Installation Factors That Affect Performance of Railroad Geotextiles

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ABSTRACT

The design of tracks on subgrades, which are identified as likely to be unstable if ballasted without the use of a separation layer, needs to have special attention paid to details that will prevent track pumping. These include, within the cross section, both good drainage practice and a suitably graded granular subballast or a granular-geotextile combination to function as a separation layer. Good drainage practice includes attention to side-ditch drainage, groundwater lowering, and internal track drainage. Particular attention is paid to internal track drainage because this topic has been found to receive insufficient consideration in numerous case histories investigated by the writer. Track that has been constructed with the deficiency of a suitable separation layer, or whose drainage is poor, or that is impacted at discontinuities of the rail such that segregation of fines from within the separation layer occurs, will need rehabilitation that should incorporate drainage improvement and possibly a heavy geotextile. These improvement requirements are explained for a number of typical locations where such problems are likely to occur. The requirements are illustrated with the description of a turnout pack geotextile used in Canadian National's Atlantic Region. Geotextiles must be correctly installed in order to maintain good track condition. Indeed, incorrect installation (particularly the lack of good drainage practice) may result in detrimental behavior.

Conventional ballasted railway track is essentially a loose assemblage of rail, crossties, ballast, granular subballast, and subgrade. These materials spread the load from the vehicle's axles and wheels to the earthen foundation beneath the track structure. In order that ballasted railway track ensure good riding qualities, there are two main requirements for adequate subgrade stability. First, a sufficient granular cover between the base of the crossties and the subgrade to reduce the loading intensity to a safe level for subgrade stability is required. Second, a granular filter blanket to be used in preventing fine-grained particles from the subgrade from penetrating upward into the ballast should be installed.

Both subgrade strength and the minimizing of particle migration are facilitated by good drainage practices. Such practices include (a) adequate side-ditch drainage to deal with surface water, (b) the lowering of the groundwater to increase the subgrade strength, and (c) the internal drainage or cross-fall sloping of subgrade and subballast surfaces to prevent water from seeping into the subgrade load-bearing area. Internal track drainage is by far the most difficult to ensure in rehabilitation work; however, in new construction, both the subgrade and subballast layers should be constructed with a 5 percent slope as illustrated in the typical cross section shown in Figure 1 for a two-track line.

In any corrective work involving the use of subballast or geotextiles, proper and adequate drainage must be incorporated into the planned maintenance. Although granular material for track support may be required to reduce the subgrade stresses to an acceptable level, geotextiles within the track structure should be selected only on the basis of their handling strength requirements and their ability to separate, filter, and facilitate drainage. Of particular importance is the geotextile's ability to facilitate drainage by transmitting water within its plane (1). Reinforcing can only occur if deformations are permitted to tension the geotextile, thus generating its tensile strength. Deformation failures are unacceptable as good design. Discussion of such deformation failures along with the depth of granular cover is beyond the scope of the work reported herein.

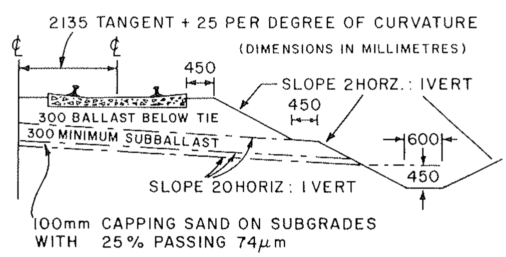

FIGURE 1 Typical track cross section for new double track construction.

UNSTABLE SUBGRADES CAUSED BY DEFICIENCY OF SEPARATION REQUIREMENTS

Irrespective of the amount of compaction a subgrade or a subballast receives during construction, some degree of permanent deformation occurs due to repetitive traffic loading. This loading is greatest below the rail causing the formation of a depression, which, if deep enough, would collect water during a

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rainstorm. On good subgrades, this depression may only be millimeters deep, but this could be sufficient to cause water ponding and considerable softening of any fine-grained subgrade soils. In order to prevent silt-sized fines from penetrating upwards from such subgrades, a separation layer will be required. Such a layer may be a subballast that incorporates nonplastic sand-sized materials grading down to the 74-micron (No. 200) sieve or a nonplastic sand-sized granular capping material. To be effective, whatever material is used must act as a filter to prevent subgrade fines from being vibrated or pumped upwards, or both. Similarly, subballast or capping sand should be either graded to prevent its finer particle sizes from vibrating upwards into the ballast, or a geotextile should be placed on the subballast or capping sand to prevent such movement (2,3). It is the author's opinion that the geotextile, if used, should be of a nonwoven type (1).

Geotextiles have been receiving considerable prominence as a possible alternative material for performing the separation function (4,5). Unfortunately, because of their equivalent opening size in relation to silt and clay-sized particles, if used alone, they only act as a partial filter to such silt- or clay-sized fines. Most geotextiles, if used alone, only retard ballast fouling. They are, however, beneficial where granular material is scarce or expensive. Geotextiles are also used on soft subgrades during new construction as reinforcement or as a working platform. However, as already noted, discussion of such reinforcement use is beyond the scope of the work presented herein.

