CASE STUDY OF RAIL DESIGN ON GOLD COAST LIGHT RAIL

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SUMMARY

Gold Coast Light Rail is a world-class public transport system involving 13km of linear light rail infrastructure between Southport and Broadbeach on Queensland’s Gold Coast. The system runs Bombardier Flexity 2 Light Rail Vehicles at speeds up to 70km/hr and at a peak headway of 3.5 minutes.

As the track is partially integrated with the road network the majority of it is embedded grooved rail. The rail is supported by a concrete trackslab whose design encompasses elements of pavement and reinforced concrete slab design theories in order to reduce material quantities and construction times.

The elevated structures utilise direct fixation slab track with Vignole rail. The differing rail profiles, track form and supporting structure required an innovative solution to the transition zone that was able to accommodate differential settlement of the supporting ground.

From the outset, a Wheel-Rail Interface study was undertaken to ensure the safe passage of vehicles at each stage of the projects life cycle whilst minimising rail wear, track loading and the risk of derailment. The findings of this study were used to refine the structural design of the slab track, identify trouble spots requiring head-hardened rails and influenced the angles of the complex delta-junction at the depot entrance.

During the tender stage the consortium identified numerous opportunities to improve the track geometry by adopting European light rail specific guidelines. A quantitative analysis of journey time, land take and passenger comfort was undertaken resulting in the European guidelines ‘Rules on the Alignment of Rail Systems in accordance with the German Federal Regulations on the Construction and Operation of Light Rail Transit Systems (BOStrab) or ‘BOStrab Alignment Rules’ being adopted.

1. INTRODUCTION

The Gold Coast is one of the fastest-growing cities in Australia and the country’s premier tourist destination, drawing approximately 10,000 new residents and more than 10 million visitors each year. The Gold Coast Light Rail (GCLR) project is an ambitious, city-changing infrastructure project that aims to integrate new and existing transport systems, support urban regeneration and facilitate sustainable transit-oriented development. It will bring together the world’s best infrastructure and urban design solutions to create a vibrant and bold future for the City. The Project also realises part of the overall infrastructure strategy proposed to service the 2018 Commonwealth Games to be held in the Gold Coast.

Figure 1 shows the Stage one rail alignment which effectively runs through the most highly populated and busy tourist areas of the Gold Coast. The route starts at Griffith University (in Southport) and runs south through the Southport shopping district, over the Nerang River, down Surfers Paradise Boulevard, through Surfers Paradise itself and down the Gold Coast Highway to Jupiters Casino and the Pacific Fair Shopping Centre in Broadbeach. The system is largely at-grade but includes approximately 200m of underground track at the north end and 1km of track on bridges. The at-grade sections, which negotiate nearly 50 existing road intersections, vary from fully segregated to fully integrated running with respect to road traffic and the pedestrian network. There are 16 stations along the route spaced at between 500m and 1km apart, along with 2 bus interchanges. The Depot is located towards the north end of the system and accommodates the maintenance building (and control centre) and stabling sufficient for 14 vehicles. Further stages are planned to link this stage with Helensvale Train Station to the north and the Gold Coast Airport at Coolangatta to the south.

The GoldLinQ consortium won the tender to design, construct and operate the system for a 15 year period. GoldLinQ comprises of Keolis SA, Downer EDI Ltd, Bombardier Transportation Australia Pty Ltd, McConnell Dowell Constructors Pty Ltd, Plenary Group Pty Ltd and Arup.

2. RAIL DESIGN

The Rail Alignment and Permanent Way design utilised innovative thinking and first principle designs to solve the unique complexities of this project.

Being a new piece of infrastructure with no previous guidelines in place it was necessary to research over a dozen existing systems from around the world and to consider new technologies. This led to the development of the Rail and Trackwork specification, where all decisions were supported by first principle calculations. All this resulted in a rail and trackwork specification that is unique to GCLR.
The following is a summary of several smarts that contributed to the success of the Permanent Way design and the project as a whole:

2.1 Transitions

As with all rail projects, special attention was necessary at the transition between different track types and supporting structure.

Transitions are normally complex due to the sudden change in track stiffness or track modulus ‘k’, particularly for transitions from ballasted to slab track. GCLR is all slab track and each variant was designed to have a similar track stiffness. Any variation in stiffness would be a result of the supporting ground/structure below.

