TRANSPORT ACCIDENT INVESTIGATION COMMISSION
TE KOMIHANA TIROTIRO AITUA WAKA

NO 94-127

TRAIN 901

DERAILMENT

EDENDALE

13 DECEMBER 1994

ABSTRACT

On 13 December 1994 at 1717 hours, Train 901, the southbound "Southerner" express passenger service between Christchurch and Invercargill, was travelling at 94 km/hr when the Locomotive Engineer noticed a buckle in the track ahead. He was unable to bring the train to a halt in the space available, and although the locomotive and three passenger carriages remained on the rails, all wheels of the trailing vehicle, a luggage van, were derailed. Safety recommendations were made relating to the safety deficiencies identified which were the training and supervision of key track staff, the clarity of instructions to staff, and compliance with established standards for the formation and maintenance of continuous welded rail.

TRANSPORT ACCIDENT INVESTIGATION COMMISSION

RAIL OCCURRENCE REPORT NO. 94-127

Train Type and Number:	Christchurch-Invercargill Express Passenger, No 901
Date and Time:	13 December 1994, 1717 hours
Location:	Near Edendale, at 561.25 km, Main South Line
Type of Occurrence:	Derailment of Luggage Van
Persons on Board:	Crew: 3 Passengers 30
Injuries:	Crew: Nil Passengers Nil
Nature of Damage:	Approx. 180 broken sleepers in track
Information Sources	Transport Accident Investigation Commission field investigation
Investigators in Charge:	Mr W J D Guest/Mr R E Howe
Participants	The Land Transport Safety Authority participated in this investigation by providing a track systems specialist consultant. The material contribution of Mr F J Drury of Kennedy & Donkin Transportation Limited, Australia, is acknowledged.

1. NARRATIVE

The Derailment

1.1 On 13 December 1994, Train 901 operated by New Zealand Rail Limited (NZRL) was the southbound "Southerner" express passenger service between Christchurch and Invercargill.

1.2 At 1717 hours as the train was travelling at 94 km/hr along straight track north of Edendale, the Locomotive Engineer (LE) noticed a buckle in the track ahead. The continuously welded rail (CWR)[1] track had buckled over approximately 35 m with a maximum deviation of approximately 675 mm from centreline over a distance estimated to be 16 m, as recorded after the train had passed over the buckle site.

1.3 The LE was unable to bring the train to a halt in the space available, and although the locomotive and three passenger carriages remained on the rails, all wheels of the trailing vehicle, a luggage van, were derailed. There were no persons on board the luggage van and no injuries to passengers or crew on the train. A photograph of the buckled track and the derailed luggage van is shown as Fig. 1.

1.4 The LE had passed over the same stretch of track about 40 minutes earlier in a northbound freight train, and had noticed nothing unusual in the track then. He had changed over to the southbound passenger train at Mataura and was returning to Invercargill.

1.5 The speed of the train was determined from the locomotive's electronic event recorder which was analysed after the derailment. The train was therefore slightly above the authorised maximum speed for the area of 90 km/h, but the excess is not considered significant in the derailment.

Weather Conditions

1.6 The weather in Southland was warm and sunny. The weather in Otago and Southland had been hot over the preceding few days, with some locations being reported in the newspapers as having their highest recorded temperatures in a century. However, December 13 was not considered to have been as hot in Invercargill as a few days earlier. The air temperature was recorded as 24°C at Invercargill, but it could have been warmer at Edendale, some 30 km inland. A local resident said that there was no wind at Edendale, and described the day as "hot".

Continuous Welded Rail and Track Buckles

1.7 CWR track is formed by welding together adjacent lengths of rail to eliminate the bolted joints between them. It is a well established worldwide practice and was first used in New Zealand in the early 1970's. The resulting length of rails can be measured in kilometres, and this was the case at Edendale, where the rails formed a continuous length of some six kilometres. Because there are no joints in the body of the rail, it is necessary to take suitable measures to compensate for the effects of temperature variations on the rail. In addition to specific requirements for the ballast, sleepers, and fastenings, it is essential that CWR is formed so that there is no stress in the rails at a defined rail temperature, usually called the "neutral temperature".

1.8 At temperatures below the neutral temperature, there is a tensile stress in the rails, which is resisted by the fastenings of the rails to the sleepers, and the sleepers in the ballast. At tempera-

[1] CWR is any rail of length 40m or more (NZRL definition)

