



Hamilton Rapid Transit Preliminary Design and Feasibility Study

B-LINE

TRACKWORK DESIGN BRIEF

Version:2.0



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February 2012

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APPENDICES

Appendix A: Details of Flexible Rail Fixing

1.0 Introduction

This report summarizes the proposed trackwork elements for the Hamilton LRT B-Line. It includes the general performance specifications, typical cross sections, special trackwork and recommended types of trackwork and track elements to be considered for various alignment segments.

As the location of the Maintenance and Storage Facility (MSF) at the time of the preparation of this report has not been determined, the details of the access track to the MSF and the tracks within the yards are not included.

The Trackwork for the Hamilton LRT B-Line will be based on proven transit technology and design, as used in many similar operating systems around the World. The design, supply, installation and construction will be in accordance with applicable standards including AREMA.

The selection process for trackwork components and materials will take into consideration functionality, ease of construction, minimal maintenance, durability and suitability. During the detailed design stage, drawings and specifications should be prepared for the installation and construction work, clearly showing the infrastructure constraints and tolerances to which the guideway structure and trackwork will be built to ensure the overall integrity and performance of the operational system.

The installation and construction of trackwork will ensure that the finished product meets the overall performance requirements established in the design process. The control of the alignment will provide us with the greatest flexibility in addressing utility diversions, interfaces with streetworks, structures, and ensuring that service Reliability, Availability, Maintainability and Safety (RAMS) objectives are met or exceeded.

2.0 General Performance Specification

The Hamilton LRT B-Line will be approximately 14 km in length and fully segregated from traffic except through International Village, where property access is required and at intersections.

Where prudent from an interface design perspective, the LRT tracks shall be embedded such that the trackway can accommodate rubber tired vehicles. Initial service plans will have this area segregated for LRT-only; however, opportunities exist for limited shared use by transit buses and emergency vehicles. This would facilitate queue-jumping and other engineered traffic management solutions.

Generally, the track surface will be made of concrete, and provisions for additional drainage requirements for the guideway will be included in the design.

Table 2.1 outlines the performance criteria for the trackwork.

2.1 General

A dual track guideway runs along the entire alignment. It is developed from McMaster University grounds starting at Cootes Drive, then follows a centre running grade separated alignment along Main Street continuing across the Highway 403. The guideway then continues at grade and side running along King Street until the Delta, then along Main Street to Strathearne Avenue. East of Strathearne, the guideway is developed along Queenston Road as centre running and grade separated until the Centennial Parkway.

There will be a connection to the MSF to be determined at a later stage.

Table 2.1 – General Performance Criteria - Trackwork

Specification	Unit	Notes
Vehicle Mass	70.1t	
Buffer Load	200 kN	
Revenue Track	Mainline running track including turnouts	
Secondary Track	MSF tracks including lead/access tracks	
Trackway/Guideway	Dedicated or shared with road vehicles	
Track Centre Spacing	3.29 m minimum on all tangent revenue tracks	
Storage Track Spacing	4.0 m minimum in the MSF	
OCS supports location	Between tracks or on sidewalks	
Safety Zone	200 mm between the light rail vehicles exclusive of the dynamic envelope and the vehicle bodyline displacement due to curvature for side catenary support and 900 mm for central catenary support.	
Vehicle Dynamic Outline	To be determined upon selection of vehicle manufacturer	
Track Gauge	1435 mm measured 16 mm below top of rail	
Rail inclination	1:20 No Rail Inclination	
- For Ballasted Track		
- For Embedded Track		
Superelevation		

<ul style="list-style-type: none"> - For Embedded Track - Elsewhere 	<p>None required except to match pavement crossfall in curves</p> <p>If required, limited to 150 mm achieved by rotating high rail above low rail</p>	
Rail – designed as Continuously Welded Rail (CWR), shall be insulated to mitigate against stray current	TBD based on availability and economy (rough estimate 2,900 t – 3,300 t exclusive of MSF and turnouts, MSF approximately 700 t)	
Tee Rails	AREMA Standard	
Street Rails	62E1 or equivalent R35 optional for Red Hill Bridge	
<p>Rail Electrical Isolation (Typical in dry condition)</p> <ul style="list-style-type: none"> - New Installation - In service 	<p>500 Ohm / 1000 track ft.</p> <p>250 Ohm / 1000 track ft.</p>	

2.2 Trackwork Types

2.2.1 Mainline Track

There are many different types of trackwork designs available and the choice of the type is dependent on the use of the guideway as well as the intended urban design and streetscape approach.

Figure 2.1 shows the different types of guideway/track beds that are possible for this type of system. The choice of track is dependent on the following criteria:

- Use of guideway (is there need to have other vehicles on the guideway and if so, what types of vehicles).
- Are there sensitive uses nearby that require noise and/or vibration protection in trackwork structure.
- Minimizing capital and maintenance costs

Based on the general performance criteria listed in Table 2.1, for the purpose of preliminary design, it is recommended to use embedded track with a concrete surface for a majority of the alignment. The use of composite pavers and grass tracks can be evaluated in the next design phase based on an economic benefits case analysis, as well as further detailed streetscape requirements.

2.2.2 Embedded Track

The embedded track system will be used for the majority of the alignment. This track can be used in areas that call for varying finishes such as asphalt (across intersections), finished coloured and patterned concrete.

The general form of the track system (See Figure 2.2) consists of a concrete slab with troughs for incorporating the running rail. The size of the trough allows enough tolerance to adjust the grooved running rail into its final alignment. This system allows for a progressive increase in placement accuracy as the work progresses. The rail is held rigidly in place with frames while a cementitious grout is placed, locking the rail into position.

The top of the concrete slab is not the final road surface. The required surface material should be applied in the field to match the top of the grooved rail and to create the final road profile.