In highway construction, modified clay layers are sometimes used as a subbase to perform the function of a separator layer. Unfortunately, dynamic loading experienced within a railway track support fill is much greater than that generally experienced by any highway support system. Impact loading from flat wheels can impose dynamic loads several times those resulting from static loading (6). Modified clay subgrades, which form a brittle, hard subgrade surface, are therefore generally subject to cracking, which, during wet conditions, results in erosion of the underlying subgrade. Consequently, they must be covered by a nonplastic granular filter material.

Should a granular subballast lacking finer sizes be used on a silt or clay subgrade, even if both are well compacted, summer dry weather may be expected to cause drying of the surfaces in contact with the subballast. Wetting after such dry weather may then be expected to cause, on the surface of the subgrade, collapse of the soil structure, which accelerates the erosion of fines upwards into the subballast. Over time, such erosion would be expected not only to foul the substandard subballast but also to foul the ballast. Once fouled, both materials may be expected to heave during freezing weather.

The importance of using a suitably graded subballast material on new construction projects, such that the material would remain unfouled by eroding fines from any underlying material and also be suitably graded (so as not to itself be vibrated upwards thereby fouling the ballast), cannot be overstressed. This material must be nonplastic so as to deform (or collapse) easily by flowing and not permit vertical fractures. On rehabilitation work, it is generally too expensive to undercut sufficiently to incorporate a subballast layer. Thus, geotextiles can be of great benefit (when correctly installed) and are often found to be the only economical solution.

GENERAL METHODS OF REHABILITATION OF FOULED BALLASTED TRACK

Rehabilitation of fouled ballast generally takes one of three forms. In the first form, undercutting of the track is performed using (a) a chainlike belt feeding down under one side of the track and up the other side, or (b) a chainsaw-type blade that extends under the track from one side only. In the belt technique, dirty ballast may be cleaned by sieving and the cleaned ballast returned for future use. Alternatively, like the chainsaw-type technique, ballast may be completely wasted. Where geotextiles are used, it is general practice to waste the ballast because it is difficult to install geotextiles between the undercutter chain and the discharge chute of the cleaned ballast.

In the second form, the track is removed by a crane, or by being pulled out of position, or by some mechanized removal equipment. Typical of the mechanized removal systems are the various switch and panel exchangers (7,8).

The third form of surface preparation for geotextiles involves the ploughing or sledding of fouled ballast. In the former technique, the plough's blades remove the crib ballast (i.e., the ballast above the base of the tie) and a small distance (about 50 mm) of ballast below the existing crosstie base level (9). Alternatively, the crib ballast may be flattened by sledding (10). When either ploughing or sledding is used, the track elevation (after rehabilitation) is raised as much as 300 mm, particularly if a geotextile is installed.

PURPOSE OF GEOTEXTILES

The accumulated fines in the dirty ballast may have come from many sources including subgrade migration, impermeable fines in the original subballast source, aggregate breakdown of either subballast or ballast, transported fines in flood water, freight car droppings, windblown sources, locomotive sand, and so forth. Geotextiles will not prevent fines from foreign sources such as freight car droppings, windblown sources, and so forth from contaminating any cleaned ballast but are of value where the foreign source has already contaminated the track support and action has been taken to prevent or minimize further foreign source contamination.

In the presence of excess water, most contaminating fines below a track, subject to repetitive wheel loads, will be pumped and migrate upwards through the track structure. The more free water there is, the faster (in general) the upward migration of fines. Thus, drainage improvement (whether the improvement of side-ditch drainage, or the lowering of the groundwater, or internal track drainage) is always the first and most essential item in any subgrade stabilization work. This is true whether or not geotextiles are used.

Special attention should be given to the undercutting of long lengths of track where, as shown in Figure 2, a "canal" effect is produced by undercutters. If, after or before undercutting, the shoulder ballast is not removed and cleaned, drainage cannot occur from the load-bearing area to the side ditches. Where possible, the shoulder undercutting should be deeper than the track undercut, as shown in Figure 3. On flat and marshy land, French drains (shown in Figure 4) may be required. Similarly, as shown in Figure 5, short lengths of undercut track such as grade crossings that are not subsequently (or during undercutting) provided with drainage will result in a "bathtub" effect. Grade crossings also suffer from the disadvantage of lacking drainage along the width of the highway. They should be provided with French drains through the crossing, as shown in Figures 6 and 7, that discharge into side ditches beyond the crossing's limits. Geotextiles should never be used as a substitute for good drainage. Indeed, if the geotextiles are in-

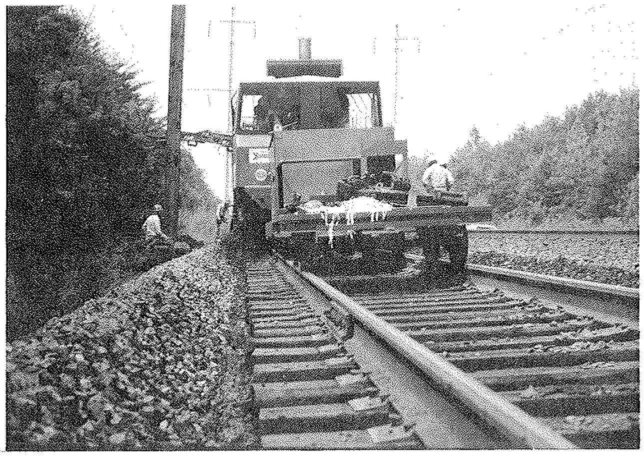


FIGURE 2 Canal effect created by undercutting operation before removal of shoulder ballast.

