site and the ends shall be cut square and free from burrs. Dowels shall be clean and free from mill scale, loose rust or oil.

Dowels shall be used where new concrete is to be placed adjacent to existing concrete, or concrete that has hardened, and no other means of vertical support is in place to prevent differential settlement, ie a new pit constructed between the rails. In these cases dowels are to be placed at approximately 300 mm centres and approximately 200 mm below top of concrete level. Dowels shall penetrate the old and new concretes by 150 mm.

The Contractor shall ensure that all dowels are securely held in their correct position until the concrete has set.

8.6.4 Formwork
Formwork shall be of straight, seasoned timber or steel, and shall be free from warps, bends or kinks. Formwork shall be of adequate cross section and strength and so secured as to resist the pressure of the concrete when placed and the impact and vibration of any equipment it supports without yielding, springing or settlement. The method of connection between sections shall be such that the joints do not move.

The formwork shall be placed true to alignment, grade and level, and checked by the Contractor immediately before placing the concrete.

The formwork shall be cleaned and oiled prior to use.

Forms shall be used where required and shall conform to the shapes, lines and dimensions of the concrete shown on the Drawings. Forms shall be substantial and sufficiently tight to prevent leakage of concrete. They shall be so supported and braced that they will not deflect, nor distort, nor move out of position when filled with concrete. The surface of all forms in contact with concrete shall be clean and before the concrete is placed shall be wetted or oiled as approved by the Superintendent.

Forms shall be supported independently of freshly poured concrete. Timber separators will not be permitted.

Any surplus moisture shall be removed from the forms prior to placing of concrete.
Formwork for exposed concrete surfaces ("off form concrete") shall be dressed or shall be approved tampered "masonite" or "resoply" or other approved dressed formwork material, (or approved steel formwork) to give a fair face concrete. Any projections shall be chipped off and ground smooth.

Forms shall not be stripped until the concrete has hardened to the satisfaction of the Superintendent.

8.6.5 Weather Conditions
When concreting in cold weather, that is, when the surrounding air temperature is below 5 degrees celsius, the concrete shall have a temperature not lower than 10 degrees celsius when placed in the forms. Precautions shall be taken to prevent the concrete from freezing at any time during the curing period. Salts and chemicals shall not be used to prevent freezing. The method(s) adopted shall be subjected to the approval of the Superintendent.

The sub-base course shall be prepared and protected and shall be entirely free of frost when the concrete is deposited.

Any concrete damaged by freezing shall be removed to the full depth to the nearest contraction or construction joints and replaced at the expense of the Contractor.

When concreting in hot weather, precautions approved by the Superintendent, shall be taken to avoid premature stiffening of the fresh mix and to reduce water absorption and evaporation losses. Concrete shall be placed in the coolest part of the day.

All precautions to allow for adverse weather shall be understood to be included within the Contract Sum.

Concrete shall not be placed during rain. When rain appears imminent, the Superintendent may direct that concreting operations cease and that all concrete less than 12 hours old be protected by covering with waterproof covers.

8.6.6 Chuting
Where chutes must be used they shall not be inclined at more than 30 degrees to the horizontal plane.

Where concrete is placed by chuting, the whole of the plant shall be arranged to give a continuous flow of concrete without segregation and so as to deliver the concrete close to the point of deposit.

The whole of the plant shall be flushed with clean fresh water before the pouring commences and after each stoppage of operations exceeding fifteen
minutes. The water used for this purpose shall be discharged outside and clear of the forms.

8.6.7 Compacting
All concrete shall be thoroughly compacted during and immediately after placing to the satisfaction of the Superintendent. Care shall be taken to fill every part of the forms, to force the concrete under and around the rails and reinforcement without displacing it, to work back coarse aggregate from the face, and to remove all air bubbles and voids.

External faces of formwork shall be vibrated sufficiently to ensure that the exposed surfaces of concrete shall be smooth and free from air bubbles and voids.

All compaction shall be carried out by use of approved immersion (poker) vibrator equipment unless directed otherwise by the Superintendent. A vibrator, on standby, shall be on site at all times concrete is being poured to cater for faulty vibrators in service.

