VACUUM EXCAVATION TECHNOLOGY FOR BALLAST AND GRADE REMEDIATION ON SPECIAL TRACK WORKS

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SUMMARY

The Railvac purchased by MRS in 2012 was a very good investment. The comparison of Tunnel 12 proved the economics of the Railvac methodology over the traditional method for MRS by reducing project duration 87%, reducing resource requirements 76%, and increasing the productivity (work completed per total hours expended) over 3,000%.

With the use of Loram's Railvac, the CN was able to clean up an environmental concern safely with less waste than traditional methods and in half the expected time.

A 7.5 m (24.6 ft.) mud spot next to a platform and on third rail track was totally restored and back in service with one hour to spare of the 4.5 hour work window granted for the project.

MRS tracked their productivity (m^3/hour) for one full year (March 26, 2013 to March 26, 2014). During this period MRS operated the Loram Railvac a total of 125 days and 243.75 hours. Its production for that year averaged 25.9 m^3/hr. MRS continues to make improvements in their productivity and have recently reduced the Railvac operating crew from four to two people, which will further reduce the cost.

These are just a few examples of how the Railvac can help you keep Specialty Trackwork ballast maintained and healthy while also saving time, money, and resources over the traditional methods of Specialty Trackwork Ballast Remediation.

The Railvac can take your Specialty Trackworks from:

This To This To This

in less time, with fewer resources and less disruptions than traditional methods for your Specialty Trackworks Ballast Remediation Projects.

INTRODUCTION

Specialty Trackwork Ballast Remediation is the process of correcting moderate to severe ballast deterioration conditions through ballast replacement to regain required drainage and stability attributes on Specialty Trackworks including switches, crossings, bridge decks, viaducts, tunnels, platforms, random mud spots or track with third rail electrification.

Specialty Trackwork is an expensive part of any railroad's infrastructure. In North America, the Special Trackwork annual cost, for just turnouts and diamonds, is more than $1 billion USD. Maintenance and train delay represent over 50% of that cost (1). Specialty Trackwork maintenance represents approximately 5% of maintenance budgets and up to 50% of train delays are attributed to Specialty Trackworks. The payback for keeping Specialty Trackwork maintained can be significant.

Although ballast has many functions, there are two main applications in its interaction with Specialty Trackwork structures. First ballast needs to anchor the track and provide resistance against lateral, longitudinal, and vertical movement of ties and rail while distributing the applied load with diminished unit pressure to the subgrade beneath. The second important function of the ballast is to provide drainage (2). However, the repeated impact loading on the ballast, as trains pass, cause the ballast's sharp edges to break off and wear down into fines. The ties also begin to deteriorate and add to the fines from the ballast. These fines then begin to impede the drainage of moisture. As moisture and fines combine, the ballast begins to lose its ability to provide the stability. This deterioration begins with the first load applied to the ballast as the trains begin rolling on the rails. If the fines and silt are not removed with routine maintenance, the ballast loses its ability to restrain the track from lateral, longitudinal, and vertical movement. If not corrected with removal of the contaminated ballast and replaced with good ballast, the probability of broken rails and derailments is significantly increased. Even with proper maintenance for drainage, over time the ballast will deteriorate and lose its ability to provide resistance to lateral, longitudinal and vertical movements because the sharp edges and corners of the ballast become worn over time and lose their interlocking strength thereby requiring ballast replacement.

The most effective means of restoring track performance on Specialty Trackworks is ballast replacement. Traditional ballast replacement practices are expensive, highly disruptive, and often involve the removal of the superstructure so off-track equipment can be used to remove the ballast. In areas where off-track equipment use is not feasible, using manual labor or deploying an undercutter, if available, are options. However, undercutters are designed for use on major track rehabilitation projects and availability for a Specialty Trackwork project usually does not have the priority over the major rehabilitation project. If the Specialty Trackwork has restrictive clearances, the undercutter is not an option. Furthermore these processes render the track inaccessible, create significant track outages, and are resource intensive.

1. MRS LOGISTICA S.A. OVERVIEW

MRS Logistica S.A. (MRS) is a Brazil-based company engaged in transportation services. The company focuses on freight railroad transportation and is active in the control, operation and monitoring of the Southeastern Broad Gauge Network (Figure 1) since December 1996. The company has been in railway transportation of cargo including iron ore, finished steel products, cement, bauxite, coal, containers and agricultural commodities, among others. It interconnects the Brazilian states of Minas Gerais, Rio de Janeiro and Sao Paulo, as well as ports of Rio de Janeiro, Guaiba, Itaguai and Santos. This region amasses approximately 55% of Brazil's gross domestic product and is home to the country's largest industries.