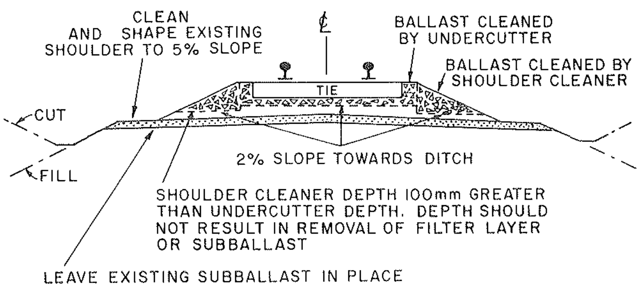


FIGURE 3 Recommended undercutting and shoulder ballast rehabilitation.

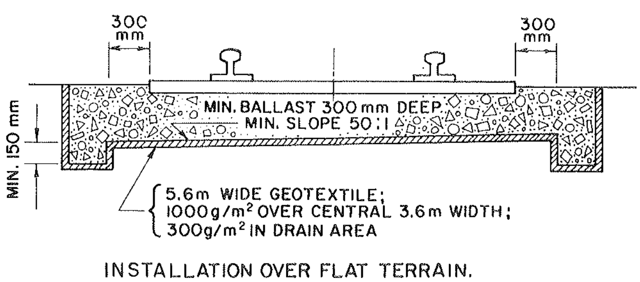


FIGURE 4 Recommended undercutting with French drains over flat terrain.

stalled without an ability to drain and discharge by gravity to side ditches or French drains, they will, as shown in Figure 8, facilitate the retention of water within the load-bearing area of the track. Water that is trapped within the load-bearing area of the track can be expected to provoke or stimulate the pumping phenomenon along with the possibility during cold weather of frost heave.

Geotextiles for tangent track have found their greatest use in terrain that is poorly drained, such as flat and marshy country. They are also being used at locations where it is difficult to maintain good drainage or at locations that have high localized impact loadings and where the geotextile, by facilitating drainage, reduces the amount of maintenance required. This is particularly true of places such as grade crossings, diamonds, turnouts, and track structures.

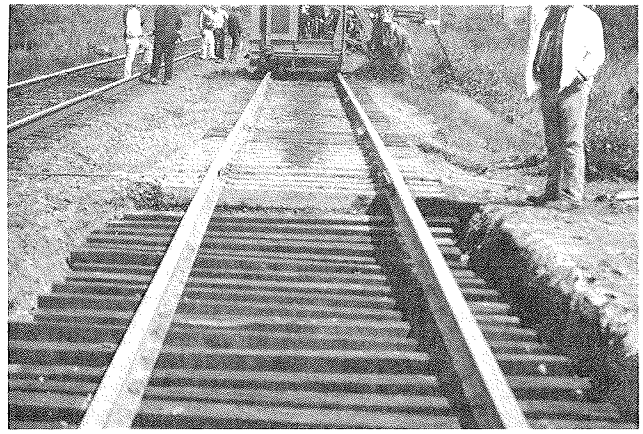


FIGURE 5 Bathtub effect produced at grade crossing rehabilitation before construction of outlet drains to ditches.

BASIC FUNCTIONAL REQUIREMENTS OF GEOTEXTILES

In general, when dealing with track rehabilitation problems, the track has been in existence for some time and excessive subgrade settlements have ceased. The use of a geotextile's strength for subgrade reinforcement will not, under these circumstances, be a major consideration. Rather, they should be highly abrasion-resistant and durable to withstand the harsh environment of ballast particle movement on ballast or subgrade aggregate. On undercut, ploughed, or sledded track in which the rail remains in place during rehabilitation, the prepared surface to receive a geotextile, as shown in Figure 9, will contain ballast particles either lying on the surface or protruding from the surface. Although raking would remove some of these protrusions, the prepared

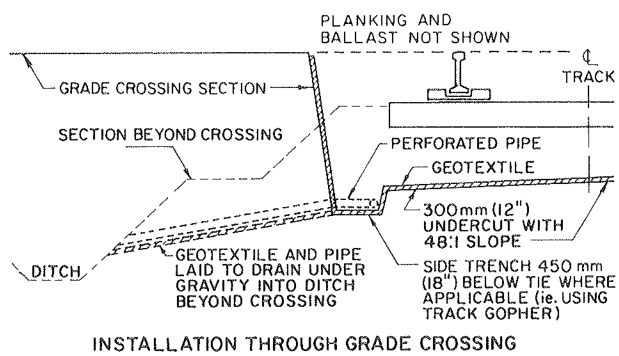


FIGURE 6 Typical grade crossing rehabilitation with geotextile.

