

Edinburgh Tram Network
On Street Trackform



Edinburgh, 02 December 2010



Content of presentation

- Introduction to Rheda
- How the Rheda System works
- Background to Princes Street
- Nature of deterioration in Princes Street
- Findings of investigation
- Lessons learned

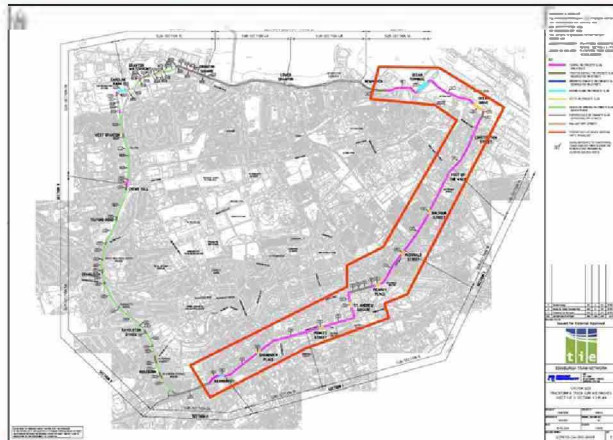
Rheda Trackform Types Used On ETN

- On street trackforms

* Rheda City C	Continuous support for on-street straight sections
* Rheda City D	Discrete support for on-street curved sections
* Rheda City Green	Grass track
* Rheda SLC	Stations and Level Crossings (short sections)
* Rheda City Open	Open formation used on the Guided Busway

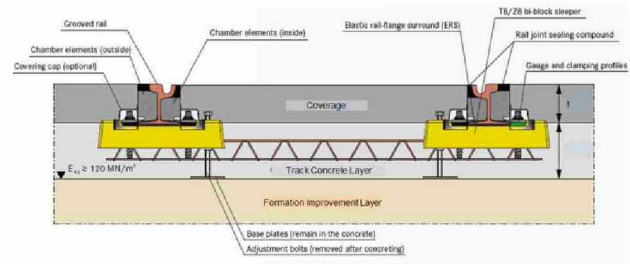
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Introduction to Rheda

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Introduction to Rheda



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Construction Pictures

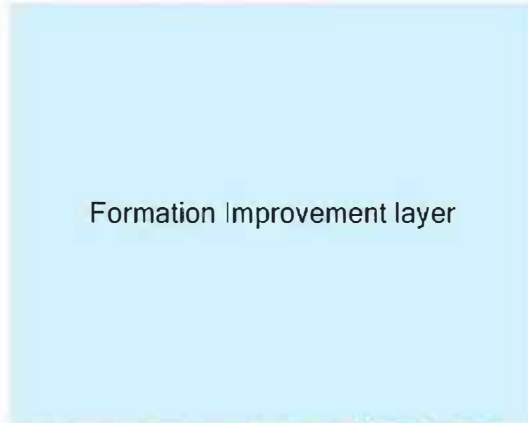
Pre-assembled components allow for
simple and accurate installation



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Video Animation Rheda Construction Sequence



Formation Improvement layer

Chamber Filler Blocks for On-Street Trackform



Fig. 1 SEDRAPUR® standard filler block

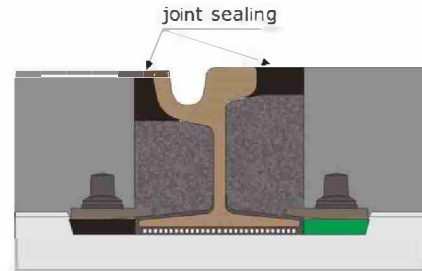
Sedrapur Filler blocks characterised by:

- Noise and Vibration damping and electrical insulating properties
- Absorption of track deformations caused by horizontal and vertical forces
- Compatibility with the track joint hot sealing compound
- Ease of handling
- Accurate fit
- Geometric adaptability and
- Recyclability

These elastic filler blocks have been in use since 1990. At the present time at least 200 kilometers of on-street track has been built with the Sedrapur standard filler block.

