AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: Engineering (Track & Civil) **Category: Code of Practice**

Ballast

Section 4

Applicability

ARTC Network wide	✓

Primary Source

Document Status

Version	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
2.7	05 Sep 12	Standards	Manager Standards	Operational Safety & Environmental Review Group	Safety & Environment Committee 17/09/2012

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
2.0	25 Nov 09		Implementation draft of network wide document which is an amalgamation of the CoP for SA/WA & Vic and NSW requirements.
2.1	18 Jun 10		Banner added regarding mandatory requirements in other documents and alternative interpretations.
2.2	18 Jan 11		Track classification A.B,C and D amended to show "Heavy Haul Lines", Interstate lines", "Intrastate Lines", and "Light Weight Lines".
2.3	08 Nov 11		Banner added regarding elements of RISSB National CoP being incorporated
2.4	10 Jan 12	Tables 4.3, 4.4 & 4.5, and Figures	Tables simplified following requests from field staff. Shoulder

		4.1 & 4.2	width S changed to Shoulder width W.
2.5	24 Feb 12	Tables 4.3, 4.4 & 4.5, and Figures 4.1 & 4.2	Tables updated to include fractions for ballast profile (shoulder height and width). These were replaced with words in previous version to simplify for field staff. Amendments to put fractions back into tables.
2.6	07 Aug 12	4.1.2 & Table 4.1	Updated to apply 300mm ballast shoulder width to NSW (as per the rest of the ARTC network).
2.7	05 Sep 12	4.1.2	Note regarding ballast shoulder surcharge added, for compatibility with AS 7643.

This ARTC CoP has drawn on the Rail Industry Safety and Standards Board (RISSB) National Code of Practice Volume 4, Track and Civil Infrastructure, but is not identical. The ARTC CoP has been subject to Risk Assessment as required by the various State Rail Safety Regulators. The results of these risk assessments have made it necessary to deviate from the RISSB CoP in some areas. ARTC maintains traceability of the differences.

Contents

Mandatory requirements also exist in other documents.

Where alternative interpretations occur, the Manager Standards shall be informed so the ambiguity can be removed. Pending removal of the ambiguity the interpretation with the safest outcome shall be adopted.

4 Section 4: Ballast

4.1 Design and Rating

4.1.1 Ballast

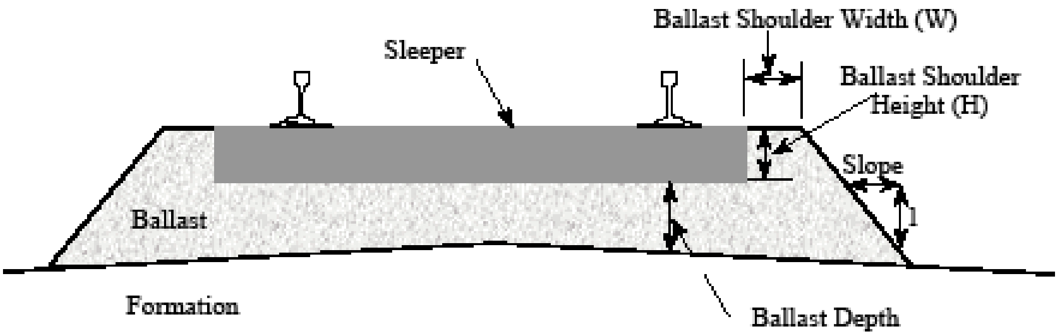
The material specification and acceptance testing for the supply of railway ballast should be based on AS2758 "Aggregates and rock for engineering purposes, Part 7 Railway Ballast".

Ballast is to be standard grade 60 as specified in AS 2758.7. Use of alternative grades, either as specified in AS 2758.7, or specifically designed, may be approved by ARTC to meet special requirements such as grades necessary in conjunction with reduced ballast depths or when used in lieu of standard grade ballast on branch lines which are, or are intended to be, fully steel sleepered.

4.1.2 Ballast profile

A typical track cross-section illustrating ballast profile is shown in Figure 4.1. Recommended nominal ballast profile dimensions are given in Table 4.1 for different track classes.

