SECTION 2

TRACK MATERIALS

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2.1 INTRODUCTION - RAILS

The rail is the most important component in any railway. Generally speaking, the strength and standard of maintenance of a track are expressed in terms of the size of rail with which it is laid. Hence the description '31 kg track' would immediately imply to most people a heavy track maintained to a high standard for main line traffic.

Rails are described by their mass expressed in kilograms per metre (or lb per yard in the imperial system) and by the section to which they are rolled.

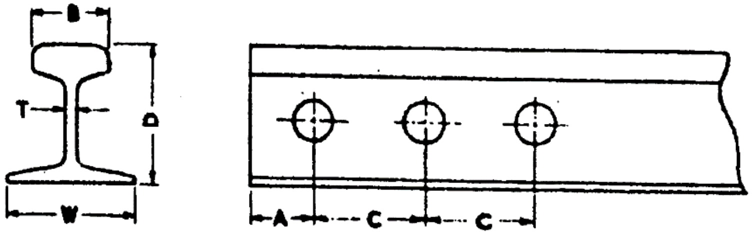
2.2 DEVELOPMENT OF RAIL SECTIONS

All rails used are of the 'T' section, more widely known as flat bottomed rail. This rail is designed to be readily spiked or otherwise fastened to sleepers and to act as a girder and distribute each wheel load over several sleepers. The designs of the present Australian Standard rails have been developed over many years, and modern rails are high grade, strong, durable, and serviceable products. However most rails used in cane railway tracks are reclaimed from State railway systems. These rails were either imported late last century or early this century or manufactured in Australia. In all cases they were manufactured to imperial dimensions and all carry identifying marks accordingly. Therefore the following paragraphs refer to imperial dimensions and marks used for these rail sections.

The earlier rails were all imported from Europe, the first being the 41¼ lb, which was later followed by the 42 lb, then the 60 OS and the 61 lb. All these rails were supplied in lengths ranging from 24 feet (7.32 m) to 30 feet (9.15 m). Some 40 feet (12.2 m) 61 lb rails were produced later. The principal dimensions of most of the more common rails used by the sugar industry are given in Table 2.1. Complete details of the 60 lb OH (Ghan Rail) are not available. The OH indicates the steel was produced by the open hearth process. The rail is believed to be similar to an early British standard specification dated prior to 1928.

In the 60 lb class, the 61 lb rail was followed by the 60 BHP (sometimes called 60 NSW), 60 AS, 60'A'AS, and then the 60'B'AS, which was later renamed the 63 lb. This is the present Australian Standard rail of 60 lb nominal size. After World War II, the Australian steel mills were unable to meet the demand for rails, and large tonnages were imported from England. This added a new class - the 60 RBS. The letters 'RBS' stand for Revised British Standard.

Table 2.1 Dimensions of standard rail



Rail	Actual mass		Depth overall D (in)	Head width B (in)	Web thickness T (in)	Flange width W (in)	Fishbolt No. per joint and size (in)	Bolt holes in web			Rail length	
	kg/m	lb/yd						Dia.	A	C	(ft)	(m)
41 1/4	20.4	41.2	3 5/8	1 7/8	7/16	3 1/4	4-11/16 x 3	3/4x1	1-15/16	4	24	7.32
41 1/4QR	20.9	42.1	3 11/16	1 7/8	15/32	3 1/4	4-11/16x3 &3 1/2	3/4x1	1-15/16	4	24	7.32
								1 dia	2	3		
42	21.0	42.4	3 11/16	1 7/8	15/32	3 1/4	6-11/16 x 3	15/16	1-7/8	4	24	7.32
45	22.3	44.9	3 11/16	2	27/64	3 11/16	6-11/16 x 3	15/16	1-29/32	3 3/4	24	7.32
60 OS	30.3	61.0	4 1/2	2 1/4	7/16	4	4-7/8 x 3 7/8	1 1/8 x 1	2-3/16	4 1/2	24	7.32
61	30.6	61.6	4 1/2	2 5/16	1/2	4 1/4	6-7/8 x 3 7/8	1 1/8	2 1/8	5	40	12.2
											30	9.15
60 BHP	30.1	60.7	4 3/8	2 9/32	7/16	4	6-7/8 x 4	1 1/8	2 1/4	5	40	12.2
60 NSW												
60 AS	29.9	60.22	4 1/2	2 1/2	29/64	4 1/4	6-7/8 x 4 1/8	1 1/8	2-5/32	4 1/2	40	12.2
60 AS	29.9	60.22	4 1/2	2 1/2	29/64	4 1/4	6-7/8 x 4 1/8	1 1/8	2-3/8	5	40	12.2
60 AS	29.9	60.22	4 1/2	2 1/2	29/64	4 1/4	6-7/8 x 4	1	2-3/8	5	40	12.2
60 ‘A’ AS	29.9	60.22	4 1/2	2 1/2	29/64	4 1/4	6-7/8 x 4 1/2	1 1/8	2-7/16	5	40	12.2
63 AS	31.4	63.36	4 5/8	2 1/2	29/64	4 1/4	6-7/8 x 4 1/2	1 1/8	2-7/16	5	40	12.2
60 ‘B’ AS												
60 RBS	29.8	60.01	4 1/2	2 1/4	7/16	4 5/16	6-3/4 x 4 1/8	1	1-7/8	4	40	12.2
75	37.2	74.97	4 13/16	2 7/16	17/32	4 13/16	6-7/8 x 3 7/8	1 1/8	2 3/8	5	30	9.15
80 AS	39.8	80.30	5 1/4	2 3/4	33/64	5	6-7/8 x 4 3/8	1 1/8	2 3/8	5	40	12.2
80 ‘A’ As	39.8	80.30	5 1/4	2 3/4	33/64	5	6-1 x 5 1/2	1 1/4	2 7/16	5	40	12.2
80 ‘B’ AS	40.1	80.79	5 3/8	2 1/2	33/64	5	6-1 x 5 1/2	1 1/4	2 7/16	5	40	12.2
82 AS	40.7	82.00	5 3/8	2 1/2	33/64	5	6-1 x 5 1/2	1 1/4	2 7/16	5	40	12.2
80 RBS	39.7	80.04	5 1/4	2 1/2	17/32	4	6-7/8 x 4 11/16	1 1/8	1 7/8	4	40	12.2