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Joint Sealant Compound



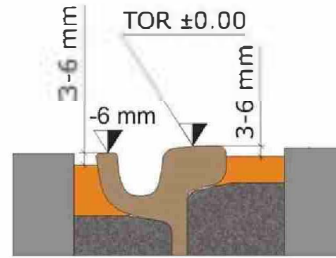
SEDRAFER EXTRA:

- Bituminous hot sealing compound for tram tracks
- Prevents water or foreign matter penetration into track joints
- Enriched by polymers to provide elastic properties

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Joint Sealant Compound

Level of joint sealant compound



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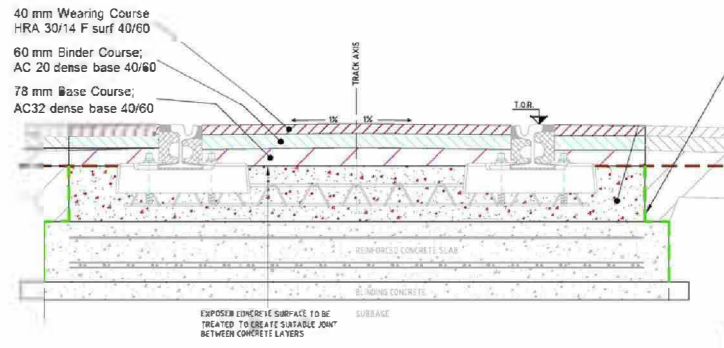


How the Rheda System works

- Two integrated structures – road and track
- Able to move independently from road
- Flexible sealant between the road and track
- Rail electrically insulated to control stray current
- Surfaces levels of road and rail co-ordinated

How the Rheda System works

Pavement Design 'As Built' in Princes Street



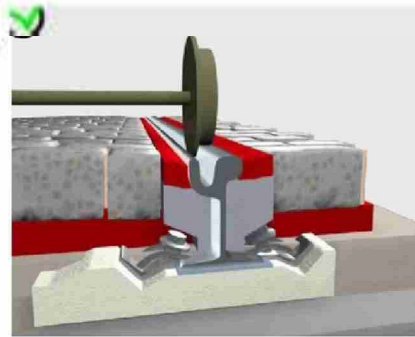
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How the Rheda System works

Rheda System under traffic or tram load



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How the Rheda Systems work

Rheda in use



Magdeburg, Germany
6 years of use



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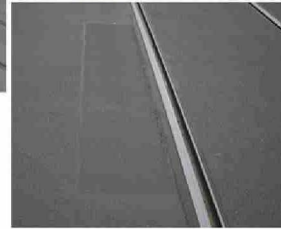
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How the Rheda System works

Rheda in use



Siegfriedstraße, Berlin
10 Years use



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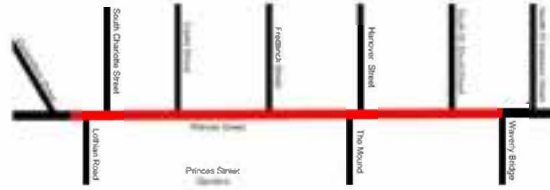
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Background to Princes Street

Start of Construction 23 March 2009
Open to traffic 29 November 2009



Background to Princes Street

Difficulties during construction

- Requirement to allow bus traffic to run westbound
- Ongoing MUDFA work
- Scottish water valve leak in South St David Street
- Resolution of Crawley Tunnel
- Accommodating pedestrian routes through site during Festival Season
- Periods of adverse weather conditions
- Working through hours of darkness

Background to Princes Street

Fact Sheet

- Opened to traffic 29 November 2009
- Work incomplete at opening
- Deterioration evident almost immediately
- Safety critical repairs continue
- Infraco investigations into deterioration
- Rectification plan submitted

Nature of deterioration

- Asphalt adjacent to the rails breaking up



Nature of deterioration

- Asphalt near the rails subsiding below rail level



Nature of deterioration

- Rail/asphalt joint sealant coming loose



Nature of Deterioration

Detailed Investigation

Expert consultation from:

