RailKonsult

Office of Rail Regulation

Review of European Renewal and Maintenance Methodologies
Technical Appendix Number 4

Formation Rehabilitation Train

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Executive Summary

This report focuses on the use of specialist formation rehabilitation trains.

Current conventional track renewal and maintenance practices will have to be replaced by an amalgam of sophisticated production line technology, detailed planning, programming and logistics in order to meet the challenges of reduced cost, lower track access and higher track quality.

There is extensive investment proposed in track renewals in Control Period 4, accounting for around £3,500m of expenditure. Although the amount of direct formation work proposed is low, formation rehabilitation is key to achieving good track quality. Benefits would be reflected in lower maintenance and generally reduced life cycle cost. Of equal significance, use of this equipment would reduce the amount of complete renewals required during Control Period 4.

In Europe, this activity is achieved through the deployment of large, specialist items of plant that undertake the complete operation without the need to remove the track.

The benefits identified through the use of this system include:

- Capability to rehabilitate track formation without removal of track panels;
- Increased production rates in delivery of formation rehabilitation;
- Potential to undertake renewal with single line possessions;
- Capability to avoid full asset renewal where only the formation has failed; and
- Specialist plant and dedicated team leading to reduced risk of site accidents.

The net result of these benefits is a reduction in possession time requirements, improved asset management, reduction in construction costs and improved safety.

As with other recently introduced European high output machines, some modifications would be required in order to operate existing machines within the British railway environment. However, as demonstrated with other high output machines, these problems could be overcome. It is estimated that such a system could be in full production within three years.

The financial savings are estimated to be up to 40% over the cost of traditional methods, although a capital investment of the order of £25-30m would be required.

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Disclaimer

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1.0 FORMATION RENEWAL WORK

1.1 Formation Renewals

Good track quality can be impaired by many influences. One example occurs when the formation is insufficiently strong to carry the loads imposed by rail traffic. This can lead to a worsening of the track profile, eventually leading to speed restrictions being imposed. The remedy is to rehabilitate the formation.

In Europe, specialist-engineering equipment undertakes formation rehabilitation works. Operations are typically on a single line, allowing traffic to pass on the adjacent line, and work is undertaken in short track access periods, seven days a week. These trains are operated by several large track renewal contractors and undertake work on behalf of different Infrastructure Managers across Europe.

Picture: Eurailpool's Formation Train (PM200-2R)

Courtesy Eurailpool GmbH

The following is a table of work undertaken by Network Rail in 2006/7 that involves the track being broken and either formation or ballast layers being replaced. This work has been identified as not suitable for treatment by current UK ballast cleaning machines

Type of Work	Category	Extent Km	Cost (£ per metre)
Rerail, Reballast, Traxcavate	6	3.15	548
Reballast Traxcavate	7	24.4	553
Resleeper, Reballast Traxcavate	9	6.69	661
Relay, Reballast Traxcavate	11	81.85	743
Reballast, formation, Traxcavate	12	15.41	647
Resleeper, Reballast, Formation Traxcavate	13	3.33	648
Relay, Reballast, Formation Traxcavate	14	11.58	787

Notes:

1. Total amount of track requiring formation treatment = 30.32km
2. Total amount of track requiring traxcavation treatment = 146.41km (formation and reballasting amounts). Note it might be possible to Reballast this track with a modern MOBC or HOBC

Whilst references are made to specific products and systems that are in use in particular countries, there may be other products available that provide a similar functionality. The report does not review available alternatives, or their comparative merits. The case studies are included as being indicative of alternative approaches in asset management.

1.2 Extent of Method

The method described in this paper is adopted throughout northern Europe, particularly Germany and Austria.

1.3 Applicability

This is a renewal related element only.