Rail sections below 41 kg/m (82 lb/yd) are no longer manufactured in Australia.

2.3 RAIL COMPOSITION

Rails are made of steel which is fundamentally a mixture of iron and carbon, the percentage of carbon varying between 0.5 and 0.75. Steel also contains small percentages of other materials, namely manganese, silicon, phosphorus and sulphur. Carbon has the effect of hardening the iron, making it stronger and more resistant to wear, but too much carbon produces a 'brittle' steel, which is unsatisfactory for rails, because there is an increased risk of breakage. The permissible amounts of the other materials mentioned above are laid down by Australian Standard Specifications, because when present in too great a quantity, they are generally harmful. The rails used in the sugar industry are known as carbon steel rails, because carbon is the principal alloy material used to make the steel.

Rail steel is relatively hard and tough, but it can be bent to form curves and stock rails provided bending is done with a proper rail press. Rails must not be notched, nicked or dented, otherwise fractures are likely to develop from these blemishes as the steel ages under repeated loading. Rail steel will 'flow' under heavy wheel loadings and the movement of metal into the rail joints or the forming of a lip on the outside of the low rail of curves is often observed. Fortunately, as the steel is subjected to the hammering of wheels, it hardens slightly. This process is called work hardening. Provided special precautions are taken, rail steel can be welded by several methods.

2.4 MANUFACTURE AND IDENTIFICATION OF RAILS

Rails are formed by passing steel at a high temperature through rolls which produce the required profile, and after the final rolling the rail is still hot. When cooled, the rail is given a final straightening at the mill. A special press which can bend the rail sideways and vertically is used for this purpose. During the final rolling, certain identifying marks are formed on the web of each rail. With Australian rails, these marks comprise the letters 'AS' signifying Australian Standard, the mass per yard, the year of the Australian Standard design, the manufacturer's initials, and the month and year in which the rail was rolled. Thus the markings 'AS 60 lb 1964 AIS XII 1969' would mean:

AS	-	Australian Standard.
60 lb	-	The mass per yard of the rail.
1964	-	The date of the Australian Standard Specification for the manufacture of the rails.
AIS	-	Australian Iron and Steel - the manufacturer.
XII 1969	-	The rail was rolled in December, 1969.

Other markings appear on the other side of the web of the rail, and these allow it to be more closely identified. These markings include a letter which shows whether the rail was the first, second or third, etc., rolled from the ingot of steel, an ingot number, and a furnace and cast number. Thus, on the opposite side of the rail web described above, could be found the markings 'F 16 282989', which would give the following information:

F - This means the rail was the sixth rolled from the ingot.

16 - This is the ingot number - A quantity of ingots are made from each cast.

282989 - The first two figures 28 are the steel mill furnace number, and the last four, viz. 2989, give the number of the cast of steel made from that furnace.

It can be seen that the markings on the rail convey valuable information and permit the history of each rail to be traced if necessary. Markings on older rails will vary from the above, but will convey similar information. To the trackman much of the above has interest value only, but it is important to know that the markings allow rails to be positively identified.

2.5 TRACK COMPONENT DIMENSIONS AND QUANTITIES

2.5.1 Rails, Fishplates and Bolts

The quantities of standard track components for the various rail sections used by the sugar industry are given in Table 2.5.1.1. This table is a soft metric conversion of the imperial sizes for rails, fishbolts and nuts. Table 2.5.1.2 shows quantities for metric fishbolts.

