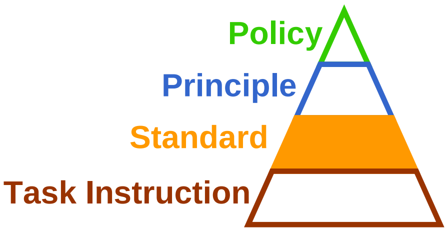

Track Standard

Track Design

Purpose

This standard defines the critical track design parameters and provides the requirements for the design of plain line track and other track structures. It also covers work that may be undertaken during projects, track renewals, maintenance or life extension of track assemblies, turnouts, level crossings, open deck bridge structures and the track substructure.

Document Control

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Date Effective	31/12/2022	**Author**	Mark Fleet
Prepared (P) **Reviewed (R)** **Amended (A)**	Mark Fleet (A)	**Checked and Approved By**	Track Technical Committee
		Authorised for Release By	Professional Head of Track

1. Revision Procedure and History

This is a 'living' document, that will be updated every five years or whenever KiwiRail determines that changes to it and processing requirements documented herein are appropriate.

If changes arise from the review this document will be reissued, however, if no changes arise from the review, the current version of this document will remain in force.

Refer to the **Briefing Note(s) for T-ST-DE-5200 Track Design and Document History** (at the end of this document) for full document changes.

Issue No	Prepared (P) Reviewed (R) Amended (A)	Authorised for Release By	Date Effective
1.0	M Singh (R) B Hourigan (A)	Professional Head of Track	3/03/2017
1.1	M Fleet (A)	Professional Head of Track	3/04/2017
2.0	M Fleet (A)	Professional Head of Track	30/06/2019
3.0	M Fleet (A)	Professional Head of Track	30/09/2021

1.1 Changes in this issue

Issue No	Section	Description	Page(s)
4.0	Table 12.1	Horizontal curves table updated	12
4.0	12.1.9	Update to formulae	16
4.0	Table 12.5	Curve speeds and geometry guide, table updated	21
4.0	13.1.1	Last paragraph updated	23
4.0	14.4.1	Centre throw formulae updated	25
4.0	Appendix 1.1	50kg turnout structures table updated	42

1.2 Withdrawn, closed and superseded

Old Reference	Title	Replaced by

2. Associated Documents

Level	Number	Title
3	T-ST-DE-5212	Track Clearances
3	T-ST-MM-5709	Use of Track Materials
3	T-ST-AM-5301	Classification of Second-hand Materials
3	CE 300153	Insulator Gauge Pattern 22.5t Drawing
3	CE 300167-6	Insulator Gauge Pattern 25t Drawing
3	CE 100862	Drainage and Formation Detail Standard Drawing
3	CE 120535	Sand Blanket Separation Layer Standard Drawing

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3. Acronyms and Definitions

Acronyms	Definition
AMS	Actual Maximum Speed
C	Chord Length (measured in meters)
CAD	Computer Aided Design
CL	Centre Line
CTP	Common Tangent Point
Ea	Applied Cant
Ed	Cant Deficiency
En	Negative Cant
Eq	Equilibrium Cant
IP	Intersection Point
m/s	Metres Per Second
mm/s	Millimetres Per Second
OLE	Overhead Line Equipment
PH	Professional Head
POS	Point of Switch
POF	Point of Frog
R	Radius of Curve
RCA	Road Controlling Authority
Re	Equivalent Radius
ROCOC	Rate Of Change of Cant
ROCOCD	Rate Of Change of Cant Deficiency
S	point of Spiral
TL	Transition Length
TNC	Theoretical Nose of Crossing
TQI	Track Quality Index
TG	Track Gradient
V	Velocity in km/h
v	Versine
Vc	Vertical Curve
Vm	Maximum Permissible Speed

3.1 Notes, caution and warnings

Icon	Definition
	Note(s) to point out something of special importance
	Caution or warning – drawing special attention to anything of important reminder or a safety message

4. Scope

This standard sets the requirements for all design of plain line track and other track structures. It also covers any track work that may be undertaken during projects, track renewals, maintenance or life extension of track assemblies, turnouts, level crossings, open deck bridge structures and the track substructure.

Track must be correctly designed to ensure that the life cycle of the assembly itself, its components and the substructure below the sleeper is optimised. Failure to have the correct design or to maintain the track to the approved design through its life cycle leads to accelerated wear on the track and rolling stock, unnecessary maintenance interventions and a shortened life cycle for track components and rolling stock.

Track design parameters require reviewing, as necessary, when the operating environment changes such as when new locomotives and rolling stock are introduced or technological advances are made in the design of components.

4.1 Use in the field

This document has been designed to be used in the field. It is expected that this document will be opened in an iPad via ‘Briefcase’ and used as reference to complete the task. Note as written on the front cover the controlled version is held on SharePoint. **Printed copies of this document are uncontrolled**.

5. Safety in Design

A Safety-in-Design register shall be recorded and submitted to KiwiRail for all new track design. The designers are accountable for a ‘safe design’ for all plain line track and track structures. This means the implementation of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risk to health and safety throughout the life of the track that is being designed. The designer must take into account all safety considerations during the construction, maintenance and operational phases

6. Responsibilities

To manage the track design process the responsibilities are designated here:

- **Analysis and instigation of design requirement**: Track Engineering or Asset Engineer/Project Engineer.
- **Undertake survey and design**: Track Engineering or suitably competent Field Asset Engineers or surveyors / designers from external suppliers.
- **Checking and sign off of design**: Professional Head (PH) – Track or delegated to competent person.
- **Ensuring the design is implemented correctly and recorded as complete**: Production Manager / Project Engineer.
- **Monitoring the design has achieved improved TQI quality**: Asset Engineer / Project Engineer / Track Engineering.

7. Track Activities that Require a Design

7.1 New infrastructure projects

This involves any track and / or substructure works.

7.2 Track renewals

- All re-sleepering operations involving the replacement of timber sleepers with concrete.
- All re-ballasting operations undertaken by either ballast cleaners or undercutters
- All turnout renewals.
- All rerailing works where the existing track has side wear or where other track signs indicate inconsistent rolling stock behaviour (eg rolling contact fatigue damage).
- De-stress sites to ensure optimum track geometry is achieved and settled prior to the tensioning of rail.
- All major works in OLE areas to determine whether original design alignment can be restored.

7.3 Track maintenance

- For works in excess of 50 m involving re-ballasting and involving track realignment.
- For track where the TQI is poor, and the geometry needs verifying and redesigning as necessary.

Note for all maintenance work, irrespective of length, the existing track alignment work must be surveyed by production staff before the work commences. The existing track design must then be replicated (or improved if necessary) using a survey equipment such as siting boards, versine (v) checks and cross levels as required.

If a track freeze design has been monumented on an OLE mast or equivalent structures, track maintenance should reset the geometry to the monumented offsets and parameters.

7.4 Life extension activity

For all works in plain line sections and through turnouts where the track geometry may be altered.

7.5 Level crossing renewal

For all level crossing renewals including marrying up the road surface profile and track levels.

Note this will not only require track design, level crossings will require road design to meet the RCA standards and approval.

7.6 Bridge replacement or re-sleepering

- All bridge replacements including online and offline replacements.
- All face re-sleepering over open decked structures.

8. Extent of Design

The following elements of track design are required as follows:

- All mainline, siding, and crossover alignment work within new infrastructure projects.
- Any construction staging design required.
- Horizontal alignment through the track renewal and a minimum of 100 m each side of the affected zone. Run out areas to be no less than 100 m on a regular curve or tangent.
- Vertical alignment through the length of a track renewal and a minimum of 100m of track each side. New track gradients (TG) and vertical curves (Vc) to be designed in whole.
- Any lifts/slews beyond 50 mm will require the survey to be extended.
- If the survey encompasses a transition in horizontal or vertical profile, then the survey is to be extended to a point at least 100 m beyond the S or CTP point.
- Track geometry on a curve, including the cant, deficiency, transition lengths (TL) and rate of change of cant (ROCOC) and rate of change of cant deficiency (ROCOCD). Confirm tolerances are within KiwiRail limits for the entire curve.
- On level crossing renewal works the road surface profile must be surveyed and designed as appropriate and as agreed with the RCA or 50 m overall (25m either side of track centreline) if the RCA does not specify less.
- Any area where consideration is required for clearances envelopes or limited clearance.

9. Pre-design Survey

The following methods are approved for the pre-design survey:

- Hallade horizontal curve alignment survey and design method.
- Level and line survey using equipment such as Dumpy level or Theodolite.
- Survey by electronic surveying equipment using competent surveyors and a proprietary Computer Aided Design (CAD) design package.
- Laser scan survey of surfaces.
- Photogrammetry or other surface capture equipment.

Note Hallade surveys should be combined with level surveys for assessment of both horizontal and vertical curvature.

An electronic survey must be undertaken in accordance with KiwiRail Topographic Survey Specification and Guidance Notes. Track Engineering may need to be consulted before carrying out any survey as the level of detail and accuracy required for the survey can vary depending on the nature of the project.

10. Definitions of Track Design

Item	Definition
Horizontal Alignment (Line)	The path of alignment parallel to the horizon formed from a combination of tangent track, transitions (spiral curves) and circular arc curves.
Tangent Track	A straight section of track or a curve of infinite radius.
Circular Arc Curves	Curves with a constant radius.
Compound curves	A combination of two or more circular arc curves of differing radii and same direction (left hand curves or right-hand curves) joined together directly or by transition curves.
Reverse Curves	A combination of two or more circular arc curves in alternate directions linked by transition curves. In some cases, these curves will have tangent track between the curves.
Transition Curves	A curve of progressively varying radius (spiral curve). Transition curves are used to link either a straight with a circular curve or two circular curves of different radii. Transition curves provide a smooth transition between tangent track and circular arcs. Transition curves are used to develop cant.
Virtual Transition Curves	A virtual length used to calculate change in forces that a rail vehicle experience travelling from straight to circular arc or circular arc to circular arc when no physical transition curve occurs. Its length is equal to the spacing between the rolling stocks bogies and is theoretically placed symmetrically about the CTP.
Cant (Ea)	The vertical distance (in millimetre's) by which one rail is physically raised above the other and measured between the surveyed running edge of the two rails.
Negative Cant	When the inner rail on a curve is canted over the outer rail.
Cant Deficiency (Ed)	Cant deficiency is the difference between the equilibrium cant (Eq) and the applied cant (Ea).
Cant Equilibrium (Eq)	Equilibrium cant is the amount of cant applied on a curve that positions the resultant of the weight of the vehicle and the centrifugal forces in the centre of the track at the equilibrium speed of trains around the curve.
Excess Cant	Excess cant is defined as the difference between the applied cant provided and the theoretical cant required for the actual train speed. When a train travels on a curved track at a speed lower than the equilibrium speed, then a cant excess occurs because the resultant force between the vehicle mass acting vertically and centrifugal forces is below the centreline of the track.
Rate of Change of Cant (ROCOC)	The rate at which cant is developed relative to the speed of the vehicle.
Cant Gradient	Cant gradient is the rate by which cant is increased or decreased to connect a tangent to a curve through a defined TL. It is also known as cant run in or cant run out.
Rate of Change of Cant Deficiency (ROCOCD)	The rate at which cant deficiency is developed relative to the speed of the vehicle.
The Maximum Permissible Speed (Vm)	The Maximum Permissible Speed (Vm) is the highest speed permitted on a curve taking into consideration of the radius of curvature, applied cant, deficiency of

	cant, the length of the transition curve and rate of change of cant and cant deficiency.
The Equilibrium Speed (VEq)	The Equilibrium Speed (VEq) is the velocity(V) at which the effect of centrifugal force is exactly balanced by the cant provided.
The Actual Maximum Speed (AMS)	The Actual Maximum Speed (AMS) at any site that can be achieved by any train in either direction at any location. This may well be less than the Vm for the route and is dependent on gradients, transitions, curvature, braking/acceleration constraints and locomotive power.
Vertical alignment (Top)	Elevation change of a horizontal alignment by use of constant grades crest and sag curves.
Vertical Curve	A curve of constant radius applied in the vertical plain linking two separate grades.
Grade	The degree to which the track inclines / declines.
Curve Compensated Grades	The effect of horizontal curvature on grade resistance. To be added to actual grades for design consideration.