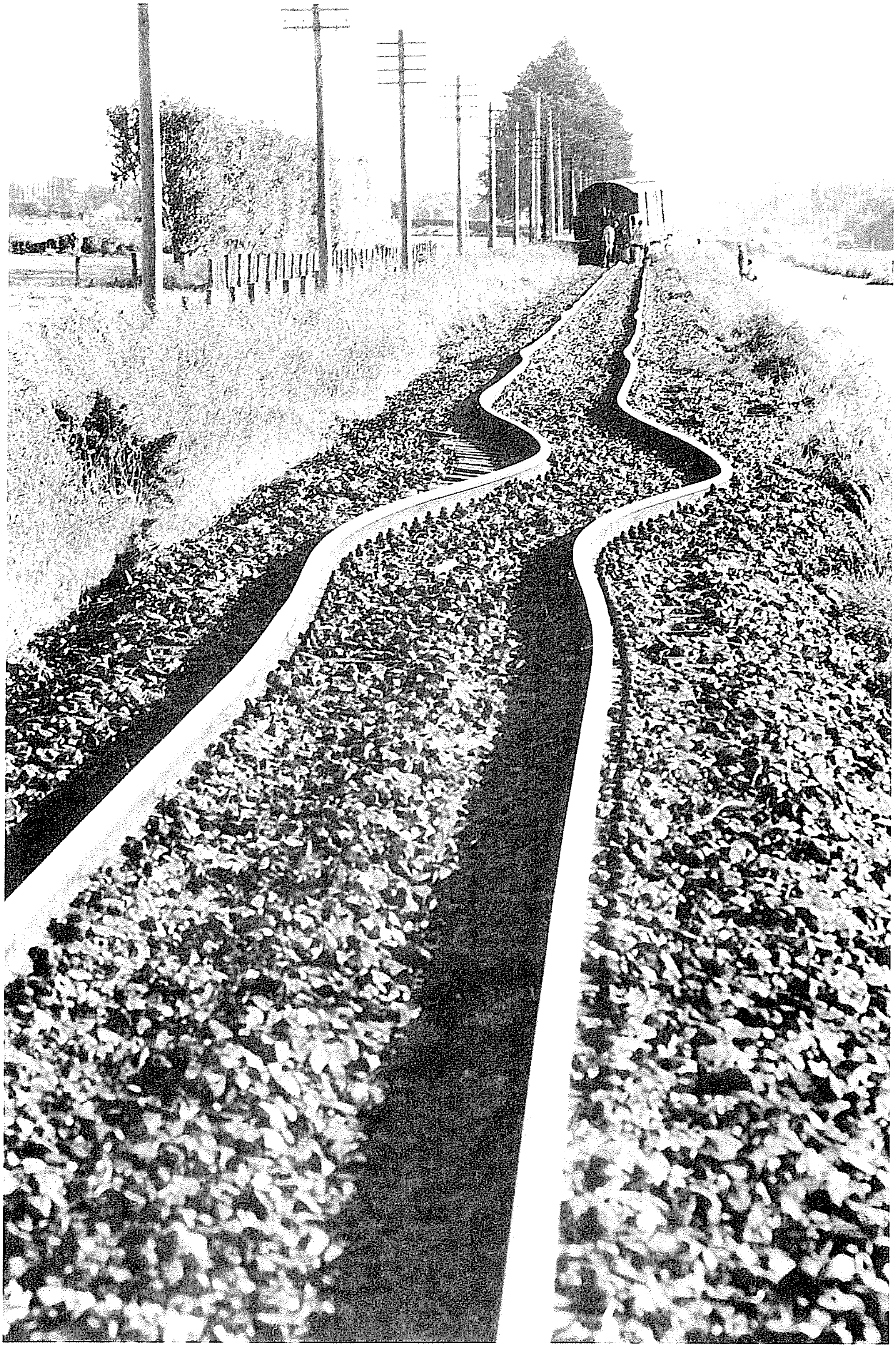

Fig 1: General view of derailment scene
Photograph supplied courtesy of the Southland Times

tures above the neutral temperature, the stress is compressive and could cause buckling unless the rails and track are adequately constrained.

1.9 The design neutral temperature and applicable tolerance ranges are set by Railway's Engineers after taking into account the likely maximum and minimum rail temperatures that may be encountered, so that the maximum compressive stress caused in the rails by hot weather, and the maximum tensile stress caused by cold weather, can be safely coped with in the track. For NZRL, and its predecessor, the New Zealand Railways Corporation, the design neutral temperature is 27°C.

1.10 If the actual neutral temperature of a length of CWR track is outside the defined neutral temperature range, either the maximum tensile stress or the maximum compressive stress in the rails will be greater than intended. In particular, if the rail has a neutral temperature below the defined minimum neutral temperature, the compressive stress that will occur in warm weather will exceed intended values.

1.11 At the time the Edendale straight was welded into CWR (1988/1989 Summer) the instructions for installing CWR allowed it to be formed within a range of rail temperatures between 15°C and 35°C without destressing[2]. This gave a tolerance of -12°C and +8°C on the design neutral temperature of 27°C. However the instructions also contained strict provisions for such aspects as site control by authorised technical staff, recording of all details of the formation of the CWR, and requirements for ballast quality to new supply specification. Records do not exist for Edendale but current site conditions are such that it is most unlikely that these instructions were complied with.

1.12 The general principles for the management of CWR track in order to control the risk of buckling involve:

- the formation and maintenance of the CWR at or near the specified neutral temperature, in such a manner that the maximum compressive force in the rails is acceptable; and

- the provision and maintenance of ballast, sleepers, and fastenings that provide adequate resistance against buckling of the track when it is subjected to the maximum design compressive force.

1.13 A detailed study of the application of CWR to New Zealand conditions was made by the New Zealand Railways in 1981. (Reference Way & Works Branch Research Report No. 195 - "A Study Into the Stability of Continuous Welded Rail" - May 1981.) This report was initiated by a desire to extend the use of CWR on concrete or treated pinus radiata (TPR) sleepers to curved track. The report recommended the retention of the then current design neutral temperature of 27°C and concluded that a rail temperature rise of 40°C above this was appropriate for design purposes. This was based on a recorded range of main trunk route rail temperatures of -13°C to 62°C. The report also concluded that CWR on concrete sleepers or TPR sleepers had a factor of safety against buckling of 2 (1.7 for disturbed track) in these conditions and related to NZR's then standards. The report did not quantify the stability of CWR on hardwood sleepers as at that time existing hardwood sleeper sites did not meet the defined criteria for CWR formation. (The use of new hardwood sleepers for main line track in New Zealand was phased out during the 1960's and 1970's due to quality and availability problems and the technical and economic advantages of TPR and concrete options.) As a result of this study the standards were reissued in 1982 allowing CWR to be formed on concrete sleepers or TPR sleepers on defined curved track.

1.14 In 1987 NZRL revised and reissued the instructions for installation and maintenance of CWR. The reassessment was based on two key factors:

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[2] Destressing is the unfastening and refastening of rail in such a way that it is stress free within a defined rail temperature range

- The behaviour of rails between 36 m and 76.8 m in length. Up to 1987 these were by definition not CWR but exhibiting many of the characteristics of CWR. (Prior to 1987 CWR was defined as rail greater than 76.8 m.)

- The need to prepare standards to support NZRL's desire to carry out a rail joint elimination programme to increase track standards and decrease maintenance costs.

  In 1992 NZRL changed its procedures for forming and maintaining CWR (Code Supplement CSP 131 - Issue 1 - June 1992) since amended by reissue 31 August 1994. The most significant changes since the formation of the CWR at Edendale and as related to the incident were:-

- Under heading "Track Standards Needed" the sleeper and ballast requirements to be met prior to such CWR formation were defined. The sleeper requirements included:-

  - ideally 1 in 4 sleepers spotted. *(This means that on average in any group of four old hardwood sleepers one would have been replaced with a new or first class concrete or TPR sleeper.)*

  - 75% of sleepers holding effectively.

