LR55 Field Installation
Rotherham Bus Station Trial
FINAL REPORT

1993 - 1995

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Trampower

Leading to better transit

CONTENTS

1. Introduction

1.1 Requirements for Street Tracks

Light rail tracks laid in public highways used by normal road vehicles have several conflicting requirements. They must be capable of supporting the static and dynamic loads imposed by rail vehicles and retain track gauge, so that rail vehicles can operate safely. They must also not reduce the structural integrity of the highway (Fig 1) and thus be able to support the static and dynamic loads of road vehicles passing along and across rail tracks.

In electrically powered systems, the tracks usually provide the return path for electrical current. Additionally, they must not cause a nuisance to road users by having ridges or sharp troughs, which might damage road vehicles or cause accidents. The technical task is then how to install and sufficiently support tracks in roads so that the requirements for light rail vehicles and other remaining road users can be met.

1.2 Testing LR55

The new low profile LR55 track system had been developed after a thorough review of all tramway track systems by Professor Lewis Lesley. The next stage was then to demonstrate the strength, reliability and durability of the LR55 system to show its applicability for real use. This involved extensive laboratory testing for a variety of conditions undertaken at Liverpool John Moore's University.

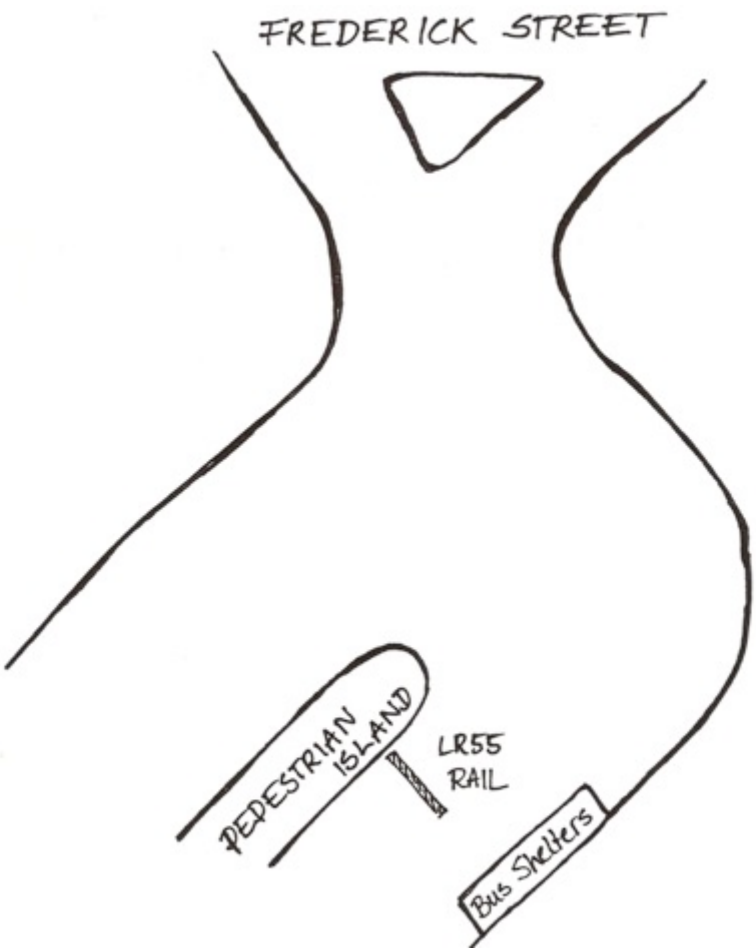
After completing a battery of laboratory tests of the LR55 system, which including cyclic and static loads at or above main line railway axle loads (25tonnes), as well as environmental conditions, destructive and non destructive testing and full FEA analysis using test data for calibration, a site for a field test was sought.

Looking at the literature and photographic survey of live UK tramways, it was clear that the primary damage to tramway tracks is inflicted by heavy road vehicles. A site with a high volume of heavy road vehicles was looked for. With the co-operation of the South Yorkshire Passenger Transport executive, Rotherham Bus Station was offered. A visit to the Bus Station, showed that the best place was the entrance plaza, where buses would cross, turn, reverse and run along the site.

1.3 Pavement conditions.

The Bus Station had been constructed over a landfill site. When the first trial hole was excavated, the pavement was found to be only 150mm deep made of compacted asphalt with mixed aggregate. Underneath this was the top of the landfill site, which had been simply consolidated with no special strengthening treatment. Fig. 12 shows the condition of the pavement and upper surface of consolidated landfill, in a trench excavated under the LR55 track.