11. Track Gauge

The standard gauge of track is:

- Tangents: 1068 mm
- Curves: Refer to Table 11.1
- Turnouts: The gauge of track through turnouts is 1068 mm on straight roads and through frogs (Refer to Appendix 1 for gauge widening in the turnout curved road)
- Measured at 16 mm below top of the rail head.

Table 11.1 Track gauge on curves

Curve Radius	Increase Over Standard Gauge	Gauge of Track
≥250 m	0 mm	1068 mm
Less than 250 m	6 mm	1074 mm

The gauge on concrete sleepers for tight radius curves is altered progressively by the application of insulators with different heel sizes. The resulting gauge change and types of insulator used is shown on standard drawings CE 300153 and CE 300167-6 for differing sleeper types.

12. Horizontal Alignment Parameters

This section specifies KiwiRail's parameters for horizontal alignment design.

12.1 Horizontal curves

Table 12.1 below shows the minimum curve and tangent parameters.

Table 12.1 Minimum parameters for horizontal curves

Parameter	Value
Desirable Minimum Curve Radius	150 m
Absolute Minimum Curve Radius	90 m
Maximum Bend Deficiency	20 mm
Absolute minimum Circular Curve Length – mainlines & loops	20 m
Absolute minimum TL – mainlines & loops	20 m[1]
Absolute Minimum Tangent Length – mainlines & loops	20 m[1]
Absolute minimum Circular Curve Length – yards & sidings	15 m
Absolute minimum TL – yards & sidings	12 m
Absolute Minimum Tangent Length – yards & sidings	15 m

[1] This will affect maximum permitted speed, refer to clause 12.2

Note that curves are handed to either the left or right in the direction of increasing metrage.

All curves on main line tracks shall have the S and CTP monumented with the appropriate marker at an offset of no less than 2.3 m from track centreline.

The minimum radius value in yards or sidings where coupling/uncoupling of rolling stock is undertaken shall be 140 m.

12.1.1 Radius of a curve (R)

The radius of a curve can be calculated from the formula: $R = C^2/8v$

The required v of a curve can be calculated from the formula: $v = C^2/8R$

Where:

C = Chord length (typically 10-20 m)]

v = versine measured in metres at half the chord length

(eg if chord = 20 m measure v at 10 m)

12.1.2 Maximum curve speed (V)

The maximum permissable speed for any curve is: $V = 3.82 \times \sqrt{R}$

Where:

V = Speed in km/h

R = radius of curve in metres

12.1.3 Station platform curves

Table 12.2 shows the curve parameters for use at station platforms.

Table 12.2 Curve parameters for station platforms

Parameter	Radius
Desirable Curve Radius at all Stations	Tangent Track (no curve)
Minimum Curve Radius for platforms on the outside of a curve	1750 m
Minimum Curve Radius for platforms on the inside of a curve	600 m

Where horizontal curvature within the platform is unavoidable, the clearance set out of the platform edge shall take into account end throw, centre throw and any cant effect. It is desirable that no cant is applied on track at platforms.

12.1.4 Reverse curves

It is desirable that reverse curves have a minimum of 20 m of straight track provided between transition curves. If a 20 m straight cannot be achieved the transitions should be placed back to back, this is only permitted on curves ≥200 m radius.

Back to back reverse curves must have a uniform ROCOCD through both reversing transitions, to the nearest whole number. It is desirable but not always possible to achieve uniform rate of ROCOC through both reversing transitions.

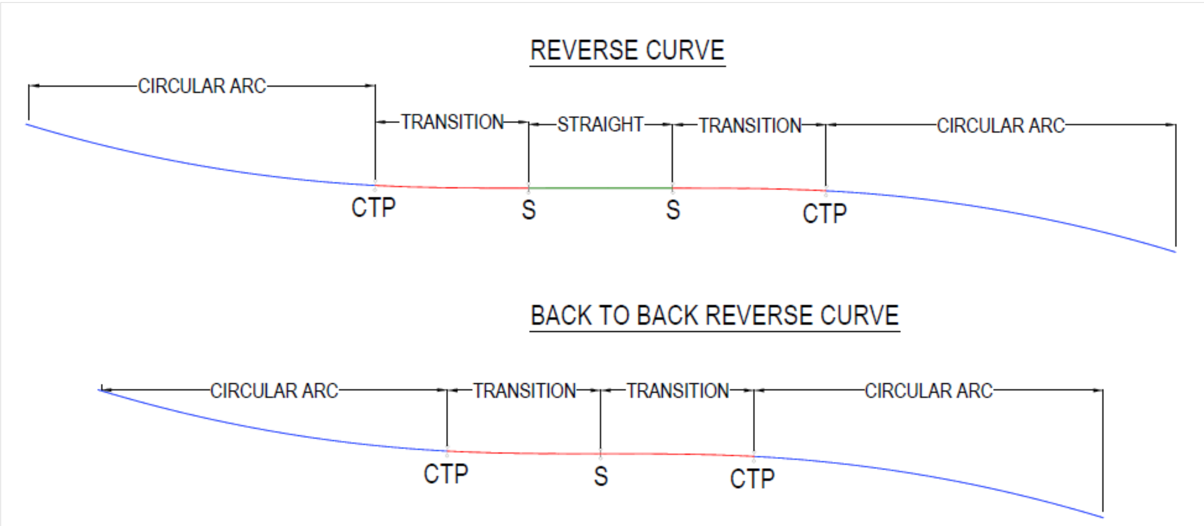


Figure 12.1 Reverse curves

Back to back reverse curves should be avoided for any new track design. Refer to section 12.2.6 for ROCOCD and ROCOC formulae.

Reverse circular curves less than 200 metre radius shall be separated by a minimum 12 m length of straight track.

12.1.5 Compound curves

Geometry consisting of a singular curved circular arc should be used instead of compound curves within curve track alignment design.

When designing compound curves it is desirable to provide a transition with a minimum length of 20 m between circular arc sections. Where this is provided it is permitted to have different cant values applied. The ROCOC and ROCOCD shall not exceed 35 Millimetres Per Second (mm/s) desirable or 55 mm/s as absolute maximum.

For compound curves with no physical transition between circular arcs a 12.2 m virtual transition must be used with a ROCOCD not exceeding the limits in section 12.2.6. When using virtual transitions, the cant must remain constant across both circular arcs.

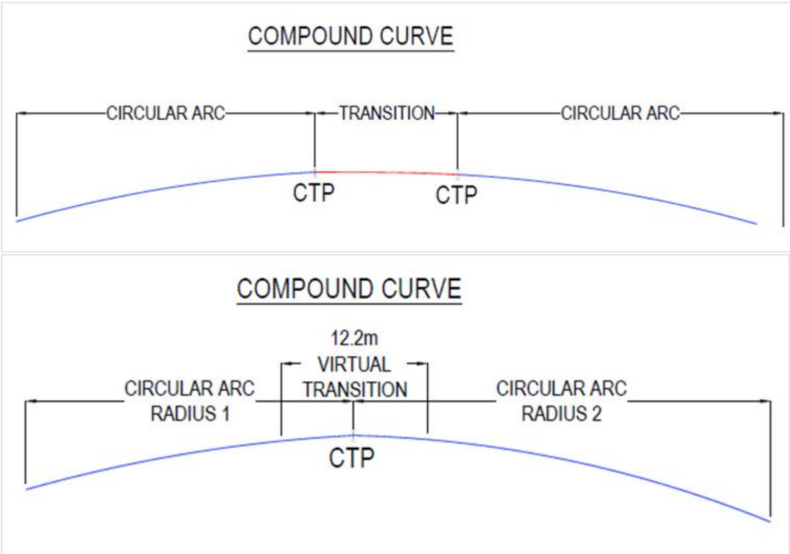


Figure 12.2 Compound curves

12.1.6 Transition curves

A cubic parabola is the only form of transition that is permitted to be used on the KiwiRail network.

Seek approval from the PH of Track on a case by case basis if a clothoid spiral is proposed to be used, as these have undesirable dynamic characteristics due to the large roll acceleration and rate of change.It is also much more complicated to set out such curves on site accurately.

Transition curves are to be provided wherever possible between a circular curve and an adjoining straight track, between circular arcs within compound curves and at the adjoining ends of circular arcs that form reverse curves. Refer to Figure 12.3.

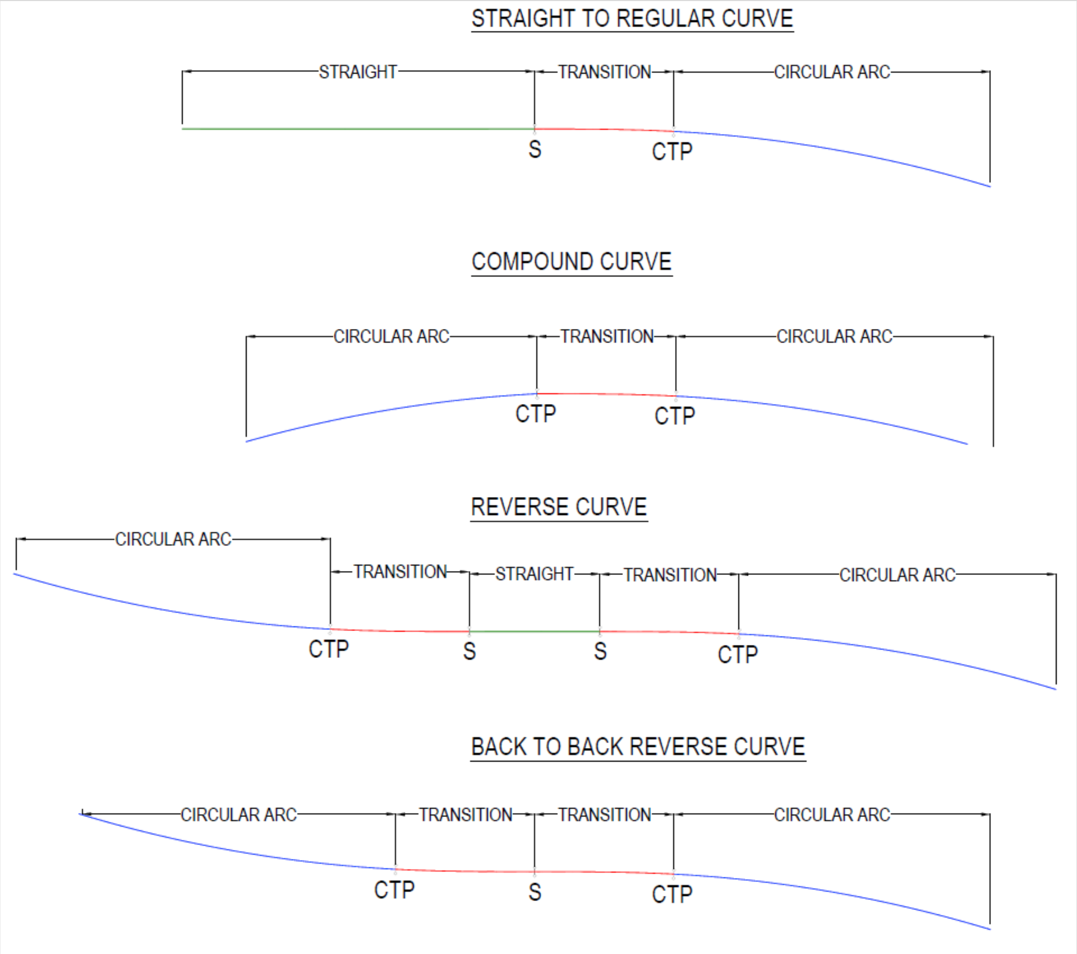


Figure 12.3 Application of transition curves

If required the minimum TL must be greater than 20 m and determined from the formula below:

$$L = \frac{V \times \Delta D}{3.6 \times Drocd}$$

Where:

L = length of transition (m)

V = speed (km/h)

ΔD = difference in cant deficiency (mm)

Drocd = desirable rate of change of cant deficiency shall be 35 mm/s, with a maximum of 55 mm/s.