2.0 EUROPEAN APPROACH

2.1 Method Deployed

Critical to the success achieved in Europe is the initial site assessment and design of an appropriate solution. Considerable effort is taken to survey and analyse the bearing strength of the formation layers so that an appropriate treatment is applied. The use of ground penetrating radar, core sampling and analytical analysis in a laboratory is standard practice in ensuring that the correct treatment is specified.

All work is undertaken by a bespoke train, for example a PM200-2R Formation Train. Seven formation rehabilitation trains currently operate throughout Europe. They typically consist of the following:

- Formation train itself;
- Attendant wagons to facilitate spoil removal and blanket / ballast material insertion; and
- A dedicated team that operates the train as well as planning the work and logistics support.

The formation train has the ability to remove the existing ballast and the formation itself down to a variable width of between 4.30 and 6m and to a depth of 1.4m. The train has a sophisticated recycling capability to minimise the environmental effect of track formation renewal. All formation rehabilitation trains have similar functionality, being able to all replace or refurbish both the formation and the existing ballast.

The train has two cutter bars. One removes the ballast layer and the other the formation materials. The old formation material is removed to the attendant wagons with the existing ballast being washed, re-profiled and returned into the track.

The new formation design is installed as the excavation proceeds. This is achieved by adding as necessary geotextiles, geogrids and a sand or dust layer that is compacted as part of the operation. New ballast is inserted from the attendant wagons to top up the ballast.

All the operations are controlled by wire guidance and/or laser systems. Quality control is undertaken by attendant staff. Tamping machinery incorporated into the formation train attains the design track alignment.

The train requires some 2.5 hours to set up and 1.5 hours to break down after operation. Machine production is dependant on the depth of the excavation and can vary from 40 to 80 metres per hour. The work is typically undertaken on a single line with the adjacent line open to traffic. Each train will undertake some 25 to 50km of formation treatment per annum.

In Germany, the required strength of formation measured through the dynamic modulus of resistance (Evd) is set within standards and measured on site for compliance. Dynamic plate testing equipment is used. Both the employer's and contractor's representatives sign that these levels have been met. If this is not achieved, remedial action to further stiffen the formation is undertaken immediately.

Testing is also undertaken on the sand layers to ensure that compaction is achieved using Isotope probes and dynamic plate equipment.

The manner in which formation rehabilitation trains are used in Germany results in a selling price to the Infrastructure Manager of between €300 and €600 per metre. This price excludes the cost of materials, e.g. ballast, sand and geotextile.

The variation in unit costs is driven by the site-specific logistics, actual possession length and the breaks between the possessions. However, other factors that affect the cost include:

- Recycling quota of the ballast;
- Annual productivity (both in number of shifts and metres delivered);
- Logistics required for the machine; and
- Competence and experience of the workforce and the managerial staff.

2.2 Management Approach

These machines are complex to plan and operate, with each train having a dedicated team of staff. Some thirty operators manage each work shift.

In Austria, the Infrastructure Manager usually defines the work site, including the location of any loading and unloading points for materials. The contractor will undertake the logistical planning. In Germany, the definition of the construction site, maybe done by the Infrastructure Manager, as in Austria, or by the contractor.

Local engineers identify sites requiring formation rehabilitation from an assessment of the track condition. These assessments take into consideration such factors as:

- Track alignment measurements;
- Track quality deterioration trends; and
- On-site investigations, including techniques such as geo-radar and drilling.

This information is consolidated into a report setting out the appropriate renewal measure required (formation rehabilitation) together with an assessment of the suitability of site for the high output formation rehabilitation train (HOFRT).

Sometimes a HOFRT cannot be used due to the length of the available possessions or specific local environmental restrictions, i.e. there is no suitable location to unload of material. Factors such as this can influence the cost such that some sites are cheaper to treat using conventional traxcavating technology (that is, the use of multi-purpose road-rail excavators).

The requirements of the regions are collected centrally and then integrated and scheduled according to the annual budget. This process produces a long range, rolling planning cycle.