8.6.8 Bonding Fresh and Hardened Concrete
Before depositing new concrete on or against concrete which has set, the surface of the set concrete shall be roughened, cleaned of foreign matter and laitance and thoroughly moistened with water. Any excess water is to be removed prior to placing of the concrete.

8.6.9 Construction Joints
The work shall be programmed to be completely free of construction joints except that shown on the Contract drawings. In the event of an unplanned stoppage to concrete placement, the Superintendent will direct the location and details for the construction joint. The joints shall be constructed to the satisfaction of the Superintendent. The Superintendent shall approve joint sealants or dowels.

8.6.10 Curing
Proper curing is considered vital to the long term durability and surface toughness of the slab.

‘Special 50 MPa Concrete’ is to be cured a minimum of five hours after last load placed, prior to tram services resuming.

When rain appears imminent, all concrete less than 12 hours old shall be protected by covering with waterproof covers.

8.6.11 Tolerances
All concrete shall finish true to the dimensions, lines and levels shown on the Drawings.
The following tolerances shall be observed:

<table>
<thead>
<tr>
<th>SITUATION</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan dimension of slab</td>
<td>+ 10 mm or - 10 mm</td>
</tr>
<tr>
<td>Thickness of slab</td>
<td>+ 10 mm or - 0 mm</td>
</tr>
<tr>
<td>Cover to reinforcement</td>
<td>+ 5 mm or - 3 mm</td>
</tr>
<tr>
<td>Finished level of slab</td>
<td>+ 3 mm or - 3 mm</td>
</tr>
<tr>
<td>Foundation Level of slab</td>
<td>+ 0 mm or - 20 mm</td>
</tr>
</tbody>
</table>

8.6.12 Slab finish
Slab surface shall be uniformly level, flat and free from bumps, hollows and other irregularities. All exposed concrete surfaces shall be true, even and free from stone pockets, depressions and projections. Defects or voids shall be made good by methods approved by the Superintendent.

A groove shall be formed along the running edge of each rail in accordance with TS1405-YT.

The slab surfaces shall be broomed to provide a non-slip finish.

Any unsatisfactory finish shall be rectified by the Contractor and to the complete satisfaction of the Superintendent.

All concrete vertical surfaces shall be "off form finish" unless otherwise specified, and shall be neat, smooth, and regular in appearance. All exposed edges shall have 10mm x 45 deg. chamfers.

Upon completion, the surface shall be carefully protected against damage by other building work.

8.6.13 Defective Concrete
The Contractor shall be fully responsible for employing effective methods of placing, protecting, and curing concrete, and for adequacy of forms. Approval of any such working methods by the Superintendent will be tentative only, and shall not relieve the Contractor of his responsibility.

Concrete which is not placed and completed in accordance with this Specification, or which is in the opinion of the Superintendent defective, or in which the reinforcement has been displaced, shall be removed within the limits assigned by the Superintendent and replaced to his satisfaction and at the expense of the Contractor.
1.7 Concrete Acceptance Testing

8.7.1 General
During the progress of the Works the Contractor shall arrange tests to be carried out at a NATA endorsed laboratory authorised by the Principal, to determine whether the concrete being produced complies with the requirements of this Specification.

The cost of supplying concrete, moulds, preparation, curing, transporting, testing and reporting shall be at the Contractor's account.

The Contractor shall arrange for a separate copy of test results to be sent direct to the Superintendent.

The Contractor, under the supervision of the Superintendent, shall prepare the test specimens (standard cylinder).

8.7.2 Records
The Contractor shall keep records showing:

(a) Areas of individual pours (to be recorded on a Drawing).
(b) The date of the pour.
(c) The identification of test cylinders from each pour.
(d) The quantity of concrete in each pour.

The signature of the Superintendent or his authorised representative shall certify each of the above items.

8.7.3 Sampling
The methods used for obtaining samples shall be in accordance with the requirements of AS 1012, Part 1, Methods for Sampling Fresh Concrete.

The composite sample from which test specimens (standard cylinders) will be formed in accordance with AS 1012, Part 1, from the samples taken.

