RAILWAY OCCURRENCE REPORT

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
TRAIN NO. E-283-21-05
MILE 34.55, KINGSTON SUBDIVISION
COTEAU-DU-LAC, QUEBEC
06 MAY 1997

REPORT NUMBER R97D0113

Railway Occurrence Report

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Canadian National
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Mile 34.55, Kingston Subdivision
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Summary

On 06 May 1997, at approximately 0040 eastern daylight time, Canadian National (CN) train E-283-21-05, proceeding westward on the Kingston Subdivision, encountered a depression in the subgrade at Mile 34.55 near Coteau-du-Lac, Quebec, derailing 2 locomotives and 12 freight cars. Approximately 12,000 litres of diesel fuel was spilled; most was not recovered. Two crew members sustained minor injuries.

Ce rapport est également disponible en français.

Other Factual Information

On 05 May 1997, at approximately 2100[1], the train departed Drummondville, Quebec, travelling westward destined for Toronto, Ontario. At about 0040 on 06 May 1997, as the train was proceeding along the north track at Mile 34.55, the train crew felt the lead locomotive sag. The train dropped into a depression in the roadbed. The 2 locomotives and the first 12 cars derailed. The lead locomotive came to rest on its side, foul of the south main track. The trailing locomotive was upright but covered by derailed equipment. The crew contacted the rail traffic controller (RTC) and initiated emergency procedures. The RTC had noted that the signal line in the area had just ceased to function. The train crew had not observed any unusual track conditions as they approached Mile 34.55.

The fuel tanks on both locomotives were punctured and approximately 12,000 litres of diesel fuel drained into the nearby Rouge River. Although emergency personnel placed booms and absorption materials in the river, little diesel fuel (1,000 litres) was recovered.

The train consisted of 19 loaded EcoRail cars[2]. It was approximately 1,060 feet long and weighed about 1,000 tons. The 2 locomotives and 12 freight cars sustained minor damage. Approximately 270 feet of track was destroyed.

The train crew included a locomotive engineer and a conductor positioned in the lead locomotive. The crew members were qualified for their respective positions and met fitness and rest standards established to ensure the safe operation of trains. The locomotive engineer and the conductor sustained minor injuries.

The track structure consisted of 136-pound continuous welded rail, laid on double-shouldered tie plates on hardwood ties and fastened with four spikes per tie. The ballast was crushed rock with full cribs and 24-inch shoulders. All track components were in good condition.

The derailment occurred on a tangent section of double main track constructed on an earth fill embankment. The embankment consisted of about 3 m of crushed rock ballast, and gravel roadbed, over 11 m of a variety of clays. The Rouge River is located approximately 10 m north of the tracks.

The north slope of the embankment and roadbed had slid away, leaving approximately 20 m of the north track unsupported. The fill and base material had moved northward into the Rouge River. The slide debris completely filled the river channel and diverted the river flow.

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1 All times are eastern daylight time (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

2 EcoRail is a term used to describe a train comprised of specially designed highway trailers that are equipped with a fifth wheel attachment on the front and the rear. The trailer is attached through the fifth wheel attachment to the freight car bogies.

Pieces of fibre-optic cable were found in the slide debris. A buried fibre-optic communication cable ran parallel to the tracks along the right-of-way. This cable carried limited, non-vital code information used for railway operations. It became inoperative at 0020 on 06 May 1997. Although the company owning the fibre-optic cable could immediately determine the area of failure to within 20 miles and there was an informal protocol to inform the railway of the failure, there was no process to identify that the reported communication cable problem could potentially indicate a more serious condition such as a washout.

The Rouge River flows towards the St. Lawrence River via a culvert under Highway 338 approximately 800 m south of the derailment area, and through a siphon under the Soulanges Canal, 1 km further south. Local residents indicated that, during the spring, the culvert and the siphon often became blocked by ice and debris which caused a large rise in the water level of the Rouge River. On 07 May 1997, a considerable pile of debris was found near the inlet to the culvert, and an underwater examination of the siphon commissioned by CN revealed that it was partially blocked. Signs of high water along the river bank indicated that the water level in the recent past had been approximately 2.25 m above that found on 07 May 1997. High springtime water levels at this location did not provoke concern from CN track maintenance and inspection employees.

At Mile 34.55, the authorized timetable speed is 95 mph for passenger trains and 60 mph for freight trains. A Special Instruction indicates that all EcoRail consists may operate at Express Train Speed (65 mph). The average train traffic per day on the north and south track is 20 passenger trains and 35 freight trains. Traffic is controlled by the Centralized Traffic Control System authorized by the Canadian Rail Operating Rules and supervised by an RTC located in Montreal. The event recorder data indicated that the train was travelling at approximately 45 mph when a train-initiated emergency brake application occurred.