Figure 2-1: Types of guideway structures suitable for Hamilton LRT B-Line

#	Type of Trackwork Structure	Order of Magnitude Cost per Track Metre	Advantages	Disadvantages	Where it could be applied	Est. Savings vs. Embedded Grooved Rail
1		\$1,500	Lowest capital cost overall with simplest off-the-shelf material. Easiest to repair or replace.	Higher maintenance cost overall. No use of transitway by emergency vehicles.	Stations: 0+000 - 1+850 10+650 - 11+300	2 500m x \$4 400 = \$11 Million
2		\$2,500	Lower capital cost overall with simplest off-the-shelf material. Easiest to repair or replace. Use of transitway by emergency vehicles possible.	Higher maintenance cost overall. Frequent leveling may be required.	Stations: 0+000 - 1+850 10+650 - 11+300	2 500m x \$2 400 = \$6 Million
3		\$3,700	Lowest maintenance cost. Highest durability.	Highest capital cost.	Along the entire length of Line B	\$0
4		\$3,700	Moderate maintenance cost. Higher durability. Good appearance.	Highest capital cost.	Stations: 0+000 - 1+850 10+650 - 11+300	\$0

Figure 2-1 (contd.): Types of guideway structures suitable for Hamilton LRT B-Line


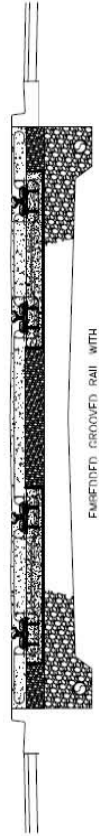

#	Type of Trackwork Structure	Order of Magnitude Cost per Track Metre	Advantages	Disadvantages	Where it could be applied	Est. Savings vs. Embedded Grooved Rail
5	 EMBEDDED GROOVED RAIL SECURED TO COMPOSITE TIE PLATES	\$3,700	Lowest maintenance costs. Highest durability	Highest capital cost	Stations: 0+000 - 1+850 10+650 - 11+300. Could also be applied in sections of the one-sided transitway where cross traffic accessing adjacent properties is not heavy.	\$0
6	 EMBEDDED RESILIENT RAIL WITH RESILIENT LAYER	\$4,500	Lowest maintenance costs. Highest durability. Additional resilience against ground-borne vibration and noise	\$800 per linear metre of single track more than the highest cost of other options.	To be applied where vibration and noise are of concern	N/A
7	 EMBEDDED T-RAIL WITH RUBBER FLANGEWAY	\$3,500	An alternate to the grooved booted rail	\$200 less than (3)	Along the entire length of Line B	Approx. 10km x \$400/m: \$4 Million less than (3)



Figure 2-2 - Example of Embedded Track - Geneva Switzerland

2.2.3 Direct Fixation Track

Direct Fixation Fastener Track System (DFF) will be used for LRT construction on proposed elevated structures (bridges) and can be used in areas where it is not necessary to have other vehicles running over the track surface area (for example in completely segregated areas of the guideway). It is generally also used along steep grades over 3.5% to prevent the migration of Continuously Welded Rail (CWR) and longitudinal stresses.

2.2.4 Ballasted Track

Ballasted track at grade will not be used along the proposed alignment, but will be used in the Maintenance and Storage Facility yard area. Generally, the ballasted track is constructed with CWR, standard pre-stressed concrete ties and elastic clip fasteners.

Running rails are joined using the Flash Butt Welding (FBW) technology.



Figure 2-3 - Example of Ballasted Track - Minneapolis LRT, USA

2.2.5 Maintenance and Storage Facility Trackwork

The MSF will be design to satisfy the various functional criteria. The ballasted track structure will be used in the yard area. The tracks inside the Inspection/Service building will consist of a combination of embedded and pit/pedestal track. The embedded track system is also used where floor hoists are installed, and at service doors and pit approaches.



Figure 2-4 - Typical MSF Yard Trackwork - Reims Tramway, France

2.2.6 Track Construction Tolerances

All standard track and special trackwork components should be designed and fabricated to minimum tolerances that conform to the track construction tolerances.

The final gauge, cross level, superelevation (on the Highway 403 Bridge), horizontal alignment and vertical profile of all tracks should be within the tolerances specified in the relevant standards.

2.2.7 Running Rail

Running rails should be welded into continuously welded rail (CWR). CWR is chosen to minimize long term maintenance, provide smoother and better ride quality and reduce wear and tear on LRT equipment including wheel wear.

Rail expansion joints should be provided as defined in the detailed design phase.

Recommended methods for joining rail are:

- Flash Butt Welding – for creating the continuous strings for the mainline
- Aluminothermic welding – to weld the strings together

2.2.8 Direct Fixation Fasteners

Direct fixation rail fasteners should be designed to attach the rail to the concrete trackbed on all primary tracks.

Direct fixation rail fasteners consist of hardware, which supports and connects the rail to the concrete track bed.

They should be chosen based on the following criteria:

- CWR/Structure interface forces
- The ability to achieve and maintain desired rail tolerances
- The ability to prevent rail buckling under high temperatures
- The ability to permit the structure to move longitudinally owing to structural flexure and thermal expansion or contraction beneath the rail which remains fixed
- The ability to withstand fatigue and wear of fasteners components with low maintenance requirements.
- The ability to reduce airborne noise and vibration to an acceptable level
- The ability to withstand the local environment without the need to replace components.

The maximum effective load carried per track fixation fasteners must be determined from quasi-static loading of the track structure, schematized as an elastically supported beam, with an increment added for dynamic influence.

2.2.9 Special Trackwork

Special Trackwork is installed in locations where it is necessary to transition light rail vehicles from one track to another either to change direction or to run single-track around an obstruction or maintenance activity. These will be located at the terminal stations and elsewhere along the alignment as required to facilitate normal and emergency operating scenarios. cross overs will be used for short turns to operate with temporary closure of alignment segments.

Table 2.2 – Trackwork specifications

Specification	Unit	Notes
Track Types	1:6 R50 and 1:4 R25 embedded turnouts and crossings	
Ladder Tracks for MSF	1:4 R25	
Turnouts for MSF	1:4 R25 and 1:6 R50	
Turnouts for yard lead tracks	1:6R50	
Frogs	Embedded Monoblock	
Rail expansion joint on aerial structures	TBD	



File: Hamilton LRT Line B Trackwork report Version 2.0 January 2012.doc
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The term special trackwork is used to designate those trackwork units requiring special plates and machined parts necessary where track converge, diverge or cross one another (see Figure 2.5).

Special trackwork should be designed and supplied as new, manufactured, fabricated, inspected and tested in accordance with UIC Standards.

All fabrication tolerances for special trackwork must conform to acceptable track tolerances. All components should be designed such that the specified tolerances can be maintained throughout the operating life of the special trackwork with minimal maintenance.

All special trackwork must be designed with due consideration to noise and vibration sensitivities, and is supplied as complete units, having similar resilience characteristics as adjacent regular tracks.