Fig. 1 Location of LR55 installation



2. The Installation process

2.1 Introduction

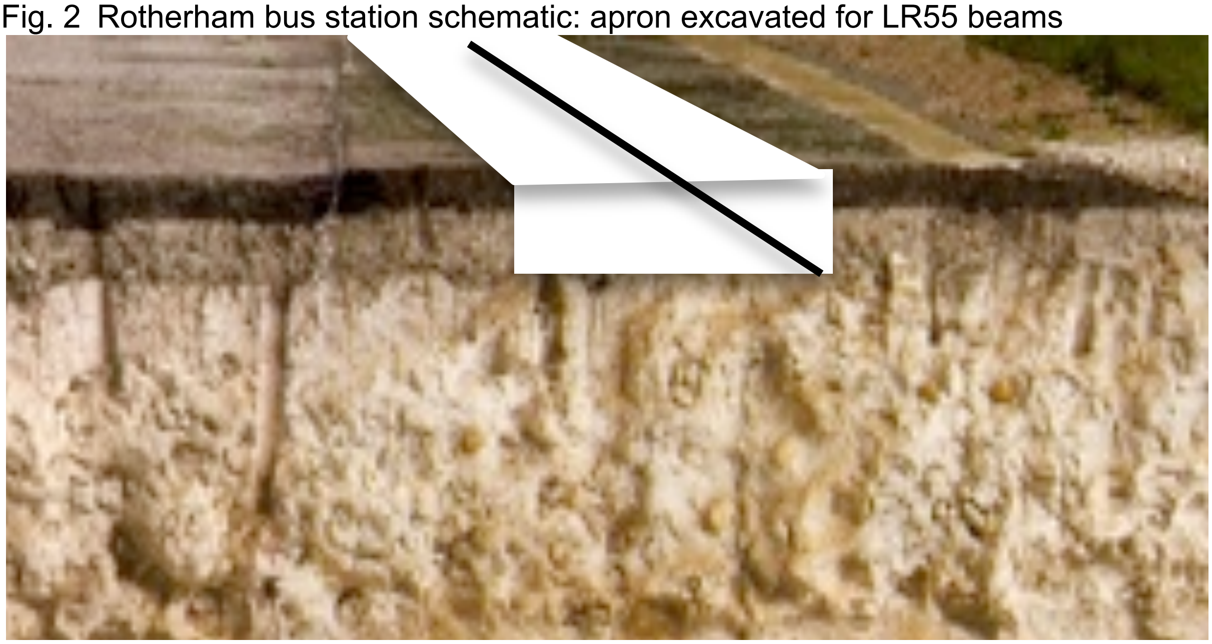
The rail was installed at the entrance of the bus station, at right angles to a pedestrian island located in the centre of the station entrance (Fig 1). This location was chosen to ensure the highest possible number of heavy road vehicles passing over the track, at a variety of attack angles.

On Sunday 14th March 1993 contractors employed by South Yorkshire PTE cut the pavement at the location of the trial using diamond tipped disc cutters. Two parallel 5rnrn saw cuts 400rnrn apart were made. The pavement between the saw cuts was then excavated to a depth of 200rnrn and the bottom of the trench was levelled. A bedding layer some 20rnrn thick of 1:4 dry mix was spread over the bottom of the trench. Onto this bed the concrete foundation beams were laid, lined and levelled. The beams were mechanically connected with steel dowels. When the troughs were laid, the gap between the edge of the troughs and the pavement was filled with a bitumen based mastic sealer. The troughs were then temporarily plated over.

2.2 Foundation Beams

After cutting the bus station pavement, revealing the land fill surface with a CBR of about 1%. Precast foundation beams made by Costain's were brought to site (Fig. 3) and primed by Sika (Fig. 4) before being laid in the prepared recess

Fig. 2 Rotherham bus station schematic: apron excavated for LR55 beams



LR55 recesses 200mm deep and 400mm wide

Fig. 3 LR55 Pre-cast 40N concrete Foundation Beams delivered to site

These were then grouted into the bus station pavement using a asphalt rich aggregate mix, compacted to ensure the spaces between beams and the pavement were fully engaged.

2.3 Treatment of Beams

SIKA technicians then primed the beams (Fig. 4) and the LR55 rail, which had been cast in sections and welded to the required length by Edgar Allen Ltd. a specialist tramway track maker, at their nearby plant in Sheffield. Before priming, strain gauges were embedded in the base of the rail, with connecting cables leading to a data logger.