Curve transitions must be of sufficient length to achieve desired cant gradients. Refer to section 12.2.5 Cant gradient.

Examples of TLs for various curvatures are tabulated in Table 12.5 curve speeds and geometry guide.

12.1.7 Virtual transition curves

Virtual transition curves are lengths of track used to calculate the rate of change in cant deficiency that a rail vehicle experiences travelling from straight to circular arc or circular arc to circular arc when no physical transition curve occurs. Its length is equal to the spacing between the rail vehicle's bogies and is theoretically placed symmetrically about the CTP.

A 12.2 m virtual TL shall be used to calculate the rate of change in deficiency where no physical change has been provided as identified above. Refer to Section 12.2.6 for ROCOCD limits.

12.1.8 Check rail on curves

Curves ≤100m radius on main lines must be fitted with a continuous check rail on the low (inside) leg. The flange gap must be set at 50 mm clearance.

12.1.9 Bends

Bends (change in heading without use of a curve) in the horizontal alignment are permitted if the cumulative change in angle does not exceed one degree per 800 m length. Bends are not permitted for new track work.

The equivalent cant deficiency of a bend can be calculated from the formula below:

$$D\beta = \frac{\beta V^2}{4.85Bc}$$

Where:

$D\beta$ = bend deficiency (mm)

β = bend angle (decimal degrees)

V = speed (km/h)

Bc = virtual transition length (12.2m)

The calculated bend deficiency above, shall be used to determine the ROCOCD of the bend based on the vehicle speed and virtual TL. The limits in Table 12.1 and Table 12.3 apply.

12.2 Cant and speed

Table 12.3 shows the cant parameters for use on the network.

Table 12.3 Cant parameters

Parameter	Value
Maximum Cant (Ea)	70 mm
Maximum Negative Cant	40 mm
Maximum Cant Deficiency	60 mm
Maximum Equilibrium Cant	130 mm
Maximum Cant Gradient	1:500
Desirable Cant Gradient	1:1000
Minimum Cant Gradient	1:1500
Desirable ROCOC	≤ 35 mm/s
Maximum ROCOC	55 mm/s
Desirable ROCOCD	≤ 35 mm/s
Maximum ROCOCD	55 mm/s

12.2.1 Applied Cant (Ea)

The maximum amount of cant that can be applied on KiwiRail infrastructure is 70 mm. Cant shall not be applied in yards.

The maximum amount of negative cant that can be applied on KiwiRail infrastructure is 40 mm. This will lead to a reduction in operating speeds.

Ea should be approximately 2/3 of Eq (in the range of 60 – 72% of Eq).

12.2.2 Equilibrium Cant (Eq)

The maximum Eq that can be applied on KiwiRail's infrastructure is 130mm.

The formula to determine Eq cant is shown below:

$$Eq = \frac{k \times V^2}{R}$$

The maximum design speed for the Eq shall be determined by the formula:

$$V = \sqrt{\frac{Eq \times R}{k}}$$

Where:

k = cant constant (8.89)

V = design speed (km/h)

R = radius (m)

12.2.3 Deficiency of Cant (Ed)

Cant Deficiency Is the difference between the Eq and the actual cant applied (Ea).

Deficiency of Cant (Ed) = $Eq - Ea$

Eq = Equilibrium Cant

Ea = Applied Cant

The maximum deficiency of track that can be applied on KiwiRail's infrastructure is 60 mm. Any negative cant deficiency should be avoided.

Note cant deficiency of track alignment with multiple operating speeds should be assessed at each operating speed and designed to prevent negative deficiency.

12.2.4 Excess cant

This is to be minimised by designing cant for slower speeds while ensuring maximum cant deficiency is not exceeded for higher speeds.

The designer is required to confirm the operating speed of rolling stock on the section under review.

12.2.5 Cant gradient

The maximum allowable Cant Gradient is 1 in 500, with a desirable 1 in 1000 and minimum of 1 in 1500. Applied numbers shall be rounded to the nearest ten.

The PH of Track may permit a steeper run out on existing track geometry but this will have an effect on reducing the authorised curve speed.

12.2.6 ROCOC and ROCOCD

As a train passes over a transition from tangent to curve it is running from zero cant and deficiency on the tangent to whatever Ea and deficiency is on the curve. This change of cant and cant deficiency can be calculated by using the following formula:

ROCOC = $\frac{\text{Ea x V}}{\text{3.6 x TL}}$

ROCOCD = $\frac{\text{Ed x V}}{\text{3.6 x TL}}$

Where:

Ea = Applied cant

Ed = Cant deficiency

V = design speed (km/h)

TL = Transition length (m)

Note if no physical transition is in place a virtual TL of 12.2 m should be adopted.

The ROCOC and ROCOCD must be checked on compound curves to ensure that the rate of gain of cant (if different cants are applied) and rate of change of deficiency are within the acceptable limits (less than 35 mm/s desirable, 55 mm/s maximum). A transition must be re-designed if ROCOC and ROCOCD are above the maximum limits.

The formula for ROCOC and ROCOCD through a compound curve is shown below:

ROCOC = $\frac{\text{(difference in cant between cirular arcs) x V}}{\text{3.6 x TL}}$

ROCOCD = $\frac{\text{(difference in cant deficiency between circular arcs) x V}}{\text{3.6 x TL}}$

Where:

V = design speed (km/h)

TL = Transition length (m)

12.2.7 Operating speed

Train operating speed is an important element of track design. It is important to understand the operating speeds of all traffic at any location and in either direction, then to take the most realistic speed as the equilibrium speed at that location. It follows that the equilibrium speed of trains will vary from curve to curve and will be driven by TG's and the performance of the various types of trains crossing each route. The maximum operating speed must be no more than the limits set in this Standard.

A speed category of one to five is given for all routes (or portions of routes) as shown in Table 12.4 is further defined in document T-ST-MM-5709 Use of Track Materials.

Table 12.4 Speed categories

Speed Category	Maximum Allowable Speed (km/h)	Comments
1	110	Passenger vehicles only
2	70	-
3	50	-
4	40	-
5	25	Includes yards and terminals

When designing curve speed, it is important to factor in the operating speeds of all train movements on that line. For example, in a Speed Category 1 location there may be EMU's operating at 110 km/h and freight running at a maximum speed of 80 km/h. Levels of applied cant, deficiency of cant, the length of the transition curve and ROCOC and ROCOCD will need to be assessed at both speeds to ensure they are within KiwiRail limits for both types of rail vehicle. Typically, the track will be designed for the 80 km/h speed with maximum cant deficiency applied for the 110 km/h speed.

Likewise, consideration should be given to where curve geometry determines the maximum operating speed for a particular section. For example, a 1500 m curve sandwiched between two 180 m curves would have to be designed to complement these sharper radius curves either side of it. This is normally undertaken by modelling train movements in OpenTrack or a similar modelling program.

12.2.8 Curve limits

All curve design parameters must be calculated to ensure they meet the KiwiRail requirements identified in section 12 of this document (horizontal alignment parameters).

Table 12.5 indicates the varying curve radii, maximum curve speed, cant limits applied, the desirable and minimum TLs and the track gauge. This may be used for verifying existing geometry for maintenance activities.

Where applied cant is adjusted to meet required cant gradients, the design speed may need to be reduced to meet cant deficiency limits.

Once all the horizontal design parameters have been calculated, the vertical parameters must also be assessed to ensure they are not less than the horizontal alignment speeds. The lowest value calculated has the governance on the design speed.

When undertaking track design, it is crucial to understand the actual operating speed at the location of the curve which may be less than the maximum design speed. If this is the case the applied cant may need to be reduced to avoid undue rail wear.

Table 12.5 Curve Speeds and Geometry Guide

Curve Radius			Curve Speed	Cant (Ea)	Transition (desirable)	Transition (absolute minimum)	Gauge	Minimum Vertical Radius (greater than 20 m in length)
(m)			(km/h)	(mm)	(m)	(m)	(mm)	(m)
95	-	115	35	70	70	35	1074	1650
116	-	150	40	70	70	35	1074	1650
151	-	180	45	70	70	35	1074	1650
181	-	220	50	70	70	35	1074	1650
221	-	270	55	70	70	35	1074[1]	1650
271	-	320	60	70	70	35	1068	1650
321	-	370	65	70	70	35	1068	1650
371	-	420	70	70	70	35	1068	1714
421	-	480	75	70	70	35	1068	1967
481	-	550	80	70	70	35	1068	2239
551	-	610	85	70	70	35	1068	2527
611	-	680	90	70	70	35	1068	2833
681	-	760	95	70	70	35	1068	3157
761	-	840	100	70	70	35	1068	3498
841	-	920	105	70	70	35	1068	3856
921	-	1070	110	70	70	35	1068	4232
1071	-	1290	110	60	60	30	1068	4232
1291	-	1540	110	50	50	25	1068	4232
1541	-	2000	110	40	40	20	1068	4232
2001	-	2400	110	30	30	20	1068	4232
2401	-	tangent	110	0	0	0	1068	4232

[1] >250m radius curves are 1068mm gauge

Note: this table must only be referred to as a guide, always calculate the actual values.

12.2.9 Relationships between speed, cant and deficiency

From section 12.2 it can be seen that applied cant, cant deficiency and TLs are all important factors when undertaking horizontal design and all must be taken into consideration when designing horizontal alignment and track cant.

The desirable TL shall be used on routes that have scheduled passenger services. Shorter transitions may be applied on freight only routes down to the absolute minimum TLs, but this requires close scrutiny of the track geometry.

13. Vertical Alignment

Vertical track alignment (Top) consists of straight gradients or Vc's as shown in the diagram below. Straight gradient is the difference in elevation for a given distance of the track. Vc's may be required to join straight gradients and are termed either 'trough' in a dip or at the 'peak' of the connecting gradients.

Figure 13.1 shows a sample vertical track alignment with a number of straight gradients connected by Vc's.

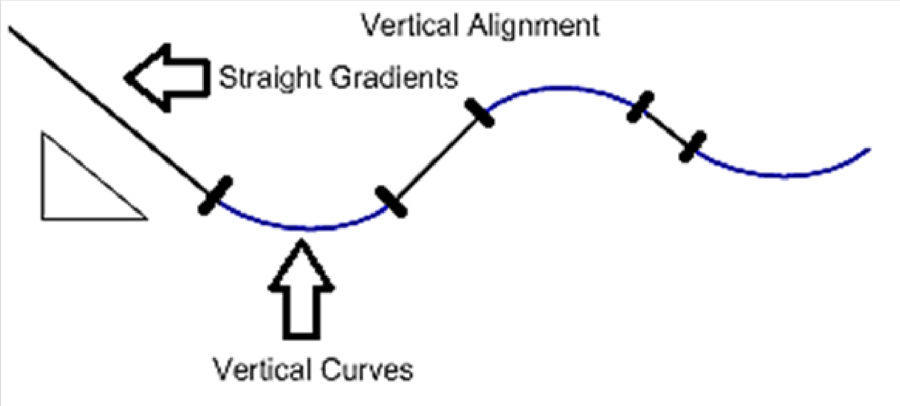


Figure 13.1 Vertical alignment with straight gradients and vertical curves

Table 13.1 below shows the minimum curve and grade parameters for use on the network.

Table 13.1 Minimum parameters for vertical curves

Parameter	Length
Minimum Vc radius	$= \frac{V^2}{2.859}$
Absolute minimum Vc radius – mainlines & loops	1650 m
Absolute minimum curve length – mainlines & loops	20 m
Absolute minimum Vc radius – yards & sidings	700 m
Absolute minimum curve length – yards and sidings	15 m
Desirable minimum gradient length	>30 m
Absolute minimum gradient length	20 m
Absolute maximum curve gradient*[1]	1:32 (3.125%)
Desirable maximum curve gradient*	1:80 (1.25%)
Maximum gradient for yards, sidings and station platforms	1:200 (0.5%)
Maximum change of grade without a Vc	1:333 (0.3%)

*= application of curve compensation will increase these values

[1]= without any operational restrictions

Note the actual end points of the straight gradients at a Vc location should be identified from a level survey so that the actual length of the Vc can be checked against the required length.

