ISERT - Improving the Stiffness of Existing Railway Track


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Project Aims and Objectives
The aim of the research is to reduce maintenance costs by improving the stiffness of existing railway track without removing the track, sleepers and ballast. The research has four objectives:

- The identification of preferred stabilisation techniques and equipment, together with a method statement for use on operational railway track.
- An indication of the potential for mechanising the process in a form suitable for railways.
- Preliminary design guidelines, linking existing subgrade conditions with loading, required stiffness and options for strengthening. The guidelines would advice on depth and frequency / density of injection or treatment.
- Advice on techniques for measuring the stiffness of operational railway track and the potential for future development.

Summary of Project
Current Problems with Existing Track
The majority of railway track still reflects its original construction some 150 years ago. Figure 1 shows a typical cross section of railway track in which the ballast layer has been placed directly onto a subgrade that has received little or no treatment other than shaping to the approximate line and level required. The stiffness of the subgrade is variable and deteriorates due to the ingress of water through the open textured ballast and from the dynamic loading of railway vehicles. These variations in stiffness result in variable movements in the ballast and track components when the structure is loaded. This necessitates maintenance, usually by repacking the ballast possibly with the addition of fresh stone, and / or renewal to restore the line and level of the rail.

Figure 1: Railway subgrade problem and solution

Measuring Track Stiffness
There is a lack of a commonly acceptable means of defining and measuring the stiffness of railway track and in addition there is no accepted desirable level of stiffness for existing or new subgrade. To investigate these issues and to gain an understanding of taking measurements on an operational railway a number of techniques for measuring the stiffness of the railway track were examined. The most commonly used techniques for the project involved the Falling Weight Deflectometer (FWD) modified for use on railway tracks. Such techniques use a series of
geophones to measure the response of the subgrade to a weight that falls onto a sleeper that has been uncoupled from the rail. Cone penetration tests were also carried out.

**The Leominster Site**
The selection of trial sites in a post Hatfield atmosphere proved difficult but Railtrack and Carillion Rail identified a suitable site at Leominster. The site had a clay subgrade and demonstrated considerable problems on the heavily loaded up-line, which carried steel freight trains from South Wales. A site investigation involving FWD measurements was carried out over a long length of track so that treated and untreated areas could be compared.

**Alternative Techniques for Improving Stiffness**
A review of techniques used in the highway industry for improving subgrade stiffness was carried out to identify suitable techniques, which could be used in the railway environment. From this study a short list of possible techniques was identified and a series of laboratory experiments and off site trails conducted to further evaluate the process.

**First trial and initial results**
The first selected technique for the clay subgrade at Leominster involved a soil/grout mix using cement slurry, augered through the ballast using a 300mm diameter auger. A series of grouted columns that penetrated about 1m into the subgrade were placed between the cribs formed by the sleepers and rails as shown in Figure 2. Reducing the length of the columns provided a transition between the existed and treated part of the track. Some 30 columns were placed in a single overnight possession period. FWD measurements taken some months after the work showed that stiffness had increased over the treated area compared with the untreated area although additional work is required to understand more fully the cause and effect.

![Figure 2: Soil Grout Columns at Leominster](image)

**Second trial and results**
The second selected technique for the clay subgrade at Leominster involved mild steel reinforcing bars driven below ballast level at a certain depth and pattern. A series of 40mm diameter, 4m long soil-nails were driven into the subgrade at 450 to the vertical between the cribs formed by the sleepers, as shown in Figure 3. The nature of the technique creates transition between the
existed and treated part of the track. Some 60 soil-nails were placed in a single overnight possession period (~8 hours). FWD measurements will be taken within certain time intervals for several months after the installation work. Additional work is currently being undertaken in order to understand more fully the cause and effect.

![Figure 3: Soil-nails at Leominster](image)

Scientific Achievement to date
The core of the scientific and technological achievement within ISERT has been the demonstration that effective strengthening techniques can be applied to operational railway track without first removing the rails, sleeper and ballast. The two trials showed how limited productivity is during overnight possessions. Production rates, however, would be improved significantly by undertaking some simple changes to the methodology. They also showed that:

- A small volume of surface spoil and waste was created by the first technique causing ballast contamination. Improving the grout-injection system design, however, would reduce this problem.
- Soil/cement mixing is a relatively simple technique that can be used within the zone of influence, which is primarily governed by the auger diameter. Unlike other grouting techniques, soil-mix columns can be built to more defined dimensions. Columns of soil mixed with cement grout can be constructed through ballast.
- Soil nailing is an even simpler, but at the same time a lot faster technique.
- The treated track sections were not significant enough for changes to be measured using the FWD test. However, the results suggest that there has been some improvement.
- In both cases there was minimal disturbance to line and level of the track.

Conclusions
This is an interim report based on one test site and two techniques. Further test sections are planned using additional techniques of soil modification or strengthening. It is also hoped to carry out a trial of drainage techniques since the fundamental issue is one of excess water penetrating into the subgrade. An additional benefit of the research has been the investigation into very local areas of failure beneath the ballast known as wet spots and initial trials of treatment techniques have begun.