TS 01049:1.0

CRN CS 240

Standard

Ballast

Issue date: 30 January 2022

Effective date: 30 January 2022

Disclaimer

This document has been prepared by Transport for NSW (TfNSW) specifically for its own use and is also available for use by NSW public transport agencies for transport assets.

Any third parties considering use of this document should obtain their own independent professional advice about the appropriateness of using this document and the accuracy of its contents. TfNSW disclaims all responsibility and liability arising whether directly or indirectly out of or in connection with the contents or use of this document.

TfNSW makes no warranty or representation in relation to the accuracy, currency or adequacy of this document or that the document is fit for purpose.

The inclusion of any third party material in this document, does not represent an endorsement by TfNSW of any third party product or service.

For queries regarding this document, please email Transport for NSW Asset Management Branch at standards@transport.nsw.gov.au or visit www.transport.nsw.gov.au

Document information

Owner:	Director Corridor Infrastructure & Engineering, AMB, SER
Mode	Heavy Rail
Discipline	Civil

Document history

Revision	Effective date	Summary of changes
1.5	30 January 2022	TfNSW template applied
2.0	30 January 2022	First full UGLRL version

Table of contents

1. Scope and application

This Standard establishes functional and design requirements, approved configurations, acceptance standards, damage limits and repair standards for rail ballast.

It is applicable to all Country Regional Network (CRN) main line and siding tracks and shall be applied to the design of new trackwork, track renewal, reconditioning and ballast cleaning.

2. References

2.1. Australian and International standards

AS 2758.7 - Aggregate and rock for engineering purposes Part 7: Railway Ballast

Unless otherwise specified, all references relate to the latest standard versions, including amendments and relevant superseding standards.

2.2. CRN documents

CRN CS 200 - Track System CRN CP 241 - Ballast

2.3. Other references

Track Technology and Substructure Management, 1994, pp 7.11f, Selig, E.T and Waters, J.M

2.4. Definitions

Ballast: Ballast is a free draining coarse aggregate or metallurgical slag used to support railway tracks.

Nominal Size: The designation of an aggregate which gives an indication of the largest size particle present.

3. Engineering authority

Design and selection of infrastructure detailed in this standard for use on the CRN may only be undertaken by persons who have been granted appropriate Engineering Authority by the Principal Track and Civil Engineer.

4. Design & performance criteria

4.1. Track configuration

The configuration of track elements, including ballast, is specified in CRN Engineering standard CRN CS 200 “Track System”.

4.2. Ballast design criteria

The ballast material design and track cross-sectional ballast profile in this standard have been developed in consideration of the following criteria:

4.2.1. Loading

Service loads including effects of track alignment, maintenance standards, and traffic task.

4.2.2. Materials

Ballast consolidation requirements.

4.2.3. Interfaces with other rail infrastructure

Sleeper material, type and spacing.

Electrical properties in track circuited areas.

4.2.4. Support requirements

Required track modulus.

Track support conditions and deflection criteria.

Track formation material and condition.

4.2.5. Performance requirements

The need to interlock sufficiently, provide resistance against excessive vertical, lateral (buckling of the track) and longitudinal movement of sleepers and bearers.

The need to reduce excessive loading and failure of the track formation.

The need to provide adequate drainage of the track structure to the cess and allow fines to migrate out.

The need to be durable enough to resist crushing when subjected to design axle loadings specified for the relevant track class in CRN CS 200.

5. Approved configurations

5.1. Ballast material and grading

For existing applications, detailed in CRN CS 200, all ballast shall meet the material and grading requirements of CRN Engineering specification CRN CP 241 “Ballast”.

Ballast grading shall be selected in accordance with the track class detailed in CRN CS 200 and as detailed in Table 1 and Table 2. The ballast gradings are detailed in Table 3.