Fig. 4 Priming the rail and beams

2.4 The LR55 rail

After delivery to site (Fig. 3) and the installation of strain gauges (Fig. 5) and priming (Fig. 4), the rail was lowered into the top of the foundation beam sections (Fig. 6). Temporary clamps were used to hold the rail 20mm proud of the bottom of the beam and horizontally. As this was the first field installation, there was a learning period while the clamps were adjusted to provide the required void space underneath and to be level with the pavement upper surface (Fig. 5). Strain gauges 1- 12 were installed in the base of the LR55 Beams.

Fig. 5 Location of strain gauges in Rail

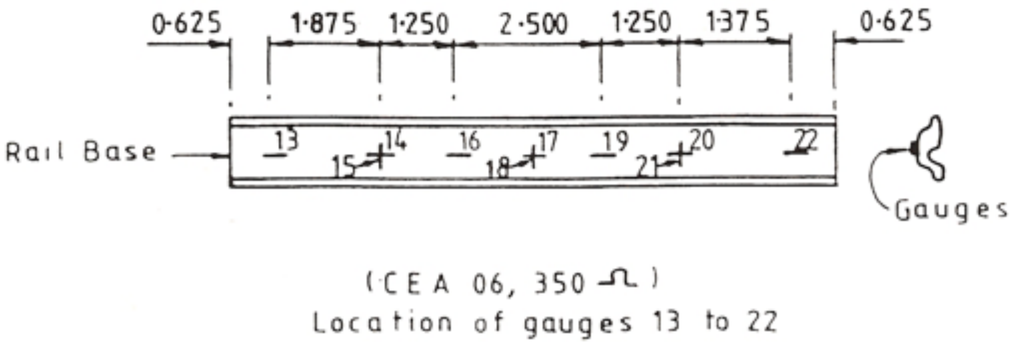


Fig 6 Lifting the railing into position

Fig. 7 Adjusting LR55 rail for alignment

2.5 Bonding rail into LR55 Beams.

In the laboratory testing, the elastomeric bonding grout KC330 was used. This had been previously used for the Light Rail system in Calgary, after the University of Calgary had undertaken a series of tests. Those undertaken in the Structures Laboratory of the Liverpool JM University, replicated the Calgary results.

For a shortLR55 installation of 10m rail length, the two part KC330 grout was hand mixed, and then hand poured down one side of the rail (Fig/ 8)l, into the void between rail and beam. Grouting was poured continuously until it appeared and was level with the other side of the rail, thus confirming that the space between rail and beam were completely filled.

Fig. 8 Bonding LR55 rail to foundation beams

After the pour was completed, it was covered to allow for a complete cure, 70% strength in 4 hours and full strength in 24hours (Fig. 9).

Fig. 9 LR55 bonding grout cures

3. Into use.

Once the KC330 grout had fully cured, the installation was uncovered (Fig. 10), clearly showing the existing pavement, the foundation beams and rail, with the relevant bonding. Although the bus station had remained open during the LR55 installation, buses did not use this part of the entrance. Fig. 11 shows Scott Hellewell one of the advisors and Director of Operations of the Manchester Metrolink, providing an indication of scale.

With the rail and beam firmly bonded, all buses resumed using this part of the entrance apron (Fig. 10). During two years from March 1993, the LR55 trial length experienced an average daily passage of 2,500 heavy vehicles, with bus axle loads of up to 11 tonnes and over along, across and turning. For the first three months, while other work was being undertaken in the bus station, buses were entering and exiting across the LR55 track, making 5,000 heavy vehicles per day. A total of over 30 million axles is approximately equivalent to 20 years of normal operation of track being installed into the pavement of a busy urban main road.