13.1.1 Vertical curves

Vc's shall be parabolic in form, they should not be positioned in the same location as horizontal curves. If this is unavoidable the Vc shall completely overlap the horizontal curve or start and end in the circular arc section of the horizontal curve. Do not start or complete a Vc within a horizontal transition.

Vc's for mainlines are required to have radial acceleration limited to 0.0225 g. Their minimum length to be calculated from the formula:

$L \geq R(p - q)$

Where:

L = Length (m)

R = nominal radius = $\frac{V^2}{2.859}$ (m)

V = max line speed (km/h)

p and q = adjacent grades expressed as a decimal (e.g. 1 in 100 = 0.01)

The absolute minimum Vc radius is to be 1650 m on mainlines and loops. For yards or sidings it shall be 700 m.

On mainline or loops Vc's shall be at least 20 m long and there should be a nominal 30 m of constant gradient between curves. In yards or sidings this shall be a minimum of 15 m long.

Vc's may be imposed to join two track gradient's. A Vc must be provided where there is a gradient change in excess of 0.3%.

13.1.2 Track Gradients (TG)

TG is the relative elevation of the two rails along the track. This can be expressed in the distance travelled horizontally for a rise of one unit. This is shown in Figure 13.1.

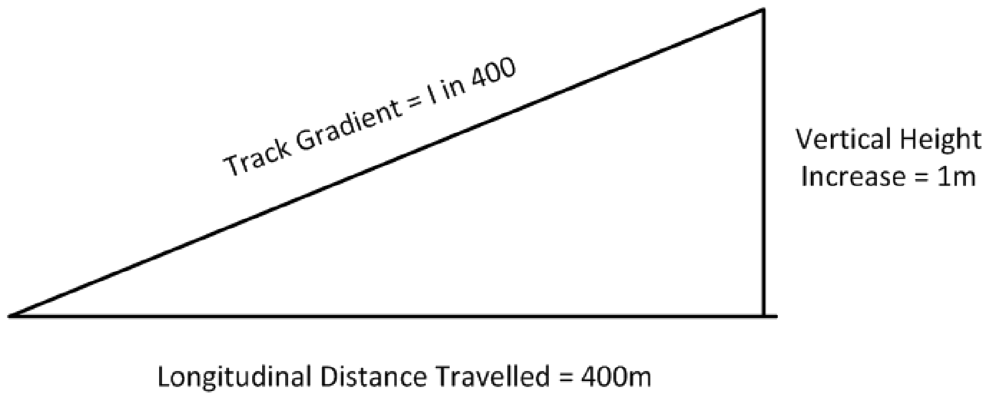


Figure 13.1 Track gradient

The desirable maximum curve compensated grade on mainlines for new works is 1 in 80. The absolute maximum curve gradient is 1 in 26, although anything steeper than 1 in 32 shall have operational restrictions applied. Design work that requires TG's steeper than the desirable must be specially authorised by the PH Track.

Track in yards, sidings and at station platforms should be level where possible. The maximum allowable grade in yards, sidings and platforms is 1 in 200, for yards/sidings sloping away from the mainline but towards the buffer stop.

13.1.3 Curve compensation on grade

Where a train is rising up a gradient and traversing a horizontal curve at the same time the effect of horizontal curvature on vertical grade resistance needs to be considered on mainlines and loops only.

The equivalent grade on the curve shall be calculated according to the following formula.

Equivalent Grade on Curve (percentage) $= \mathrm{GA} + \frac{62.5}{\mathrm{R}}$

Where:

GA = actual grade (percentage)

R = radius of horizontal curve (m)

14. Clearances

All track design activities must be undertaken with a view to ensure that critical interface measurements between the track alignment and structures/electrification systems are not impaired prompting the risk of a train striking a structure or causing wire displacement.

Before any track design is undertaken, where structures or overhead lines are present, Track Engineering and the relevant PH must be consulted.

Track Engineering holds the gauging records for all structures on KiwiRail's infrastructure and can verify clearances for CAD designs.

All designs must ensure that the structure gauge relevant to the location of design is complied with and that the design is within overhead height and stagger tolerances from the track.

When track design is being undertaken adjacent to a structure the PH of Structures must be consulted to ensure the track alignment design doesn't affect the bridge strength and any obvious alignment irregularities are considered.

Particular care must be taken when undertaking track design in platforms to ensure height and clearances are within clearance tolerances.

Refer to document T-ST-DE-5212 Track Clearances for more detail on track clearances.

14.1 Fixed structure clearances

The fixed structure gauge in Standard Drawing CE 300157 show minimum clearances for new construction on straight track. On curved track the calculated effect of vehicle throw (end throw, v or centre throw and any cant effect) is to be added onto these dimensions.

14.2 Track centre spacing

Track centre spacing is defined by the distance between centre lines of tracks running next to each other, measured horizontally and at right angles to the track.

Do not reduce existing track centre distances without the authority of the PH of Track. Maintain existing track centres between the main line, yards or sidings and any existing track next to it to a minimum centre-line to centre-line distance of 3.67 m. Any track centres measuring less than 3.67 m must be restricted to use, those less than 3.8m clearance may need further mitigations.

These distances shown in Table 14.1 must be increased to allow for cant effect, end throw, and v (centre throw) in relation to all tracks to make sure actual clearances are achieved.

Table 14.1 Track centres for new construction

Tracks	Desirable Minimum (m)	Absolute Minimum (m)
Two mainlines within station limits	5.2	4.0
Two mainlines outside station limits	4.0	3.8
More than two mainlines		
Between each pair of mainlines	5.2	4.0
Between a pair of mainlines and a single mainline	5.2	4.0
Mainline loop or siding	5.2	4.0
Loop or busy siding that is shunted (requiring staff access between wagon rakes or where staff ride on moving rail vehicles)	5.2	4.0
Between sidings not otherwise specified	4.0	3.8
Between ladder roads and any track	-	5.2
Between any siding used for loading or discharging wagons and any mainline or loop or busy siding	-	5.2

14.3 Relationship between track and structures

When designing track alignment and geometry it is essential to consider the effect any movement in the track design with the clearance to lineside structures such as bridges and tunnels, overhead wires, mast locations and signalling equipment such as signal posts and location cabinets.

With structures, any re-design or changes must check the impact of:

1) Lifting or lowering the track levels.
2) Slewing the track in either direction.
3) Recanting the track.

With overhead lines any track design must consider:

4) The impact on overhead wire height and stagger dimensions.
5) The allowable tolerances for wire heights and staggers.

14.4 Clearances required to compensate for cant and curve

Minimum clearances shown in Section 14 exclude any allowances for curvature. Cant, end-throw and v (centre-throw) values must be added.

The Kinematic Envelope is not required to be known on routes where the standard Structure Gauge limits are adhered to. For restricted clearances such as tunnels this may be calculated for that location/route as it is cant/curve dependent and the class of rolling stock that has running rights for that section.

14.4.1 End and centre throw

These are caused by rectangular shaped rail vehicles travelling around a curve. Both are likely to affect lineside structures like platforms and may reduce passing clearances between two vehicles so adjustment must be made for this when considering the horizontal design alignment.

Horizontal track alignment design must allow the impact of curvature in relation to the movement of rail vehicles. Use the diagram in Figure 14.1 and formulae below to determine end throw and centre throw.

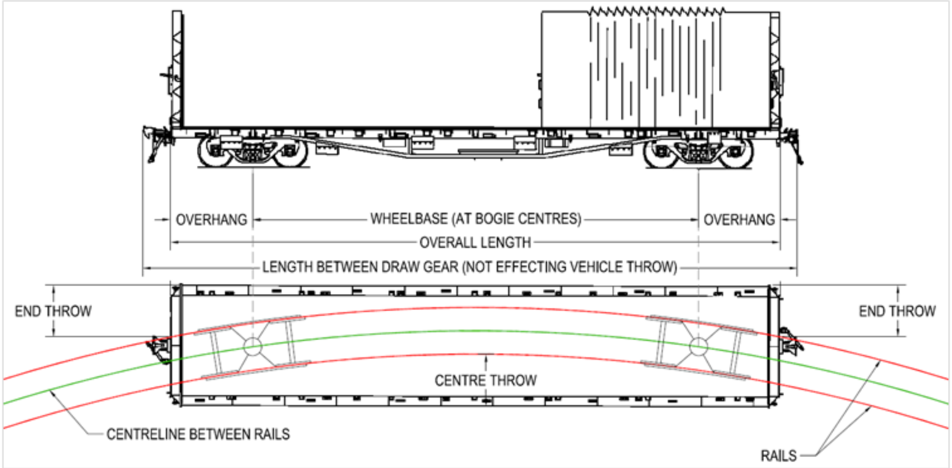


Figure 14.1 Vehicle throw

Vehicle Throw Formulae:

Maximum Centre Throw = $\frac{A^2}{8 \times R}$

Maximum End Throw = $\frac{L^2 - A^2}{8 \times R}$

Where:

L = Overall length of the vehicle

A = Wheelbase or distance between bogie centres

R = Radius of curve

Note it is important to select the worst-case vehicle in use (or that will be in use) on that line to determine the effects of throw.

In some situations, this may be a combination of vehicles, for example if you compare a DSC shunting Loco to a UDA wagon. On a 100 m radius curve the throw effects of the DSC are 30 mm centre throw and 112 mm end throw. The UDA throw effects are 157 mm centre throw and 97 mm end throw. Therefore, if the track design is only going to carry these two vehicles, the design will apply the end throw of the DSC and Centre throw of the UDA to determine the required clearances.

14.4.2 Compensation for cant

Additionally, to the effects of end and centre throw the reduction in clearance due to the effect of canted track must be considered. The impact of cant affects must be assessed using the current clearance information available or based on the kinematic envelope of passing vehicles at that location

Use the following two formulae to determine the effect of cant on vehicle clearance.

$$\text{Cant Effect Horizontal} = \frac{\left[\text{Height} \times \text{Cant Applied} \pm \left(\text{Cant Applied} \times \frac{\text{Absolute Cant Effect Vertical}}{2}\right)\right]}{\text{Gauge}}$$

$$\text{Cant Effect Vertical} = \frac{[\text{Cant Applied} \times (\text{Wagon Width} \pm \text{Gauge})]}{2 \times \text{Gauge}}$$

Gauge in mm

Cant applied in mm

The width of wagon is to be based on the KiwiRail static gauge or worse case width.

14.4.3 Passing clearance

Vehicle passing clearances between adjacent mains and sidings within close proximity of each other must be assessed. The separations shown in section 14.2 Track centre spacing will need to be increased to allow for the vehicle throw and cant effects from vehicles travelling on each main. The worst case conflicting throw and cant effect will need to be added up to increase clearance separation.

For example the image below shows the vehicle on the outside main is projected toward the Inside main by centre throw and the vehicle on the inside main projects toward the outside main with end throw. The require separation between both mains will be determined by the minimum clearance shown in Figure 14.2 (Track centres for new construction) + the centre throw + cant effect from the outside main + the end throw but - cant effect from the inside main.

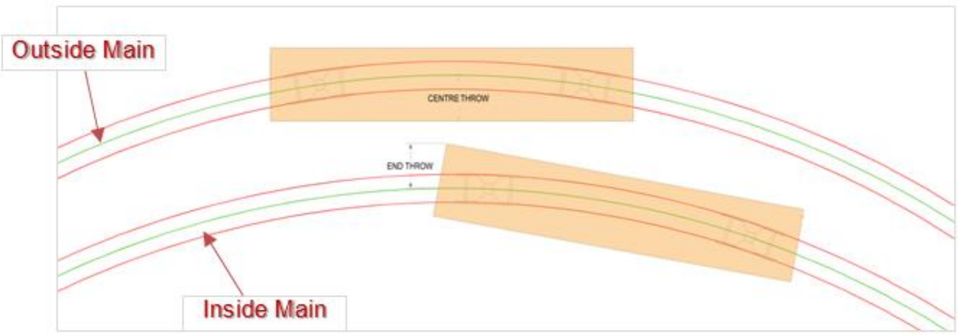


Figure 14.2 Passing clearance

14.4.4 Fouling point markers

Markers shall be placed in yards and sidings where the two parallel tracks start to converge into the turnout ie the track centres start to reduce, but in all cases, must be greater than the collision point, which is where the CL to CL dimension between tracks is 3030 mm but shall be no less than 3800 mm without operating restrictions.