Table 1 – Ballast Selection – Main Line

Track Class	Ballast Grading
1	Standard
2	Standard
3	Standard
3G	Standard
5	Standard

Table 2 – Ballast Selection – Sidings

Track Class	Ballast Grading
1	Standard
2	Standard
3	Standard

Table 3 – Ballast grading

	Standard (Note 1) (AS 2758.7)	Enhanced(Note 3) (AS 2758.7)	Medium (Note 2) (AS 2758.7)	Fine (Note 4)
Sieve size (mm)	60*	60 Graded (TfNSW ASA)*	60 Steel Sleepers*	50 Graded (TfNSW ASA)*
63.0	100**	100**	100**	–
53.0	85 – 100**	85 – 100**	95 – 100**	100**
37.5	20 – 65**	50 – 70**	35 – 70**	70 – 100**
26.5	0 – 20**	20 – 35**	15 – 30**	–
19.0	0 – 5**	10 – 20**	5 – 15**	40 – 60**
13.2	0 – 2**	2 – 10**	0 – 10**	–
9.50	–	0 – 5**	0 – 1**	20 – 30**
4.75	0 – 1**	0 – 2**	–	10 – 20**
2.36	–	–	–	–
1.18	–	–	–	5 - 10**
0.075	0 – 1**	–	0 – 1**	0 –- 5**

* Nominal size (mm)

** % passing by mass

Note 1: Standard grade ballast is the default ballast grade in the CRN, and may be used in lieu of other gradings for consistency without approval from the Principal Track and Civil Engineer

Note 2: Medium grade ballast may be used in lieu of Standard grade when used on lines which are or are intended to be fully steel sleepered.

Medium ballast more easily fills sleeper pods and is denser and more readily compacted. Where Medium grading is proposed for use, an engineering assessment of the drainage situation shall be undertaken on a case by case basis, as the denser grading is more prone to fouling. Guidelines are indicated in Table 4.

Table 4 – Guidelines for ballast grading for steel sleepers

Situation	Grade
Normal open well drained situations	Medium
Constrained drainage situations such as cuttings/ platforms/ ballast top bridges	Medium
Areas with poor drainage and a history of drainage problems	Standard

Note 3: Enhanced grade ballast is recommended at locations of transitioning track stiffness such as approached to transom top bridges and slab track, and requires approval from the Principal Track and Civil Engineer for use.

Note 4: Fine graded Ballast is not approved for use on CRN infrastructure except where authorised by the Principal Track and Civil Engineer. It is intended for application in walkway areas in sidings where specially approved

Special ballast gradings (either as specified in AS 2758.7 or specifically designed) to meet specific requirements (e.g. special gradings necessary in conjunction with reduced ballast depth) must be approved by the Principal Track and Civil Engineer.

5.2. Ballast profile

A typical track cross-section illustrating ballast profile is shown in Figure 1.

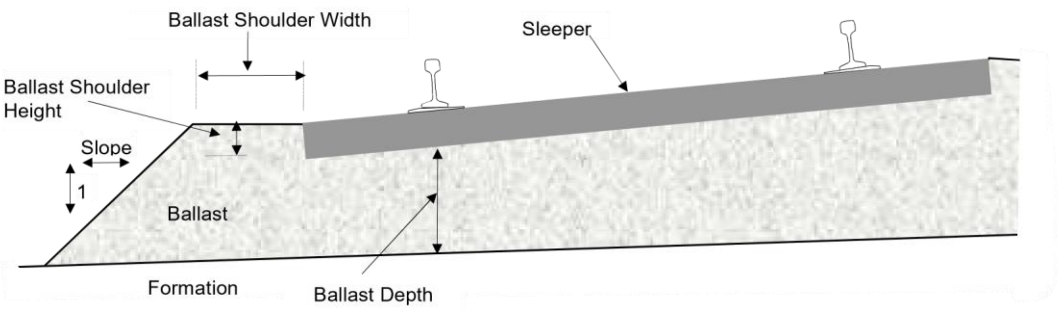

Figure 1 - Typical track cross-section and ballast profile

5.2.1. Shoulder height

Ballast shoulder height (the distance from sleeper soffit (bottom of the sleeper) to the underside of the rail) is determined by the sleeper design. The ballast shall be profiled to the top of the end of the sleepers. Depending on the sleeper design, the rail seat area may be higher than the centre and ends.

5.2.2. Crib height

The ballast shall be profiled to the top of the centre of the sleepers.