  For Edendale virtually no sleepers had been spotted since installation in 1963. It was estimated that only 50% of sleepers were holding effectively.

  The ballast requirements referred to Code Supplement CSP/55 issued in 1992. This defined the requirement for supply of new ballast but had no minimum standard for degraded ballast in sites to be formed into CWR.

- The need for rail anchors[3] to Code Supplement CSP/39 for all newly created timber CWR sites or when carrying out specific upgrading works on timber sleeper sites. At the time of the derailment there were no rail anchors installed on the Edendale straight.

- The need to identify existing sites which did not comply and establish plans for upgrading to appropriate standards.

The Edendale straight came into the category of a CWR installation that did not conform to standard and required planning for upgrading. At the time of the derailment the only upgrading work planned was destressing of the length from 562.4 km to 562.8 km (the site of the 1992 track buckle) as part of NZRL's separate priority destressing project. This was completed in November 1994. As a result of a reassessment of priority lengths for destressing the full Edendale straight was added to the list as Priority 1 in early 1995, and it was destressed and had rail anchors installed in February 1995. NZRL have indicated their intention to spot sleepers at a minimum of 1 in 4 at a future date consistent with overall priorities.

- A raising of the bottom limit of the neutral temperature range from 15°C to 23°C. This was considered desirable to avoid the possibility of CWR formation at a neutral temperature which would create unacceptable compressive forces in the track being formed into CWR at the time.

1.15 The advantage of eliminating the rail joints by forming CWR is a reduction in maintenance work. It is usually considered economic to adopt the higher technical standards for the installation and maintenance of CWR than to persist with jointed track. CWR is a proven technology that has been in use worldwide for a number of decades.

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[3] Rail anchors are a device which, when driven onto the foot of the rail, bear on the side of the sleeper. Should the rail move longitudinally the rail anchor ensures the sleeper moves with the rail and thus activates ballast resistance.)

1.16 Track maintenance staff cannot measure the stress in rails, or the extent to which the resistance of the fastenings, sleepers, and ballast provide a margin of safety against buckling, by any direct means. The track must be constructed and maintained in accordance with standards which are known to provide a satisfactory result, and which are based on extensive research and experience overseas and in New Zealand. However, experience has shown that track which is prone to buckling has specific characteristics, and track which is close to buckling often displays minor visual clues. The purpose of special track patrols in hot weather conditions is to identify such areas and to apply appropriate speed restrictions.

1.17 The forces in the rails are significant. For each degree of temperature difference from the neutral temperature, the rails in the body of the CWR build up a stress of 2.2 N/mm^2. For the rail size at Edendale, the force in each rail would have been approximately 1.2 tonnes, or 2.4 tonnes total for the track, for each 1°C difference from the neutral temperature. Thus for a neutral temperature of 15°C and a rail temperature of 45°C the compressive force in the track would be 72 tonnes. The compressive force at the New Zealand design parameter of 40°C increase in rail temperature would be 96 tonnes.

1.18 Buckles occur in locations where the ballast, sleepers, and fastenings do not provide sufficient resistance. Once a compressive stress has built up in the rails, buckles are initiated by some "triggering" factor. The most common such factors are minor misalignments in the line of the track, the approach and passage of a train, and track maintenance work which reduces the friction between the ballast and the sleepers. However initiated, a buckle develops within a second or two.

1.19 Minor misalignments may occur as the rails build up stress if the ballast, sleepers, and fastenings allow the rails to move slightly. The compression force in the rails accentuates the misalignment, and exerts a lateral (sideways) force on the fastenings and sleepers.

1.20 A track buckle can sometimes be initiated by the approach of a train. The weight (and possibly the vibration) of the train causes a disturbance in the track ahead of and under the train which can be sufficient for the buckle to occur.

1.21 The friction between the sleepers and the ballast can be reduced temporarily by track maintenance work, and it takes the passage of trains over a period of time to "bed in" the track by reconsolidating the ballast to restore the full friction between it and the sleepers.

Track Details

1.22 The buckle occurred near the middle of a six kilometre long straight a short distance north of Edendale (between the 558 and the 564 kilometre pegs on the Main South Line). The track has an easy varying gradient downwards to the south, averaging about 1:400.

1.23 The track along the six kilometre straight consisted of 91 pound/yard continuous welded rails on bedplates fastened to jarrah (Australian hardwood) sleepers with screwspikes, a spring washer, and a steel clip. This fastening detail, known as the "N-type" is shown in Fig 2.

1.24 The track along the straight was renewed in 1963. At that time the rails were 252 feet long with bolted fishplated joints.

1.25 NZRL do not keep records of the dates of the ballasting of the track. Representative samples of the ballast from the surface, and from underneath the sleepers were taken in the vicinity of the buckle site. The grading of the top ballast indicated that at some recent date, a dressing of new ballast had been placed over undersized ballast with fines and dirt content. This is not encouraged by NZRL but under new Code requirements is an acceptable way of achieving full ballast section on older track that has been welded up to CWR, as at Edendale. The old ballast underneath the sleepers was well outside the grading requirements for new ballast supply (50% passed a 16 mm sieve compared to a specified 0% to 4% range for new ballast) and contained fines and dirt. NZRL currently have no definition of degraded ballast considered suitable for CWR track.

1.26 During the 1988/89 summer, the bolts and fishplates were removed and the rails welded together to form continuous welded rails over the whole six kilometre straight. The jarrah sleepers, rails and probably the bottom ballast had therefore been in the track for 25 years when the CWR was formed.

1.27 The life of jarrah sleepers has generally been 20 to 30 years in New Zealand conditions, depending on track tonnage and ballast conditions. Hardwood sleepers reach the end of their life when splitting and decay render them unable to hold fastenings securely, and unable to provide a sound interface with the ballast.