Figure 1: MRS Logistica Southeastern Broad Gauge Network

MRS has 1,643 km (1,021 mi) of 1600 mm (63") track with 76 km (47.2 mi) of tunnels and 32 km (19.9 mi.) of closed platform bridges and viaducts. The track traverses through very rugged mountainous terrain which receives an average rainfall of 100 -150 cm (40 - 60 in.) per year. Traffic density is very high on this track with axle loads of 32 tonnes (35 tons). These difficult conditions and the abundance of Specialty Trackwork assets such as tunnels, bridges, viaducts and switches require a tremendous effort to keep the track well maintained.

2. MRS CHALLENGE

MRS realized it was time to find a better method of rehabilitating their Special Trackwork following a 2009 derailment in Tunnel 9 (Figure 2) caused by a broken rail as a result of ineffective ballast and drainage maintenance.

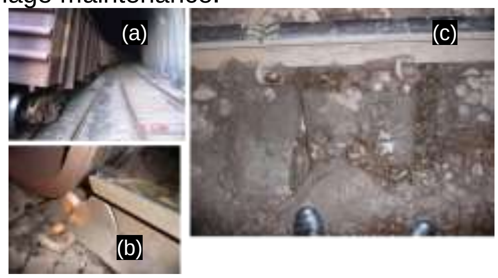

Figure 2: (a) Derailment; (b) Broken Rail; (c) Ballast Condition[SAB1]

MRS had been performing manual track maintenance, but it was becoming very apparent this ballast and drainage maintenance was inadequate. The quantity and quality of ballast maintenance on MRS's Specialty Trackwork assets was not sufficient for the demands placed on those assets. The amount of Specialty Trackworks Ballast Remediation was not enough to keep up with the rate of deterioration. The quality of the Specialty Trackworks Ballast Remediation was not sufficient to sustain strong ballast functions between routine maintenance schedules. In fact the ballast condition had reached a point where it was jeopardizing the safety and reliability of the track.

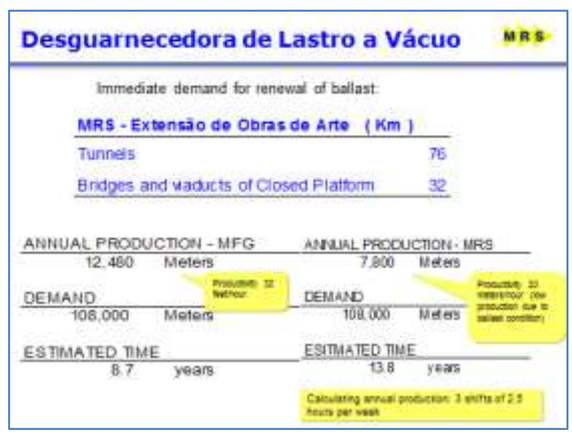

Figure 3: Estimated time for entire Specialty Trackworks System Ballast Remediation with Traditional Method (right side) and with Loram's Railvac (left side)

Tunnels, bridges, and viaducts became MRS highest priority. The system has 76 km (47.2 mi.) of tunnels and 32 km (19.9 mi.) of bridges and viaducts that needed ballast replacement and with their current method of manual labor, it would take an estimated 13.8 years to accomplish (Figure 3). Out of the entire system it was determined that 10 km (6.2 mi.) of tunnels and 26 km (16.2 mi.) of bridges and viaducts were critical to the success of MRS and needed immediate rehabilitation. To accomplish this goal would take an estimated 4.6 years with manual labor (Figure 4).

Even the time frame for renewing only the critical tunnels and viaducts was unacceptable. MRS needed to find a better and more productive Ballast Remediation method for their Specialty Trackworks System.

Figure 4: Estimated time for Critical Priority Specialty Trackworks System Ballast Remediation with Traditional Method

3. MRS SEARCH FOR A NEW SPECIALTY TRACKWORKS REHABILITATION METHOD

Realizing the current method of ballast and drainage maintenance on Specialty Trackwork assets was insufficient, MRS went on a mission to find a better and more productive method. MRS hired Delachaux Group as a consultant. Following a study of the MRS System, Delachaux Group provided a report of their findings. A part of the Delachaux Group's report relating to the concrete viaducts recommended the complete removal of the existing badly contaminated ballast and replaced with good quality new ballast and a new track (ties and rail) at the same time (Figure 5).