5.2.3. Shoulder slope

For freestanding ballast, the slope of the ballast shoulder is assumed to be 1:1.5 (height: width)

5.2.4. Shoulder width

The minimum shoulder distance is determined by the track stability requirements of rail length. The requirements for current applications are detailed in Table 5 and Table 6.

Table 5 – Ballast Shoulder widths – Main line

Track Class	Rail Length	Design Ballast shoulder width (mm) minimum	Design Ballast shoulder width (mm) maximum
1	CWR / LWR	400	700
2	CWR / LWR	400	700
3/3G	CWR / LWR	400	700
3	Loose	250	700
5	Loose	250	700

Table 6 – Ballast Shoulder widths – Sidings

Track Class	Rail Length	Design Ballast shoulder width (mm) minimum	Design Ballast shoulder width (mm) maximum
1	CWR / LWR	400	700
2	CWR / LWR	400	700
3	CWR / LWR	400	700
3	Loose	250	700

Ballast Shoulder width is measured from the extreme end of the sleeper, not the visible end when the track is fully ballasted.

The ballast shoulder should extend horizontally from the sleeper end. It is, however, acceptable for the ballast shoulder to be profiled in the plane of the sleeper for a normal ballast shoulder width (nominally 400mm) to suit ballast regulators. Any extended shoulders, such as on bridges, should be horizontal.

Design ballast shoulder width is one factor that contributes to overall track lateral stability. Additional ballast shoulder width above the minimum and a ballast windrow up to rail height outside the sleeper may be necessary in areas of poor track lateral stability to provide adequate resistance to track buckling on sharp curves where design radius is outside normal limits.

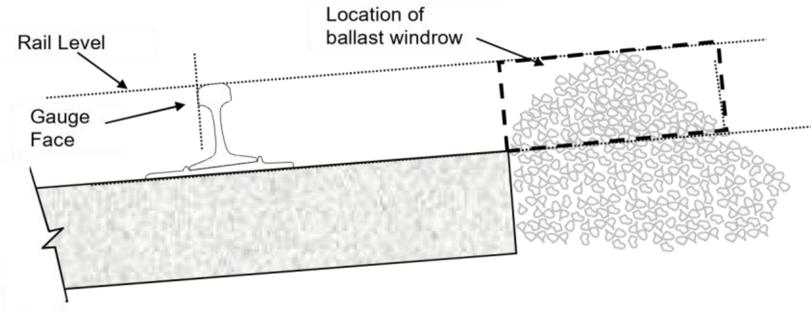

Figure 2 - Location of ballast windrow

5.2.5. Ballast depth

Ballast depth in plain track

Ballast depth is the distance from the underside of the sleeper to the top of the finished formation. It does not include the capping layer.

Note: Ballast depth below steel sleepers is measured from the bottom of the sleeper and does not include the depth of ballast in the pod

On superelevated track, the depth of ballast is measured from under the low rail.

Design ballast depth shall be selected in accordance with the Track class detailed in CRN CS 200. Some variations are required when alternative sleeper type and rail size are used. Approved ballast depths for each Track class and for alternative sleeper type and rail size are detailed in Table 7.

Table 7 – Ballast depth

Track Class	Sleeper / rail type	Design Ballast Depth	
		Minimum	Maximum
Main Line			
1	Concrete – 60kg rail	300	500
	Concrete – 53kg rail	270	500
	Steel	270	500
	Timber – 60kg rail	300	500
	Timber – 53kg rail	270	500
2	Timber/Steel	270	500
3	Timber/Steel	200	500
3G	Timber/Steel	150	500
5	Timber/Steel	150	500
Sidings			
1	Timber/Steel	250	500
2	Timber/Steel	200	500
3	Timber/Steel	150	500

Note 1: Full ballast depth in existing track includes ballast that is not free draining

Free draining ballast may include ballast with fines such as sand, brake dust and other fine material that does not restrict water flow.

Note 2: Existing track may not necessarily achieve the target ballast depth.