Table 2.5.1.1 Quantities for rails and fastenings

Section of rail	Rails					Fishplates					Fishbolts and nuts					Spring washers				
	Stnd. length of rail (m)	Mass per rail (kg)	No. per tonne	No. per km track	Mass per km track (tonnes)	Size (in) and type	Mass per pair (kg)	No. of pairs per tonne	No. of pairs per km track	Mass per km track (tonnes)	Size (inches)	Mass per bolt (kg)	No. per tonne	No. per km track	Mass per km track (tonnes)	Size dia. (in)	Mass per washer (gm)	No per tonne	No. per km track	Mass per km track (tonnes)
41¼ lb	7.32	150	6.68	274	41.1	14 Strap 14 Angle 18 Angle	4.55 6.99 8.77	220 143 114	274 274 274	1.25 1.92 2.40	11/16 x 3 N 11/16 x 3 N 11/16 x 3¾N	0.319 0.319 0.334	3135 3135 2991	1096 1096 1096	0.35 0.35 0.37	13/16 13/16 13/16	43 43 43	23,300 23,300 23,000	1096 1096 1096	0.047 0.047 0.047
42 lb	9.15	191	5.24	219	41.9	16 Angle 25 Angle	7.27 11.41	138 88	219 219	1.59 2.50	11/16 x 3 N 11/16 x 3 N	0.319 0.319	3135 3135	876 1314	0.28 0.42	13/16 13/16	43 43	23,300 23,300	876 1314	0.038 0.056
45 lb	7.32	163	6.14	274	44.7	26 Angle	11.03	91	274		11/16 x 3 O	0.319	3135	1644	0.52	13/16	43	23,300	1644	0.071
60 OS	7.32	218	4.60	274	59.7	18 Strap 21 Angle	6.82 15.27	147 65	247 274	1.87 4.18	_ x 3_ N _ x 3_ N	0.520 0.520	1923 1923	1096 1096	0.57 0.57	15/16 15/16	47 47	21,100 21,100	1096 1096	0.052 0.052
61 lb	9.15 12.2	277 370	3.61 2.71	219 164	60.7 60.1	 31 Angle 31 Angle	15.68 23.25 23.25	64 43 43	219 219 164	3.43 5.09 3.81	_ x 3_ N _ x 3_ N _ x 3_ N	0.520 0.520 0.520	1923 1923 1923	876 1314 984	0.46 0.68 0.51	15/16 15/16 15/16	47 47 47	21,100 21,100 21,100	876 1314 984	0.041 0.062 0.046
60 BHP 60 NSW	12.2 12.2	364	2.76	164	59.7	31 Angle	19.36	52	164	3.17	_ x 4 O	0.573	1745	984	0.56	15/16	47	21,100	984	0.046
60 AS	12.2	365	2.75	164	59.9	27 Angle 30 Angle 30 Angle	24.44 27.16 27.16	41 37 37	164 164 164	4.0 4.45 4.45	_ x 4_ O ¾ x 4 O _ x 4_ O	0.582 0.413 0.582	1718 2421 1718	984 984 984	0.57 0.41 0.57	15/16 13/16 15/16	47 43 47	21,100 23,300 21,100	984 984 984	0.046 0.042 0.046
60 ‘A’ AS	12.2	3.65	2.75	164	59.9	30 Angle	27.37	37	164	4.49	_ x 4½ O	0.611	1636	984	0.60	15/16	47	21,100	984	0.046
60 RBS	12.2	364	2.76	164	59.7	24 Angle	16.93	60	164	2.78	¾ x 4_ R	0.494	2024	984	0.49	13/16	26	38,500	984	0.026
63 AS 60 ‘B’ AS	12.2 12.2	384	2.61	164	63.0	30 Angle	27.37	37	164	4.49	_ x 4½ O	0.611	1636	984	0.60	15/16	47	21,100	984	0.046
75 lb	9.15	341	2.94	219	74.7	31 Angle	27.27	37	219	5.97	_ x 3_ N	0.520	1923	1314	0.68	15/16	47	21,100	1314	0.062
80 AS	12.2	487	2.05	164	79.9	30 Angle	34.6	30	164	5.67	_ x 4½	0.611	1636	984	0.61	15/16	47	21,300	984	0.046
80 ‘A’ AS	12.2	487	2.05	164	79.9	30 Angle	37.03	27	164	6.07	1 x 5½ O	0.93	1675	984	0.92	1 1/16	78	12,800	984	1.0
80 ‘B’ AS	12.2	490	2.04	164	80.4	24 Angle	37.03	27	164	6.07	1 x 5½ O	0.93	1675	984	0.92	1 1/16	78	12,800	984	1.0
80 RBS	12.2	485	2.06	164	79.5		22.39	45	164	3.67	_ x4 11/6 O	0.744	1344	984	0.73	15/16	29	34,500	984	1.0

N = Nib, O = Oval, R = Round

TABLE 2.5.1.2 TABLE OF METRIC FISHBOLTS AND NUTS

Shank Dia. (mm)	Thread Dia.	Length (mm)	Mass Each Kg	Mass per 100 (kg)	No. per Tonne	No. per Bag
20	M20	100	0.519	51.9	1926	50
		105	0.569	56.9	1737	50
22	M22	115				
		120	0.559	55.9	1789	50
24	M24	110	0.730	73.0	1370	50
		115	0.754	75.4	1326	50
		120	0.778	77.8	1285	40
		130	0.822	82.2	1216	40
		135	0.844	84.4	1185	30
		140	0.856	85.6	1168	30

2.5.2 Fastenings - Quantities

The quantities of standard fastenings for timber and concrete sleepers are given in Table 2.5.2.