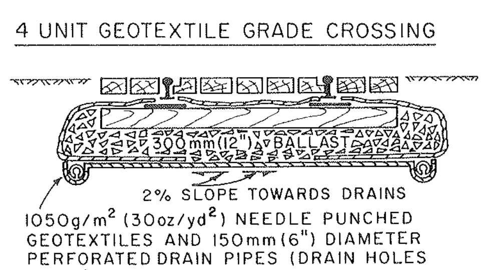


FIGURE 7 Recommended grade crossing rehabilitation with encapsulating geotextile to minimize fouling by salting and sanding.

FIGURE 8 Effect of installing a geotextile without adequate drainage.

surface will remain rough and any geotextile placed on it will not only have to be abrasion-resistant, but should also have the ability to elongate around such protrusions without puncture or tear. If punctured or worn through, the geotextile will clearly lose some of its ability to filter and separate.

The ability to transmit water within the plane of the geotextile has been observed on a number of installations during the passage of a train. When an axle or group of axles passes a location, the track support compresses. If saturated or near-saturated, water will either escape or try to escape along the path of least resistance. Geotextiles with in-plane permeability offer such a path even when placed in sand or broadly graded gravel layers. Water pumping from the edge of a geotextile with the passage of each group of axles has been observed on a number of installations. Such water must be permitted to drain into the side ditch and not back into the load-bearing area of the track.

From the material already presented, it is apparent that the basic functional requirements of geotextiles in railroad bed rehabilitation technology are the capacity

1. To drain water away from the track roadbed (on a long-term basis, both laterally and by gravity) along the plane of the geotextile without build-up of excessive hydrostatic pressures;

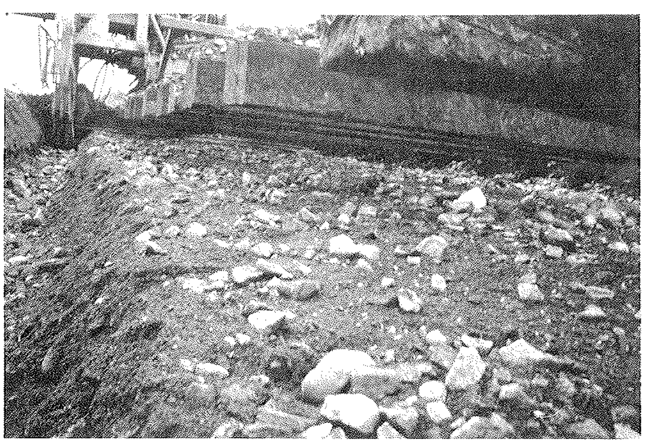


FIGURE 9 Typical condition of undercut surface prepared to receive geotextile.

2. To withstand the abrasive forces of moving aggregate caused by the tamping and compacting process during cyclic maintenance, tamping during initial compaction, and by the passage of trains on a frequent basis;
3. To filter or hold back soil particles while allowing the passage of water;
4. To separate two types of soils of different particle sizes and gradings that would readily mix under the influence of repeated loading and of water migration; and
5. To have the ability to elongate around protruding large angular gravel-sized particles while resisting rupture or puncture.

SHOULDER REMOVAL FOR DRAINAGE

When fouled ballast is removed from a track structure, it is important to achieve good drainage in the track shoulders. As shown in Figure 3, the ballast shoulders should be removed and cleaned or replaced to a level below the freshly prepared track surface. Care should also be taken to see that the excavated surface is sloped toward the side ditches. Where shoulder replacement is not practical, a French drain or equivalent should be used. Dirty ballast will retard lateral drainage to the side ditches or French drains unless care is taken to adequately remove the spoiled pile of dirty ballast at the shoulder, particularly when the spoil has been discharged on the shoulder. Another undesirable feature that has been frequently observed is the backfilling of undercutter trenches (typically produced by turnout or switch undercutters) with dirty ballast on the pretext of cost savings on ballast replacement. Unless water can drain away from the track-bearing area, it will pond within the track structure, softening the trackbed and facilitating its return to the original fouled condition. Such trenches should be used to advantage and converted into French drains. In multitrack areas, it may be necessary, as shown in Figure 4, to excavate additional French drains on both sides of the track. Underdrains should also be used to discharge the central French drains to the side ditches if side ditches exist. Excavated soil should not be deposited on the track because this allows water to wash the fouling fines back into the French drains or into the track-bearing area.