- UK asphalt experts
- European asphalt experts
- European tram experts
- UK designers of other tram systems

Investigations:

- Asphalt core tests
- Surface level survey

Nature of Deterioration

Investigation conclusions

- Design is fit for purpose
- Weather conditions affected results
- Programme pressure over-ruled methodology
- Scope for improved methodology
- Design enhancements could assist implementation
- Exceptionally frequent wheel turning forces at junctions
- Early introduction of traffic

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Findings of investigation



Investigations findings detail:

Traffic running on unfinished road/rail joint

Findings of investigation

Investigations findings detail

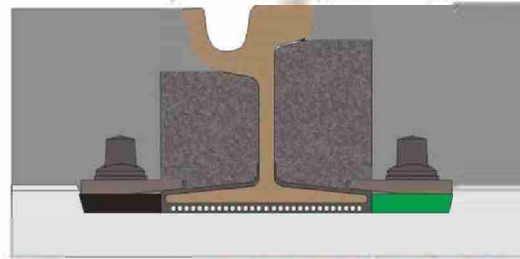
Correct Asphalt Compaction adjacent to the rail, prior to designated milling operation



Findings of investigation

Pavement damages due to unfinished work

Asphalt prior to milling and sealing



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Findings of investigation

Investigations findings detail

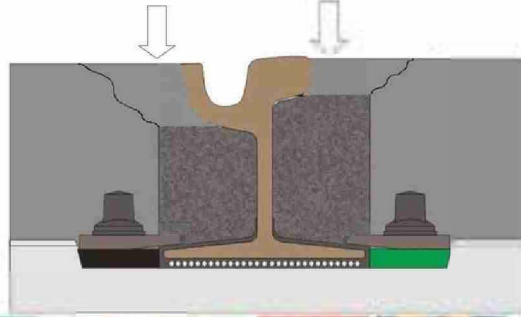
Traffic running on unfinished road/rail joint



Findings of investigation

Pavement damages due to unfinished work

Traffic loads cause the surface to fracture
over the Chamber Filling Elements

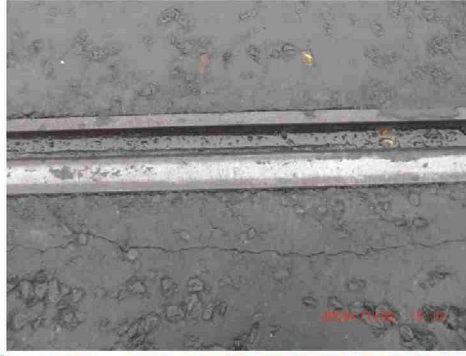


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Findings of investigation

Pavement damages due to unfinished work

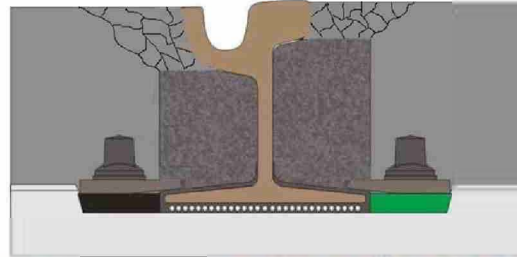
First damages of cracking asphalt on top of chamber filler blocks visible



Findings of investigation

Pavement damages due to unfinished work

Soon the surface adjacent to the rails is completely broken up



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Findings of investigation

Pavement damage due to unfinished work

Developing damage



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Findings of investigation

Pavement damage due to unfinished work
Sealant fills damaged zone



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Findings of investigation



Weather Conditions not conducive to required asphaltting and joint sealing

Findings of investigation

Limiting Weather Conditions

Manual of Contract Documents for Highway Works Volume 1 Specification for
Highway Works Series 900