The minimum number of composite samples to be taken during placement is related to the concrete volume to be poured during any continuous phase of casting operation. The sampling frequency is to be as in the table below:

<table>
<thead>
<tr>
<th>Volume cast in one continuous operation (cubic metres)</th>
<th>Minimum number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>1</td>
</tr>
<tr>
<td>25-50</td>
<td>2</td>
</tr>
<tr>
<td>50-100</td>
<td>3</td>
</tr>
<tr>
<td>Each additional 50</td>
<td>1</td>
</tr>
</tbody>
</table>

Standard cylinder test specimens shall be made from each composite sample. Each test specimen will be in accordance with AS 1012, Part 8,
Method for Making and Curing Concrete Compression, Indirect Tensile and Flexure Test Specimens in the Laboratory or in the Field.

For Special 50 concrete each composite sample of concrete shall comprise four standard cylinder test specimens.

For 32 Mpa concrete each composite sample of concrete shall comprise three standard cylinder test specimens.

8.7.4 Curing
The Contractor shall provide, at his own cost, facilities for initial curing of samples as required by AS 1012, Part 8, Method for Making and Curing Concrete Compression, Indirect Tensile and Flexure Test Specimens in the Laboratory or in the Field.

These facilities shall be subject to the approval of the Superintendent.

If the Contractor fails to provide any or sufficient storage facilities with controlled conditions, the specimens shall be stored on site in the open and covered by timber, or galvanised iron. The results of tests on these specimens will be used to assess the strength of concrete in accordance with this Specification and no allowance will be made in consideration of the storage of the specimens under these conditions.

On the day after casting, or as soon as possible thereafter, the Principal, without cost to the Contractor shall transfer the test specimens, still in the moulds, to the testing laboratory. The specimens shall then be stripped from the moulds and placed in curing tanks containing water at controlled temperature in accordance with AS 1012, Part 8.

8.7.5 Testing
Testing shall be in accordance with AS 1012, Part 9, Methods for Determination of Compressive Strength of Concrete Specimens.

For Special 50 concrete, two(2) standard cylinder test specimens shall be tested for compressive strength at 24 hours and the remaining two (2) shall be tested at 7 days.

The test strength of the concrete at 24 hours and at 7 days shall be deemed to be the average of the strengths of the two (2) standard cylinder test specimens used for each respective test.

For 32 Mpa concrete, one standard cylinder test specimen shall be tested for compressive strength at 7 days and the remaining two shall be tested at 28 days.

The test strength of the concrete at 28 days shall be deemed to be the average of the two (2) standard cylinder test specimens used for the test.
The cost of testing the cylinders shall be borne by the Contractor.

8.7.6 Slumps
Unless otherwise approved in writing by the Superintendent, for the concrete work in its various locations, the concrete slump shall be a maximum of 75mm or as indicated in the Drawings when determined in accordance with AS 1012, Part 3, Methods for the Determination of Properties Related to the Consistency of Concrete.

8.7.7 Strengths
The Superintendent will accept the concrete represented by the test specimens meets strength requirements when the test strengths defined previously exceeds the specified compressive strength at 7 days (for Special 50 concrete) and at 28 days (for 32Mpa concrete).

Notwithstanding any acceptance of concrete represented by the test specimens tested at 24 hours (for Special 50 concrete) or at 7 days (for 32 Mpa concrete), the Superintendent will reserve his right to reject the concrete should the other test specimens representing that concrete fail to meet the acceptance conditions for the tests to be carried out at 7 days or 28 days respectively.

8.7.8 Finished Surface
All exposed concrete surface finishes shall be of a high quality and those portions of the Contractor's work not in accordance with this Specification will be liable to rejection notwithstanding the fact that the poured concrete may be structurally sufficient.

8.7.9 Rejected Concrete
At the discretion of the Superintendent any concrete rejected under this Specification shall be removed and replaced to the satisfaction of the Superintendent. The cost of removing the rejected concrete and of its replacement by concrete complying with this Specification shall be borne entirely by the Contractor.