On GCLR, the trackform transitions were from embedded rail on earth fill to direct fixation plinth track on piled structure. The transition between the slightly different k-values was achieved using a transition slab that bridged the two track forms.

The Performance Scope and Requirements ‘PSR’ specified a minimum transition length of just 6m, it was necessary to increase this and use a 13m continuous slab with the change from embedded to plinth track occurring half way along.

An additional concern was the predicted differential settlement between the two. The plinth track was not expected to settle and the embedded rail on imported fill had a worst case predicted to settle of up to 30mm.

Transitions between ballast and slab track, have the advantage that misalignment due to settlement can be rectified by reinstating the ballasted track to its original position. With embedded rail it is not feasible to adjust the alignment thus an innovative solution was required.

The solution was to install the first few lengths of plinth track lower than necessary and achieve the require rail level with removable packers. If the settlement causes the rail alignment to be out of tolerance the packers can be removed such that a compliant alignment is reinstated. Effectively, as the earth structure settles, we lower the first 15m of the bridge alignment in varying degrees to suit.

It was necessary to select a baseplate and fastening system that had the flexibility to adjust the rail level independently of the baseplate but more importantly allowed for the shims to be removed without cutting and removing the rail. The chosen fastening system was the Vossloh UTS 300.

Each abutment had a different predicted settlement due to the varying substrata and volumes of imported fill. The length of each transition slab and extent of removable shims on the structure was calculated to suit ensuring the slab length was minimised to provide a cost effective solution.

The rail profile also changed at the transitions. Plinth track utilised Vignole rail 49E1 and the embedded rail utilised grooved rail 51R1. The corresponding depths were 150mm and 130mm. In addition the Vignole rail is symmetrical, and installed with a 1:40 inclination, whilst the grooved rail is asymmetrical and is installed vertically with a 1:40 inclination machined in the rail head. These major differences, See figure 2 ruled out the use of composite welding.

Although this was not the best option, a composite welded rail was still used between the embedded and plinth track. It was necessary to use a compromise to meet the performance parameters, however the potential for misalignment and settlement issues was clearly understood.

Figure 1: Aerial view of route showing station location

Image Courtesy of the GoldLinQ consortium, delivering stage one of the Gold Coast light rail project.

Figure 2: Mismatch in rail profiles
The solution was to machine a bespoke transition monoblock panel. The design needed to permit welding to the rail profile at each end, provide a smooth transition between and be able to be supported on plinth track. Figure 3

![Figure 3: 49E1 to 51R1 Transition monoblock](Image Courtesy of the GoldLinQ consortium, delivering stage one of the Gold Coast light rail project.)

### 2.2 LRT specific alignment guidelines

During the tender phase the operating arm of the GoldLinQ consortium, suggested the alignment wasn’t generating journey times that they might expect on comparable LRV systems in mainland Europe. A comparison of the GCLR Requirements was performed against the European Light rail specific guidelines and other alignment guidelines based on Arups global experience.

It was found that the GCLR requirements were more in line with Urban commuter rail and in some respects similar to that of High Speed Rail, and not necessarily suitable for a street running system.

In summary the limiting horizontal criteria as outlines in Table 1:

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Original PGCLR requirements</th>
<th>BOStrab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curves</td>
<td>Cant deficiency = 80mm</td>
<td>Lateral acceleration: 0.67m/s² max 0.97m/s² exceptional</td>
</tr>
<tr>
<td>Transitions</td>
<td>Rate 55mm/s</td>
<td>Max jerk rate 0.65m/s³</td>
</tr>
<tr>
<td>Gradient</td>
<td>1 in 400</td>
<td>1 in 400</td>
</tr>
</tbody>
</table>

**Table 1: Comparison between the two alignment requirements**

The benefits to line speed can be seen by comparing a simple Tangent to curve arrangement. For a radii of 85m and a transition length of 12m, the applied cant will be the same for each, that being 30mm. The resulting speeds are:

- 28kph (25kph posted) for original requirements; and
- 35kph (35kph posted) for BOStrab.

Therefore a 10kph, or a 40% increase in speed.

The case for using specific LRV guidelines with a proven record from some 52 systems in Europe, in preference over those that were derived from other modes of rail was accepted by the client. Not all the speed improvements were capitalised on due to signalling, operational constrains and speed restrictions dictated by adjacent infrastructure users, but there was a marked improvement on the journey time, contributing to fewer LRVs, a smaller depot ultimately resulting in a more economical design.