TABLE 2.5.2 QUANTITIES FOR FASTENINGS

Fastening Type (mm)	Length (mm)	Mass per Fastening (kg) **(1)**	No. per Tonne **(2)**	No. per Km **(3)**	Mass per Km (tonnes)
Dog spike	85	0.254	3936	6560	1.67
(16 x 16)	100	0.273	3480	6560	1.88
	120	0.323	3097	6560	2.12
CF2 spike	-	0.187	5386	6560	1.22
Spring spike	-	0.220	4550	6560	1.44
Gauge Inside	See Sect. 2.5.3	0.218[(2)]	4580[(3)]	6560	1.43
Gauge Outside		0.218[(2)]	4580[(3)]	6560	1.43
1200 Series Pandrol Clips	-	0.186	5376	6560	1.22
1400 Series Pandrol Clips	-	0.305	3279	6560	2.00
1600 Series Pandrol Clips	-	0.451	2217	-	-

Notes: [(1)] Average mass per fastening; [(2)] Average No. per tonne; [(3)] At 610 mm sleeper spacing.

2.5.3 Gauge Spikes

The size of gauge spikes for various rail sections is given in Table 2.5.3. These spikes are supplied to imperial dimensions shown in the Table.

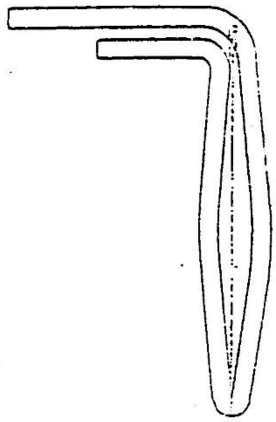


TABLE 2.5.3 DIMENSIONS OF GAUGE SPIKES FOR VARIOUS RAILS

Rail Size	Dimension 'A'		Dimension 'B' All Spikes (inches)
	Gauge Side Spike (in)	Field Side Spike (in)	
30 C.S.R.	1 15/32	1 9/32	3/4
30 B.H.P.	1 15/32	1 7/32	3/4
35 C.S.R.	1 1/16	1 25/32	3/4
39¾ LB.	29/32	1 9/16	3/4
40 B.S.	25/32	1 9/32	3/4
41 S.A.R.	29/32	1 11/32	7/8
41 B.H.P.	7/8	1 15/32	3/4
41¼ Q.	29/32	1 13/32	3/4
42 Q.	29/32	1 13/32	3/4
45 B.H.P.	3/4	1 1/8	7/8
45 A.S.C.E.	3/4	1 1/8	7/8
50 A.	23/32	1 1/32	7/8
60 B.A.	3/4	13/16	7/8
60 B.I.	23/32	27/32	3/4
60 B.H.P.	3/4	27/32	3/4
60 S.A.R.	21/32	21/32	3/4
63 B.H.P.	23/32	19/32	3/4
60 A.S.	23/32	19/32	3/4
61 Q.	5/8	11/16	3/4
60 W.A.G.R.	21/32	25/32	3/4

2.5.4 Pandrol e Clips

Pandrol clips, Figure 2.5.4, are used with cast-in shoulders on concrete sleepers and hold the rail to gauge. The clips are supplied in two sizes, namely e 1200 series and e 1400 series. The e 1200 series provides a toe load of 3.8 kN per clip and the e 1400 series a toe load of 5 kN.

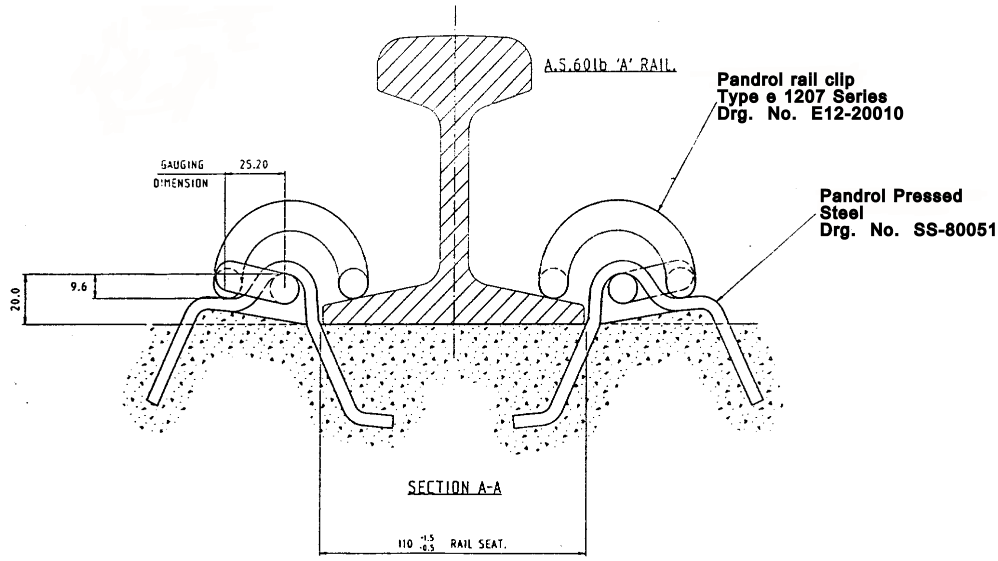


Figure 2.5.4 Pandrol e clips

Pandrol e 1600 series clips are used in conjunction with weld on shoulders for steel bearers of prefabricated turnouts.