If the Superintendent allows the concrete, represented by the specimens which fail to achieve the required strength to remain in position, the Contractor shall forfeit all rights to payment for the whole quantity of concrete so represented or for such a proportion as the Superintendent and/or Principal may determine. The rate shown in the Schedules of Additional information for supply of ready-mixed concrete, material shall be used to calculate the total amount to be deducted from payments to the Contractor relating to rejected concrete.
9. COMPLETION OF WORKS

9.1 Trackwork

On completion, the Contractor shall leave the trackwork neat and tidy and ballasted correctly to profile. The tops of sleepers shall be swept clean of ballast. All surfaces and drains shall be clear and to the correct section and all damage shall be made good.

All surplus ballast shall be removed from the formation surface and the site. Where approved by the Superintendent, surplus ballast may be utilised to increase the shoulder width or height on completed work.

9.2 Track Condition

The Contractor shall ensure all tracks, grooves, switches and drains are clean and in good working order before handing over the works to the Principal.

Prior to running trams on the new tracks, the Contractor shall arrange to clear the construction site of any debris. On concrete track this should include:

- the use of a street sweeper (to be arranged by the Contractor)
- the use of a scrubber car (to be arranged through the Superintendent)
- the clearing of the groove by manual methods if necessary.

Prior to the running of the first scheduled tram service, each section of newly constructed track shall be inspected by the Superintendent to determine its suitability for running tram traffic. The inspection shall, as a minimum, check the following:

(a) Finished ballast profile and concrete and asphalt surfaces
(b) Temporary connections
(c) Rail joints
(d) Gauge and alignment of track
(e) Position and security of bollards, barricades, signage and flashing lights
(f) The grooves (where applicable) are clean and free from any rubbish or material which may de-rail a running tram.

9.3 Asphalt Paving

All asphalt paving works which are to be carried out under this contract, shall be in accordance with VicRoads Standard Specification for Roadworks and Bridgeworks, July, 1992.
The work to be carried out shall include the following:

(a) New asphalt paving over tram track concrete verges,
(b) Reinstall asphalt paving removed and/or damaged during construction,
(c) Any other paving affected by the works.

The asphalt in the margins shall be 10 mm bituminous concrete and shall be finished flush with the outside edge of the rail and the adjoining road surface.

Where the existing road pavement is to be reinstated, it shall be carried out in accordance with the relevant VicRoads standards and to the satisfaction of the Superintendent.

9.4 Tram Priority and Line Marking

The Contractor shall re-instate any road linemarking to new designs, if applicable, including but not limited to, lane lines, clearance lines, turn arrows, as well as reinstatement of reflectors and any other road markings as required. This shall include the reinstatement of tram and vehicle detection loops removed as part of the works. In addition the Contractor shall make arrangements with VicRoads to restore tram or bus priority measures to original conditions following completion of the works.

9.5 Maintenance of Track during Defects Liability Period

During the Defects Liability Period, the Contractor shall maintain, to the satisfaction of the Superintendent, all track and turnouts laid or relocated as part of this Contract.

As part of this requirement the Contractor shall, on request from the Superintendent, correct any track geometry defect that exceeds the tolerances given in the following table.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line (variation on 10 m chord)</td>
<td>10 mm</td>
</tr>
<tr>
<td>Wide Gauge</td>
<td>6 mm</td>
</tr>
<tr>
<td>Top (variation on 10 m chord)</td>
<td>12 mm</td>
</tr>
<tr>
<td>Cant</td>
<td>15 mm</td>
</tr>
<tr>
<td>Twist (over 10 m base)</td>
<td>15 mm</td>
</tr>
<tr>
<td>Twist (over 3.5 m base)</td>
<td>5 mm</td>
</tr>
</tbody>
</table>

If during the Defect Liability Period any weld defect exceeds the rejection criteria specified, the Contractor shall arrange for the defective weld to be cut out and replaced with a new length of rail and re-welded in accordance to this specification. All new welds shall be retested.
9.6 Recovery of Materials

All surplus materials, unless otherwise specified shall remain the property of the Principal. Surplus rails, platework, fastenings, sleepers and other trackwork components, whether removed from existing track or supplied under the terms of this contract, shall be recovered, sorted by type and suitably stockpiled at a location designated by the Superintendent. Supplied material shall be kept separate from recovered material. Surplus material shall be handled in a manner that will not be detrimental to the material.