Figure 2-6 - Typical Embedded Special Trackwork - Geneva Tram – Switzerland



Figure 2-7 - Embedded Special Turnouts - Reims, France

2.2.10 Rail Arrestors

Rail arrestors should be designed and supplied to be capable of safely stopping impacting vehicles within the specified criteria. The rail arrestor is intended to bring the impacting vehicle to a stop on the track.

The choice of the rail arrestor is dictated by the amount of kinetic energy resulting from the vehicle mass, impact velocity and the maintaining a balance between the maximum retardation rate allowed, the amount of track available and the amount of force that the impacting vehicle can withstand.



Figure 2-8 - Rail Arrestor for Minneapolis LRT



Figure 2-9 - Rail Arrestor System - Reims Tramway, France

2.2.11 Drainage

Figure VV shows a typical Cut Away Section for an embedded drainage chase. These drainage chases are typically placed at key locations along the track to ensure proper and sufficient drainage and are connected to the city's storm sewer system at appropriate locations.

These drainage chases are modified at special trackwork boundaries to account for special trackwork component openings.

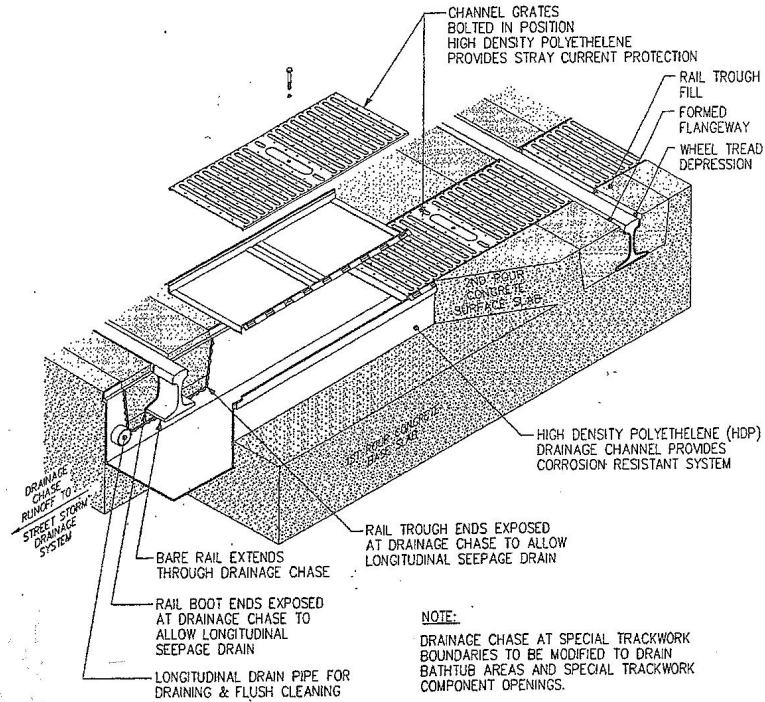


Figure 2-10 - Cut Away Section Embedded Track Drainage Chase - Source TCRP Report 57 – Track Design Handbook

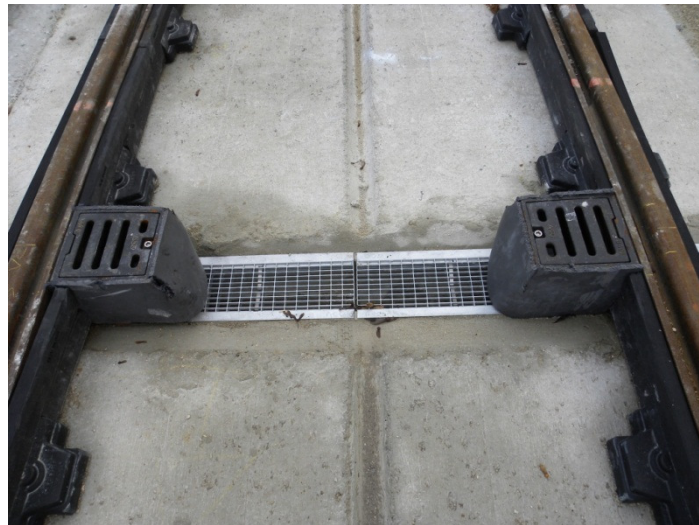


Figure 2-11 - Example Drainage system - prior to placing final topping

3.0 Trackplan and Key Segments

3.1 Trackplan

Figures 3-1 and 3-2 show the general track layout for the proposed B-Line alignment including station locations, termini and special trackwork (cross-overs and turnouts). The operations plan related to this track plan is provided under a separate report.