Pandrol e clips are supplied in open top 200 litre drums. Table 2.5.4 shows the approximate number of clips per drum.

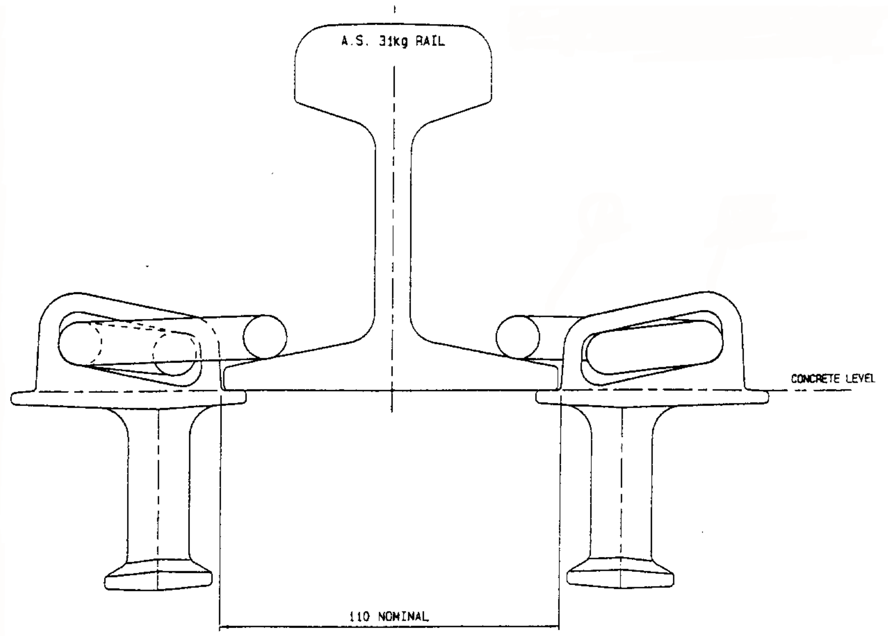
TABLE 2.5.4 QUANTITIES OF e CLIPS PER 200 LITRE DRUM

Clip	Number Per Drum
e 1200	2000
e 1400	1500
e 1600	1000

2.5.5 Pandrol cane clips

Pandrol cane clips, Figure 2.5.5, are used with cast in high ductile iron shoulders which hold the rail to gauge in a similar way to the e clip (Figure 2.5.4). The clips are manufactured from 14 mm dia. steel bar and provide a toe load of about 6 kN. The low profile design of the cane clip makes it less prone to damage from derailed wheels. Because cane clips can be inserted into the shoulder bi-directionally they can be used for sleepers located close to the end of angle type fishplates. Cane clips are also easier to fit than other types of resilient fastenings. Cane clips are supplied in open top 200 litre drums and each contains approximately 1500 clips.

Figure 2.5.5



Pandrol cane clips

2.5.6 CF2 Clips

CF2 clips are used to hold the rail to gauge on concrete sleepers. A CF2 clip is shown in Figure 2.5.6. The clips are supplied in open top 200 litre drums. There are approximately 2500 clips per drum.

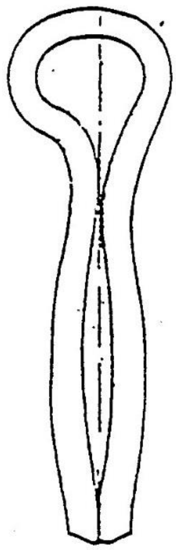


Figure 2.5.6 A CF2 Clip

2.6 BALLAST

Ballast is the name given to the selected material placed between the sleepers and the formation for the purpose of holding the track to surface and line.

Obviously the deeper the ballast below the sleeper the better, but because good ballast costs money, the need for economy imposes a practical limit on what can be provided. In the design of railway track, the depth of ballast varies in relation to the volume of traffic, axle loads, rail size, speed of trains and load bearing capacity of the formation.

2.6.1 Functions of Ballast

The functions of ballast are:

(1) To provide a firm even bearing surface for the sleepers and to distribute the loads imposed by traffic as evenly as possible over the formation.

(2) To provide a resilient bed or cushion below the sleepers to absorb some of the shock from the passage of loads over the track.

(3) To hold the track in line by (i) filling the cribs or boxes between the sleepers, (ii) providing a shoulder at the ends of the sleepers, and (iii) by friction beneath the sleepers.

(4) To prevent longitudinal movement of the track, i.e. rail creep.

(5) To provide drainage of the track structure so that the variation in bearing distribution when wet and dry is minimised.

(6) To provide a material which can be easily worked to enable top and line of track to be adjusted or improved without the formation being disturbed.

Ballast, particularly crushed stone ballast, is an expensive component of a railway track, and it is most important that it is used correctly, without waste or contamination. In some cases where poor formation conditions exist, a bottom ballast is used below the ballast proper to provide a better distribution of loading on the formation and improve drainage. In most cases, bottom ballast consists of gravel or screenings and often comprises the material with which the track was originally ballasted.