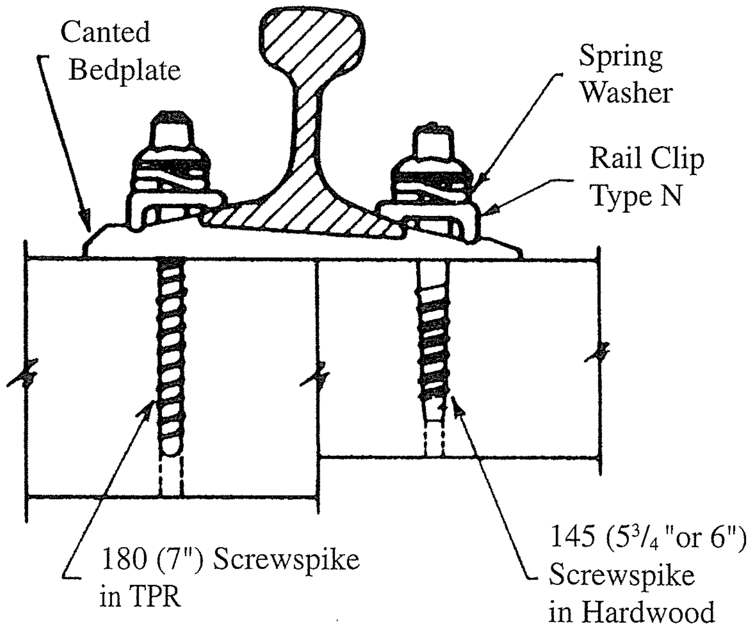
1.28 The site was inspected a week following the derailment, and the following points noted:

1.28.1 An estimated 50% of the sleepers were significantly decayed underneath and in the centre. (see Fig 3)

1.28.2 A significant proportion of the screwspikes had been replaced on the derailment site because they were ineffective (not because they suffered damage in the derailment or required replacement to regauge the track). It is estimated that at least 50% of the sleepers were not holding effectively at the time of the buckle.

1.28.3 The ballast profile on the shoulders (i.e. at the ends of the sleepers) was less than the standard laid down by NZRL for CWR track.

1.28.4 The grading of the ballast below the sleepers was well below new ballast standard. While the surface ballast was of reasonable quality and grading, the ballast under the sleepers was mostly small and rounded material, wet in places, with a high proportion of fines and dirt. (See Fig. 4)



Canted Bedplate Assembly TYPE "N"

Fig 2: N-type fastening

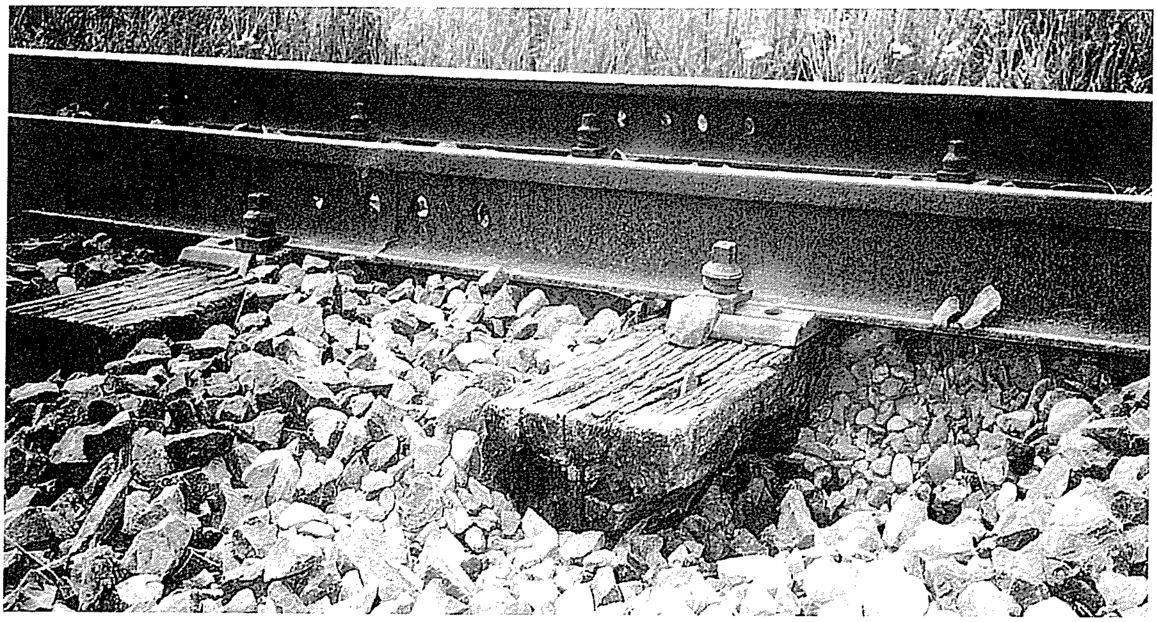


Fig 3: A jarrah sleeper partly exposed by the removal of ballast. The sleeper appears reasonably solid on top, but has extensive decay underneath.