The Contractor shall be responsible for security of the surplus material until completion of the contract or until removed or disposed of by the Superintendent.

9.7 Existing Structures and Services

The Contractor shall be responsible for and make good at his cost any damage to drainage works, buildings, fencing, footways, grassed verges, roads, bluestone edging, kerbs, surfaces generally, poles, aerials, cable pits, passenger loading areas, shrubs, trees, and any other work or property which may be disturbed or damaged by his operations in carrying out this contract.

9.8 Standsites, Storage Sidings and Completed Works Area

On completion of Contract work, the Contractor shall remove all standsites and storage sidings and shall make good such sites, as well as the completed works area, to the satisfaction of the Superintendent. Making good shall include, but not be limited to, sweeping the road, track and footpaths, and washing the area.
**CABLE LENGTHS**

<table>
<thead>
<tr>
<th>Typical Application</th>
<th>Reference</th>
<th>Cable Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint</td>
<td>E14-501 / 300</td>
<td>300</td>
</tr>
<tr>
<td>Rail Bond</td>
<td>E14-501 / 2700</td>
<td>2700</td>
</tr>
<tr>
<td>Track Bond (End Pins)</td>
<td>E14-501 / 3200</td>
<td>3200</td>
</tr>
<tr>
<td>Track Bond (Centre Pins)</td>
<td>E14-501 / 4000</td>
<td>4000</td>
</tr>
</tbody>
</table>

**CABLE TYPES**

<table>
<thead>
<tr>
<th>Typical Application</th>
<th>Nom. Area (sqmm)</th>
<th>Conductor</th>
<th>Construction (Strands/mm²)</th>
<th>Nom. O.D.</th>
<th>Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Insulated For Non-Insulated Track</td>
<td>112</td>
<td>Annealed Copper</td>
<td>91/24</td>
<td>16.0</td>
<td>PVC</td>
</tr>
<tr>
<td>Insulated For Insulated Track</td>
<td>112</td>
<td>Annealed Copper</td>
<td>91/24</td>
<td>25.5</td>
<td>PVC TO RV</td>
</tr>
</tbody>
</table>

**Note:**
- The surface to which the Cadweld material is welded to must be thoroughly cleaned using a file.
- This drawing replaces drawings 07-151 & 877-707.
- The preparation and Cadweld process is to be carried out in accordance with the manufacturers specification.

---

**Sinclair Knight Merz**

Project: Track and Rail Bonds

**Track and Rail Bond Standard**

---

**Cadweld**

Melted metal within cadweld material produces bond between capped cable end and steel back. Design and material specified.

Prep steel block
Size: 25x25x20
All cables installed to 600 depth (from new ground level)

Approx. 16M

1200
300

400 sq mm Copper Conductor

Approx. 16M

2 Rail Bonds E14.501/3400
Welded to rail

NOTE: ALL WELDED CONNECTIONS MUST BE BEYOND MANGANESE SECTIONS.
Bonded together by Cad-Weld method at this point

Welded to Foot of Rail via MS Lug on End of Rail Bond Cable

400 sq mm Conductor

400 sq mm bare copper conductor in a continuous length or joined by Cadweld.

Two Track to Track Bonds E14-501/2200

400 sq mm Copper Conductor 15 M (561 Bond).

P.T.C. ENGINEERING SERVICES GROUP

TYPICAL LONG BONDING JUNCTION

ORIGINAL SHEET BY

SHEET: 1

SCALE: 1:100

DRAWN:

REVISION

DATE: 04/01/2020
12:57:48 PM
Note:
1. Locations of all buses shall be marked on the top of the rail and opposite side to the running edge. Each mark shall consist of 1 straight cut coming to a point at the edge of the rail head - each cut to be 30mm long x 2mm wide x 2mm deep.
2. Attention is to be paid to the condition and cleanliness of the cable ends being connected.
3. Installer must record location detail including depth of all 1/0 cables.

GENERAL COMMENT:
All bonds to be connected to track. Connections to manganese or other special works to be avoided.