### 2.3 12d Modeller

The light rail system occupies much of the existing road corridor requiring alterations to the functionality of the road network. The design required a seamless interface between the rail and road alignments to ensure an integrated design was achieved.

It was decided to deliver the detailed design as a fully integrated 12d project, including rail, road, stormwater drainage and survey (MacDow).

Before commencing design, the team integrated a member of 12d’s software development team into the design office to identify and understand the unique modelling requirements of a light rail system. The existing tools available in 12d software were compared against the specific requirements to efficiently and accurately deliver the project.

The particular issues identified were applying cant about the centre of the low rail and also applying the inclination to the surrounding trackslab, kerbs etc. Till this time 12d was predominantly a civil based design tool and these rail specific functions weren’t present at the time.

In addition the chosen software was required to analysis and document Sight Stopping Distances to a 200mm object on the track. This is a standard requirement for highway design, but not for rail projects which typically operate in a segregated corridor and relies on signalling, not line of sight. Therefore the software needed to apply highway tools inside the Light Rail corridor.

During the initial stages of the design process it was necessary to develop and adapt of a number
of macros within the 12d software to efficiently and accurately model the light rail design.

Following the success of the GCLR design stage, these tools are now inbuilt into the latest versions of 12d. This close working with the software developers demonstrated that this is mutually beneficial to all parties and should be encouraged.

### 2.4 Track stiffness and Rail Stress analysis

GCLR has a unique combination of the Bombardier Flexity 2 LRV, Vossloh 300UTS DFF baseplates, 49E1 and 51R1 and the phoenix 3 piece boot. Without the luxury of another system with this exact combination to demonstrate the compatibility and behaviour for these combinations it was necessary to result in first principle design to prove the track system as a whole met the requirements.

Several techniques were used, such that each could validate the other.

The track loading was determined using Huddersfield University outputs from the Wheel Rail Interface analysis, and reviewed by Arup designers using the Eisenmann and AREMA dynamic factor calculations.

The first technique was to use Arups in house design software ‘GSA’, to determine, deflection, stresses, thermal expansion, rail/structure analysis.

Finally, each of these aspects were calculated independently using first principle design calculations. Testing is currently occurring on site and at the time of writing this paper, we do not have final results. The majority of rail design today is done by applying asset owner standards that are well documented, proven and have been refined over many years of empirical data. The designers on GCLR had the opportunity to apply and learn skills that are no longer common in the Permanent way engineers tool box.

### 2.5 Wheel Rail Interface (WRI) Study

Arup engaged the Rail Technology Unit from Manchester Metropolitan University (now Huddersfield University) to run simulations of the Light Rail Vehicle (LRV) on the alignment. These simulations incorporated vehicle suspension, a range of vehicle masses (to suit passenger loading) and aspects like track cant, wheel and rail wear, rail lubrication and wind loads. The primary objective was to assess issues like wheel-rail compatibility, risk of derailment and rail wear. However, the simulations were also able to produce detailed track loads generated by the vehicle under various load cases, including dynamic enhancements. The results of this study were used to determine lateral and vertical loading combinations for the route (see Table 1 for summary of route-wide maximum values). In designing the trackslabs, localised loads were used where possible to give more economical designs.

<table>
<thead>
<tr>
<th></th>
<th>Vertical Load</th>
<th>Lateral Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel (kN)</td>
<td>108.71</td>
<td>65</td>
</tr>
<tr>
<td>Wheel Set (kN)</td>
<td>135.46</td>
<td>56.3</td>
</tr>
<tr>
<td>Bogie (kN)</td>
<td>266.76</td>
<td>84.21</td>
</tr>
</tbody>
</table>

Table 2: Results from WRI Study

### 2.6 Components for Embedded Rail

Although this system is new for Queensland, all components used in the construction were required to have a minimum of 5 year service record in an equivalent system around the world. All suppliers were required to have proof of this criterion when proposing their products.

#### 2.6.1 Rail

The 51R1 grooved rail profile was chosen based on the WRI study to match the preferred wheel profile of the Flexity 2 tram used on this project. The rail is welded continuous over the project length and protrudes by a nominal 6mm above adjacent track slab top surface to allow for future rail wear.