14.4.5 Track adjustment and its effect on the pantograph

Any realignment or recanting of the track will have an effect on the position of the pantograph contact wire. Discuss any proposals of track design with the PH Traction and Electrical so that any necessary readjustment of the wire position can be undertaken in conjunction with the track activity.

Figure 14.3 shows the behaviour of the vehicle on a canted track and the effect that cant has on the structural and electrical clearances.

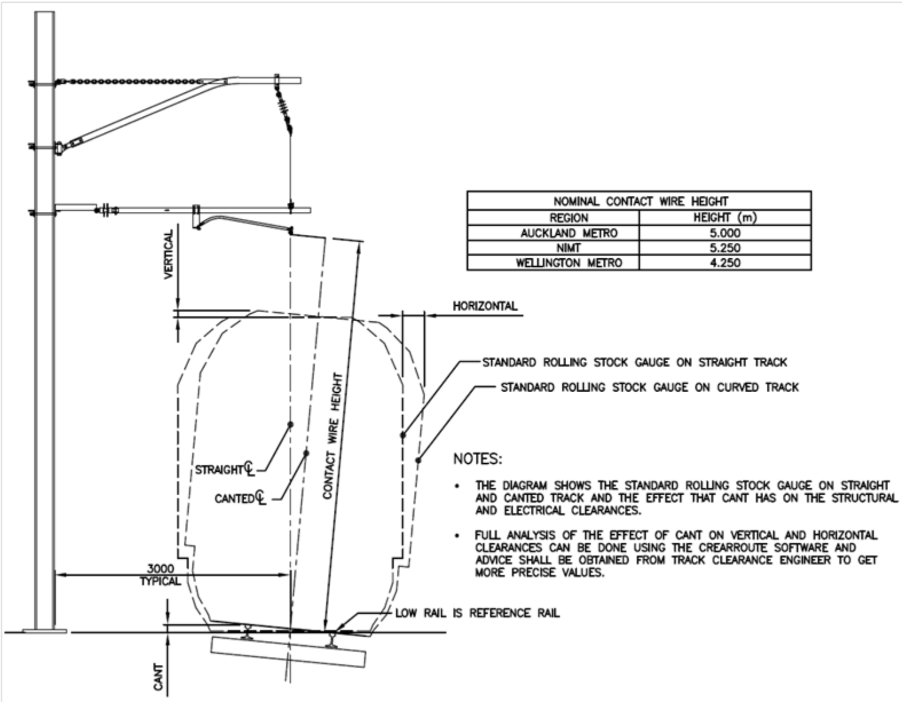


Figure 14.3 Vehicle behaviour on canted track

15. Ballast Depth and Profile Design

Figure 15.1 shows the standard ballast profile with the shoulder width requirements on straights and curves. This can be substituted by a level shoulder from the top of the sleeper end that is at least 550 mm wide.

Table 15.1 shows the minimum and maximum ballast depth requirements for different line classes.

Table 15.1 Ballast depth under sleeper for different class lines

Class of Line	Minimum	Maximum
A and B	300 mm	450 mm
C and Yards	200 mm	300 mm

Temporary works may apply Class C line parameters, but they must be speed restricted to 40 km/h.

Table 15.2 Minimum ballast shoulder width for different radii curves

Radii	Shoulder width - S
≥ 540m (incl tangent track)	350 mm
< 540m - Jointed track < 540m - CWR	350 mm 450mm

The ballast shoulder height at the ends of the sleepers shall be 100mm (+50mm and -0mm).

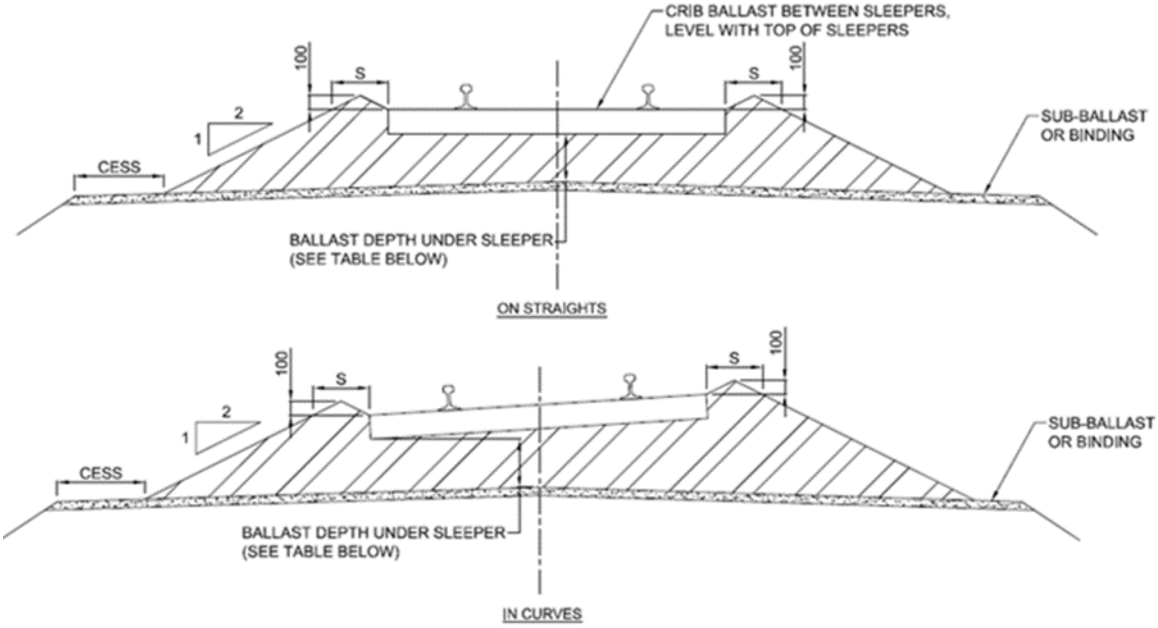


Figure 15.1 Ballast profile

On straight track, the interface between ballast bed and sub ballast / formation is to be raked across to provide a crossfall of 1 in 33 (3%) across the formation. This crossfall is to be raked toward a suitable drainage design (Refer to Civil Engineering standard drawing CE100862). On curved track, the crossfall must be set at the lowest sleeper soffit, this will increase the ballast depth under the high rail.

Geotextile or a separating layer must be added where required by survey and design analysis, refer to Civil Engineering Standard drawing CE 120535. Drainage systems must be cleaned out or installed as required by survey and analysis refer to Civil Engineering standard drawings CE 100862.

16. Turnout Design

16.1 General principles

All new turnouts and other track structure configurations shall be designed to allow for all rail vehicles to safely negotiate extremes of track curvature being:

1) 1:7.5 turnout crossover on parallel tracks 3800 mm apart forming a reverse curve of 96m radius. Refer to Figure 16.1 for an illustration.

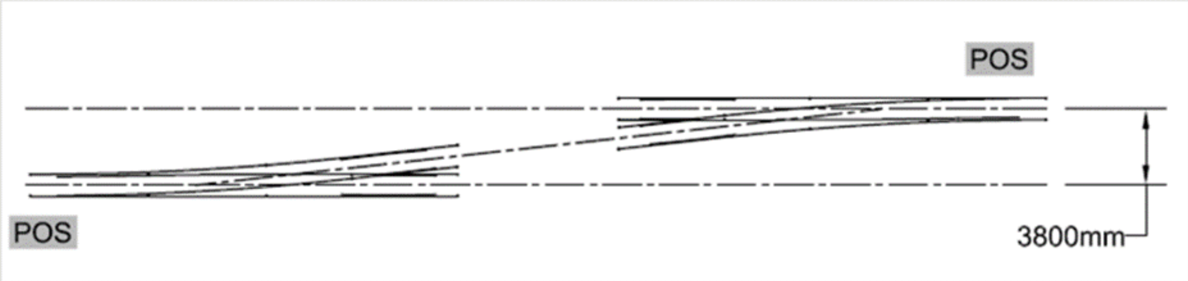


Figure 16.1 One in 7.5 turnout crossover with 3800 mm track centres

2) The desirable straight length between turnouts is 20m. Two 1:7.5 turnouts located nose to nose on the same track with a permitted or signalled move require a minimum of 12m between the POS (switch tips) of the two turnouts. The minimum permitted straight length is 8 m for 1:9 or greater turnouts. Refer to Figure 16.2 for an example of two 1:9 opposite hand turnouts.

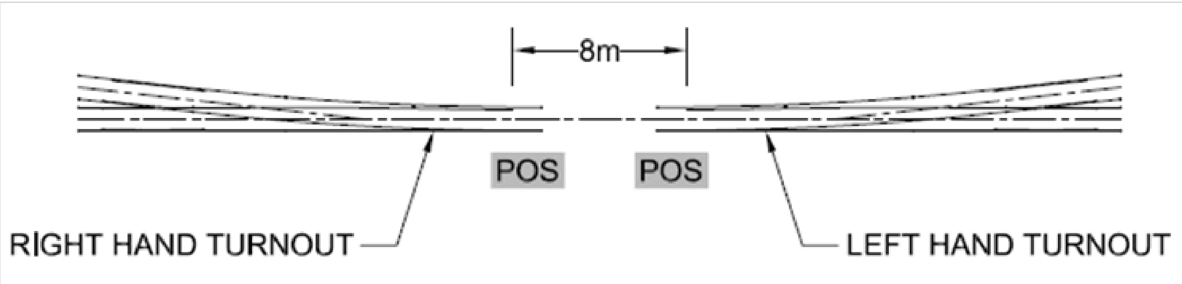


Figure 16.2 Opposite hand 1:9 turnouts located nose to nose

A survey and design for all new turnouts installed must be produced. The new layout should be located on a tangent and on a consistent vertical gradient (the switch section of a turnout must never be installed on a Vc). Re-ballasting should be undertaken as part of all turnout renewals.

Whenever possible a new turnout will be installed in an existing footprint.. The footprint is shown in Figure 16.3. Movement of the footprint may cause problems with the ‘strike’ of the turnout as well as signalling and overhead wire designs. It is therefore vital that the POF of the new turnout is in the same location as the original. Any alterations require a designed solution approved by the relevant discipline PH.

Where new turnouts replace older designs, the lead may vary resulting in a change in position of the POS and associated signals equipment. Refer to Appendix 1 for turnout dimensions (including lead) for the various manufacturers.

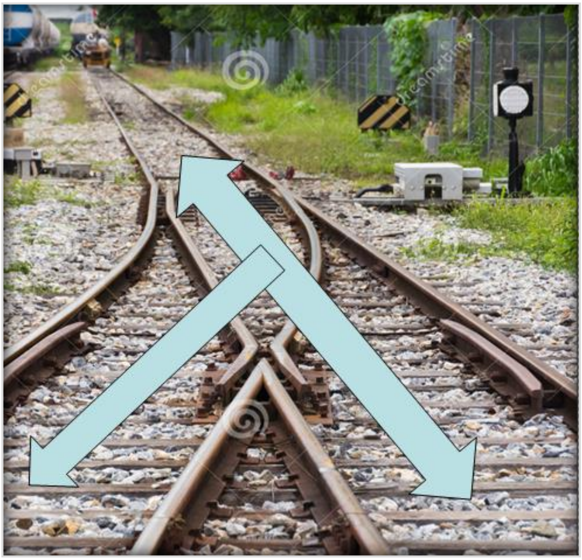


Figure 16.3 Turnout footprint

16.2 Materials

All new turnout designs come as a kit set and are based on the use of NZR 50 kg rail or its equivalent with either concrete, composite or hardwood bearers.

Concrete bearer 50 kg turnouts are the preferred material for installation in main lines with minor lines / yards using composite or hardwood bearers.

For Class A and B track the following are to be used:

- 1:9, 1:12 and 1:18 turnouts
- Concrete bearers (where line speed is ≤25 km/h hardwood or composite may be used).