Fig. 10 LR55 Track fully installed

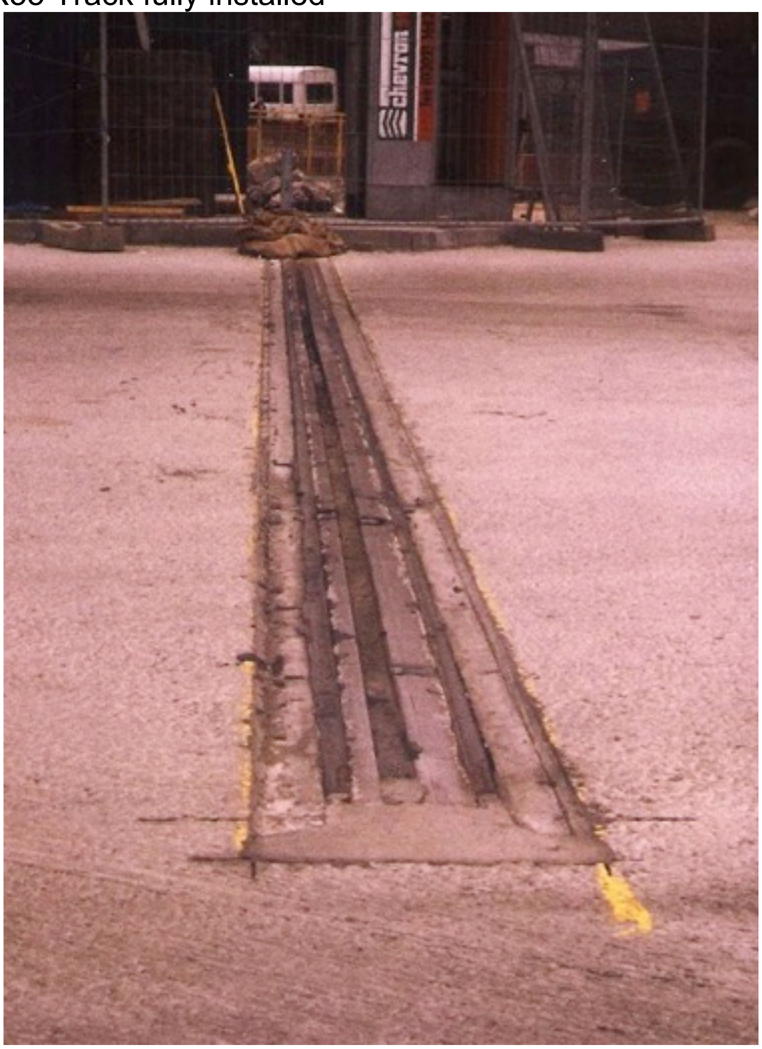


Fig. 11 LR55 Track open for business (data logger in background)

Fig. 12 2500 buses per day over LR55 track

4. The Data

The performance of the instrumented LR55 installation was monitored using a computer based data logger adjacent to the site. This was downloaded periodically onto a lap top computer for analysis at Liverpool John Moore's University. The strain gauges had a life of about 1 million cycles or about 8 months in the conditions at the site.

The data logger lacked sufficient storage capacity to make instantaneous monitoring of all gauges practical. Therefore the monitoring of the gauges was the detection of a change of status. The logged data was analysed and exceptional results indicating the co-incident impact of a bus noted.

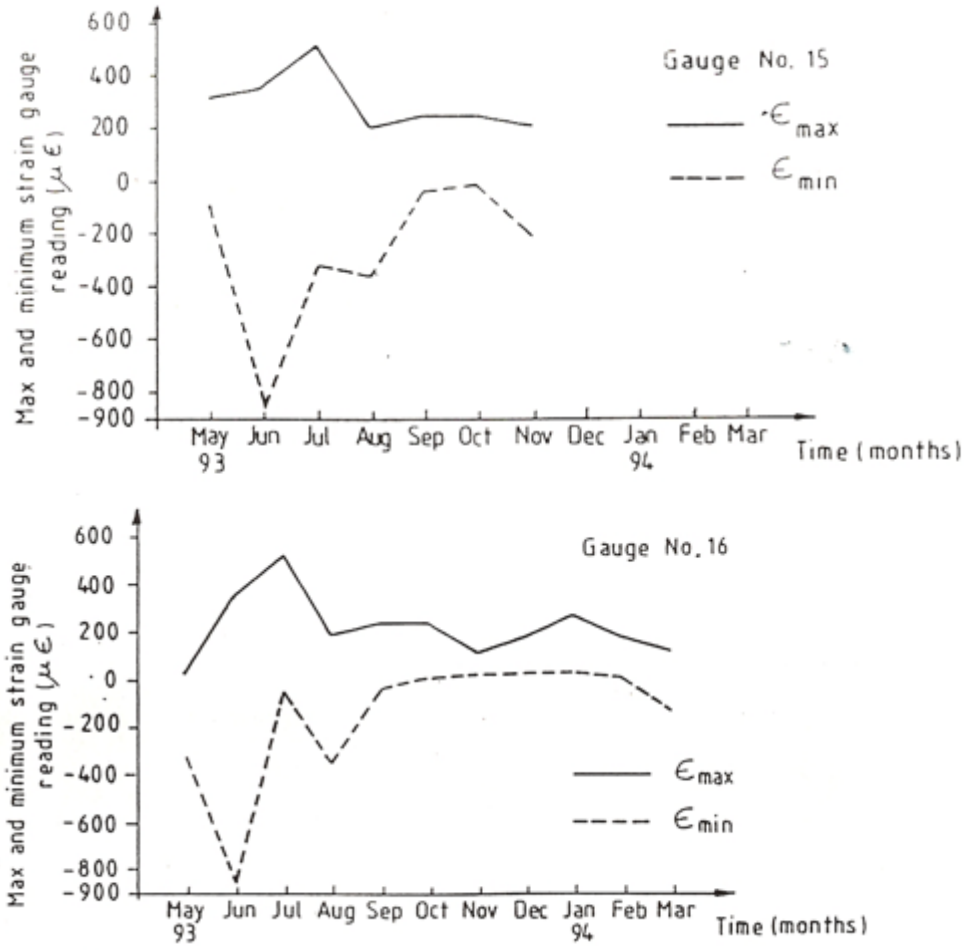
Fig 12 shows the highest and the lowest readings of the strain gauges 15 and 16 for the period of May 1993 to March 1994. It can be seen that the highest change of the strain gauge reading is limited to 850*μ* strain. This value is very low and well within the elastic limit of the steel used in the manufacturing of the LR55 low profile rail.