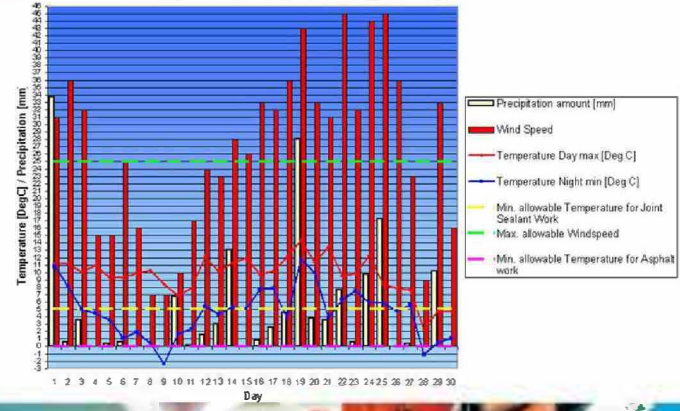
Clause 945 Weather Conditions for Laying of Hot Bituminous Mixtures

- Minimum Air Temperature 0° C
- Wind speed (maximum at any air temperature) 40 km/h (25 mp/h)
at 2 m height or
50 km/h (31 mp/h)
at 10 m height
- Minimum delivery temperature of material 155° C

Minimum air temperature for joint sealant work
(accord. to EdilonSedra specification) 5° C

Findings of investigation

Weather Data November 2009 (GMS Gogarbank)



Findings of investigation

Admission requirements, joint maintenance periods and other special requirements

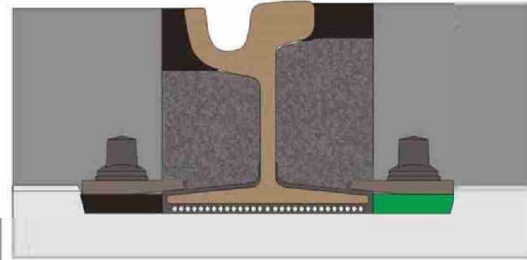
Activity	Admission requirements											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Trackwork												
2. Signalling												
3. Power supply												
4. Other												

- Days on which a night-time job is carried out
- Days on which precipitation is expected
- Days on which wind speed exceeds 40KPH
- Days on which temperature falls below 5 degrees C
- Days on which temperature is not below 5 degrees C
- DAYS ON WHICH SUPPLYING JOINTS IS RECOMMENDED

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Findings of investigation

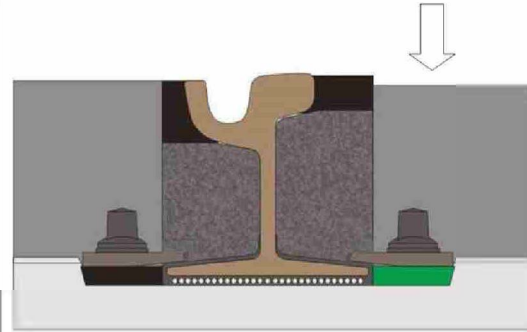
Weather Conditions



Despite using correct compaction techniques, laying asphalt at the lower end of the recommended or specified temperature range may be too cold for full compaction close to the rails

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Findings of investigation
Weather Conditions



If full compaction is not achieved during construction, compaction continues under traffic loads over a period of time

Insufficient time to sandblast some rails before sealant applied

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Findings of investigation

Preparation of sealant groove

The groove must be sandblasted, cleaned and dried thoroughly before priming and pouring of sealant



Findings of investigation

Joint sealant damage due to lack of sandblasting

If preparation stages are skipped, there is a risk the sealant will debond from the rail



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Findings of investigation

Groove preparation

When time was allowed to prepare properly, the sealant results were good



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Findings of investigation



Cold asphalt temperatures encourages material segregation

Findings of investigation

Pavement damage due to construction under adverse weather condition

Material segregation at the backside of the chamber filler blocks



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Findings of investigation

Pavement damage due to construction under adverse weather condition

Material segregation at the backside of the chamber filler blocks



Lessons learned

Investigation findings

- Traffic running on unfinished road/rail joint
- Conditions not conducive to required asphaltting and joint sealing
- Rails not sandblasted before sealant applied
- Cold temperatures encourages material segregation