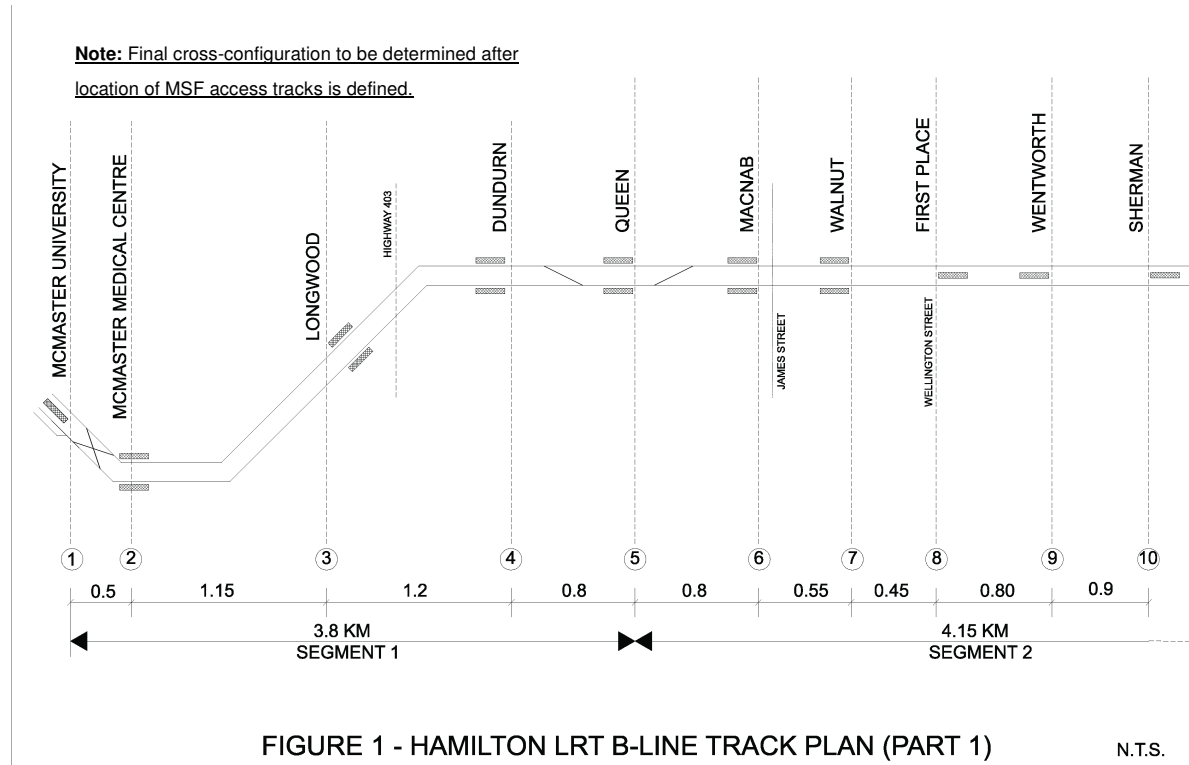
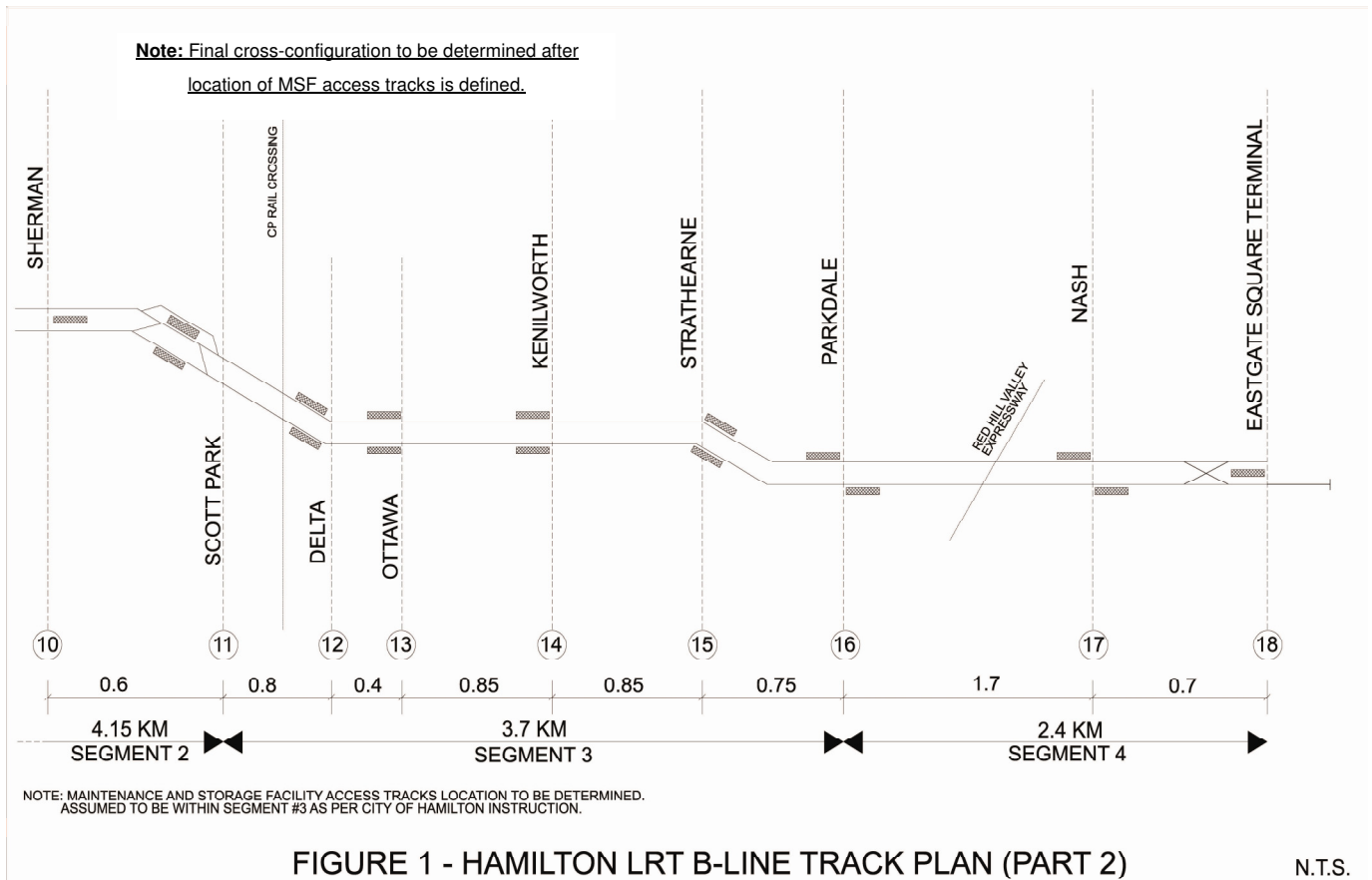


Figure 3-1 - Segment 1 and 2 of Track Plan



N.T.S.

Figure 3-2 - Segment 3 and 4 of Track Plan

4.0 Noise and Vibration – Design Considerations

There are three zones that have been established to address the recommendations in the Hamilton LRT - Noise and Vibration Assessment Report. These zones have levels of mitigation against groundborn vibration that can be addressed in the trackform design. These zones are required due to proximity of residential, commercial, and institutional areas that are sensitive to identifiable frequencies of vibration. The basic methodology is to isolate certain vehicle/rail vibration frequencies from propagating from the trackform through the subgrade and away from the guideway. It is important that further study considers proposed future land uses and built form along the corridor. Nodes and Corridors staff should be consulted as further study is done to ensure land uses and built form under consider for mitigation are appropriate.

The trackform will be developed to mitigate against these frequencies in the most appropriate, effective and economical way.

Level 1 trackform is rail that is encapsulated in a boot and embedded in the pavement. This encapsulated structure has some attenuation in lateral, vertical and longitudinal axis. This is the basic trackform for Hamilton LRT.

Level 2 trackform requires more isolation. This can be accomplished by means of a softer, thicker boot system or by means of fully encapsulating the rail in an elastomeric medium. This level of isolation can also be accomplished by isolating the base slab with commercially available vibration isolation pads or a combination of the two.