For Class C track and in yards and sidings:

- 1:7.5 and 1:9 turnouts
- Hardwood or composite bearers.

16.3 Turnout design details

Standard new turnout design strike angles in use are 1:7.5, 9, 12 and 18. The gauge required is 1068 mm on the main through line.

Switch type – Undercut chamfered type with asymmetric switch. Flexible (Heel-less) switches are used for all new 50 kg turnouts.

All new frogs are cast manganese monoblock. All frogs are designed with straight legs to allow interchangeability between right and left-hand turnouts. The frog strike angle is calculated using the right-angle method shown in Figure 16.4 below. With this method, the smallest angle and the largest radius are obtained.

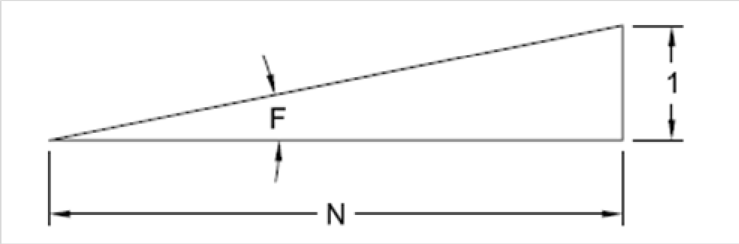


Figure 16.4 Frog strike right angle method

tan F = 1/N

For example, find the angle of a 1:7.5 crossing.

tan F = 1/7.5

F = 7°35’41”

Weldable legs are fitted to allow for reducing the number of mechanical joints in turnouts. These must be welded. All new turnouts are designed using a resilient fastening system e.g. Pandrol shoulders and clips which are suitable for CWR.

Check rails and wings for flange guidance must not be further apart than 992 mm from contact edge to contact edge. Gauge widening difference must be applied on the turnout road.

16.4 Gauge widening requirements

For 1:7.5 and 1:9 turnouts, 6 mm gauge widening is applied on the turnout road giving a gauge of 1074 mm.

16.5 Speeds through turnouts

The following Vm’s through turnouts have been calculated taking the maximum cant deficiency of 60 mm.

Table 16.1 Speed through turnouts

Strike	Angle	Max Speed in km/h
1:7.5	7º35’41”	25
1:9	6º20’25”	30
1:12	4º45’49”	40
1:18	3º10’47”	60

Tables in Appendix 1 show the critical dimensions for all the 91 lb and 50 kg turnouts.

16.6 Siting of turnouts and other configurations

It is essential to site the mainline route of the turnout on straight track. This optimises the full speed potential of the turnout and maximises service life.

Designing on curves with consistent radii and cants is possible but not preferred. This will cause a standard turnout leg to be either sharper or flatter dependent on whether the turnout is contra-flexure or similar flexure. The impact of designing turnouts on curves is that the speed across the turnout leg is altered and any replacement unit or component like switches and frogs will be non-standard for radii and service life is greatly reduced. Additionally, contraflexure turnouts will have negative cant on the turnout leg if the main line is canted. These turnouts must be specially designed and manufactured.

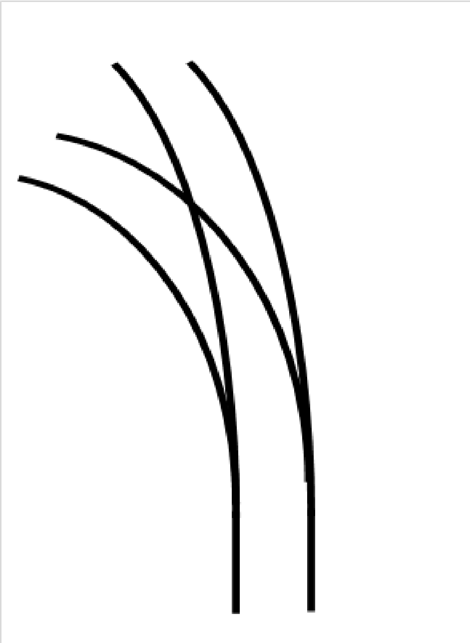


Figure 16.5 Similar flexure turnout

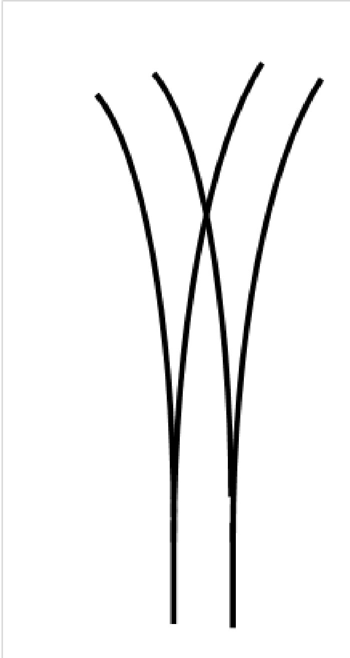


Figure 16.6 Contraflexure turnout

The formulae for increasing or decreasing the radius of the turnout curve are shown below and must be used to assess the resultant turnout speed.

Contra-flexure: Re = (Rm × R) / (Rm – R)

Similar-flexure: Re = (Rm × R) / (Rm + R)

Where:

Re = equivalent radius

Rm = radius of the main line

R = radius of diverging road on turnout

16.7 Restrictions on the location of turnouts

Turnouts should not be designed to be on horizontal transitions or Vc's. In all cases the switch rail must be located on continuous gradients and tangent track.

The limiting values of radius of Vc's for turnout design are:

- Desirable design curve on a crest 5000 m, on a hollow 3000 m
- Absolute minimum curve on a crest 3000 m, on a hollow 2000 m.

Where contra-flexure turnouts are located on horizontal curves a design check must be made to determine if the main line cant is more than 40 mm and if the speed across the turnout leg has been reduced as a result of the negative cant effect. Horizontal curves or transitions ahead of turnouts shall commence no less than 4.2 m from the POS, noting the minimum requirements listed in Table 16.1. Beyond turnouts they shall commence no less than 2.1 m past the last long bearer. For slab track they may commence beyond the last supplied turnout rail end (dimension H in Appendix 1.1)

It is not permitted to design or install a crossover on a curve without specific site design approval from the PH Track.

16.8 Different types of track structures

The following diagram shows the various types of track structures. The desirable units to be used are standard single turnouts and crossovers. Design proposals which include the use of special structures such as slips, diamonds etc. must be approved by PH Track.

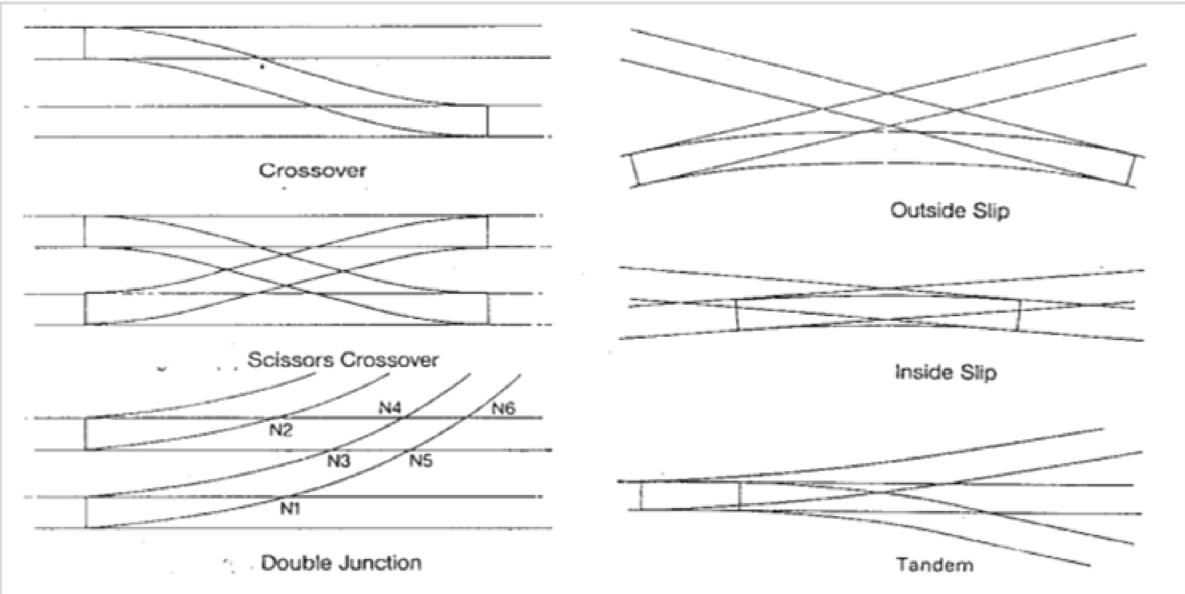


Figure 16.7 Track structure types

Crossovers are a pair of turnouts of same strike angle arranged to permit a train to cross from one line to another. They are to be placed where two tracks are parallel to each other.

Note: the design must ensure that the two lines are parallel at the standard spacing's of 3.8m or 4.0m, although a crossover of >4.1m shall comprise of two standard turnouts.

All new / replacement crossovers require a full measure up for design. Refer to diagram in Appendix 1 for the crossover measure up dimensions required.

Scissors crossovers are a combination of two crossovers of the same angle in opposite directions which intersect with a diamond in the middle. They are used where there is insufficient space to fit two back to back crossovers. These are considered as a special and are designed unique to that location. There are currently three designs of Scissors Crossovers:

- 1:7.5 Scissors crossover
- 1:9 Scissors crossover

- 1:12 Scissors crossover.

Double junctions are where two crossovers are adjacent to each other, with the second crossover also going across the second mainline with N1 and N2 being similar standard frogs, N4 and N5 similar obtuse frogs and N3 and N6 are special frogs unique to the obtuse angle (refer to Figure 16.5). Continuous check rails may be required. All new installations will have a special angle or a curve through them, these are specials and require a design unique to the location. When the obtuse frog angle is flatter than 1:8 then switch diamonds are to be used.

Standard slips allow a slow speed change in direction (25 km/h or less) where a scissors is too complex. These are permitted as:

- 1:7.5 Single Slip - either inside or outside slip design
- 1:7.5 Double Slip – comprising both inside and outside design

Slips at a flatter angle than 1:7.5 are not permitted. This is due to the length of unchecked gap between the POF of centre frogs. Due to the larger unchecked gap, these frogs have a higher risk of being struck by wheel flanges which can cause a derailment.

Tandem turnouts also known as a three throw, are only to be used in yards where space is extremely limited and no alternative layout designs are possible. Operating speed is restricted to less than 25 km/h. Installations such as these are specials and require a design unique to the location.

16.9 Safety points, trap switches and stop blocks

There are three types of protection arrangements used to prevent vehicles in sidings and crossing loops fouling the Mainline. These are safety points, trap switches and stop blocks. The use of these is governed by train speed and whether or not vehicles in the loop or siding are stationary or subject to movement by shunt locomotive. For details on the use of the type of safety points refer to Signals Engineering drawing S 23836.

Safety Points (runaway turnouts) are a complete set of switches and frog which lead to a short length of track protected at the end by a buffer or a sand drag. They are normally fitted where the direction of a derailed train would foul the mainline where it is permitted to have simultaneous movements on sidings, loops and main lines.

Trap switches comprise of a single 91lb 18 ft long straight switch half set or a 50 kg 1:9 single switch on mainlines, a 1:7.5 may be permitted in sidings. They are only installed on one side of the track and are used mainly in sidings, and with restriction on some crossing loops.

These are normally fitted where the direction of a derailed train will not foul a mainline with no simultaneous movement permissible or no motive power in sidings. Refer to Standard Drawing CE 84565.

Stop blocks (derailers) are a steel block placed across a running rail which will either stop a vehicle or derail it away from the main line or crossing loop. They are permitted where train speeds are 25 km/h or less on lightly trafficked non-signalled lines, typically used in sidings and workshops.

17. Design Life and Decommissioning Requirements

17.1 Design life requirements

The designer should take the following criteria into account when designing track it should be:

- capable of supporting the operation of rail traffic at the designated loads and speeds for each section of track
- designed to achieve a minimum pre-established operating life while operating at the capacity required for the relevant Operating Class before requiring upgrading or a major maintenance intervention
- designed to be in line with the requirements of the Asset Management Plan.