It is understood that there is a period of approximately 4 to 6 months from identification of the need for formation rehabilitation at a specific site through to execution of the work. This includes detail planning, engineering, and tendering of the job. The exact period is dependant on factors such as:

- Method of scheduling of the trains;
- Type of contract in place (framework or single site tendering); and
- Availability of budget.

The contracting strategy adopted by various Infrastructure Managers varies across Europe. In Austria this type of work is usually undertaken within a framework contract. The unit price varies depending on the actual metres undertaken per annum.

In Germany, Deutsche Bahn has recently switched from framework contracts to contracting for each individual formation rehabilitation site. However, the lack of a firm long-term programme for the machines has resulted in no opportunity for economical optimisation. Elsewhere in Europe, there is also a strategy of letting single site contracts, but usually involving significantly longer track lengths than has become the norm in Germany.

It was noted that the trains are used for ballast renewal in Germany. This capability is especially useful on sites where there are several changes in the work, e.g. formation rehabilitation, followed by ballast cleaning, followed by a further section of formation rehabilitation. It is also possible to utilise the machine for plain ballast cleaning. Although this is more expensive than use of a purpose built high output cleaner, it is more efficient than buying a HOBC and being not able to achieve a good productivity.

2.3 Technology Involved

The PMR 200-2 formation renewal system can segregate ballast from the sleeper underside for recycling with up to 12 tonnes of material excavated per metre compared with 5 tonnes on conventional operations. The system will leave a consolidated track formation with a depth up to 600mm. Two formation membranes can also be installed (usually a geo-fabric and a geo-grid).

Such formation trains are large items of plant, typically 200 metres in length and weighing 800 tonnes. These figures increase when the attendant wagons are also considered.

The attendant wagons are generally of MFS type, similar wagons to those used with high output equipment in the Great Britain. They are used to convey excavated material from the formation train and to introduce new materials such as ballast and formation blanket materials. This approach enables single line operation of the train to be adopted, i.e. adjacent tracks are available for traffic.

Every opportunity is taken to maximise the utilisation of these wagons through methods such as unloading old materials near to the site of work and use of nearby temporary sites to bring in new materials. The front and rear two wagons are regularly used to ‘shuttle’ spoil and new materials to and from the train.

3.0 CURRENT BRITISH APPROACH

3.1 Construction Methodology

In Great Britain, formation rehabilitation work is undertaken without the use of specialist trains. The work is undertaken by removing the track followed by the ballast to expose the formation layer. This enables the formation layer to be rehabilitated by installing a blanket and/or a geotextile. The new ballast is installed, compacted and finally the track is replaced.

This approach involves the breaking of track and requires long track access periods. It also requires possession of the adjacent line to stable material trains.

Complete rakes of MFS wagons are used to shuttle from ‘Virtual Depots’ to and from British high output equipment (rather than the European model described above that is designed to maximise utilisation).

3.2 Management Approach

Framework track renewal contractors undertake this for Network Rail within their contract area. The teams delivering this work are not specialists and deliver all types of renewal work.

3.3 Technology Involved

The term “Traxcavate” is defined as the use of road rail type machines to undertake excavation works including the removal and replacement of track components. That is, the traditional British approach is to use multi-purpose excavation equipment.

4.0 BENEFITS

The following section identifies the benefits of using a formation rehabilitation train to undertake substantial quantities of formation rehabilitation works, which are currently undertaken in Great Britain using traxcavation techniques. The underlying assumption is that it is possible to manufacture a suitably modified machine that would successfully operate within the British railway environment as has happened already with other high output machines.

4.1 Asset Management

The reduction in time taken to undertake this work using the European practices will benefit the train operating companies as track access requirements are reduced.

Considerable amounts of formation rehabilitation and track renewal are currently undertaken. The opportunity exists that the formation renewal could be split from the track renewal portion on some of this work. This change could be facilitated through improved inspection, analysis and decision making (considered in a separate report).