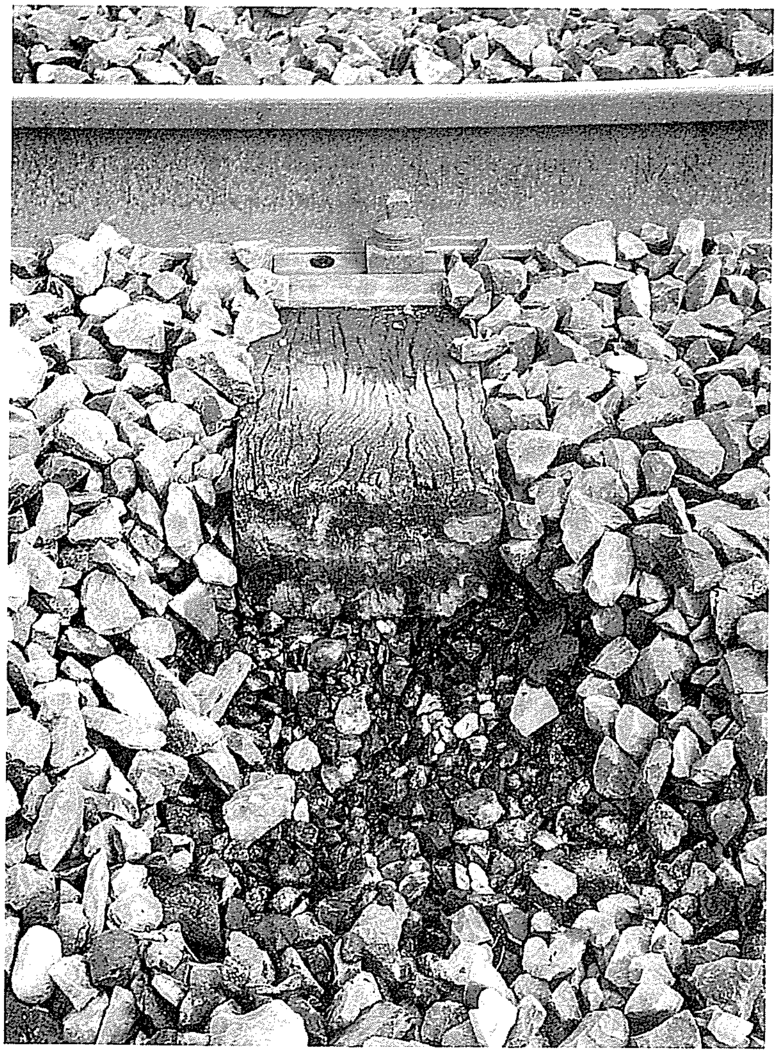


Fig 4: The careful removal of the ballast shoulder clearly reveals the difference between the top ballast and the small dirty material under the sleeper. At this location near the derailment site, the bottom ballast was wet, indicating a possible drainage problem.

1.29 The "Code of Special Instructions, Way and Works Branch" issued in 1964 contained this instruction (P.205) about track standards:

"Reballasting of track having poor or dirty ballast must be so carried out that there is at least 4 in. of new ballast placed under the sleepers. New ballast must not be used for surface dressing poor or dirty ballast."

1.30 An updated version of the same code, issued in 1980, and in effect in 1988, read similarly, but increased the depth of new or cleaned ballast to be placed under the sleeper to 225 mm (approximately 9 inches). The current NZRL instruction (Code Supplement CSP/55 issued 8 May 1992) is also the current standard needed for CWR. It defines new ballast section requirements but does not address when to ballast clean or reballast. It includes the following general guidelines on ballast use:-

"Ballast should be used as follows:

(i) when resleepering (face and spot)

(ii) to build up shoulders

(iii) before tamping track if lifting is required

(iv) for yard and turn-out work

(v) new track construction

(vi) following ballast cleaning if necessary.

For ballast to perform its job properly it should not be dirty and formations should be well drained. To get best use of ballast it should not be discharged onto dirty ballast or muddy spots.

When assessing sites for ballast the following should be done before the ballast is ordered:

- **build up and/or widen cesses to retain ballast shoulders**
- **check drainage is effective, repair if necessary**
- **remove dirty ballast from track and ensure the reason for the dirty ballast is found and the problem fixed.**

The AT & SM[4] can advise and direct on ways to do the above."

1.31 The CWR was formed some time in 1988, although exact dates and details are not documented despite a Code requirement to do so. The instructions for the installation and maintenance of CWR at that time were set out in Technical Information Circular PW20 "Welded Rail: Instructions for Installation and Maintenance". This circular contained, inter alia, the following provisions:

"A.1.3.2. A continuous record on Welded Rail Record Sheets must be maintained in Regional Offices of all track laid or welded up into lengths of 36 m or over, and each section as it is completed must be signed for by the appropriate authorised technical officer as having been dealt with in accordance with these instructions.

[4] Area Track and Structures Manager

A.1.4.3. Ballast must be clean, well-compacted, and to CCE's[5] Specification 41/3, 41/4, or 41/5. The Ballast section should comply with the minimum standard shown in Code Instruction P.191 i.e. -

(i) Desirable minimum depth of 225 mm under sleepers. (150 mm depth acceptable in existing track).

(ii) Minimum shoulder width 350 mm on straight track and curves down to 400 m radius, 450 mm on curves under 400 m radius. (Both sides).

(iii) Shoulders to be heaped at least 100 mm above sleeper top level.

(iv) Ballast in cribs to be level with tops of sleepers.

A.3.1. Before rail is welded up into longer lengths, the following conditions must apply:

(b) The full ballast section must be provided throughout"

[Note: conditions (a), (c), and (d) of A.3.1 not reproduced here]

1.32 Circular PW20 did not set out any standards for the condition of sleepers in track in which CWR was to be formed.

1.33 In respect of the above instructions, deviations were noted during the course of the investigation as follows:

1.33.1 The formation of the CWR was not documented, and there was no evidence that it had been carried out to achieve a controlled and acceptable neutral temperature.

1.33.2 The ballast profile was inadequate near the site of the buckle, in that the shoulder on the right hand (western side) did not conform with the minimum dimensions required. The buckle occurred towards the right hand side.

1.33.3 The grading of the ballast under the sleepers was well below the specified standard for new ballast, and the ballast contained fine material and dirt.

Safety Management in CWR

1.34 Track which might buckle is unsafe for fast trains because:

- Locomotive Engineers may have little time to react and to slow their trains;
- Trains are more likely to derail on a buckle when travelling fast than they are at slow speed; and
- The consequences of a derailment are potentially greater because of the kinetic energy involved.

1.35 However, the same track is likely to be safe at a lower speed. There is a link between safety and speed, and it is essential that a correct decision is made by track staff about the speed at which trains may travel over their section.

[5] Chief Civil Engineer

1.36 The decision to impose a speed restriction, its value, and the length of time for which it should be in force requires the consideration of many issues, some of which are interrelated. The skills, knowledge, and ability of staff concerned in making the decisions about speed restrictions are fundamental to safe operations in hot weather.