Figure 4.1 – Typical Track Cross-Section and Ballast Profile



Notes:

[1] H (the distance from sleeper soffit to under side of the rail) is determined by the sleeper design and therefore use of new untried sleeper types will need special consideration with regard to ballast profile, in particular for the purposes of track lateral stability

[2] Depth of ballast is measured under the rail seat and does not include the capping layer or sub ballast where used.

[3] On superelevated track, the depth of ballast is measured under the low rail.

[4] Through turnouts the minimum ballast depth under turnout bearers may be maintained by lowering the formation level as required. The change in level of the formation is to be ramped off at a maximum grade of 1 in 200 relative to the track grade.

[5] Existing track may not necessarily achieve the target ballast depth. New track is to be designed and constructed to the ballast depth and shoulder width shown in Table 4.1

except that where the line is predominantly for light passenger traffic with low levels of freight traffic (less than 2MGT) a ballast depth of 200mm is satisfactory

Table 4.1

ARTC track class	Mainline Ballast				Sidings Connected to Mainlines		
	Nominal ballast depth mm	Shoulder width welded rail mm	Shoulder width Curves sharper than 600m radius (steel & timber)	Shoulder width loose rail mm	Nominal ballast depth mm	Shoulder width welded rail mm	Shoulder width loose rail mm
Heavy Haul	300	300	400	N/A	250	200	N/A
Interstate Lines	250	300 Concrete/ steel/ timber	400	N/A	150	200	150
Intrastate Lines	250	300 Concrete/ steel/ timber	400	N/A	150	150	150
Light weight Lines	150	300 Concrete/ steel/ timber	400	250	150	150	150

Notes

[1] Ballast depth has been arrived at by theoretical and practical assessment of various loadings.

[2] Use of these 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 4.1.

[3] In general the safety of the track is determined by factors other than ballast depth. Some of these factors, such as track geometry, do however have a dependency on the ballast depth and subgrade support. Although ballast depth is one factor that determines the effort required to maintain a safe track, it is only incidentally represented in these other factors which are monitored and maintained to ensure safety.

[4] Use of the guidelines in this Clause will provide a design ballast depth compatible with the inspection and assessment guidelines given in Clause 4.3.

[5] Shoulder width is based on guidelines provided in ROA Track Buckling Study

[6] Steel sleeper shoulder width measured from the extreme end of the sleeper, not the visible end when the track is fully ballasted.

[7] Design ballast shoulder width is one factor that contributes to overall track lateral stability (refer to Section 6 Track lateral stability). Additional ballast shoulder may be necessary in areas of poor track lateral stability to provide adequate resistance to track buckling and movement, however detailed investigation and analysis of the whole track structure may be necessary in problem situations. The provision of additional ballast shoulder on sharp curves may also be necessary to maintain lateral stability. It can equally be demonstrated

that with some track structures and operational circumstances it is possible to provide adequate lateral track stability with smaller ballast shoulder widths than those specified in Table 4.1.

[8] The resistance to buckling forces may be enhanced by the provision of a ballast shoulder surcharge (windrow).

[9] Use of the guidelines in this Clause will provide a design ballast shoulder width compatible with the monitoring and maintenance guidelines prescribed in Clause 4.3.

[10] The recommendations in Clause 4.3 do not apply to low profile sleepers.

[11] Shoulder slope is to be 1 in 1.5 for timber, steel and concrete sleepers.

4.2 Construction and Maintenance

4.2.1 Construction

Track construction is to be undertaken in accordance with ARTC Construction Specifications.

4.3 Inspection and Assessment

4.3.1 Inspection

The scheduled inspection of ballast shall incorporate the guidelines prescribed in Table 4.2 and as follows:

a) Patrol Inspection

The interval between patrol inspections of ballast shall not exceed 7 days on main lines and 28 days on crossing loops or as specified otherwise in an ARTC approved Technical Maintenance Plan. During these patrols a lookout should keep for ballast defects and conditions (ie. indicators of a defect) that may affect the integrity of the track structure including the following:

(i) Track sections with inadequate ballast profile;

(ii) Track sections where the ballast profile may interfere with the operation of infrastructure (eg. signals or switches) or rollingstock;

(iii) Mud holes or wet spots that may affect the deterioration rate of the track condition and the signalling performance;

(iv) Indications of poor sleeper support by ballast (eg. cracking of sleepers and bearers, excessive vertical sleeper movement or track pumping);

(v) Heaped ballast or gaps between sleepers that indicate longitudinal track movement, sleeper skewing, or a lack of crib ballast;

(vi) Heaped ballast or gaps at sleeper ends that indicate lateral track movement, or a migration of ballast away from the track;

(vii) Accelerated loss of track geometry (eg. following wet or dry weather) that may indicate poor ballast quality;

(viii) Other obvious defects that may affect track stability and support.