Note 3: Use of the design ballast depths with poor subgrades may still cause the subgrade to be over stressed. Detailed investigation and analysis of the whole track structure including the substructure condition may be necessary in these problem situations. It can equally be demonstrated that in areas with very good subgrades (natural or designed) it is possible to provide adequate support to the track structure with lower ballast depths than those specified in Table 7.

Ballast depth in turnouts

Through turnouts the minimum ballast depth under turnout bearers is to be maintained by lowering the formation level as required. The change in level of the formation shall be ramped off as shown in Table 8. Formation drainage shall be designed to prevent ponding under the turnout

Table 8 - Ramp of formation under turnouts

Turnout installation or replacement	Maximum grade (relative to the track grade)
where adjacent track is also being installed or reconstructed	1 in 200

Turnout installation or replacement	Maximum grade (relative to the track grade)
where major track reconstruction is not being undertaken	1 in 20

Ballast Depth on rigid structures

Where ballast is laid directly on rigid structures (e.g. the concrete deck of an underbridge or culvert), these inflexible structures create an artificially high stiffness. They can also interfere with proper tamping.

Minimum ballast depths shall be as detailed in Table 9, and shall have suitable ballast mat installed as per Section 0

Table 9 – Minimum ballast depths for rigid structures

Track Class	Minimum depth to structure
1	270
2	270
3	200
3G	200
5	200

It is likely that ballast with reduced depth on rigid structures will be subject to accelerated degradation and pulverisation of the ballast depending on axle load and tonnage. The sharp difference in stiffness at the bridge ends is likely to create top irregularities.

5.2.6. Alternative ballast profiles

The following alternative ballast profile designs may be adopted:

1. Ballast shoulder width may be reduced to a minimum of 75mm provided that:
    - lateral restraint, such as a retaining wall, is provided. The additional lateral restraint shall be at least equivalent to the restraint provided by the missing shoulder ballast.
    - arrangements are made for drainage of water from the formation.
2. Ballast shoulder width may be Increased (eg for walkways or examination areas) provided that alternative arrangements are made for drainage of water from the formation.
3. Ballast depth may be reduced provided that
    - measures are included to provide strength and durability at least equivalent to the approved design

- measures are included to provide stiffness no less than the approved design (e.g. use of special vibration isolation fastenings or a ballast mat).

4. Ballast stiffness may be altered at points of transition between differing track stiffness (e.g. ballasted track to transom topped bridges or track slab, timber or steel sleepered track to concrete sleepered track) by use of transition slabs, ballast glue or side walls. All designs for use of alternative methods shall be approved by the Principal Track and Civil Engineer.

5.2.7. Ballast mat

Ballast mats shall be used in areas where insufficient ballast depth exists and/or where specified in Section 0, such as.

- on rigid structures such as a bridge or culvert
- where there is insufficient available ballast depth

Ballast mats shall not be constructed from reconstituted or re-cycled materials. Manufacturing design should provide an elastomeric, consistent modulus that may be further augmented by fibre reinforcement, and designed and tested for 25TAL at 80km/h.

Table 10 – Ballast shoulder width acceptance limits

Situation	Ballast mat material specification
Not on a structure. Reduction in ballast depth of ≤50mm	Static stiffness of 0.15N/mm3
Not on a structure. Reduction in ballast depth of between 51 and 100mm	Static stiffness of 0.10N/mm3
Not on a structure. Reduction in ballast depth of between 101 and 150mm	Static stiffness of 0.10N/mm3 only with the approval of the Principal Track and Civil Engineer
On a rigid structure such as a bridge or culvert. Compliant ballast depth	Static stiffness of 0.15N/mm3
On a rigid structure such as a bridge or culvert. Non-compliant ballast depth	Not permitted

6. Acceptance standards

All work involving the laying of ballast as part of new track installation, track renewal or resurfacing shall meet the following acceptance requirements:

6.1. Ballast material and grading

Supplied (new) ballast shall meet an approved design (CRN CP 241 or equivalent approved by the Principal Track and Civil Engineer.)

6.2. Crib and shoulder height

The ballast shall be profiled to the top of the centre and end of the sleepers.