1.37 The factors that must be considered by Gangers in respect of hot weather and track buckling problems include:

- The rail temperature
- Ballast grading
- Ballast profile
- Sleeper condition
- Fastening integrity (the ability of the fastening to hold the rail firmly)
- Buckling history
- Bridges, level crossings, or other obstructions at which track is effectively anchored and adjacent track can bunch up if the fastenings allow longitudinal rail creep
- Presence of warning signs (misalignments in hot weather, rail creep)
- Recent track disturbances (tampers, resleepering, derailment damage)
- Weather patterns (first hot day after cool weather, exceptionally hot days, lack of wind)
- Microclimates (sheltered valleys, cuttings, windbreaks)
- Track gradient (rail creep can occur downhill, contributing to buckling at the bottom of a grade)
- Traffic flow and braking patterns

1.38 A Ganger must be well-trained and competent to observe and evaluate all the relevant factors, and to recognise the priority of hot weather precautions over programmed work in order to establish patrols and apply speed restrictions where appropriate. He must have the necessary tools to measure the relevant factors.

1.39 To ensure safety, one of two broad courses must be followed:

Either-

All staff with a responsibility for track safety (Area Track and Structures Managers, and Gangers, including those temporarily occupying these positions in an acting capacity) must have proven ability to obtain and understand the information necessary to make a sound judgement about the need for patrols in hot weather and the application of any speed restrictions necessary.

Or-

The guidelines and procedures laid down for special patrols and the imposition of speed restrictions in hot weather must be simple enough to ensure that inexperienced or less competent staff will still impose speed restrictions where necessary. (Such guidelines will work by reducing the judgements required, and therefore, of necessity, will be quite "broad brush" in their approach.)

1.40 NZRL did have a requirement for special track patrols for buckles to be instituted in very hot weather. This instruction (P.90 of the Operations Group Code) read:

"Special track patrols for buckles may be needed in very hot weather conditions. This will depend on known track condition and especially when:

(a) ballast sections are below standard

(b) **the track has been disturbed within the previous month**

(c) **known misalignments exist outside acceptable standards**

(d) **any section has a previous history of buckles or joint expansion gaps are tight at comparatively low temperatures**

Speed restrictions must be applied when buckling appears likely in any area."

1.41 NZRL supplemented this code instruction with a circular addressed to All Gangers, Track and Structures Managers, and Area Managers, and entitled "Hot Weather Issues". The relevant part of this circular, which was dated 8 December 1994 and was therefore current on the day of the derailment, read:

"When rail temperatures exceed 45°C, consideration must be made to the reduction of train speeds.

All trains (including passengers) should have speeds reduced to 40 km/hr - 50 km/hr when rail temperatures are above 45°C or above 40°C and still rising. This will apply to all track that has a high risk of track buckles or track that has a known problem and not corrected (not destressed).

Track that has recently been destressed or is highly unlikely to buckle may be exempt from blanket speed reductions. Areas to be exempt must be of a suitable length to warrant not having speed reduced.

Speed restrictions must be placed over a specific length, station to station if necessary. They must be placed for a set time period, say 1400 until 2000. Staff should monitor the rail temperature to ascertain when rail temperatures are in the danger range and establish the times to place and remove TSR 's.[6]

It is appreciated that this will disrupt train schedules, however derailments also seriously disrupt schedules.

Discussions with Train Operations Planning have resulted in the following: -

- **A train advice will be issued stating the metrages of the speed restrictions**
- **The restriction will apply for defined times**
- **The restrictions WILL NOT APPLY if Train Control is advised by Ganger or Track Manager**
- **Speed boards will not be erected at restrictions**

The normal practice of hot weather patrols must also be carried out as required."

Factors Contributing to the Track Buckle

Track Conditions and Initiating Factors

1.42 The track buckled because it could not contain the thermal stress built up in the rails in the hot weather.

1.43 There is no certified record that the track conformed with NZRL's Circular PW20 when the rails were welded to form CWR in 1988, as required by that circular. With no certified record

[6] Temporary Speed Restrictions

available, the temperature and stress conditions at the time the rails were welded - key aspects of the management of CWR to prevent excessive stress - could not be confirmed, but in the light of the non-compliance apparent in 1.44 below there must be doubts as to whether the rails were welded and refastened to the sleepers within the correct stress free temperature range in 1988. The day after the derailment 700 m of one rail was unfastened and allowed to expand. The expansion (120 mm) at the prevailing rail temperature (46°C) with due allowance for rail cut-out on the day of the derailment and for frictional resistance, indicated a likely average neutral temperature over the 700 m unfastened of 17°C, ie, near the limit of the allowed range in 1988. This neutral temperature can only be considered as approximate.

1.44 The track conditions observed after the derailment indicate that significant requirements in Circular PW20 relating to ballast profile and grading were not complied with in 1988, many fastenings were loose prior to the derailment, and that many sleepers were partly decayed. It is probable that a minor misalignment developed at the site of the buckle because the rails were not securely held in position, and that this misalignment developed into a buckle due to the inability of the track structure to provide sufficient restraint.

1.45 The passage of the northbound freight train a short time before the derailment may also have contributed to the initiation of the buckle even though the LE did not observe anything unusual.

1.46 On 1 December, less than two weeks before the derailment, the line and top of the track had been maintained by a tamper-liner. This is a rail-mounted track maintenance machine that clamps on to the rails, lifts the track, adjusts the line and cross-level of the rails, and then inserts vibrating tines ("paddles") between the sleepers and squeezes ballast underneath to hold the adjusted line and top. Despite the hydraulically-powered compacting action of the tamper-liner, the friction between sleepers and ballast is reduced after the passage of the tamper-liner, and is only restored gradually by the reconsolidating effect of subsequent trains passing. NZRL have a standing instruction (Operations Group Track Code Supplement CSP/31, Section C, clause 2(e)(b)) which cautions against the use of the tamper-liner in curved track between November and March, but specifically permits it on straight track. There was no requirement for the imposition of any speed restriction at the time of the use of the tamper-liner at Edendale. However on 12 December (the day prior to the derailment) an instruction was issued by computer Email to all area offices as follows:

"Given the hot weather we are now experiencing, please ensure that speed restrictions of a minimum of 40 km/hr are left in place after tamping for at least a week on mainlines this should be up to 2 weeks on lower tonnage lines. This instruction also holds for ballast cleaning sites.
The reason for this is to allow ballast consolidation in areas that have been disturbed by mechanical maintenance machines and as such are at risk of track buckles.
This is particularly critical on passenger lines."