Where possible, crossing loops may be inspected from the mainline as part of this patrol inspection.

b) General Inspection

These inspections should identify locations of ballast degradation requiring action and determine the need for further specialist inspection.

General inspections of ballast condition should be carried out in a manner and at an interval appropriate to the ballast type, condition, rates of deterioration and other local factors, however the General Inspection should be at intervals not greater than 1 year or as specified otherwise in an ARTC approved Technical Maintenance Plan. Where appropriate the general inspection should be timed to suit seasonal factors, eg. prior to hot weather (see Section 6, Track lateral stability), and to enable identification of defects and conditions described below.

A general inspection should also be carried out when suspected defects such as pumping, disturbed or unconsolidated ballast are identified from conditions determined during patrol inspections or from work records.

This inspection should include items listed above for the patrol inspection and the following defects and conditions:

(i) Evidence of excessive track vibration (eg. powdered or rounded ballast)

(ii) Areas and extent of fouled ballast or poor ballast drainage that have resulted or may result in wet spots or mud holes in wet weather

(iii) Heaving of soil adjacent to the track which may indicate sub-grade failure

(iv) Location and extent of narrow formation, that is formation that is too narrow to maintain the design ballast profile

(v) Location and extent of substantial weed growth.

(vi) Other defects affecting track support and stability.

4.3.2 Assessment and Actions

For track designed and constructed in accordance with Clause 4.1 the assessment and response criteria for ballast shall be in accordance with Table 4.2. Condition response criteria are given in Tables 4.3 to 4.6.

The assessment response codes used in Tables 4.3 to 4.5 are defined in Table 4.6.

Table 4.2 – Inspection and Response Criteria

Defect / Irregularity **Inadequate ballast profile [1]**	**Limit**	**Method of inspection**	**Action**
Concrete sleepers	Table 4.3	Visual	Table 4.3
Timber sleepers	Table 4.4	Visual	Table 4.4
Steel Sleepers	Table 4.5	Visual	Table 4.5
Pumping	Note 4	Visual	Note 4
Unconsolidated ballast see Note 2			

Notes:

[1] Height of the shoulder ballast is measured from the sleeper base (soffit) and width of the shoulder ballast is measured from the sleeper end (see Figure 4.1).

[2] This guideline relates to construction or maintenance work where there is major disturbance of the ballast, including track construction, relay, undercutting or sledding, maintenance that removes the ballast shoulder or the full ballast profile and replaces it in an unconsolidated state, resleepering on a greater than 1 in 3 basis, and maintenance requiring large lifts or slewing of the track. The temperature, track curvature, extent of ballast disturbance, and general track condition should be included in an assessment of track lateral stability by a competent worker to determine the necessary actions eg speed restriction (refer to Section 6 Track Lateral Stability for guidance).

[3] Ballast consolidation may be achieved by means other than rail traffic (eg. mechanical ballast stabilisation, crib and shoulder compaction), in which case the imposition of a speed restriction may not be necessary.

[4] Pumping is the condition which allows excessive vertical movement of the sleeper (estimated to be greater than 25mm) and is generally characterised by the presence of mud or slurry. Track geometry criteria may govern in this situation.

Table 4.3 – Ballast Profile Condition – Concrete Sleepers
Response Codes (See Table 4.6)