At approximately 2340 on 05 May 1997, freight train No. 149 passed the derailment location on the north track; the train crew did not observe anything unusual.

A track geometry car evaluated this location on 14 April 1997 with no exceptions noted. The track was last inspected by Hi-rail on 05 May 1997 and no irregularities were observed. Track inspectors are not trained in geotechnical matters; however, they are trained in water systems management.

The CN Geotechnical Engineering Branch functions as a support group to the local district engineering staff. Eastern region, located in Montreal, employs one senior geotechnical engineer, who relies on support from consulting engineers. Their inspection program included site-specific inspections and emergent conditions. The area at Mile 34.55 had not previously come to the attention of CN's Geotechnicial Engineering Branch.

The temperature at the time of the derailment was approximately 10 degrees Celsius, and there was no precipitation. Between 18 April 1997 and 05 May 1997, however, the total precipitation measured 114.4 mm; the total precipitation for 18 April 1997 (42.2 mm) was a one-day record for April. Meteorological records also point to a relatively frost-free winter in the area and rapid snow melt in the spring.

The TSB Engineering Branch concluded (report LP 72/97) that "the failure of the embankment was the result of the interaction of a number of factors" including:

1. Meteorological conditions that favoured the creation of saturated soils and high ground water levels.

2. The presence of indigenous weak subsurface clays in the embankment (clays have a low shear-strength and are susceptible to water saturation, which further lessens their shear-strength).

3. The presence of a grey clay whose strength decreases profoundly when it is water-saturated and disturbed.

4. The surface and subsurface conditions conducive to significant water migration towards and through the embankment into the river.

5. The possibility of a rapid draw down of an elevated river level and the presence of bank erosion and ice scour.

6. The probable presence of desiccation cracks in the clay near the embankment toe, due to large tree growth.

7. The vibrations and dynamic pumping effects of heavily loaded trains.

The TSB Engineering Branch further indicated that the loss of service in the fibre-optic cable approximately 20 minutes before the derailment suggests that the toe of the embankment may have failed at that time, weakening the embankment but leaving most of it intact. It was noted that the embankment was constructed some 90 years ago when geotechnical knowledge was in its infancy (i.e., the properties and characteristics of weak subsurface clays may not have been fully appreciated or understood).

Analysis

The method of train operation played no role in the derailment. A water-saturated roadbed collapsed under the train in an area susceptible to failure. The water saturation is attributable to the unusual winter and spring weather conditions. The presence of weak clays under, around and in the subgrade compromised the strength of the embankment. The presence of the grey clay, whose strength decreased profoundly when water-saturated and disturbed, is believed to have played a significant role in the collapse, and poses a safety risk when present in or under any railway subgrade. The presence of potentially unstable fills in and under the embankment is the consequence of both the limitations of construction capabilities and the understanding of soil characteristics at the time of construction. Many sections of Canadian railways have been built in a similar fashion and require protection from unusual water events to ensure safe train operation.

A comprehensive study of the geotechnical properties of the area did not exist at the time of the failure. Such an assessment would have indicated that this area was extremely vulnerable when weather conditions led to high ground water levels and saturated soils.

Since the roadbed collapsed under the moving train, it is not considered likely that a rapid draw down of the river level, attributable to a release of blockage at the culvert under Highway 338, initiated the subgrade failure. However, such an event could have triggered the collapse of the embankment 20 minutes before the arrival of the train. Certainly, at one time, the elevated water level would have contributed to the saturation of the embankment. Rapid draw down of water levels next to rail lines can lead to roadbed failure and derailment. On 19 July 1992, the breach of a beaver dam quickly lowered the level of a pond next to Mile 135.0 of the CN Caramat Subdivision, initiating a subgrade collapse that derailed a freight train. The locomotive consist tumbled into the pond, drowning two crew members (TSB report No. R92T0183). Elevated water levels in the river, which were attributable to the culvert having been blocked, occurred regularly and were easily seen from the track. Track maintenance and inspection employees should be sensitive to the potential for rapid draw down events such hazards and react pro-actively even when the cause of the flow restriction is removed from railway property.

Although a break in the wayside fibre-optic communication cable could be attributable to other sources, roadbed collapse would certainly be a potential cause in all cases. It is noted that this system is installed in the right-of-way at many locations on the Kingston Subdivision and could give warning of subgrade problems in this corridor. The company that owns the fibre-optic cable can immediately identify a failure location to within 20 miles; such information could be used as an alarm to possible subgrade collapse and a protocol could be developed to ensure timely notification to the railway.

A significant amount of diesel fuel was lost to the environment. Locomotive fuel tanks are vulnerable to impact damage and do not resist puncture to the extent possible nor does their design restrict the amount of fuel released.