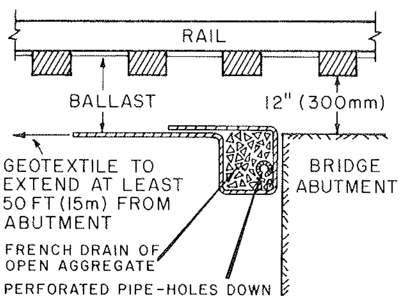
If, in cutting the trench, the subballast is removed so that the bottom of the trench is situated in the subgrade soil, a geotextile should be placed on the trench bottom and sides or a correctly graded subballast placed on the bottom of the trench as a separator. The geotextile should be engineered to be compatible with the surrounding soil so as to prevent or minimize fouling or in-filling. The trench should then be backfilled with clean ballast aggregate to aid side drainage. Fouled spoil that has been previously removed from the trackbed should not be used within the drainage trench. It is recommended that the depth of clean ballast within the trench be a minimum of 100 mm (4 in.) below the prepared undercut surface to allow for quick drainage away from the area below the track ties. Again, the fouled ballast should be deposited below the prepared trench bottom or removed completely so as to ensure good side drainage.

INSTALLATION BELOW LOCAL GROUND ELEVATION

In locations such as are shown in Figure 4, where the geotextile will be installed below the local ground elevation, steps should be taken to guard against the inflow of water from the ground surface on any sides of the track that may be elevated above the geotextile. A number of installations inspected have shown that the ballast above the geotextile and the geotextile itself may be fouled with fines from beyond the end of the ties. This fouling results from water draining laterally from above the undercut elevation into the track structure, transporting fines into the ballast. To prevent this, a French drain may be installed along the edge of the track, which is lined or encapsulated in a geotextile. The geotextile should be selected so as to filter the inflow of water from above and beyond the prepared surface. The prevention of such water inflow into the track-bearing area is an added reason for establishing a trench along the side of the track during the undercutting process. In flat land areas, it may be necessary to construct soak-away pits away from the track structure to allow drainage of the water from the French drains.

INSTALLATION AT BRIDGE ABUTMENTS

A typical bridge abutment rehabilitation is shown in Figure 10 and incorporates a geotextile and French drain combination to increase drainage rates, decrease pumping, and generally increase track stability at the transition location from soil subgrade to bridge abutment.



GEOTEXTILE: 30oz/yd^2 (1050g/m^2) MINIMUM MASS PER UNIT AREA; NEEDLE PUNCHED; 2% MINIMUM CROSS-SLOPE FALLING TO SIDE DRAINS

FIGURE 10 Typical method of rehabilitating bridge abutments using geotextiles.

INSTALLATION AT GRADE CROSSINGS

Grade crossings foul because of a lack of adequate drainage in the central region of the crossing and because of winter sanding of highways, as revealed by the removal of the crossing planks shown in Figure 11. High-impact loads may be expected at the crossing upon entering and leaving the more rigid track structure. The loads continue to overstress the track well beyond the grade crossing because of a harmonic motion established by the rolling stock. The higher stress placed on the subgrade will quite often generate localized pumping. For this reason, it is important to achieve a dry, stable subgrade at grade crossings, and it is also desirable to achieve similar conditions roughly 15 m (50 ft) to either side of it.

Drainage at a grade crossing is generally parallel to the rails until the road pavement and shoulders have been cleared. The drainage flow should then be turned perpendicular to the track to discharge into

FIGURE 11 Typical condition of fouled grade crossing having inadequate drainage at centerline.

the ditch, or into a French drain leading to a soak-away pit. Perforated drain pipes are sometimes used and may be wrapped in a geotextile or purchased pre-wrapped. Either wrapped or unwrapped, the pipes will assist the flow of water from within the crossing to the ditches beyond the crossing. The pipes should be laid with the line of perforations pointing vertically downward. Such pipe can be placed on the geotextile in the trench prepared by the bucket wheel of the undercutter. The ends of the perforated drainpipes and the crossing geotextile should then be laid with a sufficient fall towards the side ditches as shown in Figures 6 and 7. Whether perforated pipes are used in the crossing nor not, it is advisable to remove the shoulders at the corner of the crossing and turn the geotextile ends down so that the geotextile facilitates drainage under gravity toward the side ditches as shown in Figure 6.

In cold weather climates, where it is common to salt and sand highways, including grade crossings, some railroad engineers require the grade-crossing geotextiles to encapsulate the ballast to prevent or minimize surface fouling from the salt and sanding process. Such an encapsulating geotextile is shown in Figure 7.

INSTALLATION OF TURNOUT PACK GEOTEXTILE

In the Atlantic Region of the Canadian National Railways (CN), a large number of turnout pack geotextiles have been installed since 1983. It was found that geotextiles are best installed using the same work gang. On August 27, 1985, the author was present at the site of a geotextile installation performed by CN's Atlantic Region geotextile work crew. The geotextile was delivered to the site the previous day. Vandals had already removed the geotextile's weatherproof black polyethylene packaging. Fortunately, it did not rain overnight, otherwise, the geotextile would have absorbed water, which would have resulted in a dramatic increase in weight, making the geotextile difficult to handle. The delivered weight of these turnout packs when dry is between 300 and 500 kg. Because they have a porosity between 80 and 90 percent, saturation can increase their weight by a factor of 4, resulting in a saturated weight of between 1200 and 1500 kg, so that, where possible, delivery of the geotextile should be made on the day of installation. The turnout pack rolls are approximately 7 m long and were handled by six persons using three crowbars. The crowbars were positioned, one near each end of the roll and one near the center. One person was situated at the end of a crowbar.