Ballast profile (see Figures 4.1 & 4.2)		Ballast profile (simplified for field application)		Track curvature >400 m radius Nominal track speed for freight/ passenger (km/h)					
Shoulder Height H	Shoulder WidthW	Shoulder Height H	Shoulder Width W	20/20	40/40	60/65	80/90	100/115	115/-
≥3/4	≥1/4 to 3/4	Full	Half	A7	A7	A7	A7	A6	A6
≥3/4	≥0	Full	Nil	A7	A7	A7	A6	A5	A5
≥1/4	≥3/4	Half	Full	A7	A7	A6	A6	A5	A5
≥1/4	≥1/4 to 3/4	Half	half	A7	A7	A6	A6	A5	A5
≥1/4	≥0	Half	Nil	A7	A6	A6	A4	A4	A4
≥0	≥0	Nil	Nil	A6	A6	A3	A3	A3	A3
Ballast profile (see Figures 4.1 & 4.2)		**Ballast profile (simplified for field application)**		**Track curvature ≤400 m radius Nominal track speed for freight/ passenger (km/h)**					
Shoulder Height H	Shoulder Width W	Shoulder Height H	Shoulder Width W	20/20	40/40	60/65	80/90	100/115	115/-
≥3/4	≥1/4 to 3/4	Full	Half	A6	A6	A6	N/A	N/A	N/A
≥3/4	≥0	Full	Nil	A6	A6	A6	N/A	N/A	N/A
≥1/4	≥3/4	Half	Full	A7	A7	A6	N/A	N/A	N/A
≥1/4	≥1/4 to 3/4	Half	Half	A7	A6	A6	N/A	N/A	N/A
≥1/4	≥0	Half	Nil	A6	A6	A3	N/A	N/A	N/A
≥0	≥0	Nil	Nil	A6	A2	A2	N/A	N/A	N/A

Table 4.4 – Ballast Profile Condition – Timber Sleepers
Response Codes (See Table 4.6)

Ballast profile (see Figures 4.1 and 4.2)		Ballast profile (simplified for field application)		Track curvature >400 m radius Nominal track speed for freight/passenger (km/h)					
Shoulder Height H	Shoulder Width W	Shoulder Height H	Shoulder Width W	20/20	40/40	60/65	80/90	100/115	115/-
≥3/4	≥1/4 to 3/4	Full	Half	A7	A7	A7	A7	A6	A6
≥3/4	≥0	Full	Nil	A7	A7	A6	A6	A5	A5
≥1/4	≥3/4	Half	Full	A6	A6	A3	A3	A3	A3

≥1/4	≥1/4 to 3/4	Half	Half	A6	A6	A3	A3	A3	A3
≥1/4	≥0	Half	Nil	A6	A2	A2	A2	A2	A2
≥0	≥0	Nil	Nil	A1	A1	A1	A1	A1	A1
Ballast profile (see Figures 4.1 and 4.2)		**Ballast profile (simplified for field application)**		**Track curvature ≤400 m radius**					
				Nominal track speed for freight/passenger (km/h)					
Shoulder Height H	Shoulder Width W	Shoulder Height H	Shoulder Width W	20/20	40/40	60/65	80/90	100/115	115/-
≥3/4	≥1/4 to 3/4	Full	Half	A6	A6	A6	N/A	N/A	N/A
≥3/4	≥0	Full	Nil	A6	A6	A3	N/A	N/A	N/A
≥1/4	≥3/4	Half	Full	A6	A2	A2	N/A	N/A	N/A
≥1/4	≥1/4 to 3/4	Half	Half	A1	A1	A1	N/A	N/A	N/A
≥1/4	≥0	Half	Nil	A1	A1	A1	N/A	N/A	N/A
≥0	≥0	Nil	Nil	A1	A1	A1	N/A	N/A	N/A

Table 4.5 – Ballast Profile Condition – Steel Sleepers
Response Codes (See Table 4.6)

Ballast profile (see Figures 4.1 and 4.2)		**Ballast profile (simplified for field application)**		**Track curvature >400 m radius**					
				Nominal track speed for freight/ passenger (km/h)					
Shoulder Height H	Shoulder Width W	Shoulder Height H	Shoulder Width W	20/20	40/40	60/65	80/90	100/115	115/-
≥3/4	≥1/4 to 3/4	Full	Half	A7	A7	A7	A7	A6	A6
≥3/4	≥0	Full	Nil	A7	A7	A7	A7	A6	A6
≥1/4	≥3/4	Half	Full	A7	A7	A6	A6	A5	A5
≥1/4	≥1/4 to 3/4	Half	Half	A7	A6	A6	A4	A4	A4
≥1/4	≥0	Half	Nil	A6	A6	A3	A3	A3	A3
≥0	≥0	Nil	Nil	A6	A2	A2	A2	A2	A2
Ballast profile (see Figures 4.1 and 4.2)		**Ballast profile (simplified for field application)**		**Track curvature ≤400 m radius**					
				Nominal track speed for freight/ passenger (km/h)					
Shoulder Height H	Shoulder Width W	Shoulder Height H	Shoulder Width W	20/20	40/40	60/65	80/90	100/115	115/-
≥3/4	≥1/4 to 3/4	Full	Half	A6	A6	A6	N/A	N/A	N/A
≥3/4	≥0	Full	Nil	A6	A6	A3	N/A	N/A	N/A
≥1/4	≥3/4	Half	Full	A6	A2	A2	N/A	N/A	N/A
≥1/4	≥1/4 to 3/4	Half	Half	A1	A1	A1	N/A	N/A	N/A
≥1/4	≥0	Half	Nil	A1	A1	A1	A1	N/A	N/A
≥0	≥0	Nil	Nil	A1	A1	A1	A1	N/A	N/A