This was circulated to all Gangers in the Dunedin area on 15 December.

In view of the relatively low tonnage on this section of the Main South Line it is considered the friction between the sleepers and ballast had been reduced temporarily at Edendale on the 13 December by the earlier actions of the tamper liner.

Factors Contributing to the Derailment

Instructions and Procedures for Special Track Patrols for Buckles and Speed Restrictions

1.47 The derailment occurred because the train approached the track buckle at (or close to) the normal permitted maximum speed for the area. The buckle had not been detected, nor had the speed of the train been reduced by the imposition of a temporary speed restriction as a precaution in the hot weather.

1.48 No special track patrol for buckles was instituted on 13 December, 1994. The instruction for such patrols (P90 of the Operations Group Code) did not specify temperatures or conditions under which patrols should be instituted. It merely stated that patrols "may be needed in very hot weather conditions". NZRL had no procedures or working instructions to support this Code instruction.

1.49 The circular entitled "Hot Weather Issues" dated 8/12/94 relating to speed restrictions was unclear, because it did not specify how the judgement about a speed restriction was to be made.

1.50 Code Instruction P90 is non-specific and would require competent staff with proven ability to interpret and implement it to ensure safe operations. It is not supported by any working instructions or procedures linking air temperatures with rail temperatures as a guide to the need for special patrols, nor does it say how the need for speed restrictions should be assessed.

1.51 The circular "Hot Weather Issues" dated 8 December 1994 gave some guidance as to the action to be taken dependent on rail temperature, but still required knowledge and procedures that were not available in respect of the Edendale area. For example, it required a knowledge of both the rail temperatures, and of the risk of track buckling. Even if the Acting Ganger had instituted a patrol in accordance with the code instructions, there were no guidelines available to him as to where, how and when to measure rail temperature throughout his length in a way that could be related to specific sites. In the event no rail temperature measurements were taken over the 83 kilometre gang length on 13 December 1994 or on the preceding three days of unusually hot weather.

1.52 Although addressed to two levels of Managers within NZRL as well as Gangers, it is clear that the execution of the circular "Hot Weather Issues" rested almost exclusively with Gangers.

Training, Knowledge, and Experience of Staff

1.53 The Acting Ganger had been required to lead the gang from 13 December, 1994 when the Ganger was off duty attending hospital for planned treatment following an earlier road accident. NZRL did not ensure that he had all the relevant instructions and training needed to fulfil the safety management role that he was assuming as part of the duties of the supervisory position in the gang.

1.54 The Acting Ganger could not recall whether he had been made aware of the circular "Hot Weather Issues". He had never performed or been part of a hot weather patrol although he had been in the gang for the previous two years and had spent previous time in gangs covering this area during his 23 year Railway service.

1.55 At Edendale, no speed restriction was imposed despite the hot weather. The fact that a passenger train approached a track buckle at 94 km/h indicates a failure of the safety management decision-making process.

1.56 The Acting Ganger was working at or near Invercargill on the day of the buckle. A slight sea breeze in the Invercargill area made conditions warm and pleasant, but at Edendale there was apparently no such cooling wind. The Acting Ganger did not know the rail temperatures at Edendale, or realise that conditions there were critical. He did not realise the significance of the hot weather. He had no "very hot weather" criteria that told him that a special patrol for track buckles was necessary, despite the facts that the ballast section at Edendale was below standard, the track had been disturbed by the tamper-liner twelve days prior, and the straight had a history of rail buckling (at the 562.500 km in 1992) - three of the four guidelines given in Code Instruction P90.

1.57 The documentation of track conditions, maintenance records, and local factors were inadequate for sound track safety management.

2. FINDINGS

2.1 The train was being operated normally prior to the sighting of the track buckle.

2.2 Nothing in the condition of the train, nor any action of the Locomotive Engineer, contributed to the derailment.

2.3 The track buckled because it could not contain the thermal stress in the rails in the hot weather experienced at Edendale on the day of the derailment.

2.4 It is probable that at the time of the formation of the CWR in 1988, the track did not conform with the then standards of the New Zealand Railways Corporation in respect of the ballast profile or grading.

2.5 Quality control documentation procedures for the formation of the CWR were not complied with, and there is no evidence that procedures for forming CWR were complied with.

2.6 No remedial work appeared to have been undertaken since the formation of CWR to improve areas of non-conformity.

2.7 Factors contributing to the inability of the track to contain the thermal stress in the rails included:

2.7.1 The possibility that the rails were formed into CWR without complying with Circular PW20 in such a manner as to create track with a neutral temperature less than 15°C.

2.7.2 The disturbance caused to the ballast by the passage of the tamper-liner 12 days prior to the derailment.

2.7.3 Inadequate ballast shoulders in some locations, but particularly on the western side of the track in the vicinity of the derailment site.

2.7.4 Decay in the bottom of many of the 32 year old jarrah sleepers.

2.7.5 Undersize ballast, including fines and dirt, under the sleepers.

2.7.6 Many loose fastenings.

The above are listed in perceived order of importance although it is not possible to quantify the relative impact of each factor.

2.8 Factors contributing to the derailment included:

2.8.1 The Acting Ganger at Edendale did not have adequate training to accurately assess the need for a speed restriction at Edendale to mitigate the potential effects of a track buckle.

2.8.2 NZRL's instructions on special track patrols for buckles, and the imposition of speed restrictions in hot weather over track that might buckle, lacked the detail and guidance necessary to ensure unambiguous interpretation and result in the patrols and restrictions necessary to maintain safe operation.

2.8.3 NZRL management staff did not adequately supervise or guide the Acting Ganger.

2.9 NZRL management did not detect or prevent the violations of standard procedures as set out in 2.4, 2.5, and 2.7.1 above.