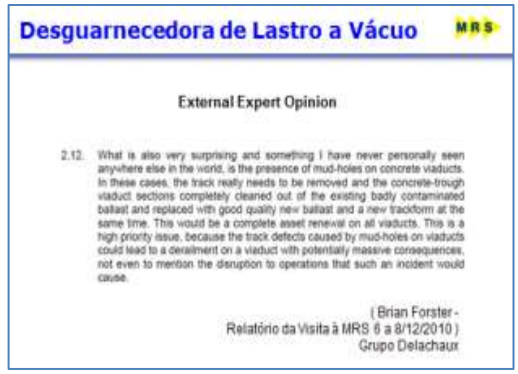

Figure 5: Section 2.12 of the Delachaux Group Report

An MRS exploratory team visited a North America Class 1 railroad to discover how they were cleaning their tunnels (Figure 6). On their visit, they witnessed a Loram Railvac™ undercutting fouled track in a tunnel with tight restrictive clearances, which mirrored the conditions on MRS's system. The track had serious drainage issues and the ballast was very wet and contaminated. The MRS Exploratory Team realized that with a Railvac they could be more productive in maintaining the ballast in their tunnels and on their bridges and viaducts. With the Loram Railvac the opportunity to maintain their Specialty Trackwork assets to a higher standard was possible. The team's next step was the development of a justification for the investment in equipment and training for the next generation of Specialty Trackwork Rehabilitation Methodology.

Figure 6: Visit to North America Class 1 Railroad

4. MRS'S RAILVAC JUSTIFICATION

Because the tunnels, bridges, and viaducts had been without effective maintenance for decades, MRS's ballast condition was jeopardizing the safety and reliability of the rail system. MRS realized the need for a complete change in the approach to Specialty Trackworks Ballast Maintenance. They needed a better method of restoring track performance that still included ballast replacement but was less expensive, less disruptive and required fewer resources. It would require the purchase of a Loram Railvac (Figure 7) machine plus the operation and maintenance training.

Figure 7: Loram Railvac[SAB2]

MRS saw the Loram Railvac as a versatile machine with a tremendous amount of flexibility. It was designed to work as an undercutter, excavator, or high performance debris or Hazmat collector capable of working in open track areas as well as in the restrictive clearance environments that are commonly associated with Special Trackworks. The six degrees of freedom on the nozzle (Figure 8) and the capability of rotating the nozzle 45° from vertical in all directions (Figure 9) would make it easy to reach those difficult spots when undercutting and trenching. The Railvac was also very versatile in handling the waste material. It could store 15 m^3 (20 yd^3) of material onboard, dispose of the material, onto the right of way, up to 9 m (30 ft) either side of track center or transfer the material directly to a material handling car. The Railvac can also haul four full ballast cars at speeds up to 80 km/h (50 mph).

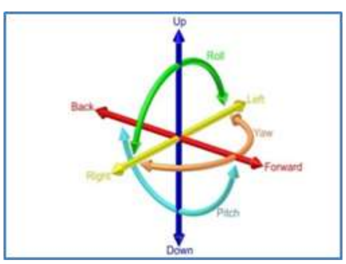

Figure 8: Six Degrees of Freedom Diagram

Figure 9: Nozzle rotating to 45° from vertical

In compacted ballast conditions, the Railvac's work arm could use its 2,270 kg (5,000 lbs.) of penetrating force and rotating nozzle to quickly break up material for quick disposal at a rate of 15 m^3/hr. (20 yd^3/hr.).

The Railvac has the unique ability to access any location by rail, eliminating the need for off-road access equipment. It has the power and ruggedness to breakup compacted ballast. It has the flexibility to reach up to 4.5 m (15 ft.) to either side of the track center to clear ditches or unplug culverts with its nozzle but still has the gentleness and finesse necessary to uncover sensitive objects like buried communication wires, drainage tile, or switch componentry without the risk of damage (Figure 10).

[SAB3]

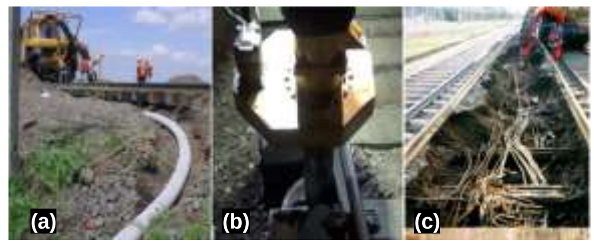

Figure 10: (a) Trenching; (b) Rotary Nozzle in compacted ballast; (c) Wires uncovered by Railvac

MRS recognized the Railvac as a machine that would allow them to provide an improved standard of ballast maintenance with minimal track disruption and extremely large reductions in resources.