The type and quality or cleanliness of ballast are important in the design of a track. Crushed stone is a dense durable material and provides a good resilient cushion beneath the sleepers. The interlocking action of the sharp angular particles of crushed stone strongly resists the shearing action to which it is subjected from longitudinal and lateral track loads. In addition, it develops a strong friction grip on the surfaces of sleepers. On the other hand, natural gravels and sands, because of the generally smooth rounded shape of the particles, do not provide a good resilient cushion. Due to their low shearing resistance and friction characteristics, these types of ballast do not give the sleepers and the track as much resistance against lateral and longitudinal movement as is the case with crushed stone.

2.6.2 Types of Ballast

A large variety of materials has been used for ballast, and in many cases the best use has had to be made of local materials available in sufficient quantity. The choice of a particular type of ballast material is dictated largely by matters of cost and the type of work it is called upon to do. The following types are in general use in the cane railways:

(1) Crushed Stone

This is the best type of ballast and consists of particles of stone uniformly crushed from good quality hard rock or gravel. Blending of materials from different sources should not be carried out and the majority of the particles should be formed by the crushing of stone. Particles should be of good angular shape and the material should not show a tendency to flake excessively. Crushed stone varies from 38 mm to 10 mm square mesh size. Dust, dirt or other impurities, if present, should only be in very small quantities.

(2) Gravel

Gravels may be obtained from water courses or gravel beds which have been formed by the action of water, or they may be obtained from ridges. The former type of gravels are generally reasonably free of clay, dirt or other foreign matter, although the grading may vary greatly throughout the pit. Ridge gravels are usually more uniform in grading but invariably contain a high proportion of fine material and some clay. Most gravel ballast is used in the pit-run condition, i.e. the material is loaded direct from the pit and is not screened or processed to any great extent, although some culling out of large stones, timber and other large impurities should be performed, either by hand or by passing the material over a type of coarse screen called a grizzly. Gravel is adequate ballast for lines carrying moderate traffic, provided it is well graded from coarse to fine size, and is free of clay or very fine material which tends to make it set hard. Gravels mostly have rounded particles which make them inclined to be lively with consequent difficulty in holding good top and line and resisting rail creep.

(3) Sand

Coarse to fine sand has been used extensively in the past. The coarser the material the better it functions as ballast. Sands tend to be blown away by high winds and passing trains, and although easily worked they do not hold track well and generally are only suitable for light branch lines. Fine sand is disturbed by moving rolling stock.

(4) Screenings

Screenings consist of crushed stone smaller than 10 mm size which is screened out during production of crushed stone ballast. Screenings are generally not available in large quantities. They are used successfully as bottom ballast or as ballast on branch lines where their characteristic of setting hard can be tolerated.

2.6.3 Depth of Ballast

The depth of ballast below the sleepers has a direct bearing on the pressure on the formation. Figure 1.4.2 shows how the ballast in contact with the underside of a sleeper carries the whole load coming on that sleeper. As the depth of ballast increases, the load is spread over a wider area, becoming of less intensity and also becoming more uniform. A number of other factors must be taken into account in selecting the depth of ballast for a particular track loading - but the object is to provide a ballast bed of sufficient thickness so that the pressure exerted on the formation is reasonably uniform over the whole road bed. In this condition, assuming a uniform character in the road bed, no one part of the ballast will be forced down into the formation to form water pockets. As shown in Figures 1.2.1 to 1.2.7, the ballast profile provides for ballast up to the top of sleeper level, but ballast should not be placed above this level. Apart from presenting an untidy appearance, ballast lying on the tops of sleepers and the flanges of rails prevents easy inspection of rail fastenings and in track circuited areas at road crossings where flashing lights are installed could cause leakage of current. The absolute minimum depth of ballast under sleepers where on line tamping machines are used is 100 mm. However more satisfactory machine operation is achieved if minimum ballast depths of 125 to 150 mm are maintained. Some mills ballast above the sleeper to minimise derailment damage. This ballast has little effect in maintaining track geometry.

2.6.4 Ballast Tamping

It is essential to keep the ballast well tamped under all sleepers to preserve good running surface and alignment. The term 'packing' is often used to describe this operation. If ballast is firmly tamped, sleeper movement does not occur to any appreciable extent, and this maintains the stiffness of the track. Looseness of tamping can greatly increase the bending stresses in the rails and the local pressures on the formation. The friction grip on the sleepers is reduced and hence the overall resistance against creep or buckling is also reduced. Ballast must be tamped under each sleeper for a distance of 200 mm inside the rail to the end of the sleeper outside the rail, and care should be taken to ensure tamping of ballast under the rail seats. Ballast should not be tamped in the centres of the cribs or under the centre portion of the sleepers between the limits stated above, but these centres should be filled with loose ballast. If the centre portion of sleepers is tamped, the sleepers will ride on the middles after the ballast under the ends becomes consolidated by the weight of traffic. This undesirable condition is known as 'centre bound' track. The finished outline of the ballast of a completed track is described as the ballast profile. The sections of the ballast profile are described as follows:

(a) Bottom Ballast

On existing lines, this is the original gravel or sand ballast which forms a base for the top ballast. On new lines, a cheaper and coarser type of ballast may be placed on the formation to support the top ballast. The thickness of bottom ballast is usually counted as part of the total depth of ballast. In general, the term 'bottom ballast' is not used unless the top ballast consists of crushed stone.