Level 3 requires the most isolation. This level is accomplished by means of isolating the majority or the entirety of the trackform. This structure may require a direct isolation of the track slabs or a thicker isolating layer consisting of a vibration mitigating material below the supporting trackbed. This can also be used in combination with the structures mentioned in Level 2 to enhance the required mitigation.

These trackform designs are conceptual and only address the condition of groundborn vibration. Design particulars such as detailed dimensions, fastener spacings and appropriate materials are to be determined. Further study must be done to assess the particular level and frequency of the mitigation required. Cross-sections 6 and 7 on Table 2.1 show alternative treatments which address the above mentioned levels.

5.0 Specific Segment Design

5.1 QUEENSTON ROAD BRIDGE OVER RED HILL VALLEY PKWY

The Queenston Bridge over the Red Hill Valley Parkway is considered a special structure, Hence, the following will need to be taken into consideration when designing the trackwork along this structure.

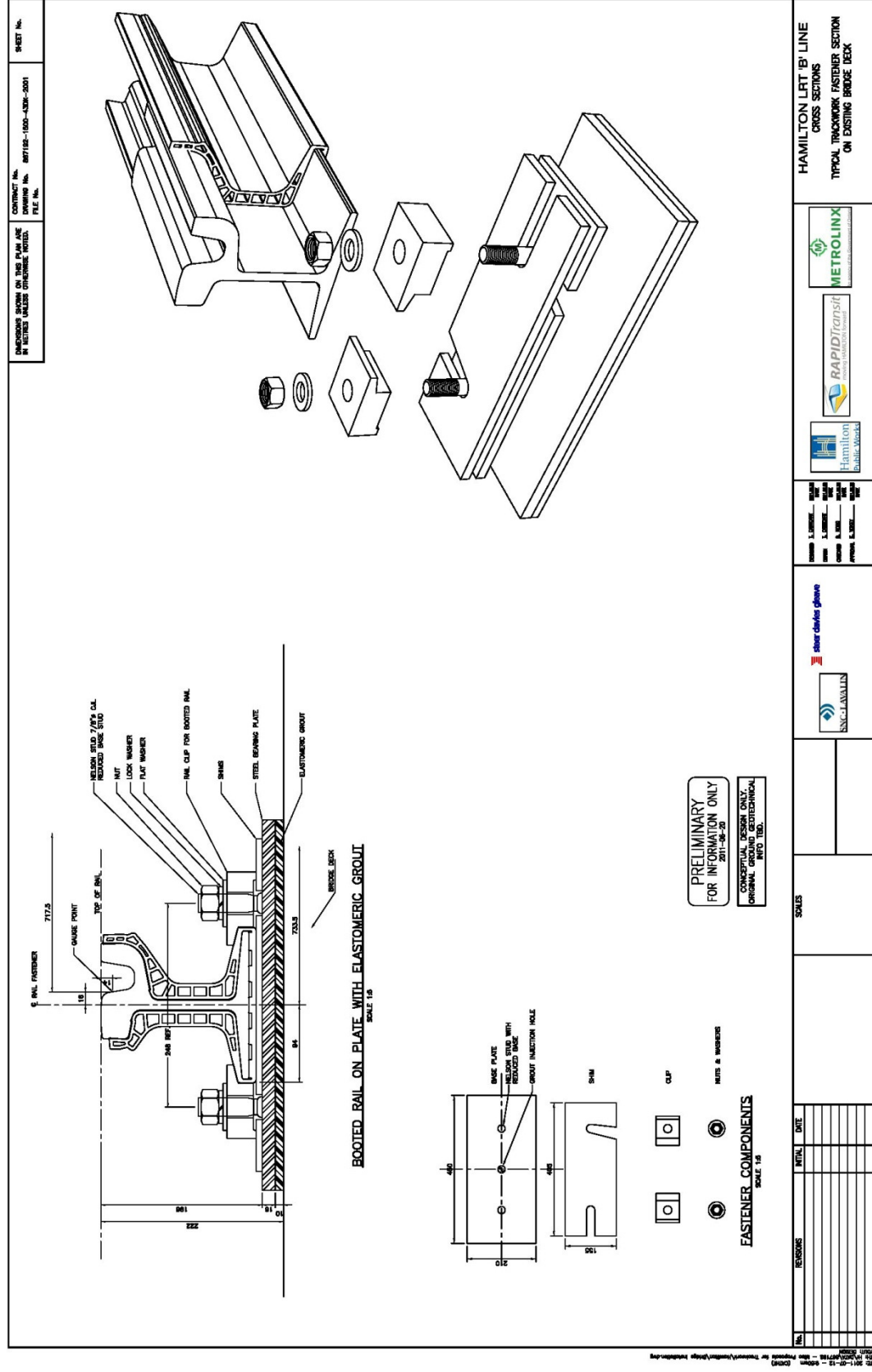
- It will not be possible to drill anchors into the bridge deck due to its hollow core slab design.
- A glued anchor option is recommended (details of such trackwork construction is included in Appendix A)
- The 90mm asphalt would be removed and the deck prepared for the glued on fasteners.
- Supershort Ri35G grooved rail is recommended so that the pavement at the two ramp intersections can be as close to flush with the existing pavement as possible.
- A protective seal to cover the glued base plates to protect from any water damage to the glued surface
- The top surface can be asphalt or concrete to embed the track system
- Only emergency vehicles should be allowed on the LRT guideway (on the bridge)
- There will be need to review drainage for the guideway in detailed design

A detailed investigation will be required at the detailed design stage including an inspection of the deck surface conditions and evaluate its suitability for using the glued method of rail fixation, and a loading test of the bridge to assess its extra carrying capacities. Figure 5-1 shows the typical design for the fastening system proposed.

As mentioned above, a flexible rail fixing by means of glued anchor is illustrated in Appendix A with an example of one manufacturer's construction methods and experience. Features of this method which are relevant to the Queenston Road Bridge track design include the capability of direct fixation without anchor bolts, and the ability of the fixation material to withstand temperatures ranging from -30 °C to +60 °C. Please note, Appendix A provides the information of one manufacturer for information purposes only, and alternative suppliers can be assessed in the next design phase.

The track over the bridge will require special trackwork in the form of a joint to accommodate the longitudinal displacements of the existing structure. Figure 5-2 shows the typical trackwork detail for the expansion joint over the bridge, such detail is for a standard direct fixation as it is not foreseen for traffic to required crossing the tracks in this location.