#### 2.6.2 Rail Boot

The rails were provided with a rubber boot system to isolate the rails from the track slab concrete for the following reasons:

- provide the rails with a resilient (flexible) support system which resulted in reduced rail wear and cushioning to the concrete;
- control and limit noise and vibration from the wheel rail interface so as to enable the environmental limits for the project to be achieved, particularly through the medical-based properties along the route;
2.6.3 Concrete Slab

Slabs are plain, minimally reinforced or fully reinforced concrete slabs into which the booted rails were cast. Sacrificial Glass Reinforced Plastic (GRP) frames with levelling screws were used to hold the rails to gauge and alignment within the slab pours.

3. STRUCTURAL DESIGN

Several trackform solution types were developed to accommodate different aspects of the track, alignment and furniture including turnouts, Over Head Line (OHL) and lighting supports, rail signalling equipment, varying track support conditions, the existing as-built environment and requirements for future services installations. This paper sets out the trackslab forms developed for the Project and expands on the design

3.1 Foundations

The route that this alignment traverses encounters a large variety of foundation material. South of the Nerang river the existing soils are predominantly sands with good support stiffness properties for ground bearing slabs and no issues with swell. The materials north of the Nerang river are a different story. The existing materials found in this area vary from CBR (California Bearing Ratio) 1 to 10 and swell values that vary of a similar magnitude as well as having areas of acid sulphate soils, high groundwater tables and of course, a decommissioned uncontrolled land fill site.

This required a variety of foundation improvement strategies in line with the design requirements of the Austroads Pavement Design Manual (APDM). The typical foundation build up started as deep as 1.5m from top of rail with some areas requiring a drainage layer in order to ensure high groundwater doesn’t affect the support to the trackform. The next layer is a select fill to reduce the impact of high swelling soils and improve support stiffness where required and varied in thickness from 800mm to 200mm. The select fill layer is capped with around 150mm of lean mix concrete, which sits at the softil level of the trackform slab.

The foundation build up in each of the verge in some areas of the alignment were also provided with subsoil drainage at the interface of new to existing soil. These subsoil drains are connected to the active drainage system that was also designed as part of the GCLR scope.

3.2 Concrete Design

The loading system for the majority of the mainline track is purely LRV with checks undertaken on incidental road vehicle loading for emergency vehicles and maintenance operations.

It is anticipated that at peak running capacity the system will run with 3.5 minute headways; this was used to predict the number of loading cycles across the 40 year design life of the structure in accordance with the project specification.

It was deemed unreasonable to assume that each of these millions of cycles would be with a maximum axle load of 6 people per square metre so a distribution was established of full, partially full and seated passengers only to give a distribution of axles loading for the structures design life. This distribution was based on the patronage models and projections for the life of the structure.

Using these loading cycles and the given design CBR of the foundation build up a first iteration of thickness design was undertaken using Austroads Pavement Design Manual (APDM) and assuming a rigid pavement. Initial calculations were based on the assumption that the vertical load from the LRV would transfer through the rail to the rail foot and only be supported by the concrete below rail foot level. This gave a slab thickness of 450mm, this being made up of 150mm rail depth including boot, 290mm absolute minimum pavement thickness below the boot for concrete fatigue stress and joint erosion and 10mm of tolerance allowance during concrete placement.

Joint erosion is a displacement or rotation of the slabs either side of a joint, which causes eventual subgrade failure and loss of support to the pavement. This initial thickness design ignored any potential contribution to the slab load carrying capacity from the concrete above rail foot level and so was considered to be an upper bound for slab thickness.

A grillage model with longitudinal and transverse beam elements on spring supports was prepared and analysed under vehicle loading (see Figure 6). This was used to determine the bending moments in the slab, from which extreme fibre tensile stresses in the slab were calculated using elastic section properties. A key assumption in this work was that the full section depth of the slab contributed to the load carrying capacity of the slab and it was noted that this needed to be verified.

A basic finite element brick model of a 4m length of slab was therefore analysed to explore the load transfer mechanism from rail, through boot to concrete and the principle tensile stresses generated in the concrete (see Figure 7). The booted rails were explicitly modelled within the slab and the longitudinal continuity of the slab was simulated using simple beam elements to extend the slab length being modelled. Grounded springs were used to simulate sub-grade stiffness.
The peak longitudinal slab soffit stresses under a bogie load from this finite element model were found to be comparable with soffit stresses obtained from the grillage analysis above. Diagonal tensile stresses were seen to develop from the outer edges of each rail foot, allowing transfer of rail loads from rail foot level to the top of the slab section.