Lessons learned

- Preventable
- Avoidable
- Avoidable
- Avoidable

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Lessons learned

Areas of Princes Street subject to very high wheel turning forces (high trafficked area)

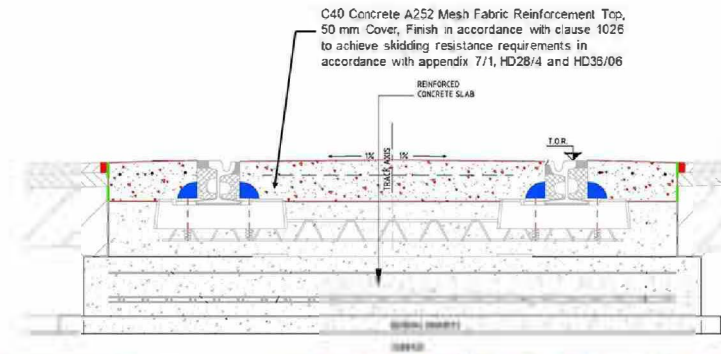
High maintenance demand prior to track installation

To reduce future road maintenance requirements, BSC has proposed as a possible solution a concrete wearing course



Lessons learned

Concrete Wearing Course Option for Princes Street



Lessons learned

Design enhancement for On-Street Tracks based on lessons learned

- Introduction of a concrete base layer instead of asphalt base layer
- Use smaller aggregate size for binder course

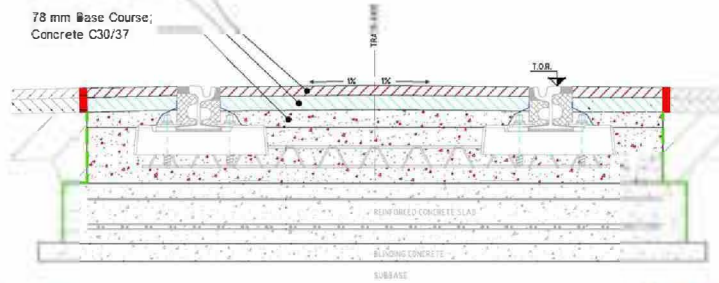
Benefits

- Less weather dependent
- Easier compaction close to the rails
- Discourage cold segregation
- Better level control of coverage layers

Lessons learned

Design enhancement for other On-Street sections

- 40 mm Wearing Course
HRA 30/14 F surf 40/60
- 60 mm Binder Course;
AC 20 dense base 40/60
- 78 mm Base Course;
Concrete C30/37



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CEC letter



John Christie
CEC Project Manager
Edinburgh Tram Project Office
Edinburgh
G1 1YU

DATE: 12/01/2017
TO: Bilfinger Berger
FROM: Bilfinger Berger

Dear Sirs,
Reference is made to your letter of 12/01/2017, concerning design drawings and submittals for the Edinburgh Tram Project.

Thank you for your request of the 12/01/2017, concerning design drawings and submittals for the Edinburgh Tram Project.

Our information concerning the status of the 12/01/2017 drawings submitted to the Council is as follows: The drawings have been reviewed and approved for issue. However, the drawings are not yet available for issue. The drawings will be available for issue as soon as the Council has approved the submittals.

- Cross-checking of the drawings against the Council's requirements has been completed. The drawings are now ready for issue.
- Your request of the 12/01/2017, concerning design drawings and submittals for the Edinburgh Tram Project, has been received. The drawings are now ready for issue.
- The drawings are now ready for issue. The drawings will be available for issue as soon as the Council has approved the submittals.
- Details of the drawings will be provided to you as soon as the Council has approved the submittals.
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Yours faithfully,
Bilfinger Berger

- The drawings are available for issue. The drawings will be available for issue as soon as the Council has approved the submittals.
- The drawings are available for issue. The drawings will be available for issue as soon as the Council has approved the submittals.

If you require any further information, please contact Andrew Russell on 01131 6272000.

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Thank you very much for your attention!