(b) Top Ballast

This is the better class of ballast, usually crushed stone, placed on the bottom ballast and up to the level of the top of the sleepers.

(c) Crib Ballast

Crib Ballast is that portion of the top ballast between the sleepers. Crib ballast is often called 'boxing ballast' as the spaces between the sleepers are commonly referred to as 'boxes'. Crib ballast holds the sleeper in position against longitudinal movement caused by temperature effects or rail creep, and also appreciably stiffens the track against buckling. Ballast should completely fill the cribs up to the level of the top of the sleeper.

(d) Shoulder Ballast

This is the portion of the ballast profile outside the ends of the sleepers. Shoulder ballast helps to hold the track in line and prevent it moving sideways under temperature or traffic loading, including the effect of rail creep. Additional shoulder ballast is used with welded track, due to the greater loads caused by temperature variations, and the width of the ballast shoulders is further increased on the outside of curves because of the extra side pressure on the track.

The side slopes of the ballast profile should be flat enough to prevent them crumbling from the effects of vibration from trains or people walking on the track. If they are too flat, material will be wasted. A slope of 2 to 1 (Figures 1.2.1 to 1.2.7) has been found satisfactory.

2.6.5 Ballast Quantities

The ballast profile, in conjunction with the sleeper spacing, determines the quantity required to ballast a track. The standard to which a track is ballasted is expressed in cubic metres per kilometre. Another method is to use the depth of ballast below the sleepers and the width of the ballast shoulder to define the ballast standard.

Quantities of ballast per kilometre of track for some combinations of track construction and ballast profiles are given in Table 2.6.5.

TABLE 2.6.5 BALLAST QUANTITIES PER KILOMETRE FOR 610 MM SLEEPER SPACING (1640 per km)

Ballast Depth Under Sleeper (mm)	Ballast per km (1) (m^3)		
	Timber Sleepers (2) (m^3)	Concrete Sleepers (0.2 x 0.1 x 1.2 m) (3)	Concrete Sleepers (0.2 x 0.125 x 1.370) (4)
100	435	390	-
150	580	520	610
200	730	660	754
250	895	815	908

Notes:

(1) Does not allow for spillage or other losses. Allow up to ten per cent more where regulators are not used.
(2) For track profiles shown in Figures 1.2.1 to 1.2.3.
(3) For track profiles shown in Figure 1.2.4.
(4) For track profiles shown in Figures 1.2.5 to 1.2.7.

2.6.6 Grading requirements

The particle size of prepared crushed rock ballast retained on Australian Standard sieves (AS1152-1973) should fall between the limits given in Table 2.6.6.

TABLE 2.6.6 BALLAST GRADING REQUIREMENT

AS Sieve Size (mm)	Per cent Passing by mass
75	100
53	90-100
37.5	52 - 80
26.5	25 - 53
19.0	6 - 34
16.0	0 - 28
13.2	0 - 20
9.5	0 -11
6.7	0 - 4
4.75	0

Crushed rock ballast of size greater than 37.5 mm is often difficult to pack with hand held tampers.

2.6.7 Properties of Crushed Stone Ballast

General Requirements

Ballast should be crushed stone composed of hard durable particles, free from injurious amounts of deleterious substances and conforming to the requirements of these specifications. Crushed river gravel should have over ninety (90) per cent of rock pieces presenting a number of fractured angular faces after crushing.

Quality Requirements

Deleterious substances should not be present in excess of the following amounts:

Soft and friable pieces	5%
Material finer than 200 sieve	1%
Clay lumps	0.5%

When tested in accordance with Australian Standard A77-1957 'Aggregate for Concrete', Appendix D, Method of Determination of Crushing Value of Aggregate, the

Aggregate Crushing Value of the material should not exceed 22%.

The flakiness index of the crushed rock should not exceed 35% nor the elongation index 40% when tested in accordance with Australian Standard A77-1957, Appendix Q, 'Method of Determination of Particles Shape of Aggregates'.

2.6.8 Ballast Testing

As an indication of the suitability of a particular stone for ballast the following tests can be done in any mill laboratory.

Test for Soundness of Aggregate (Sodium Sulphate Method)

This test assists in determining the effect of weathering on the ballast material particularly for ballast from pits not previously used for ballast material.

Test Solution

Prepare a saturated solution of anhydrous Na_2S0_4 or crystalline $Na_2S0_4.10H_20$ in distilled or demineralised water between 33 and 35°C. Use sufficient of the salt to give excess crystals after thorough stirring. Cool to between 22 and 24°C and keep at this temperature for at least 16 h. Stir thoroughly before use.

Preparation of Test Specimen

From a representative sample of stone take, at random, a specimen of at least 500 g passing a 19 mm and retained on a 13.2 mm sieve. Wash the specimen to remove all adhering material.

Dry at 105°C in a well ventilated oven and determine the mass after cooling. Continue drying until the decrease in mass after each of two successive drying periods of 4 h does not exceed 0.1% of the total mass. Let this mass be M1.

Procedure

Place the specimen in a porcelain dish and cover fully with test solution between 20 and 25°C for 7 h. Decant the solution taking care that no stone is lost.

Dry the specimen for 15 h at 105°C. Allow the specimen to cool for 2 h. This completes one cycle of the soundness test.