Work started at 10:10 a.m. local time as soon as a local passenger train had passed through the turnout to be rehabilitated. A ballast regulator first removed the ballast from the end of the ties to the ditch to a depth about 200 to 300 mm below the base of the tie on the turnout track side of the turnout. A passing siding ran parallel to the main-line track on the other side of the turnout so that ballast removal was not possible on that side. The ballast regulator completed its job in about 10 to 15 min, after which the gopher undercutter was moved to a position on the turnout about 9 m from the point of the turnout. The undercutting sequence is shown in Figure 12. The bucket excavator proceeded to excavate a trench about 4 m long and 700 mm deep so that the blade of the undercutter could be positioned to its full depth of about 300 mm below the base of the ties in order to start the undercutting operation.

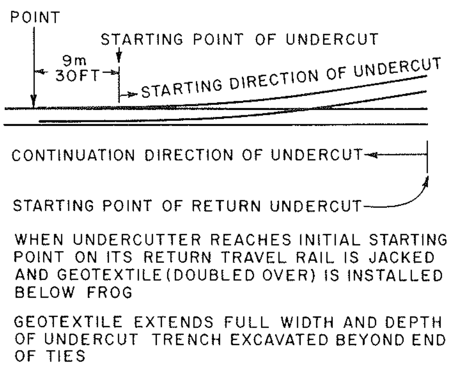


FIGURE 12 Turnout undercutting sequence observed on CN's Atlantic Region.

The track was then undercut to approximately below the closest tangent rail. This procedure continued until the undercutter had gone along the turnout track sufficiently so that its blade was extended fully under the turnout track and was well clear of the end of the ties of the tangent track. Measurements taken below both ends of a tie indicated that, although the undercutter blade was fixed horizontally during undercutting, it flexed sufficiently that the prepared surface had a 2 percent slope towards the bucket-made trench.

The undercutter was then repositioned on the tangent track with its bucket wheel swung through 180 degrees so as to undercut from the other side of the turnout. A 4-m trench was made by the bucket wheel to lower the undercutting blade below the tangent track portion of the turnout. Undercutting continued to well beyond the point of the turnout. When the undercutter had approximately 12 m more undercutting to reach the point of the turnout, the geotextile was unrolled so it could, if necessary, be shortened or positioned to fit the expected final undercut area of the turnout. Once this was done, the turnout point end of the geotextile was lifted and pulled to the wide-end portion of the turnout so that the geotextile lay doubled over for half its length. Rail jacks were then installed to raise the half length of turnout, which was to receive the doubled-over geotextile. The doubled-over geotextile was manually pulled under the wide end of the turnout as seen in Figure 13. Once in position with its edges

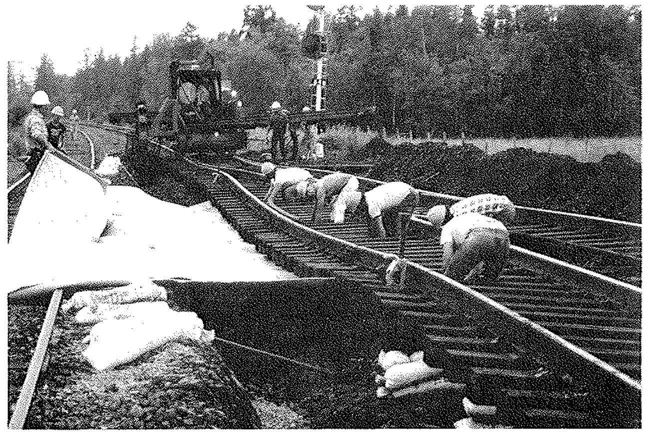


FIGURE 13 Placement of doubled-over geotextile below half area of turnout.

trailing into the ditch left by the bucket wheels, the upper layer of the geotextile was fanfolded toward the center of the turnout so that about three-eighths of the geotextile was ready to receive ballast.

Cotton bags, approximately 150 mm in diameter and 700 mm long, filled with fine-gravel-sized crushed aggregate, were then placed on the geotextile as spacers between the geotextile and the base of the crossties. Two bags were placed at each end of about every fourth to fifth tie so that when the rail jacks were removed, the bags supported the ties approximately 300 mm above the geotextile. Once the ballast bags were in place, the track jacks were released and the track gently lowered down onto the ballast bags. The jacks were then moved and repositioned. One pair was positioned at the end of the fanfolded geotextile on three ballast bags placed side by side, as shown in Figure 14. Figure 15 shows the turnout during the rail jack relocation procedures. The track was raised and the fanfolded portion of the geotextile was unfolded. It was not possible to extend the fanfolded portion fully in one unfolding so the procedure was repeated several times. Consideration could have been given to installing the turnout pack in two halves with a double heat-jointing seam. This would have simplified installation.