The use of European techniques for analysis, design and site control of operations would improve quality of operation and potentially life cycle costs on sites treated for formation rehabilitation.

Ballast or formation renewal work under track that does not need to be relayed will not require the track to be removed as it is now (Cat 7 and Cat 12 work types).

Undertaking formation rehabilitation using a train avoids any potential rutting of the formation layer as a consequence of operating road/rail plant over it. This will enhance the life of the new formation and result in improved track quality with lower maintenance intervention levels required.

Inherent within the process is the return to the track of ballast that is suitable for further use. This reduces the wagon capacity required to transport spoil and new stone. It also extends the life of the ballast by removing only the material that does not comply with the specifications.

The ability to have a single line system for the completion of formation rehabilitation will assist in the successful implementation of the “Seven-Day Railway” concept. Without this equipment on key routes the ability to undertake economic formation rehabilitation is likely to be constrained.

Although, questions have been raised over the ability to safely undertake construction activities whilst trains operate on an adjacent line on the British rail network, the teams operating the current British high output fleet have proved that it is possible to achieve.

4.2 Efficiency Savings

This section is not intended to provide a rigorous business case assessment. For example, capital investment requirements are excluded and no discounted cashflows have been considered. It is, however, included to provide an indicative view of the potential operational opportunity available if similar approaches were adopted in Britain.

A proposed British version of the Formation Rehabilitation Train would deliver a substantial part of the Category 7 and Category 12 work-banks, replacing traditional methods. As noted previously, the European trains also undertake ballast-cleaning work. This would provide a further work-bank opportunity to improve utilisation of a British formation train.

The average production rate of the existing trains (whether undertaking formation rehabilitation treatment, ballast renewal or both) is 60m per hour. This translates into a production capability of 720m in a 16-hour possession, or 240m in 8 hours.

The table below is based on European experience, with average unit cost rates of €450 per metre for formation treatment and €400 metre for reballasting treatment only. These costs are exclusive of materials and reflect the selling price to the Infrastructure Manager. That is, they do not include any allowance for overhead costs from the infrastructure manager for management of the works.

Work Category	NR 2006/7 Activity Level	Cost (Current GB Method)	Potential Cost (Formation Train)	Cost Reduction
Reballast only (Traxcavate)	24.4km	£13.5m [1]	£8.4m [2]	38%
Reballast and Formation (Traxcavate)	15.4km	£10.0m [3]	£6.0m [4]	40%

Notes:
1. Based on an average cost per metre for Category 7 work of £553.
2. Based on an average cost per metre for similar work in Europe of €400 per metre, plus an allowance of €40 for material, i.e. €440 or £343 per metre (conversion rate of £1=€1.2845 assumed).
3. Based on an average cost per metre for Category 12 work of £647.
4. Based on an average cost per metre for similar work in Europe of €450 per metre, plus an allowance of €50 for material, i.e. €500 or £389 per metre (conversion rate of £1=€1.2845 assumed).
5. Does not include savings in pre and post work due to difference between track out and in situ formation treatments
6. Does not include potential efficiencies by providing a method to renew formation without premature renewal of rail and sleepers.
7. The above total amount of work circa 40kms is compatible with work amounts undertaken per train in Europe
8.The costs and potential savings for using this train on ballast cleaning operations have not been reviewed.

4.3 Life Cycle Costs

Substantial amounts of Cat 11 and Cat 14 work can be transferred from complete renewal to either reballasting or formation renewal with the relaying portion of the work being deferred to a later date or undertaken earlier depending upon condition. That is, the premature renewal of components can be avoided through the use of a technique that enables the formation to be renewed in isolation.

This is similar to the principal deployed with the current British high output reballasting and relaying equipment, i.e. the reballasting and relaying is split into different operations and undertaken at different times. This capability provides flexibility of planning renewal of the various component parts of the track system and acknowledges that the components do not wear out at the same rate.