Figure 5-1 - Typical Trackwork Fastener Section for Red Hill Creek Bridge



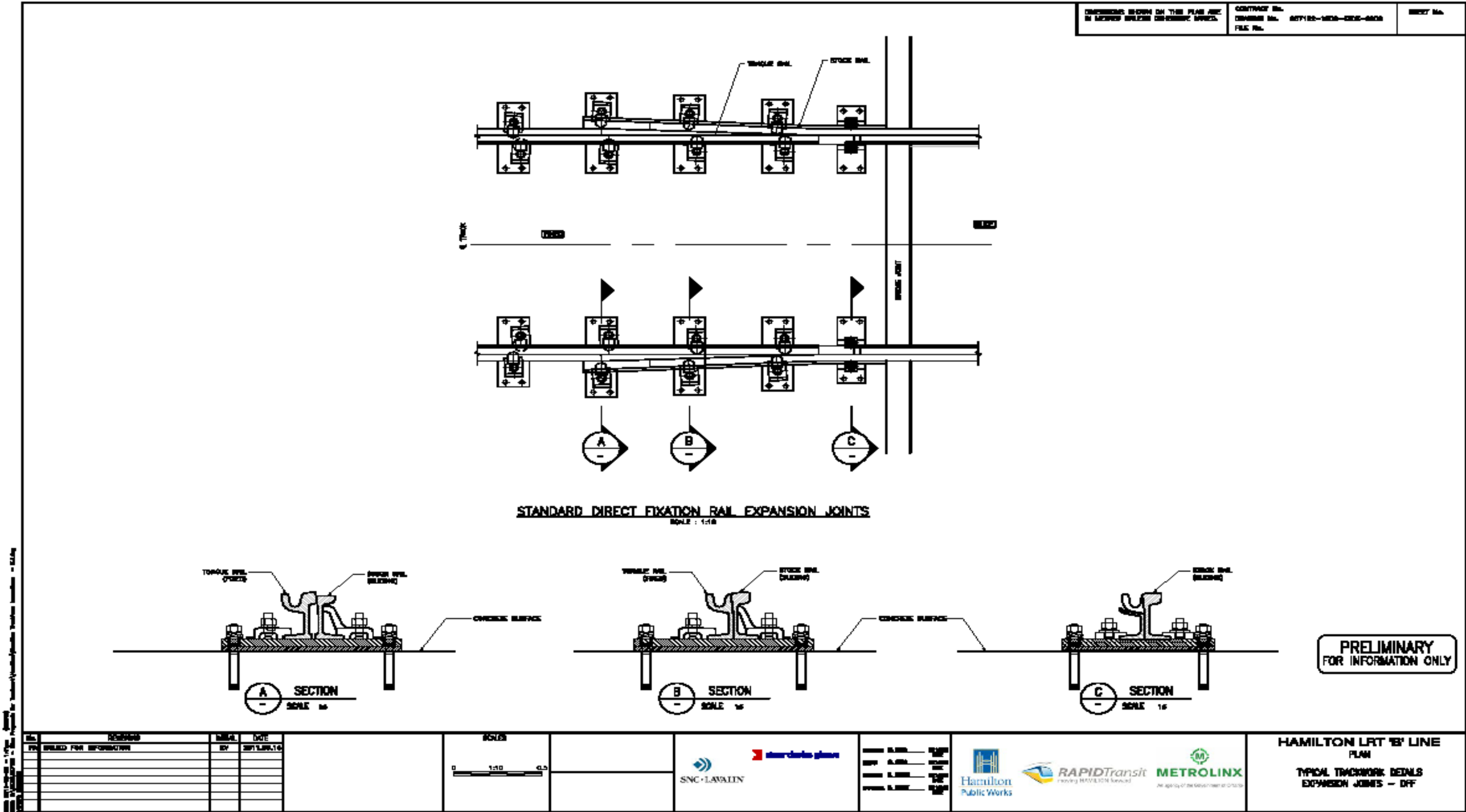


Figure 5-2 – Typical Expansion Joint Detail for Bridge over Red Hill Valley Parkway

5.2 Crossing over Highway 403

The bridge across Highway 403 will be a new structure. A Direct Fixation Method is recommended for this structure and is shown in typical cross section in Figure 5-3

Following discussions with the City of Hamilton and cross reference discussions with other municipalities such as the City of Calgary, there will not be need for embedded track along this section of the alignment, as there will not be any other traffic using this guideway other than the LRT vehicles.