In addition to the benefits that Loram's Railvac provides, there must also be an economic justification for the investment. MRS's current method required a train to haul away the waste. They knew this requirement could be eliminated because the Railvac offered many acceptable options for waste material handling.

MRS estimated an increase of 60% in productivity from 20 m^3/hr. to 32 m^3/hr. (65.5 ft^3/hr. to 105 ft. ^{3} /hr.) plus a 76% reduction of manpower. MRS had been using 50 people under their traditional method, and they estimated 12 people would be required with the Railvac.

MRS estimated the unit cost of the Railvac at R$93.95 ($29.69 USD). This included the depreciation cost of the Railvac, operating expenses and wages of 12 people. Under MRS' traditional method the unit cost ranged from R$155.13 ($49.02 USD) on the low end up to R$425.44 ($134.43 USD). This range was dependent on the complexity of the ballast replacement work being completed. The average unit cost under the traditional method is R$290.29 ($91.73 USD) (Figure 11). Comparing the average unit cost under the traditional method against the estimated unit cost of the Railvac results in a per unit savings of R$196.34/m^3 ($62.04 USD/m^3). With an annual production estimate of 12480 meters (40945 feet) the estimated annual savings would be R$2,450,260 ($774,228 USD).

Figure 11: Tunnel -Comparison used in Justification[SAB4]

5. MRS TUNNEL 12 TRACK REMEDIATION PROJECT ECONOMIC COMPARISON

Tunnel 12 of MRS Railway was chosen for a comparative study to determine the economics of the Railvac methodology versus the traditional method used at MRS. The length of Tunnel 12 is 2,233 m (1.39 mi.). The last time Tunnel 12 was re-ballasted using the traditional method, it required 110 days of 8 hour duration with 50 workers for a total cost of R$950,000.00 ($300,200 USD).

Using the Railvac on the same tunnel of 2,233 m (1.39 mi.) of track and 8 hour duration days changed the economics considerably. The project was completed in 14 days. The number of people used with the Railvac project was 12. The total cost of the project, using the Railvac, was R$209,790 ($66,290 USD).

This represents an 87% improvement in the number of days, a 76% reduction in the number of people required, and the total cost of the project improved by 78%. The cost savings for the project totaled R$740,210 ($233,910 USD).

The total hours worked with the Traditional Method was 44,000 hours (8 hour days; 110 days; 50 people) as compared to 1,344 hours (8 hour days; 14 days; 12 people) using the Railvac . Productivity calculated as meters completed per hour worked improved 3,174% from 0.051 m/hr. to 1.66 m/hr. (Fig. 12).

Tunnel [SAB5]**12 Economic Analysis**			
	Traditional	**Railvac**	**% Improvement**
Meters Reballasted	2233	2233	0%
Project duration Days	110	14	87%
Hours per day	8	8	0%
Number of Employees	50	12	76%
Project duration - Hours	880	112	87%
Total Labor Hours (1000)	44	1.344	97%
Total Cost (1,000's)(R$)	R$950.00	R$209.79	78%
Total Cost (USD) (1,000's)	$300.18	$66.29	78%
Unit Cost (R$/m)	R$425.44	R$93.95	78%
Unit Cost ($ USD/Meter)	$134.43	$29.69	78%
Productivity (m/hr.)	0.051	1.661	3174%

Figure 12: Economic Comparison between MRS Traditional Method and Railvac Method

6. MRS BALLAST REMOVAL ON DOUBLE TRACK IN MOUNTAINS

On a recent track renewal project on double main track in the mountains between KM64 and KM110 the Railvac was spot cleaning only the very contaminated sections of track.

The production records show the machine worked 1 hour and 49 minutes on June 1 and 3 hour and 29 minutes on June 2, while removing 39 m^3 and 91 m^3 respectively. For these two days of operation the average production was 24.53 m^3/hr.

One significant improvement since MRS began using the Railvac is the number of people operating the machine. MRS has reduced the number of Railvac operators from 4 to 2. This has improved the unit cost 35% from R$93.95/m^3 to R$60.62/m^3 during the first two years of operation of the Railvac.