This behaviour confirmed that the slab design could be based on the full thickness of the section and not just the concrete below the rails. It was also noted that the booted rails spread the tram wheel loads over a length of 750mm or more at a depth of 150mm (underside of rail boot), which effectively meant that the slab-rail system behaved as if the tram loads were being applied to its top surface.

The above findings allowed the trackslab to be designed by simply assessing soffit stresses assuming a full depth section with all loads applied to the top surface as would be done with a standard ground bearing slab. Subsequent analysis of the trackslab was therefore carried out using simple grillage analyses to obtain bending moments and, from this, the soffit tensile stresses. Tensile stress capacity for the slab was required to compare the applied stresses determined from the analysis. In pavement design terms, the allowable tensile stress in a concrete pavement slab is dependent on the number of load repetitions occurring within the life of the pavement. As the number of load repetitions increases, the allowable tensile stress (or utilisation factor) needs to be reduced to reflect that the concrete undergoes tensile fatigue. Table 1 of Technical Note 46 (Hodgkinson, J.R. 1982) advises a relationship between the tensile stress utilisation factor and number of load repetitions. In particular the TN notes that once the number of load repetitions exceeds 500,000, the utilisation factor bottoms out at 0.45, i.e. an unlimited number of repetitions is possible at this level of tensile stress utilisation. For the GCLR system, a 3.5 minute headways, 16 hours a day, 7 days a week, 365 days a year for 40 years results in axle load repetitions far in excess of 500,000 and so a utilisation factor of 0.45 was adopted.

Further consideration was then given to the fact that, unlike road vehicles which tend to wander laterally on a road pavement, trams would repeatedly load the slab along the same lines (channels), such that the soffit of the concrete directly below the rails would be subject to greater fatigue damage than the sections further away from the rails. This was allowed for in the design by reducing the utilisation factor by 1.13 to allow for this channelization. This reduced the allowable tensile stress formula for the pavement slab in APDM to:

\[ \sigma_{slab} = \frac{0.45}{1.13} \times 0.75 \sqrt{f’c} \]

\[ = 0.3 \sqrt{f’c} \]

\[ f’c \sigma_{slab} = \frac{0.45}{1.13} \times 0.75 \sqrt{f’c} \]

is the characteristic 28-day compressive cylinder strength of concrete and 0.75\(\sqrt{f’c}\) is its associated flexural tensile strength. This stress limit was applied at the serviceability limit state, i.e. using unfactored vehicle loads, with 3 passengers per square metre in the tram to generate a “frequent” loadcase.

A comparative structural design was also carried out under ultimate limit state vehicle loads to AS 3600. The ultimate flexural tensile strength of concrete to the AS was determined as below:-

\[ \sigma_{slab} = 0.6 \times 0.6 \sqrt{f’c} \]

This stress limit was applied at the ultimate limit state, i.e. using factored vehicle loads, with 6 passengers per square metre in the tram and/or wind loads.

Based on the above methodology, the thickness of the trackslab was reduced to 380mm for straight line track and 400mm for track on curves, where the vertical loading increases on the high rail. This thickness was then checked for the requirements of joint erosion from the APDM. A 380mm minimum slab thickness was found to be adequate to prevent joint erosion.

Joint spacing for JRCP was restricted under the APDM to a maximum of 12 metres to limit shrinkage cracks and to control their locations. These joints were saw cut and sealed on the top surface and included a crack inducing element in the bottom of the pour to generate controlled cracking. Shear dowels were installed at each contraction joint location to transfer shear load across the joint and to minimise stepping of the slab. These dowels were designed in accordance with the APDM and ignored the shear transfer capability of the rails themselves. This is understood to be conservative but not excessively so as the flexibility of the rail boot reduces the capacity of the rails to act as shear connectors.

Reinforcement in the slab was designed in accordance with the APDM for shrinkage requirements. Normally in a pavement slab, all slab reinforcement is provided at the top of the slab, but because of the relatively large depth of this Type 1 section, the reinforcement was distributed between the top and bottom of the slab. As previously mentioned, this section also must withstand loads caused by a curving or wind loaded vehicle applying lateral forces to the rail which in turn applies a load within the structural concrete section. For this reason, beam reinforcement in accordance with AS3600 was...
provided on the outside of the rail to support these loads and develop them back into the section.

4. CONSTRUCTION

Construction of the Light Rail began in early 2011 and is currently set for completion in mid-2014. GoldLinQ and MacDow are working together to deliver the 13-kilometer light rail corridor from Griffith University to Broadbeach, passing through the various key centres along the way including Southport and Surfers Paradise.