Notes to tables 4.3, 4.4, AND 4.5:

[1] The tables apply where crib ballast has not been substantially degraded from the full design profile. Where crib ballast deficiencies are found a more stringent response may be required depending on season, curvature, traffic, and other track stability parameters.

[2] In concrete sleepers the responses apply where height and width deficiencies occur over lengths of 10 m or greater. In timber and steel sleepers the responses apply to any length. This deals with general ballast profile deterioration likely to impact on track lateral stability over time. Significant ballast disturbances including more severe degradation over distances of less than 10 m should be assessed by a competent worker.

[3] H is the distance from the sleeper base (soffit) to the underside of the rail foot.

[4] W is the design shoulder ballast width from the sleeper end.

The nominal dimensions for W are as defined in Table 4.1:

W is measured from the extreme end of the sleeper, not the visible end when the track is fully ballasted. This applies particularly in the case of steel sleepers.

[5] The response action may be reduced in severity by one (1) level for tangent track in the non buckle prone season (eg. A4 becomes A5)

[6] Fractions of "H" and "W" (refer to Figure 4.2) are relative to the full design ballast profile (refer to Clause 4.1.2). For conventional sleeper designs the full design shoulder width is that defined in Note 4.

[7] Interpolation of profile measurement criteria and responses is permitted.

[8] Temperature is assumed to be within the design range (See Section 6 for extreme temperature responses).

[9] Steel sleepers are assumed to have a full pod of ballast. If the pods are less than 3/4 full, then there should be an increased speed restriction by 2 categories (eg. an A5 response goes to an A3)

[10] Track geometry limits specified in Section 5 are assumed.

[11] Rail sizes 47 kg/m to 60 kg/m and CWR/LWR (>110 metre) rail lengths are assumed.

[12] Crushed rock ballast with consolidation equivalent to >100,000 gross tonnes of traffic since the last track disturbance, is assumed.

[13] The nominal track speeds relate to freight operations (shown first) and passenger operations (shown second) separated by a "/". Passenger operations refer to locomotive hauled passenger trains with carriages not exceeding 16TAL.

[14] For trains with operational speeds greater than 115 km/h the response needs special consideration of the owner/operator organisations.