Repeat the cycle described as often as specified. After every fifth cycle, wash the specimen on a 1.70 mm sieve with hot water until no crystalline sodium sulphate is visible and continue the test with material retained on a 1.70 mm sieve.

After completion of the final cycle, wash the specimen in hot water until the washings are free of sodium sulphate. Dry the specimen to constant mass and screen on a 1.70 mm sieve. Let the mass retained on this sieve be M2.

Loss

Calculate the percentage loss in mass from the formula

100(M1 - M2)/M1

The loss in mass should not exceed 5 percent after 20 cycles of the test.

Durability Test

Preparation of Test Specimen

From a representative sample of ballast stone take, at random, 100 stones passing a 53.0 mm and retained on a 26.5 mm sieve. Wash the stones to remove all adhering material. Dry the stones at 105°C in a well ventilated oven and determine the mass after cooling. Continue drying until the decrease in mass after each of two successive drying periods of 4 h does not exceed 0.1% of the total mass.

Procedure

Place the 100 stones in a suitable container and cover with ethylene glycol between 18 and 25°C for 20 days.

If during or at the conclusion of this test no stone is found broken the material can be considered suitable for ballast provided the conditions of Sections 2.6.6 and 2.6.7 are met.

2.7 "SUPERLOCK" CLIPS FOR FISHBOLT ASSEMBLIES

2.7.1 Application

When standard thread (non-interference) fit fishbolts are used for mechanical rail joints, the subsequent loosing of the bolt and nut assembly under traffic can be overcome by fitting a 'superlock' clip (Figure 2.7.1.1) to the threads of the bolt after all joint bolts have been tightened to specifications. The clips are available to suit the range of fishbolt sizes from M18 to M30.

Fitting the "superlock" clip is additional to and NOT in lieu of the normal spring washer.

Figure 2.7.1.1 Superlock Clip

2.7.2 Fitting Instructions

The only tool required for application or removal is a flat bladed Screwdriver eight millimetres maximum width, however circlip pliers (outside type) can be used to increase the ease of application.

After the nut is tightened in position, place the “Superlock" clip in the start thread of the bolt, or, place the clip with circlip pliers in the thread just above the nut.

Ensure the correct position of the "Superlock" clip over the bolt thread with the kink or lip to the right, see Figure 2.7.2.1.

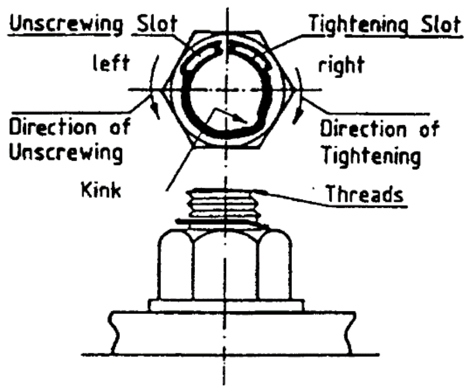


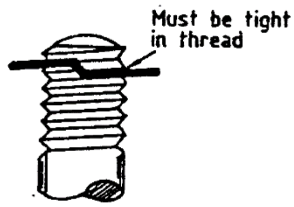
Figure 2.7.2.1 Fitting of Superlock Clip

Ensure the "Superlock" clip is tight in the thread, i.e. it cannot be turned by hand. If it can be turned by hand the clip is the incorrect size.

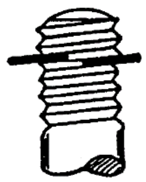
Ensure the "Superlock" clip is installed in the correct threads as shown in Figure 2.7.2.2.

Insert the screwdriver blade in the right hand slot and turn clockwise down the thread tightly into the face of the nut. One face or half of the 'Superlock' clip should be on the nut face, Figure 2.7.2.3.

To loosen, reverse the above procedure with the screwdriver in the left hand slot.



CORRECT POSITION
OF KINK IN THREAD


INCORRECT POSITION
OF SPLIT IN THREAD

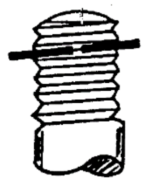

CORRECT POSITION
OF SPLIT IN THREAD

Figure 2.7.2.2 Method of Installing Superlock Clip

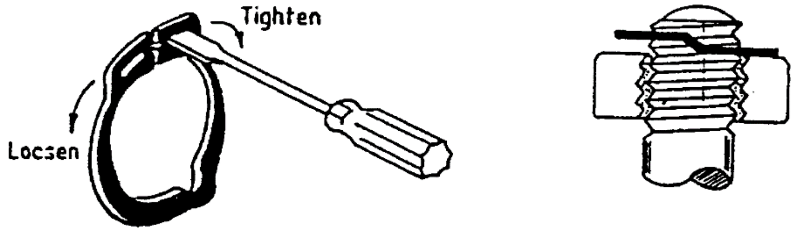


Figure 2.7.2.3 Method of Tightening or Loosening Superlock Clip

'Superlock' clips can be reused provided the clip and the bolt are not excessively worn and the clip can be secured tightly.

2.7.3 Maintenance

'Superlock' clips are designed to be maintenance free and loosening will not occur unless the incorrect clip has been used with the bolt.