Depth of all cables to be 500mm.
NOTE: All cables installed to 600mm depth
(From new ground level)
Welded to the foot of rail via MS lug on the end of rail bond cable. See Detail 'A'.

Notes:
1. Locations of all bands shall be marked on the top of the head of the rail on opposite side to the running edge. Each mark shall consist of 3 straight cuts coming to a point at the edge of the rail head - each cut to be 20mm long x 2mm wide x 2mm deep.

2. Attention is to be paid to the condition and cleanliness of the cable ends being connected.

Rail Bond E14-501/3400, Uni-Directional 91/124mm copper conductor (TAM),

120sq.mm Grap lug

Pole Bond Cable is to be enclosed in sheath.

Pole to track bond cable, copper cable 120sq.mm.
NOTES

- TIE BAR OUT OF COMMERCIAL M.S. BAR
  IN ACCORDANCE WITH AS 3679.1
- ROLLED FORMED COARSE METRIC THREAD,
  IN ACCORDANCE WITH AS 1279
- HEXAGONAL NUTS, GRADE 5 TO AS 1112
- PIECES FORMING A TIE BAR COMPRISE 1 TIE BAR & 4 NUTS.
- TIE BARS FOR USE ON CURVES UNDER 300metres RADIUS AND ON INTERSECTING
  TRACK WORK SHALL BE OUT OF 22 DIA. M.S. BAR WITH 24 ROLLED
  THREAD WITH HEXAGONAL NUTS TO SUIT,
- ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED.

SUPERSEDES ORG. NO. P.14958-B
**Standard Check Plate**

*Profile*

Scale 1:2

**Standard Assembly**

Scale 1:2

Materials: Steel to AS 3678-250, 50mm long

Tolerances:

- Width: ±0.5mm
- Length: ±0.5mm

**Spacer Block for Check Plates**

Scale 1:2

Notes:

1. Construction tolerances:
   - Flange width for check plate is ±1.0mm
   - Track gauge is ±2.0mm

2. Use Huck Pins & Collars or M24 Bolts Gr 4.6, Hex Nuts & Washers as required.

3. This drawing supersedes drawing No.s TS102, TS1103 and TS1104.

4. Refer to drawing No. YTS1008 for details of track construction at crossing and low leg of turnout curve.

5. Refer to drawing No. YTS1103 for details of track construction for low leg of track curves.

---

**Tramway Standard Standard Check Plate Block & Assembly - 41kg Rail**

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**Copyright**

YARRA TRAMS

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**Blind Date**

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**Approved for Construction**

---
Section A-A

- 48 mm Tram Roll
- Special Check Plate
- Huck Pin C50LR-632-68
- 450 x 100 x 10 UA

spacer block
48 mm x 50 long
fitted adjacent
to Bolt.

End View of Special Check Plate

- 2 mm x 20 mm Channel
- 12 holes Ø27

Materiat: Steel to AS 3678-250, 50 long
Tolerance ± 1

Special Check Plate Scale 1:4

Material: Steel to AS 3597 Grade 700, Biscoy 80 or equivalent

Groove between spacer blocks to be filled with Asphalt to top of spacer blocks

Table 1

<table>
<thead>
<tr>
<th>Curve Radius</th>
<th>Check Plate Construction Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Leg</td>
</tr>
<tr>
<td>≤100 m</td>
<td>Drg.YTS 1101</td>
</tr>
<tr>
<td>&gt;100 m &amp; ≤325 m</td>
<td>Drg.YTS 1102</td>
</tr>
<tr>
<td>&gt;325 m</td>
<td>Not Required</td>
</tr>
</tbody>
</table>