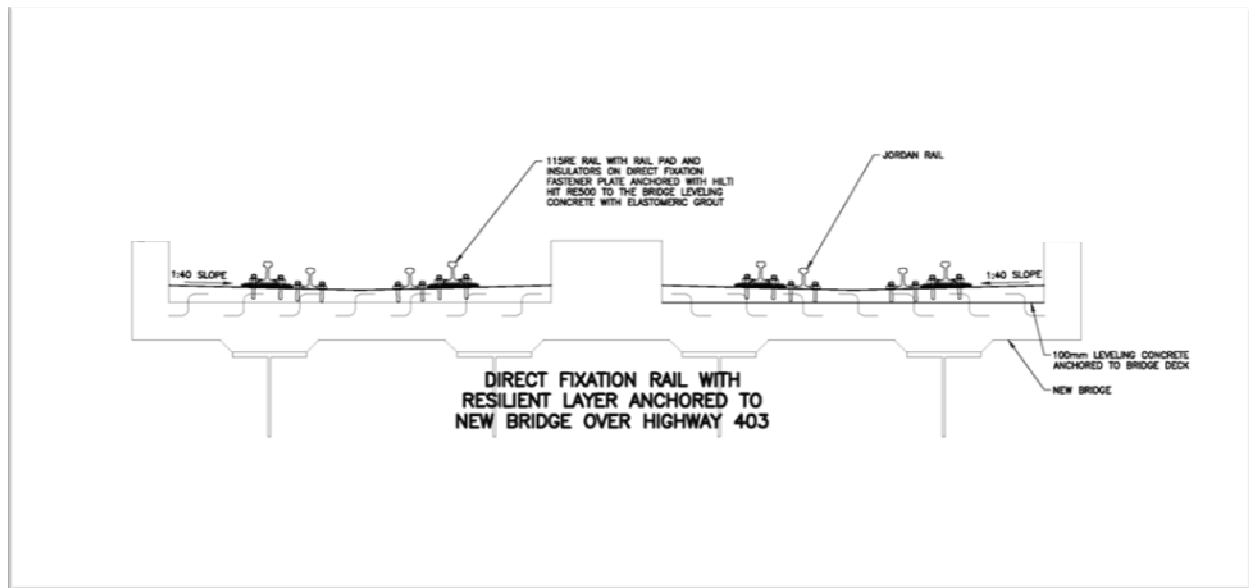


Figure 5-3 - Proposed Section for Highway 403 Bridge

Disclaimer

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APPENDIX A

VENDOR EXAMPLE OF FLEXIBLE RAIL FIXING



Heathrow Express crossover, London

Flexible Rail Fixing Solutions for rail transport world-wide

Service proven – the silent track

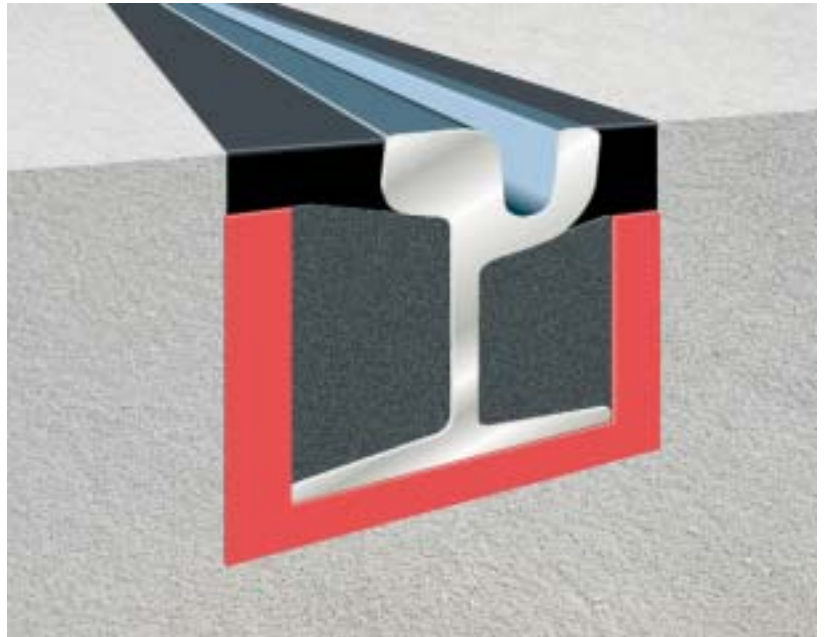
Continuous bedding of rails with Icosit® KC 340

Icosit® KC 340 reduces vibrations and considerably improves riding characteristics due to its permanently flexible consistency. The various grades of Icosit® KC 340 permit individual adaptation to the client's demands depending on vehicle and environmental parameters.

Volume compressibility combined with load-bearing capacity permit effective reduction of vibration and structure-borne sound transmission. Optimum results can be achieved when the rail is fully embedded in Icosit® KC 340.

Modern Light Rail vehicles are becoming faster and more comfortable. More powerful motors, regenerative braking and air conditioning result in more significant return currents, increasing the risk of stray current corrosion and signalling malfunction. Icosit® KC 340 fulfils the latest regulations as per EN 50122-2 regarding electrical insulation against current leakage.

Application of Icosit® KC 340 is largely independent of weather conditions as it can also tolerate damp substrates.



Embedded (floating) rail design with filler blocks





Bern/Switzerland; Kornhaus bridge. The embedded (Ri51) rail design with Icosit® KC 340 permitted lower construction height and a considerable reduction of the deadweight of this historic bridge



Stuttgart, Germany, Berliner Platz (rail junction, Ri60 continuously undersealed)



Erfurt/Germany, Anger. By continuously undersealing the Ri60 rails, vibrations were reduced by 40%.



La Pereda/Spain; F.E.R.V.E. railway bridge. As the UIC 54 rail floats in Icosit® KC, noise emissions were drastically reduced.



Memphis/Tennessee, USA. Embedded (floating) rail design. The very basic suspension system of heritage trams requires efficient damping. Suppression of stray currents to protect buried utility cables, pipes etc. is also a major concern.



Cracow/Poland, Izidora-Stelli-Sawickiego bridge. Ri60 rail continuously embedded in Icosit® KC 340/45



Zurich/Switzerland, Schaffhauser Platz, continuously undersealed Ri60 rail

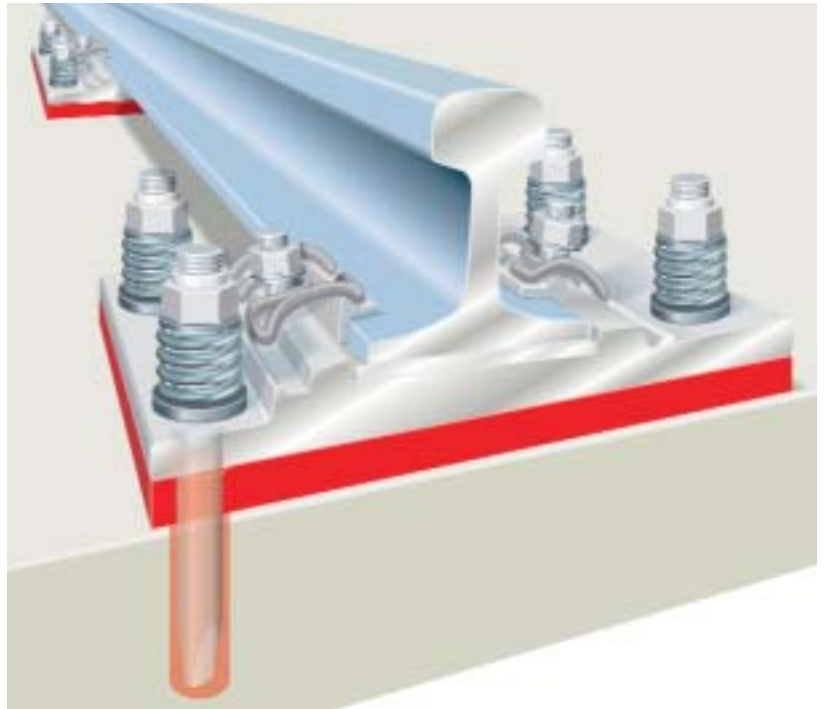
Discrete fixation of rails with Icosit® KC 340 - public transport the discreet way

The various grades of the Icosit® KC 300 series are service-proven for more than 3 decades. Maximum adhesion between concrete and steel ensures a high additional safety margin.