6.3. Ballast shoulder width

The ballast shoulder width shall be profiled to meet the minimum and maximum requirements specified in Table 5 and Table 6 to the tolerances detailed in Table 11 and Table 12.

Table 11 – Ballast shoulder width acceptance limits - Main line

Track Class	Rail Length	Ballast Shoulder Width (mm) Minimum Acceptance	Ballast Shoulder Width (mm) Maximum Acceptance
1	CWR / LWR	390	700
2	CWR / LWR	390	700
3/3G	CWR / LWR	390	700
3	Loose	240	700
5	Loose	240	700

Table 12 – Ballast shoulder width acceptance limits - Siding

Track Class	Rail Length	Ballast Shoulder Width (mm) Minimum Acceptance	Ballast Shoulder Width (mm) Maximum Acceptance
1	CWR / LWR	390	700
2	CWR / LWR	390	700
3	CWR / LWR	390	700
3	Loose	240	700

6.4. Ballast depth

The ballast depth after track renewal shall meet the minimum and maximum requirements specified in Table 7 to the tolerances detailed in Table 13 and Table 14.

Note: After maintenance resurfacing the minimum requirements may not necessarily be met.

Table 13 – Ballast Depth acceptance limits – Main Line

Track Class	Sleeper / rail type	Ballast Depth Acceptance Minimum	Ballast Depth Acceptance Maximum	Ballast Depth Minimum Free Draining
1	Concrete – 60kg rail	275	500	75
1	Concrete – 53kg rail	245	500	75
1	Steel	245	500	75
1	Timber – 60kg rail	275	500	75
1	Timber – 53kg rail	245	500	75
2	Timber/Steel	245	500	75
3	Timber/Steel	175	500	75
3G	Timber/Steel	125	500	75
5	Timber/Steel	125	500	75

Table 14 – Ballast Depth acceptance limits – Sidings

Track Class	Sleeper / rail type	Ballast Depth Acceptance Minimum	Ballast Depth Acceptance Maximum	Ballast Depth Minimum Free Draining
1	Timber/Steel	225	500	75
2	Timber/Steel	175	500	75
3	Timber/Steel	125	500	75

7. Damage limits

Ballast repair or replacement shall be undertaken when the ballast has lost its ability to drain surface water from the track to the formation.

7.1. Drainage Exceedance Limits

Ballast shall be considered to have failed to meet functional requirements when it is no longer able to function for the purposes of drainage, this occurs when the fouling index is greater than 40.

The fouling index (FI) = P(4) + P(200)

Where P(4) = percentage passing 4.75 mm (No.4) sieve

P(200) = percentage passing 0.075 mm (No 200) sieve.

The following table identifies the categories of fouling

Table 15 – Ballast Fouling Index criteria

Category	Fouling Index (FI)
Clean	< 1
Moderately clean	1 to < 10
Moderately fouled	10 to < 20
Fouled	20 to < 40
Highly fouled	≥ 40

Ballast cleaning should be completed prior to the condition of ballast being considered to have failed to meet functional requirements for drainage (i.e. Fouling Index of 40)

7.2. Monitoring of Ballast Condition

The condition of the ballast requires monitoring to determine the degree of fouling and the rate of fouling over time in order to plan when ballast cleaning or replacement is required.

Samples of ballast from the track in question are required at regularly spaced intervals to calculate the average fouling of a section of track.

The rate of change of the Fouling Index should be utilised to estimate the remaining life of the ballast in the section.

8. Repair standards

8.1. Ballast cleaning

Ballast may be cleaned to restore drainage properties by the use of a Track Undercutter or Ballast Cleaner. The ballast returned to the track from the Ballast Cleaner screens is not required to meet the grading specified in this standard however it may only be used as bottom ballast, due to it's loss of frictional properties.

8.2. Recycled ballast

Ballast that is recycled by the screening of ballast spoil excavated from the tracks (other than by ballast cleaning) may be used provided that it:

- is cleaned to remove fines and contaminants, AND
- meets an approved design (CRN CP 241 or equivalent approved by the Principal Track and Civil Engineer), OR

- has reinforcement designed to provide strength at least equivalent to the approved design, OR - is ONLY used as bottom ballast