17.2 Decommissioning

Decommissioning of track is the process of removing the track from service due to the expiration of life of track. It involves the disposal of life expired materials and recovery of materials fit for reuse. Sufficient planning of this part of the life cycle is a critical part of the whole of life cycle process.

Before the removal of any track, an inspection report should be produced which may include the following:

- confirmation of the track life expiration
- impact of decommissioning on any other systems associated with the track to be decommissioned
- impact of decommissioning on the external environment
- removal plan for reusable materials which should ensure that no damage is suffered to the recovered materials during removal, transportation and delivery
- plan for disposal of scrap material

18. Materials Classification

Line Class and Line Speed Category dictates the use of the appropriate material standard for renewals and maintenance. Refer to document T-ST-MM-5709 for details on material usage for different types of lines.

Track materials that are deemed fit for reuse shall be allocated different material classifications for reuse in track. Refer to document T-ST-AM-5301 for more details on classification procedures and criteria for second-hand materials.

19. Design Set Out

All track designs must be set out accurately on site by one of the following methods:

- Hallade horizontal curve alignment survey, for Hallade designs only. The set-out stations must be exactly the same as the original survey.

- Line and level survey using surveying equipment using competent surveyors.
- Set out must clearly provide the following details by use of pegged offsets or real time electronic track positioning:
- All S and CTP points.
- Track centreline positions at 10 m intervals on straight track and curves ≥400 m Radius. At 5 m intervals on curves <400 m and where finer track positioning is required, e.g. over bridges.
- Elevation of track low rail levels.
- Cant required.
- Turnout POF
- It is recommended when using set out pegs they be placed at least 2.6 m from track centreline. Pegging should be done as close to the time of construction as possible to minimise disturbance of the pegs.
- Track designs shall be permanently monumented for future reference by use of onsite datum plates.

19.1 Construction tolerances

New or renewed track must be constructed to the following tolerances:

Table 19.1 Parameters for ballasted track

Parameter for Ballasted Track	Tolerance to Design at Survey Station Based on 10 m Intervals (first difference)
Centre Line (CL)alignment	±10 mm
Low rail (or design reference datum rail) level	+10, -20 mm
Gauge on new timber sleepers	+3 mm, - 0 mm
Gauge on serviceable timber sleepers	+5 mm, -0 mm
Gauge on concrete sleepers	+2 mm, - 4 mm
Gauge for turnouts	+3 mm, - 0 mm
Twist (over 4 m base)	±5 mm
Cross level	±3 mm
Vertical deflection under load	-2 mm, +0 mm

Table 19.2 Parameter for slab or directly fastened track

Parameter for Slab or Directly Fastened Track	Tolerance to Design at Survey Station Based on 10 m Intervals (first difference)
CL location	±10 mm
Level	±5 mm
Gauge	+3 mm, - 0 mm
Twist (over 4 m base)	±3 mm
Cross level	±2 mm
Vertical deflection under load	±0 mm

20. Drawings

20.1 General requirements

All design drawings shall be produced in accordance with the KiwiRail AutoCAD User's Manual.

Drawings issued at different stages of the design shall have the following status stamped on the bottom right corner of the drawing:

- Work in progress drawings shall be marked 'preliminary'.
- Final design drawings shall be marked 'for approval'.
- Approved final design drawings shall be marked 'for construction'.
- Drawings created from survey carried out after construction shall be marked 'as built'.

The names of the people responsible for the design, checking and approval of the design shall be shown in printed form on the title block.

20.2 Displaying design information

Track design drawings shall have the following alignment details displayed on the drawings:

Horizontal alignment (Plan view)

- **Survey:** Topographical survey with all the critical features and annotations for all the important information.
- **Existing and designed track alignment:** Line name, track centreline for existing and designed track should be displayed. For multiple track lines, track centreline spacing, MainL, MainR, Loop and Siding number should be displayed.
- **Kilometrage:** To be displayed every 20 m at a 90° angle to the alignment. Also, to be displayed for S and CTP point locations. Kilometrage values should always be displayed so that they increase when read from left to right.
- **From and To:** Show 'From A' on the left side of the sheet and 'To B' on the right side where A and B are terminal stations on the line e.g. for NIMT show 'From Wellington' on the left side and 'To Auckland' on the right side of the sheet.
- **Fouling point:** Fouling points or Clearance markers are to be clearly displayed and labelled on the drawing.
- **Straight detail:** Length and bearing.
- **Curves detail:** Length, radius, design speed, Eq, applied cant and cant deficiency.
- **Transition detail:** Length, cant grade (1 in), ROCOC(mm/s), ROCOCD(mm/s), S and CTP points.
- **POS and POF:** These are to be clearly displayed on the drawing. Coordinates for all the points are to be tabulated for setting out purposes.

Vertical Alignment (Sectional view with table)

- **Tracks:** Line name, low rail. For Multiple track lines MainL, MainR, Loop and Siding number should be displayed.
- **Kilometrage:** To be displayed every 20 m, at vertical grade intersection points (IP), Vc start and finish points and for Vc peaks and troughs.
- **Existing and design rail levels:** To be displayed at 20 m intervals.
- **Grades:** Grades for design rail should be displayed.
- **Grade IP:** Grade IPs should be labelled with rail level shown at the point of intersection.
- **Vertical curve:** Vc's are to be displayed with curve radius, length and rail level at the IP.
- **Track lifts:** Track lifts or drops from existing to design should be included.
- **Track Slews:** Slew from existing and direction of slew (-ve to the left and +ve to the right in direction of metrage).
- **Design Formation level:** To be shown at a required depth from the design rail level.

20.3 Control of drawings

The issue and revision of design drawings shall be controlled so that the status of all copies of drawings can be identified and all the work is carried out using the latest version of the drawings.

The first issue of design drawings and any subsequent revisions shall be marked with capitalised alphabets 'A', 'B', 'C' etc. All the design drawings shall be issued in .pdf format.

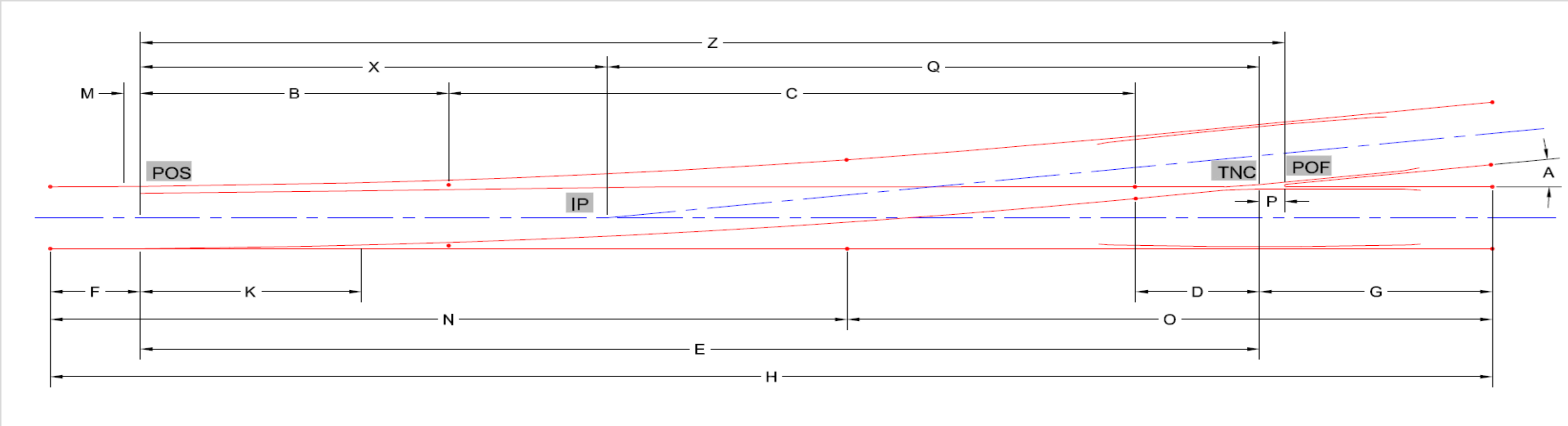
After the final approval and sign off of the drawings is complete, the original plans shall be scanned and saved under the project folder

Where design amendments are required, new amendment letter (increment the previous amendment letter) should be indicated for example Amendment 'A' becomes 'B'. A description of change to the amendment should be added in the title amendment block.

As-built drawings shall be submitted to Track Engineering to enable records to be updated including asset data. Where a drawing is superseded, a new drawing number shall be issued to the new drawing. A note should be placed at the bottom right side of the drawing to draw attention to this fact. The superseded drawing should have 'Superseded by drawing XYZ' stamped across the whole drawing.