Direct fixations with Icosit® KC 300 permit lighter and thus cost-saving bridge structures, compared to conventional ballast and most ballastless rail fixing systems.

In tunnels, slabtrack using Icosit® KC 300 permits reduction of construction height or increases clearance lost by installation of overhead power supply in refurbishment of old tunnels.

The various grades of Icosit® KC 300 ensure flexible bedding for any axle load and permit maximum precision of alignment by top-down construction.



Discrete fixation with Icosit® KC 340. Anchor bolts fixed with Icosit® KC 220. Under certain conditions, the number of anchor bolts can be reduced or they may even become superfluous thanks to the secure bond provided by Icosit® KC 340.





Karlsruhe/Germany, Siemens Allee bridge. Rph1 baseplates (345 x 210 mm) fixed with Icosit® KC adhesive grout without any anchor bolts.



Mosbach/Germany; Schefflenzer railway tunnel. Discrete fixation (loarb 199) on slabtrack after removal of ballast to increase clearance.



Cracow/Poland. Discrete fixation with Icosit® KC 340/4 Polyurethane grout on slabtrack.



Calgary/Alberta, Canada; Big Four. Discrete fixation exposed to extreme temperature variation from -35 to +60°C since 1981 – still in perfect condition



Remseck/Germany; LRV depot of SSB. Steel baseplates (360 x 210 mm) fixed with Icosit® KC 340 adhesive without anchor bolts – an extremely cost-efficient design.



Tuen Mun LRT/Hongkong. Discrete fixation with Pandrol baseplates and Icosit® KC flexible grout.



Berlin/Germany. Discrete fixation with baseplates 360 x 210 mm



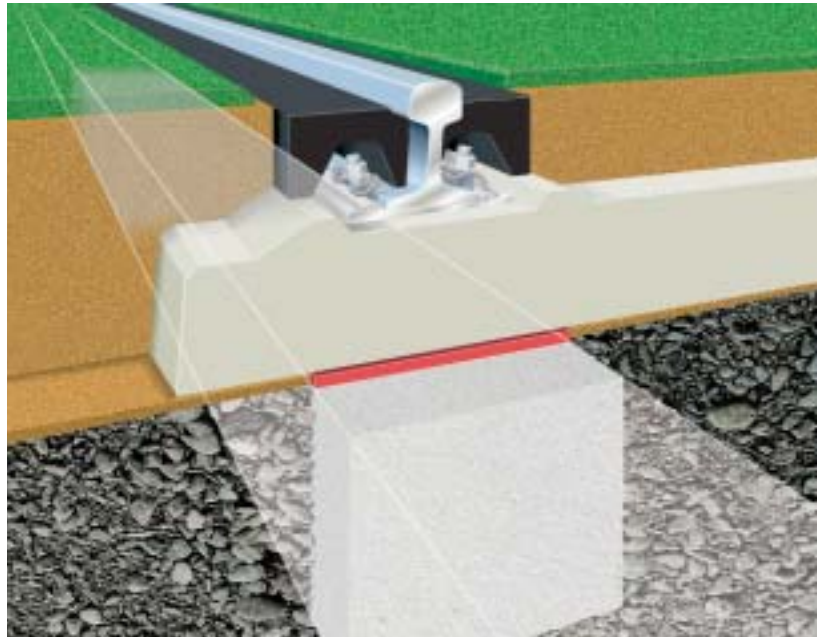
Göppingen/Germany. Discrete fixation with Icosit® KC 340 on Intercity Express track.

Lawn track designs with Icosit® KC 340 - the green alternative

Town planners prefer to segregate rail from road traffic to shorten transit times and to reduce accident risk. To reduce the environmental impact of the trackwork, lawn track designs have become very popular.

Lawn track designs with Icosit® KC 340 reduce structure borne and airborne sound to a minimum and still maintain efficient insulation against seepage of stray currents.

These designs are virtually maintenance-free (apart from grass-cutting!) and modern design techniques enable their cost of construction to be very close to that of conventional ballasted track.



Detail of "Bremen" type lawn track, emergency vehicle version



Hannover-Langenhagen/Germany.
Discrete fixation on concrete beams.



Stuttgart/Germany. Detail of "Bremen" type
lawn track before undersealing of sleepers/
ties.



Bremen/Germany. Emergency vehicle version
of lawntrack.



Tested quality provides safety

Before being released, the products of the Icosit® KC series have to undergo extensive in-house testing using sophisticated equipment under realistic conditions.

In addition to that, large scale field tests are complemented by long-term dynamic durability testing, vibration and noise behaviour, fire resistance, smoke emission and electrical conductance. These are usually undertaken by external specialists, e.g. The Technical University of München, The University of Calgary/Canada, AEA Rail Technology in the UK, the University of Louvain/Belgium, the University of Győr/Hungary and many others. German Railways (DB) are ranking Sika as "Q1" = top quality supplier. Many other railway authorities rely also on the approved track fixing designs with flexible grouts of the Icosit® KC series.



Testing tensile strength



Dynamic testing on pulsating load test rig

To supplement test reports with long-term field experience, a perfectly intact 28 year old discrete fixation with Icosit® KC grout was removed from Heinrichsheim bridge in Bavaria. The Technical University of München subsequently produced a load-deflection (spring) diagram. Comparison with the corresponding diagram from the quality control at the time of installation in 1971 showed an increase of stiffness of only 6%. A proof of outstanding longevity!



Special fields of application

Tracks for heavy gantry cranes can be exposed to extreme point loads of up to 50 tons per wheel often resulting in failure of cementitious and sometimes even epoxy grouts. The tough-elastic grades of the Icosit® KC series flex under point load, thus distributing the load over a wider surface area and consequently avoiding damage.

Resilient grouts of the Icosit® KC 300 series are also successfully employed for undersealing central ball bearings of bucket wheel reclaimers as well as rails in automated warehouses.



Container crane, Eurogate port Hamburg

Sika system solutions



Besides flexible grouts for rail fixing, Sika produces also a wide range of flexible structural adhesives for the construction of railway coaches and trams. Whether the flexible assembly of a driver cab or fitting the screens of the Transrapid high speed maglev train – flexible adhesive technology from Sika is proven world-wide



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