Findings

1. The manner of train operation played no role in the accident.

2. The subgrade collapsed under the moving train.

3. The subgrade collapse is attributable to the presence of weak clays in the embankment that were further compromised by water saturation.
4. Abnormal winter conditions, rapid spring snow melt and record high levels of seasonal precipitation led to saturation of the fill.

5. The grey clay was particularly vulnerable to loss of strength when water-saturated and disturbed.

6. A geotechnical evaluation of the area would likely have identified the hazardous subsurface embankment condition.

7. The blockage of either the culvert or siphon, with the resultant high water level next to the embankment, may have contributed to the manner of failure.

8. Railway maintenance and inspection employees were not apparently sensitive to the hazards posed by unusual events in bodies of water adjacent to railway embankments.

9. A break in the wayside fibre-optic communication cable could serve as an alarm for subgrade collapse.

10. Locomotive fuel tanks are prone to puncture and release of fuel at derailment.

Cause

The subgrade collapsed under the moving train as a result of the presence of weak, water-saturated clays in and around the embankment.

Safety Action

Action Taken

Detection of Destabilized Railway Roadbeds

After accidents attributable to roadbed failure at Conrad, British Columbia (R97V0063), and Pointe au Baril, Ontario (R97T0097), the Board issued the following interim recommendations:

> The Department of Transport, in collaboration with Canadian National, Canadian Pacific Limited, and the British Columbia highway authority:
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> a) identify locations where railway or adjacent highway roadbeds were constructed of fill laid on silts or other similar soil material;
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> b) for those locations identified as per above, assess the adequacy of existing drainage for the spring run-off and determine if the roadbed foundations are susceptible to water saturation; and
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> c) where applicable, implement a monitoring program to detect roadbed subgrade instability as a result of water saturation.
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> (R97-01, issued April 1997)

> The Department of Transport, in collaboration with the Railway Association of Canada:
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> a) evaluate the effectiveness of current track continuity warning systems vis-à-vis roadbed failures;

b) evaluate alternative methods for confirming the integrity of the roadbed during high risk periods;

c) sponsor research to develop more reliable technologies for monitoring the integrity of both the track and the roadbed.

(R97-02, issued April 1997)

Following these recommendations, meetings were held between Canadian National (CN), Canadian Pacific Railway (CPR), the provincial Ministry of Transportation and Highways (MoTH), Transport Canada (TC) and the Geological Survey of Canada (GSC) to address the issues raised in the recommendations. Various measures were undertaken to mitigate the problems in the Thompson/Fraser corridor. CN continues with roadbed and track continuity warning system initiative consisting of field tests using the technology of time domain reflectometry as well as remote-sensing electrical measurement technique (RADAR).

Time Domain Reflectometry

Time domain reflectometry technology's application in determining cable or wire integrity over long distances has developed into the phase tracking technique of continuous level control utilized to measure solid and liquid products in silos, tanks, and other enclosed vessels. A conceptual analysis has been undertaken to determine if phase tracking can be utilized to obtain a sub-roadbed signature using the existing buried fibre-optic cable with ground sheath as the "sensor". The intent would be to generate an alarm when signature variances occur due to washout or ground slip conditions.

Radar

Radar technology has been used for perimeter intrusion detection for many years. Leaky coaxial cables are used to guide a low radio frequency field in an area where disturbance detection is required. Any intrusion in this area disturbs the field, and alarms are triggered. Prototype development and testing of a landslide detection system was undertaken between 1989 and 1992. It was proposed to build upon and refine the prototype, which would provide not only rockfall or landslide detection but also include a means of detecting a washout condition.

In addition, CPR and CN cooperatively developed a training program entitled "Geotechnology for Railroaders". This program outlines the circumstances leading up to geotechnical problems with railway roadbeds and is based on recent accident case histories.

Following the derailment, CN Champlain District commenced giving all employees responsible for track inspections training on the basic principles of geotechnics to increase their awareness of the landslide issue. An information session was also given to all the chairpersons of the Champlain District Health and Safety Committees.

A detailed emergency procedure has been developed for cases where a fibre-optic cable breaks. This procedure should ensure that, as soon as a fibre-optic cable problem is detected, the railway is notified and appropriate operational decisions can be undertaken to ensure safe train operations.

Crashworthiness of Locomotive Fuel Tanks

Crashworthiness of railway locomotive fuel tanks is now covered by the Railway Locomotive Inspection and Safety Rules, which came into force on 18 March 1998. These rules require that fuel tanks on new locomotives (the rules do not apply to the existing locomotive fleets) are to be of high impact resistant design and must have gauges protected against accidental breakage where loss of fuel would be incurred.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 10 December 1998.