Notes:
1. Construction Tolerances:
   Track gauge ±1.0-0.0
2. Use Huck Pins & Collars or M24 Bolts Gr.4.6 Hex,Nuts & Washers as required.
3. Top of check plate at ends to be ramped 6 mm high x 250 mm long on site as required.
Notes:
1. The gauge widening & special check plate shown is applicable to the low leg of a turnout curve laid with zero super-elevation.
2. For turnout with crossing laid on a super-elevation the check rail on the high leg of the larger curve shall be constructed similar to low leg side of smaller curve & special check plate with 26mm groove gap and 1438mm track gauge.
3. Track gauge to be transitioned to achieve 1438 at location shown.
4. Use minimum 5 No. Hucks Pins & Collars for low leg of turnout curve opposite crossing. For other locations, M24 Bolts Gr. 4.8, Hex. Nuts & Washers may be used.
5. Construction Tolerances:
   - Flangeway width for check plate is +1.0, Track gauge is +2.0.
6. Finish tolerances:
   - Maximum check plate wear 7mm prior to welding up.
   - Maximum allowable Track gauge is 1448mm.
7. Top of check plate at ends to be ramped 6mm high x 250mm long on site as required.
8. Refer to drawing No. YTS 1102 for standard check plate.
- Drainage pipes to have a minimum fall of 2%.
- 100mm depth of crushed rock to be placed under all pipes and pits.

All dimensions are in millimetres.

PIT AND COVER

SECTION

CONTINUES TO ROAD DRAIN OR JUNCTION PIT

PLAN

AMENDMENTS

REV DATE DESCRIPTION DRAWN APP'D

ENGINEER DESIGN ENGINEER

CHECKED

PTC ENGINEERING SERVICES GROUP

TRAMWAY STANDARD

TRACK DRAINAGE

TYPICAL LAYOUT
NOTES:
- 355 mm x 40 mm SECTION TO BE CUT FROM RAIL END
- OUTLET INVERT MAY BE UP TO 50mm LOWER BUT NOT HIGHER THAN THE INLET INVERT
- ALL DIMENSIONS ARE IN MILLIMETERS
- CONCRETE PIT TO HAVE THE SAME INTERNAL DIMENSIONS AS THE PIT FRAME
- MINIMUM WALL AND FLOOR THICKNESS TO BE 100mm
- DEPTH OF EACH PIT TO SUIT MINIMUM FALL OF 2% IN PIPES

PLAN

SECTION A-A

END VIEW B-B

CONNECTION DETAILS

---

WARNING
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SWAGE LOCK ASSEMBLY
150mm P.V.C. PIPE
TS1003 SPACER BLOCK
TS1003 GUARD PLATE
TS1003 PIT FRAME

REFERENCE DESCRIPTION ITEM No.

---

PTC ENGINEERING SERVICES GROUP
TRACK ENGINEERING DEPARTMENT

TRAMWAY STANDARD
TRACK DRAIN
TRIANGULAR PIT FOR 41Kg/m RAIL
CONSTRUCTION DETAILS

SHEET: COPIES: DATE: SCALE: DRAWN: CHECKED: ISSUE:

---

To: From: Date: Subj: File: Date: Origin: File: Date: Origin:
WHEEL PROFILE IN NORMAL RUNNING POSITION

SCALE 1:1

TRAM RAIL 41, 42, 43 kg/m
NOTES:
1. GAUGE - STRAIGHT & CURVES
   SWIVELS AND CROSSING TO BE CAST MANGANESE
   ALL RAIL TO BE 43kg/m HEAD HARDENED
   WITH TONGUE GUARD PLATE
   RAIL BENDING AND CROSSING DIAGRAMS NOT TO SCALE
   ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

- INTERSECTION POINT (IP)
- TANGENT POINT (TP)
- TRANSITION POINT

- RAIL JOINING USING ELECTRODES USED STAINLESS
  OR EQUIVALENT APPROVED BY THIES.
- RAIL JOINING USING ELECTRODES NOT STAINLESS
  RAIL NUTS 36mm RAIL NUTS OR EQUIVALENT APPROVED BY THIES.

CURVE 1
INTERSECTION ANGLE 11°25'00"
CIRCULAR RADIUS 65 720
TANGENT 4 970
SECANT 228
TP - TP 910

CURVE 2
INTERSECTION ANGLE 11°25'00"
CIRCULAR RADIUS 60 000
TANGENT 5 998
SECANT 299
TP - TP 11 956

STANDARD RIGHT HAND TURNOUT 3 353 CENTRES

TRACK STANDARDS

STANDARD RIGHT HAND TURNOUT 3 353 CENTRES