7. CN BATHURST ORE IMPACTED BALLAST REMOVAL

Canadian National Railway (CN) identified an environmental concern related to the transport of mined ore concentrate containing Pb, Zn, Cu and other heavy metals from 1964 to 2013. CN unit trains transported the ore concentrate a distance of 70 km (44 mi.) from a mine site through a CN Yard to a smelter site. The track is bordered by 1000 adjacent properties, a city and several towns. It crosses 51 mapped streams and six provincially designated environmentally significant areas and bisects a First Nation (tribe) property. The visible ore concentrate on the track was mapped at various times between 2010 and 2014. At the time of the mine site closure, visible ore concentrate was present within the gauge of 23 km (14 mi.) of track because of the accumulation of small particles escaping from the unit trains during transport.

In late 2013 and early 2014, a remedial plan to recover the visible ore concentrate was developed following CN's environmental strategy that is focused on safety, emissions reduction, waste management, and environmental stewardship. The planning process was proactive and involved: monthly meetings with the project team including various CN department representatives (e.g. Environment, Engineering, Mechanical, Legal, Public Relations, and Purchasing), an environmental engineering firm, and Loram. This planning process was crucial to the success of the project. It included stakeholder engagement with consistent communication to regulators, local government, and the mine prior to starting the remedial work.

The remedial work was performed in the summer of 2014 using a Loram Railvac, equipped with HEPA filters and five Knapp cars supplied by CN. A total of 4,100 tonnes (4,500 tons) of recovered ore-impacted ballast was 1) excavated from the track by Loram's Railvac, 2) transferred to the five Knapp cars and 3) transported to the Mine site by the Loram's Railvac for re-use, which resulted in greenhouse gas reduction of >300 tonnes of CO_2 equivalent (Figure 13). During the remediation process air quality protection measures were utilized to mitigate dust and real-time particulate matter monitoring was completed.

Figure [SAB6]13: Railvac Consist used on Bathurst Project

Utilizing the specialized rail bound equipment, the remedial work was completed successfully. There was no disruption to rail service and no complaints from the public. It also resulted in significant cost savings to CN because the project generated less waste material than conventional remedial techniques and was completed in four weeks versus the projected eight weeks.

8. LORAM MUD SPOT UNDERCUTTING – THIRD RAIL & PLATFORM

In April 2015, a Loram customer had a mud spot next to a platform on third rail electrified track. The length of track requiring ballast renewal was 7.5 m (24.6 ft.). The project scope included travel from tie-up spot to work location, de-energizing the third rail, unfastening the third rail from the ties, unloading new ties and associated hardware, undercutting the mud spot site, removing old ties and subsequent tie replacement, loading old ties on to truck crane bed, reattaching the third rail, ballast replacement, tamping, reenergizing the third rail, travel back to tie up spot, and unloading hopper. The work window to complete this project was 4.5 hours.

Support equipment working with Loram's Railvac included a Hi-Rail Hydraulic Boom Truck with new ties, a Hi-Rail Material Handling Vehicle with new ballast, and a Tamper.

Railvac completed a full undercut including the removal of the fast clips on the ties, dropping the ties from the rails, pushing the old ties onto the right-of-way and staging the new ties under the rail for installation. The work crew was able to safely install ties as the Railvac was completing the undercutting work, giving the Project Leader sufficient time to complete the job within the time limits. All of this work was done in 1 hour. Another 30 minutes was required to unload and tamp the new ballast.

9. ADDITIONAL BENEFITS

Loram's Railvac offers MRS, CN, and all of its customers many additional benefits beyond the Tunnel, HazMat Cleanup, and Undercutting between a Platform and Third Rail Specialty Trackworks applications illustrated in this paper. It is an excellent machine for Ballast Excavation on Switches, Diamonds, Bridge Decks, and Viaducts or track with clearance restrictions. The Railvac can also be used to dig trenches. The uses of trenches can vary, but two types of trenches include draining water away from the track and into a drainage ditch and trenches alongside the track or under the track to bury wires and cables. It can be used to uncover buried wires and cables without damaging them (Figure 10). The Railvac can be used for undercutting switches, cleaning bridge decks, and cleaning up debris in yards and other areas where trash and debris accumulate (Figure 14).

Figure 14: (a) Undercutting Switch, (b) Undercutting Bridge Deck, (c) Debris Cleanup, (d) Bridge Deck Cleaning

Acknowledgements

MRS Logistica Railroad
Canadian National Railroad
Loram Maintenance of Way

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Listing of Table Titles and Figure Captions