The rail and bonding has also not experienced any visual deterioration, except small pieces of laminating bonding agent which had been poured over the top of the rail flange, as constant site inspections during the past two years have shown (Fig 11).

The strain gauges lasted nearly a year, during this time the number of buses and axles impacting were recorded, together with the location of impact and the impact forces. This showed that buses used the full length of the LR55 rail but with a concentration in the central section. The maximum axle load was found to be 14tonnes (the front axle of a double deck bus) compared to the legal maximum of 10.5tonnes.

Fig. 13 6 month inspection team

Fig. 14 Examples of the analysis of the logged strain gauge data



5. Seminar for Utility Companies.

After a year with over 1 million buses impacting the LR55 track and no signs of any failure, the LR55 Team organised a day Seminar for local and national Utility Companies. Presentations were made about the LR55 system. HMRI presented a draft Utility Access protocol, allowing trams to continue to operate while utility works are being undertaken under or adjacent to the track. A site visit to Rotherham Bus station was arranged, where a one metre wide trench had been excavated across and under the LR55 track installation (Fig. 15). Laboratory testing and calculations showed that LR55 track can self support over one metre wide voids, even with 25tonne axle (main line) loads.

As interesting for the contractors who attended was the state of the pavement and under pavement conditions, revealed by the excavation. The photograph below shows that the pavement to be thinner than the LR55 foundation beam, and that the ground underneath was a heterogeneous mixture of materials with a low CBR value.

The Utility Companies participating confirmed that relocation was required when a slab track foundation was proposed that would make existing plant inaccessible. Their preferred option is to leave plant in situ, provide there is access for maintenance and repair. They confirmed that LR55 clearly provides such access and with the HMRI protocol repair and maintenance works can be undertaken safely even with trams operating.

Fig. 15 After 1 million buses - LR55 excavated to examine condition

6. Conclusion

Shortly after the Utility Seminar, the South Yorkshire Supertram began operating on tracks installed by Balfour Beatty, and there were soon track failures, in particular the industrial access at Alsing Road, where there is a single track tram section to the Meadowhall Terminal,. This had failed so badly from the impact of HGV's that a 5mph speed limit was imposed.

SYPTE invited the LR55 Team to replace the failed track This was undertaken over the weekend of 15/17th March 1996. SYPTE required a 6year guarantee bond. After 6 months, when LR55 had not failed, the Bond requirement was retired and the LR55 track was given to SYPTE.

The condition of the rail at Rotherham Bus Station after two years of field trial experienced no visual deterioration due to road vehicle impacts and weather influences. Similarly there was now physical movement or transposition of the LR55 installation. This indicates that even is a pavement of poor quality, track gauge will be maintained.

Fig.16 Two year inspection

Acknowledgement
Karen Putensen was a student at Flensburg University, Germany, when she undertook this research and wrote the report reprinted here. The LR55 rail sample continued to be impacted by 2500 buses per day, without failure for over another two years, before the bus station was completely rebuilt and the LR55 installation buried.