The facility exists to install low costs cess drainage at the same time as the formation or reballasting works undertaken with the train. Drainage is currently installed manually at the side of the excavation or in separate possessions.

5.0 SAFETY ISSUES

The current British practice for undertaking formation rehabilitation works involves mechanical equipment to remove and replace both track and ballast. This imposes risk into the site primarily for lifting and excavation activities. It also introduces the risks associated with multiple vehicle movements in a confined site environment.

A formation train would provide a standardised method of undertaking these works and would be operated by a dedicated team of staff. This would be a more reliable and safer system of work

The development of safe systems to enable Network Rail's high output equipment to operate with single line working would need to be migrated to a new formation train.

6.0 IMPLEMENTATION INTO GREAT BRITAIN

6.1 Estimated Implementation Duration

A formation rehabilitation train, with functionality similar to Europe, with a capability to operate using single line working could be developed for use in Britain. Outline evaluation work has already been undertaken that confirms that a system could be designed for use in the Britain.

Formation trains have been introduced into Europe within 24 months. It is considered that a suitable train could be designed, developed and trialled within 30 months and be in full production delivery within 36 months.

6.2 Constraints and Dependencies

The following would need to be confirmed:

- Workload to support the investment and running costs will need to be available;
- Ability to build a train to the GB loading gauge will have to be fully confirmed;
- Logistical support (e.g. depots, materials supply etc) will have to be available. It is possible that existing facilities will be able to support this train.

The length of the train and its supporting vehicles is such that there will need to be detailed planning for both stabling and transit moves. This is no different to the detailed planning required for the existing high output fleet.

6.3 Investment Requirements

Based on the latest information from Europe, it is understood that an initial investment in a train of approximately £25-30m (€30m -€35m) would be required. This is the price of an "off-the-shelf" model with consequential economies of scale, thus there would be a further investment required to adapt the design for use in Britain.

Additional investment would be required to purchase the supporting wagons. The total amount required would depend on the number of wagons. This would be driven by the decision on whether to continue current British practices of wagon utilisation for high output operations, or implement the European method described previously and the possibility of sharing wagons across all high output operations.

It can be expected that the procurement of a formation train is likely to cost more than a European system and the underpinning reasons for this are shown in Appendix A.

7.0 RECOMMENDATIONS FOR FURTHER WORK

Further work is required to verify the manufacturing costs and understand any potential operational constraints associated with the use of a formation rehabilitation train in Great Britain.

Additionally, there is a need to further consider the potential mix of work that would form a suitable work-bank for the use of this equipment. This assessment would need to include consideration of the extent to which the train would be used for ballast renewals and also how much track renewal would be avoided if the formation could be rehabilitated without removal of the track.

Appendix A

Plant Costs in Britain
Comparison with other Administrations

Background
Conventional plain line track renewal undertaken in Britain is underpinned by the extensive use of road rail vehicles to undertake lifting and reballasting operations.

In Europe, similar track renewal work is undertaken using a combination of both conventional and specialised excavation plant for reballasting with specialised lifting systems (cranes or gantries) for lifting operations. Their reliance on road rail vehicles is much less than in the Great Britain. A well voiced statement from Europe is that the use of road rail vehicles is minimised on safety grounds

On Track Plant Procurement
A manufacturer will typically charge 15% more to supply a new machine to Britain than for an equivalent Europe. Reasons for this are:

- Machines developed for Europe may need redesign for the reduced structure gauge in Great Britain;
- Checks for conformance with Standards and design scrutiny review, necessitating employment of independent -approved body;
- Preparation of documentation to support Client's Safety Case and submission for approval for the machine to transit and work;
- Training and certification of operators, maintainers, trainers and assessors; and
- Certification of personnel to enable them to carry out commissioning and monitoring duties.

In Europe the approval systems are simpler with the view generally taken that acceptance and safe use in one country eases the approval into another country.

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