Figure 4.2 – Fractions of Design Ballast Profile

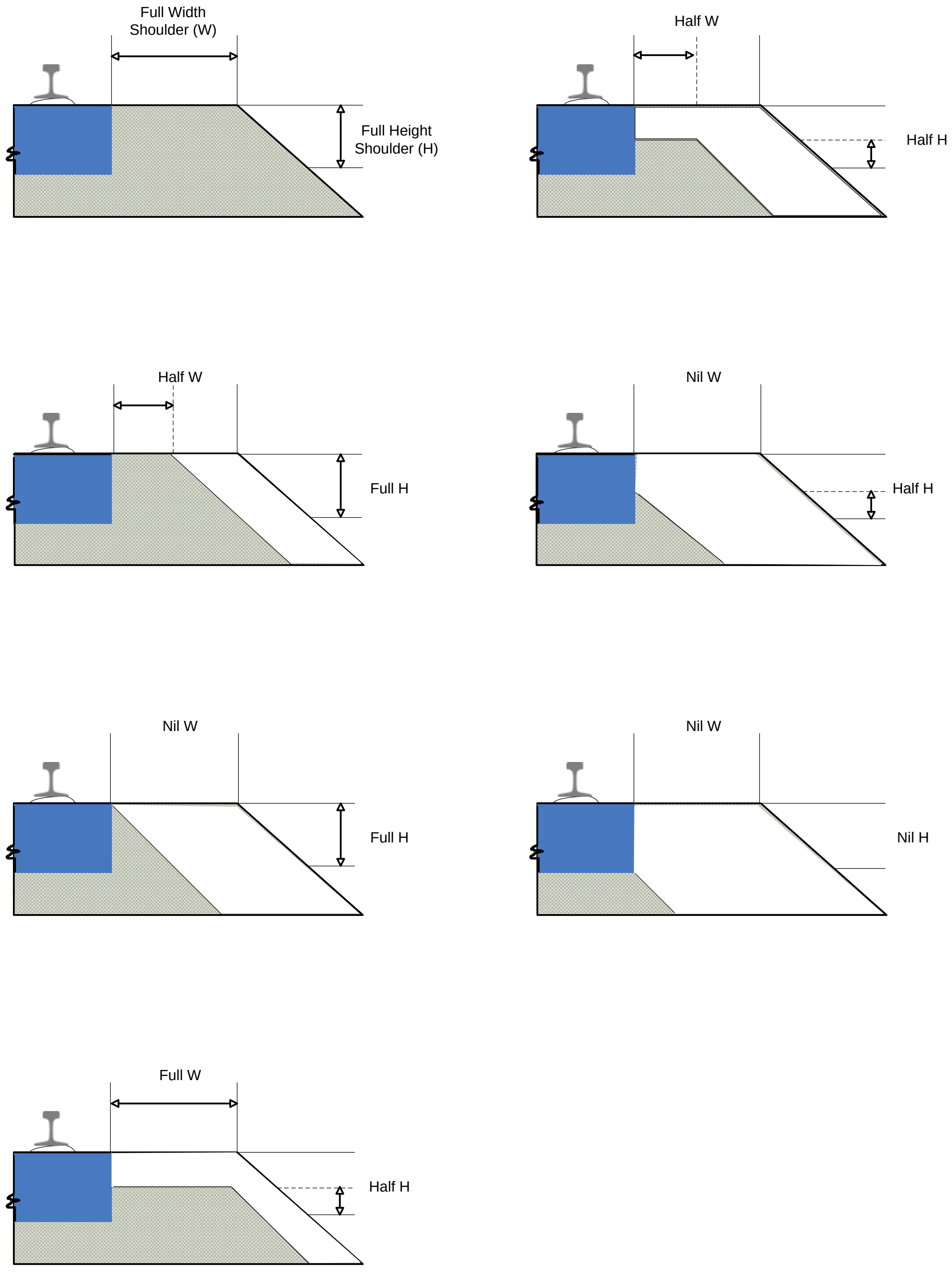


Table 4.6 – Definition of Response Codes

Response Code	Description [2]
A1	Temporary speed restriction of 10/10 [1] with pilot or repair prior to the passage of the next train [3].
A2	Temporary speed restriction of 20/20 [1] or repair prior to the passage of the next train [3].
A3	Temporary speed restriction of 40/40 [1] or repair prior to the passage of the next train [3].
A4	Temporary speed restriction of 60/65 [1] or repair prior to the passage of the next train [3].
A5	Temporary speed restriction of 80/90 [1] or repair prior to the passage of the next train [3].
A6	An appropriate increase in the monitoring [2] and follow up action as required.
A7	Routine Inspection [4]

Notes:

[1] The speed restriction is shown for both freight operations (shown first) and passenger operations (shown second) separated by a "/".

[2] Where the assessment responses include increased monitoring, a knowledge of local factors that may affect the tracks deterioration rate and performance history is required. The increased monitoring frequency should be determined by these factors. This increased monitoring should be continued until rectification work is carried out.

[3] If repairs cannot be made prior to the passage of the next train, the speed restriction should be implemented along with an appropriate increase in the monitoring [see Note 2] until actions are taken to restore the track.

[4] Routine refers to normal scheduled inspections.

[5] If the cause of a defect is known and it is known that it will not deteriorate into an unsafe condition an alternate response to that shown in tables 4.3, 4.4 and 4.5 is permitted with appropriate documentation and approval from the Civil Engineering Representative or nominated representative.