Once the turnout had been completely undercut, the geotextile completely extended, and ballast bags placed to support the track throughout its length, the turnout was ready to receive ballast. The ballast car first unloaded ballast into the French drain

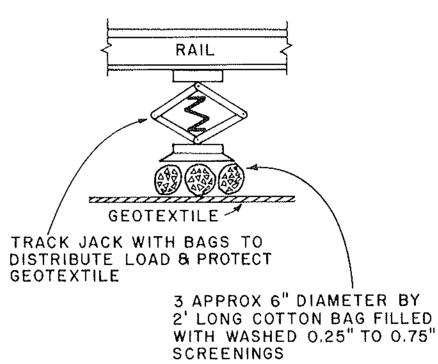


FIGURE 14 Method of protecting geotextiles from high imprint pressure of rail jack bases.

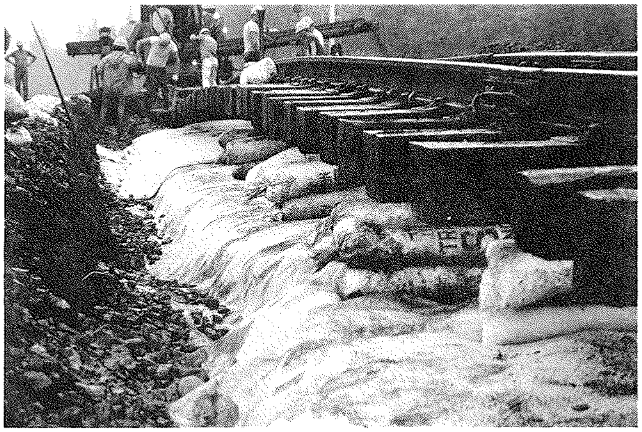


FIGURE 15 Geotextile in position below half of turnout with relocation of rail jacks taking place.

trench area beyond the end of the crossties, as shown in Figure 16. It then deposited ballast across the full undercut area. Ballast was placed until the cribs of the ties were overflowing. The turnout was left in this condition and traffic allowed through the turnout until the next day. On the next day, not only was the tamping and cleanup completed to permit traffic to proceed at the posted speed, but perpendicular trenching was performed at both ends of the bucket-made trench on both sides of the track so as to extend to the side ditching in a manner similar to that shown in Figure 17. In the case of the tangent turnout side-trench, the perpendicular trenching involved was under a passing siding. These four perpendicular trenches clearly benefit the exit of surface water during heavy rainstorms.

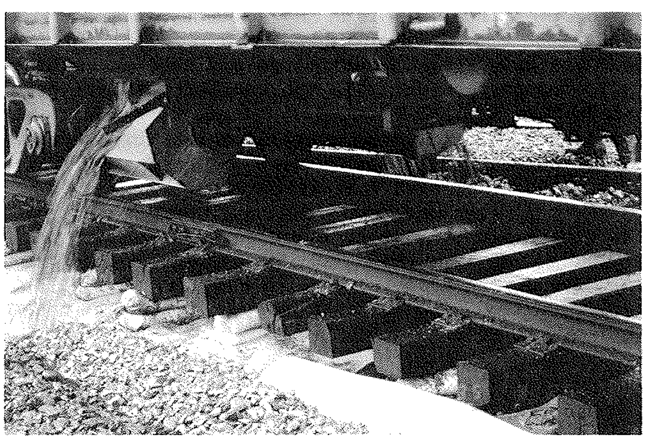


FIGURE 16 Filling French drain of turnout with ballast showing track supported by ballast bags.

DEPTH OF INSTALLATION

One of the contributing factors to a geotextile's performance in-track is the depth at which it is placed below the base of the ties. It is well known that the intensity of pressure generated from a standard wheel load is distributed through the track structure so that the pressure intensity decreases with depth. Depending on the abrasive or puncture resistance of the geotextile, or both, being installed, there should ideally be an optimum depth

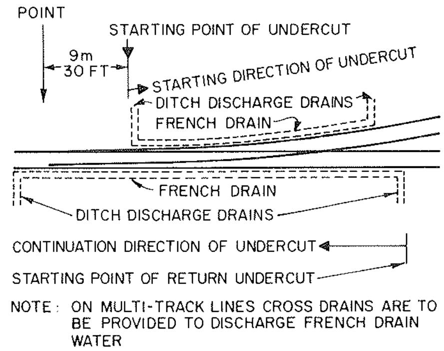


FIGURE 17 Illustration of positioning of perpendicular trench.

where the geotextile can be installed during a track upgrading process so that little or no damaging effects of ballast punctures and abrasion occur, thus prolonging the life of the geotextile. From a practical standpoint, abrasion depends on the deformations occurring at the geotextile level and, thus, subgrade modulus. The subgrade modulus is, to a large extent, controlled by track drainage, since soil behavior is very much dependent on soil suction and, thus, moisture content. Good drainage by the geotextile should result in decreased moisture and increased track modulus. Such an observed increased in track modulus when geotextiles are used is often incorrectly attributed to the geotextile's reinforcement effect. In fact, for reinforcement to occur, there must be an extension of the geotextile and, thus, a relatively large settlement of the subgrade. Such settlement is, in the opinion of the writer, undesirable. Rather, the geotextile should stiffen the subgrade by facilitating the drainage of moisture, thus reducing any chance of subgrade deformation and reducing any need for reinforcement. Increased track modulus also should mean reduced movements within the ballast and less abrasion to the geotextile from such movements.