3. OBSERVATIONS

3.1 While this is the only passenger train derailment due to track buckling the Commission has investigated, it is aware of other occurrences involving freight trains, and ongoing incidences of track buckling. Acknowledging that the Commission did not investigate any other derailments, or have access to relevant NZRL detailed reports, there is nevertheless a serious concern that, on the basis of available information, many of the factors behind the derailment at Edendale may have contributed to the six derailments caused by track buckles on NZRL during the summer of 1994-95. This is compounded by the fact that although this derailment did not result in death or injury, it had the potential to do so. Since the development of the unsafe situation at Edendale is understood not to be unique, the Commission believes that its circumstances must be analysed and reported in the context of all buckle-related derailments. In keeping with this approach the safety recommendations call for action to be taken based upon the Edendale findings, but also taking account of the number of similar occurrences. This is considered to be a prudent response in a period when the incidence of track buckles is of increasing concern.

3.2 NZRL's approach to the management of track buckles, understood to be "risk containment" (temporary reduction of train speed at recognised risk sites based upon local assessment), in combination with "risk elimination" (priority remedial works programme), is fundamentally correct. However, there appears to be an unreasonable expectation that the current procedures can be implemented properly by those responsible for the imposition of safety measures, given the number of potential risk sites and the level of relevant information available on which to make the right decisions.

3.3 The development of unstable track conditions, leading to the creation of a situation which was unsafe for the normal running of trains on that day, ultimately resulted in the derailment of the Southerner at Edendale. The derailment was avoidable, but occurred despite the existence of a track safety management system which was believed by NZRL to have been adequate. The principal system failings were found to be a combination of imprecise procedures and a failure to comply, but relevant underlying factors, such as adequacy of training and supervision were also identified.

3.4 The potential for buckling at Edendale should have been recognised prior to the derailment from a basic appreciation of the condition of the track at the site, and mitigating action could and should have been taken to reduce the consequences of, or possibly even to prevent the derailment. Whilst this was the intent of the procedures in place, this did not occur. It is relevant that between December 1994 and February 1995 there were a further three heat buckles on the Edendale straight. Two of these were found by special hot weather patrols and one by a Locomotive Engineer.

3.5 In the 1970's and 1980's NZR's CWR formation was associated with newly laid track or upgraded track with ballast to supply specifications and concrete or TPR sleepers. From the late 1980's the emphasis has changed to include formation on existing track, including hardwood sleeper track with existing ballast possibly well below supply specification. The Commission's investigation of the Edendale incident indicates the accepted design temperature rise for NZRL and its associated factors of safety as detailed in Research Report 195, may not now apply to early CWR where components, particularly ballast and timber sleepers, have degraded, or to later CWR installed on degraded components. It is suggested NZRL review the engineering justification for this change of emphasis to ensure the suitablity of "as degraded" track structures to withstand the forces associated with the recently defined neutral temperature range as part of recommendation 024/95.

4. SAFETY ACTIONS

4.1 Since early 1994 NZRL have had a specific programme aimed at destressing lengths known to be prone to buckling. The Edendale incident and liaison with regard to the Commission's preliminary report on it has resulted in the following additional actions by NZRL:

- The Edendale straight has been destressed to a neutral temperature of 23°C minimum and rail anchors installed.
- NZRL has stated its intent to amend the Code for ballast standards to identify the acceptable grades of ballast in CWR and other track.
- A new national priority list has been compiled for destressing 38 m rail lengths, 76 m rail lengths and longer lengths of CWR based on age and type of components and factors such as grade, buckling history and particular local maintenance problems. NZRL hopes to complete action on this list in priority order within two years.
- NZRL has reviewed training needs and commenced a specific retraining programme for Track and Structures Managers and Gangers, which included consideration of track buckles.

5. SAFETY RECOMMENDATIONS

5.1 It is recommended to the Managing Director of NZRL that he:

5.1.1 Review the training, knowledge, and experience of Track and Structure Managers, Gangers, and those required to act in such positions, in respect of their ability to identify and understand the factors leading to track buckles and make timely and safe decisions about the application of speed restrictions in hot weather.(021/95)

5.1.2 Ensure systems are in place to assess the competency of any appointed or acting Track and Structure Manager or Ganger concerned to make such decisions (022/95)

5.1.3 Review the adequacy of existing Codes and procedures and amend as necessary to ensure they include unambiguous guidelines as to:

- When, how, and where to measure rail temperatures.
- A check list of conditions which identify clearly track which may be prone to buckling.
- How to interpret the results of rail temperature measurements, and apply them to the immediate actions to be taken in respect of track which may be prone to buckling in order to ensure train safety when critical conditions are identified.
- The follow-up actions to be taken to ensure on-going safety. (023/95)

5.1.4 Undertake a review of the current safety management system relating to the installation, maintenance and operation of CWR track, and take appropriate steps to address those failings in the system which were identified as contributory to Edendale, prior to the 1995-96 summer season. As part of this review, particular attention should be paid to:

- The adequacy of standards and procedures relating to the installation and maintenance of CWR track
- The compliance with standards and procedures relating to the installation and maintenance of CWR track
- The adequacy of instructions and procedures for patrolling for track buckles in hot weather
- The compliance with instructions and procedures for patrolling for track buckles in hot weather
- The effectiveness of the training of track staff responsible for the safety of CWR track. (024/95)

5.2 NZ Rail responded as follows:

It is pleasing to note the inclusion of a new paragraph "Safety Actions" having been added to the report and to acknowledge a number of actions NZRL has progressed prior to your completed investigations.

My specific comments on the final safety recommendations are as follows:

Recommendations 021/95, 022/95, 023/95 as amended and presented as the final safety recommendations are accepted.

Recommendation 024/95 - As a result of recent discussions within the last month, between NZRL staff and your rail investigator, this safety recommendation is accepted. NZRL continues to review the adequacy of its standards, instructions and procedures on an ongoing basis and this has been progressed following last summer's seasonal hot weather and recorded track buckle occurrences. Further analysis is needed to be undertaken during the review and will continue to be ongoing.

5.3 It is recommended to the Director of Land Transport Safety Authority that:

5.3.1 In the light of the number of track buckles over the last two summer seasons, the LTSA should satisfy itself prior to the 1995/96 summer season that NZRL's safety system relating to CWR is sufficient and adequate. (025/95)

5.4 Land Transport Safety Authority responded supporting the recommendation and indicating that any action would be dependent on liaison with NZRL on the final report and all its recommendations prior to the approaching summer season.

16 August 1995

M F Dunphy
Chief Commissioner