Appendix 1 Critical Dimensions for Turnouts

Appendix 1.1 50 kg turnout structures



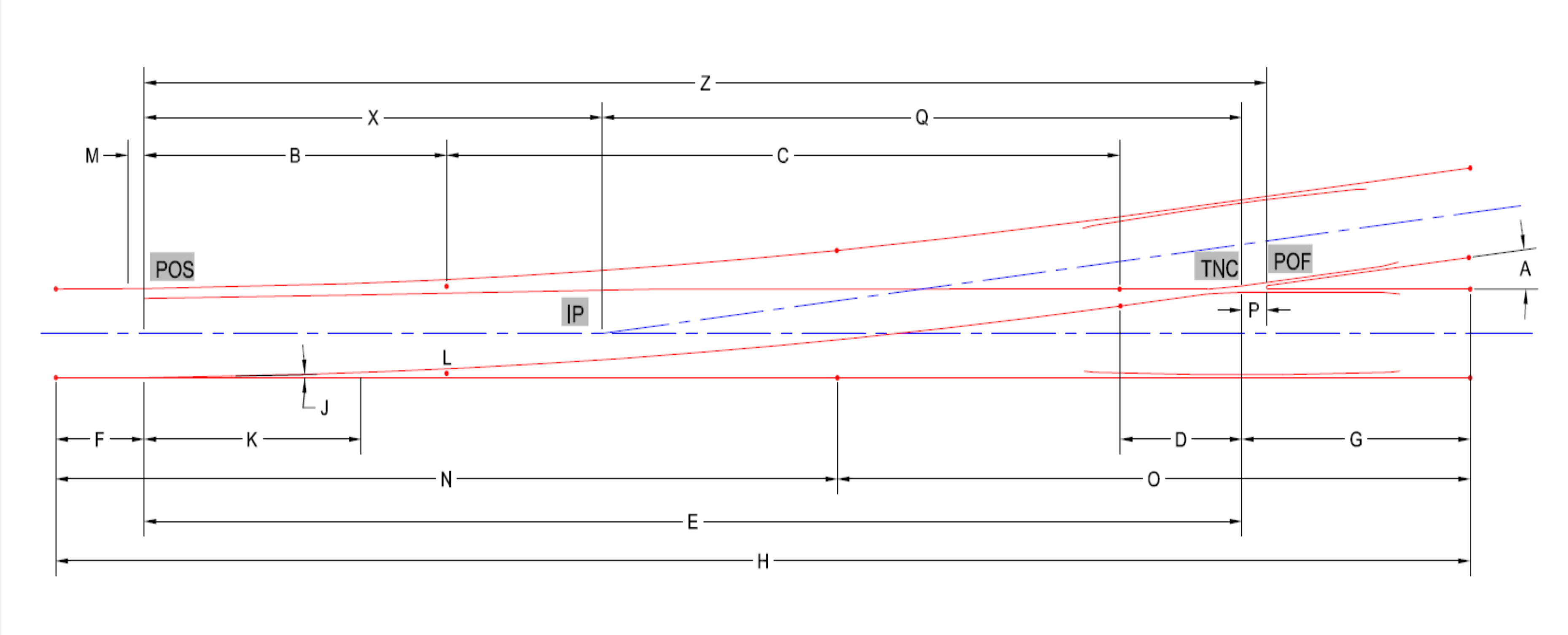
TURNOUT ANGLE		1 IN 7½					1 IN 9						1 IN 12					1 in 18		
BRAND		BB	CRSBG	GLE	MR	VAE	BB	CRSBG	GLE	MR	TW	VAE	CRSBG	GLE	MR	VAE	TW	CRSBG	MR	TW
ANGLE OF FROG	A	7°37'41"	7°35'41"	7°35'41"	7°35'41"	7°35'41"	6°21'35"	6°20'25"	6°20'25"	6°20'25"	6°20'25"	6°20'25"	4°45'49"	4°45'49"	4°45'49"	4°45'49"	4°45'49"	3°10'47"	3°10'47"	3°10'47"
LENGTH OF SWITCH	B	11807	6743	6990	8480	12051	9483	10451	8790	10290	9995	10300	10451	10590	13290	10700	11525	16815	18100	-
LENGTH OF STRAIGHT CLOSURE	C	N/A	5818	4810	3542	N/A	5398	4243	6128	4744	-	4831	8476	9404	6568	8999	9190	12708	12572	-
TOE OF FROG TO TNC OF FROG	D	1880	1780	1880	1897	1880	1856	1842	1857	1864	-	1857	2410	2407	2881	2380	-	3623	3612	-
LEAD B+C+D + EXPANSIONS	E	13756	14355	13680	13927	13878	16891	16548	16774	16905	17856	16996	21349	22401	22747	22686	23886	32963	34292	36056
OVERHANG	F	3500	2816	3500	1090	3293	3317	2331	3500	1090	1735	2479	2331	2400	1090	2399	1735	2650	1090	1735
TNC OF FROG TO HEEL OF FROG	G	3520	3520	3280	3950	3520	3544	3443	3543	3363	4000	3543	3942	4193	4689	4192	4845	6112	6888	-
LENGTH OVERALL F+E+G	H	20656	20691	20701	18967	20691	23608	22322	23818	21359	23591	23018	27622	28992	28526	29277	30621	41725	42270	44890
LENGTH OF SIDE PLANING OF SWITCH	K	2920	3220	2929	3165/ 3187	-	3597	3270	3597	3928/ 3946	3300	-	3775	4805	5419/ 5432	-	4500	6455	8360/ 8369	-
SWITCH POINT TO 1068 VERTEX	M	504	1816	530	490	333	621	1331	651	490	-	429	1331	867	490	610	-	2650	490	-
LENGTH OF STOCKRAILS	N	12400	12211	9890	9600/ 9544	12920	12800	12782	11690	11400/ 11354	11220	12800	12782	12990	14400/ 14360	13100	12750	19465	19200/ 19181	-
LENGTH OF CHECKRAIL	O	5400	3639	5400	9434/ 9405	4600	5400	4750	5400	10014/ 9985	5000	4600	4960	7200	8154/ 8161	4600	5000	7050	10496/ 10498	-
TNC OF FROG TO NOSE OF FROG	P	120	75	120	75.3	75	144	90	143	90	108	90	120	193	120	120	144	180	180	-
IP TO TNC OF FROG	Q	8010	8045	8047	8045	8045.5	9612	9642	9641	9642	9642	9645	12838	12838	12838	12838	12838	19238	19239	19239
RADIUS OF TURNOUT ROAD CURVE	R	91950	96534	92906	96000	92891	139608	140534	140506	140000	174616	140506	250534	250794	250000	251432	309185	560534	560000	693665
POS TO IP	X	5746	6310	5635	5882	5835.5	7279	6906	7133	7264	8214	7351	8511	9565	9909	9848	11048	16815	15054	16817
POS TO POF	Z	13876	14430	13802	14002	13956	17035	16548	16917	16995	17964	17086	21349	22596	22867	22806	24030	32963	34472	-
GAUGE WIDENING ON TURNOUT ROAD		6	6	6	6	6	0	6	6	6	0	6	0	0	0	0	0	0	0	0

All dimensions are in mm unless otherwise specified

Dimension H is the location of the rail end, not the last long bearer or cant reducing bedplate sleeper, refer to manufacturer's drawings.

BB	Balfour Beatty
CRSBG	China Railway Shanhaiguan Bridge Group
GLE	Grant Lyon Eagre
MR	Martinus Rail
TW	Thomas Ward
VAE	Voestalpine

Appendix 1. 2 91 lb turnout structures

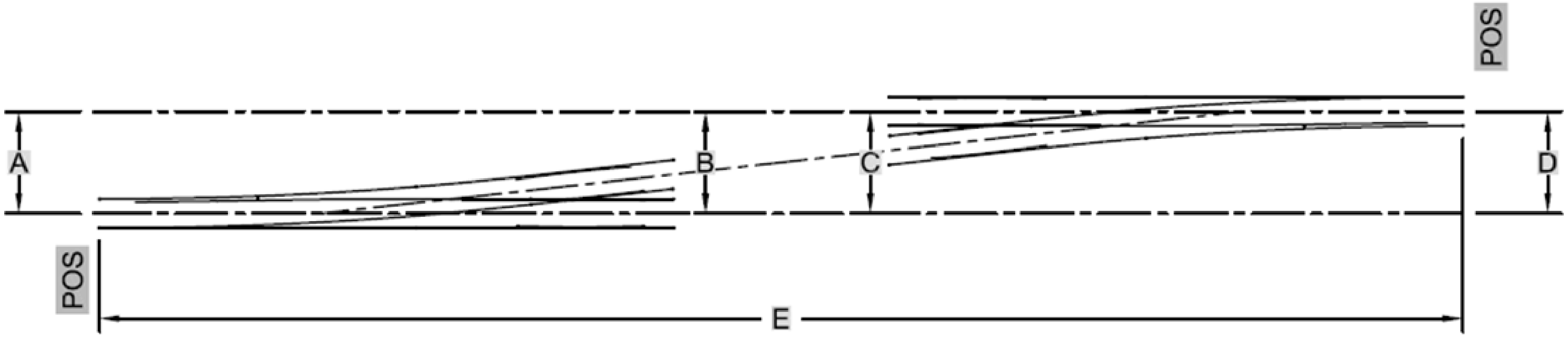


TURNOUT ANGLE	ID	1 IN 7½ 9'-6" SWTICH CCE 94783	1 IN 7½ 10' SWITCH	1 IN 7½ 14' SWITCH CCE 94784	1 IN 7½ 18' SWITCH * CCE 70904	1 IN 9 18' SWITCH CCE 94785	1 IN 12 25' SWITCH CCE 94788	1 IN 18 28' SWITCH CCE 94787
ANGLE OF FROG	A	7° 35' 41"	7° 35' 41"	7° 35' 41"	7° 35' 41"	6° 20' 25"	4° 45' 49"	3° 10' 47"
LENGTH OF SWITCH	B	9' 6⅛" (2900)	10' (3048)	14' 0⅛" (4270)	18' 0" (5490)	18' 0" (5490)	25' 0" (7620)	28' 0" (8530)
LENGTH OF STRAIGHT CLOSURE	C	8741	8519	9166	10250	11470	15078	22177
TOE OF FROG TO TNC OF FROG	D	1219	1219	1219	1325	1325	1676	2515
LEAD B+C+D	E	12867	13716	14658	17068	18288	24384	33236
OVERHANG	F	2958	1244	2994	4026	4026	3327	3296
TNC OF FROG TO HEEL OF FROG	G	1556	3286	1556	3296	3296	2438	3658
LENGTH OVERALL F+E+G	H	17380	18246	19209	24380	25610	30150	40189
ANGLE OF SWITCH	J	2° 01' 18"	1° 25' 57"	1° 17' 00"	1° 04' 37"	1° 04' 37"	0° 43' 00"	0° 40' 00"
LENGTH OF SIDE PLANING OF SWITCH	K	1665	1526	2626	3124	3124	4686	5048
HEEL OF SWITCH SPREAD - A SIDE	L	116	119	116	122	122	118	116
SWITCH POINT TO 106B VERTEX	M	179	171	283	340	340	508	543
LENGTH OF STOCKRAILS	N	10973	12802	12802	12802	15545	17348	21923
LENGTH OF STRAIGHT RUNNING CHECKRAIL	O	6401	5439	6401	11582	10058	12802	18266
TNC OF FROG TO NOSE OF FROG	P	35	35	35	35	44	57	86
IP TO TNC OF FROG	Q	8036	8036	8036	8036	9630	12824	19215
RADIUS OF TURNOUT ROAD CURVE	R	102.61m	121.1m	98.65m	108.51m	152.20m	255.46m	585.83m
POS TO IP	X	4831	5680	6623	9033	8658	11560	14021
POS TO POF	Z	12902	13751	14694	17104	18332	24441	33322
GAUGE WIDENING ON TURNOUT ROAD	-	6	6	6	6	6	0	0

All dimensions are in mm

Dimension H is the location of the rail end, not the last long bearer or cant reducing bedplate sleeper, refer to manufacturer's drawings.

Appendix 2 Crossover Critical Dimensions



CROSSOVER CRITICAL MEASUREMNTS	
WORK ORDER NUMBER	
LOCATION / TURNOUT NUMBERS	
CROSSOVER ANGLE	
CROSSOVER HAND	
EXISTING TURNOUT BRAND	
TRACK CL - CL (A)	
TRACK CL - CL (B)	
TRACK CL - CL (C)	
TRACK CL - CL (D)	
POS - POS (E)	
IS THE CROSSOVER ON A CURVE	YES / NO (IF YES ATTACH A DETAILED SURVEY)

	NAME	DATE
MEASURE UP		
CHECKED		

Briefing Note(s) for T-ST-DE-5200 Track Design

Date Effective **31/12/2022** **Issue No.** **Issue 4.0**

Background

This standard gives the requirements for all design of plain line track and other track structures. It also covers any track work that may be undertaken during projects, track renewals, maintenance or life extension of track assemblies, turnouts, level crossings, open deck bridge structures and the track substructure.

Key changes / compliance

Formulae for Curve Compensation on Grade simplified, see table on page 2 for further details.

Implementation

This document should be cascaded down to all staff impacted by this Standard in the field. The changes contained in this document will become mandatory immendiately.

Applicability **(Select relevant boxes)**	**General**	**Civil**	**Signals and Telecommunications**	**Structures**	**Track**	**Traction and Electrical**
Zero Harm	☒	☐	☐	☐	☐	☐
Learning and Development	☒	☐	☐	☐	☒	☐
Project Management Office	☒	☐	☐	☐	☒	☐
Manager Property Revenue and Grants	☐	☐	☐	☐	☐	☐
National Train Control Centre	☐	☐	☐	☐	☐	☐
Engineering Services Manager	☐	☐	☐	☐	☐	☐
National Supply Chain and Distribution Manager	☐	☐	☐	☐	☐	☐
Professional Head		☒	☒	☒	☒	☒
Network Services Managers		☐	☐	☐	☒	☐
Region Operations Managers		☐	☐	☐	☒	☐
STTE Managers		☐	☐	☐	☐	☐
Production Managers		☐	☐	☐	☒	☐
Asset Engineers		☐	☐	☐	☒	☐

Document History

Note page numbers relate to the document at the time of amendment and may not match page numbers in current document.

Issue No.	Section	Description	Page(s)
1.0		First publication	
2	1.1	Table 12.2 Curve parameters for station platforms **new**	14
		Table 12.5 Curve speeds and geometry guide **updated**	21
3		Branding and KiwiRail logo – **updated**	
		Table of Contents – **updated**	
	12.1	Table 12.1 – table heading **Length changed** to **Value** **New** paragraph added to end of the section	14
	12.1.1	Content **added**	14
	12.2.2	Content **added**	18
	12.2.5	Content **removed** after **Note**	19
	12.2.7	Table 12.4 first line under **Comments amended**	20
	12.2.8	New contents added after second paragraph and Note under Table 12.5 – **updated**	21
	13.	Table 13.1 updates in the **Length** column	22
	13.1.1	Vertical curves – **minor change**	23
	13.1.3	Formulae – **updated**	24
	14.2	Track centre spacing – **minor changes**	25
	15.	Minor changes to section	29
	16.7	New content added and updated	33
	19.	Table 19.1 and 19.2 – **updated**	37
		Briefing Note(s) – **updated**	42
		Document History – **new**	43