To assess the effect of abrasion with installation depth, data were obtained from several sites installed with a needlepunched resin-treated geotextile--all having a mass per unit area between 450 and 510 g/m². After excavation, the estimated damage to each geotextile obtained from each location was obtained by measuring the percentage of completely worn-through areas in the worst 300- x 300-mm square section (generally below the intersection of the rail and tie). These results have been plotted against the measured geotextile's depth at the time of excavation in Figure 18. The values range from 0.3 percent at a depth of 350 mm to 4.1 percent at a depth of 175 mm. The results show that the amount of damage that the geotextile received increased as the depth of ballast between the crosstie base and the geotextile was reduced. The damage was also major once the depth of ballast was less than 200 mm. Below 250 mm, the amount and rate of change in damage was small.

Also measured on the same geotextiles was the amount of soil that penetrated each geotextile sample. This was estimated as the soil content (weight of internal soil divided by weight of fiber after cleaning expressed as a percentage). These results are shown plotted against excavation depth in Figure 19. From Figure 19, it may be seen that considerable geotextile fouling occured once the geotextile depth was less than 200 mm below the tie base.

The results shown in Figures 17 and 18 suggest that a depth of about 250 mm should be used as a minimum depth for the installation of geotextiles.

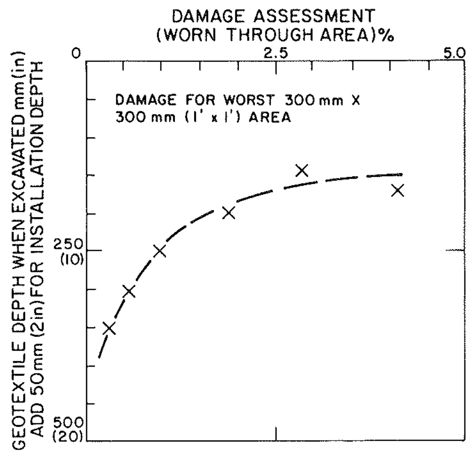


FIGURE 18 Depth of geotextile-abrasion assessment for recovered track geotextiles.

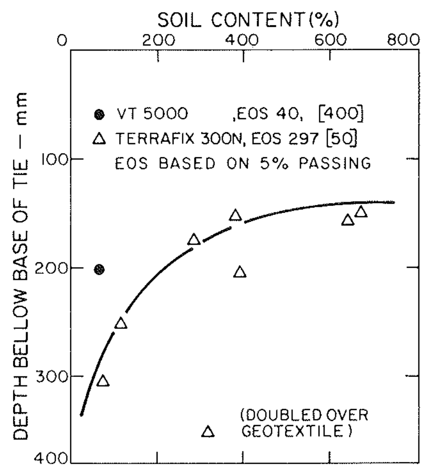


FIGURE 19 Depth of geotextile-soil content assessment for recovered track geotextiles.

Assuming that a 50-mm increase in ballast depths occurs during tamping, then a minimum 200-mm depth of ballast should be placed on a geotextile before the tamping of a rehabilitated ballasted track in which a geotextile has been installed. Where practical, a 300-mm ballast depth is recommended.

SUMMARY AND CONCLUSIONS

Design of tracks on subgrades identified as likely to be unstable if ballasted without the use of a separation layer (i.e., subgrades containing 25 percent or more passing 74 μm sieve) will need to incorporate within the cross section both good drainage practice (see Figure 1) and a suitably graded granular subballast or a granular-geotextile combination to function as a separation layer.

Track that has been constructed with the deficiency of a suitable separation layer, or whose drainage is poor, or that is impacted at discontinuities of the rail such that segregation of fines from within the separation layer occurs will need rehabilitation that should incorporate drainage improvement and, possibly, a heavy geotextile.

Particular attention needs to be directed to improving internal track drainage. This involves the sloping of interface layers or undercut surfaces toward drainage ditches or French drains. In particular, the creation of the canal or bathtub effects during rehabilitation should be avoided. Proper and adequate perpendicular drains to prevent water accumulating in the track structure or in French drains should be incorporated in rehabilitation work.

Recommended procedures for undercutting track without the use of geotextiles are shown in Figure 3. Rehabilitation with geotextiles is shown in Figures 4, 6, 7, and 10. The sequence for undercutting and installing geotextiles below turnouts is presented in the text and is shown in Figures 12 through 17, inclusive.

Highlighted is the incorporation of French drains in areas of the track difficult to drain. In particular, the discharge end of any installed geotextile must be located below the level of the undercut load-bearing area.

It is recommended (see Figures 18 and 19) that a minimum depth of 200 mm of ballast should be placed on a geotextile before the tamping of a rehabilitated ballasted track in which a geotextile has been installed. Where practical, a 300-mm ballast depth is recommended.

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