4.1 Bridge construction – Rail on Plinth Track

There are four major bridges on the Project spanning roadway and watercourses. These are; Smith Street Viaduct – Spans over the Smith Street Motorway and green fields from Griffith University to the Depot Viaduct. The structure is approximately 370m long. The form comprises of 12 spans of prestressed concrete girders with a reinforced concrete deck.

Nerang River Bridge – Carries the corridor over the Nerang River Bridge connecting Southport to Main Beach. The structure is approximately 380m long. The form comprises of 12 spans of prestressed concrete girders with a reinforced deck.

MacIntosh North and South Bridges - Carry the alignment over the Nerang River at two locations spanning approximately 32m and 43m respectively along the Gold Coast Highway. The structures comprise of precast concrete deck units and a reinforced concrete deck.

All of these adopt a plinth track construction. The plinth is a proprietary precast plinth that is anchored to the deck slab via post installed anchors. The proprietary epoxy used to anchor the bolts into the concrete deck provides electrical isolation of the bolts from the reinforcement in the deck.

Once the anchors are installed, the precast plinths are lowered into place.

The Rail alignment is set using a proprietary system that allows the rail to be suspended and the precast plinths set in place before the concrete infill is placed.
The rail is then fixed onto the precast plinth using a Vossloh Fastening System 300 UTS for 49E1 rail. The temperature at the fixing stage is critical to not induce unwanted stresses into the rail. This was mitigated by constantly checking the temperature of the rail and carrying out works during the earlier part of the day, allowing the installation of the rail at a stress free temperature, negating the need for distressing.

4.2 Bridge construction – Grooved Rail on Baseplate

The Depot Viaduct is a concrete elevated structure that connects the Smith Street Viaduct to the Depot area. The length of the structure is approximately 330m. The form of the structure is a suspended concrete slab on precast concrete piles. Due to the complexity of the expected articulation of the structure, the track form chosen was 51R1 Grooved Rail on baseplates, which allows horizontal adjustment of the rail in the future.
4.3 Trackform construction – Embedded Rail
The embedded rail track slab Type 1 incorporates the use of 51R1 grooved rail encapsulated in a rubber boot.

A proprietary system is utilised to set the rails to height and to align the rail to the correct geometry. Once the rail is set, the remaining reinforcement is tied around it and the trackform concrete is poured.

The trackform Type 4 is of a similar construction technique.

The trackform Type 7, crossover tracks, was constructed in two stages due to the mechanical equipment and the crossover tracks.

4.4 Depot – Embedded Rail
The Depot was located on disused reclaimed land with poor soil properties and unlikely ground conditions. The structure form was a suspended slab on precast concrete piles.

Figure 13: Type 4 Trackform completed
Image Courtesy of the GoldLinQ consortium, delivering stage one of the Gold Coast light rail project.

Figure 14: Type 7 Trackform completed
Image Courtesy of the GoldLinQ consortium, delivering stage one of the Gold Coast light rail project.

Figure 15: Depot – Pile installation
Image Courtesy of the GoldLinQ consortium, delivering stage one of the Gold Coast light rail project.
Over 300 precast octagonal piles were driven in the process of construction to mitigate the future settlements of the underlying soils in the future.

4.5 Maintenance and Rail Replacement

The trackform has been designed to satisfy a 40 year Design Life over which the trackform will function without replacement, refurbishment or significant maintenance, other than those maintenance activities typically associated with Light Rail Infrastructure such as rail head grinding, weld build up repairs and rail replacement where required.

As part of the trackform design, reinforcement has been arranged to allow for future saw cutting of the concrete surround and minimising demolition for rail maintenance and replacement.

The rails can then be removed and replaced as required. The channel surrounding the rail is then grouted up with a high strength free flowing grout to the finished levels required.

The required design life is relatively demanding for tight radii curves in the rail stabling yard and as such, the stabling balloon has been designed to have the 51R1 rails installed in pre-formed slots in the slab and secured in a proprietary poured elastomer by Edilon Sedra. This in turn will enable ready replacement of the rails.

CONCLUSION

Stage 1 of the Gold Coast Light Rail project utilised innovative design across the Permanent Way design, Slabtrack Design and Construction as discussed in this case study to deliver a product that is appropriate to the given conditions and within the outlined requirements and specifications.

The development of construction techniques individual to the requirements of this project were instrumental in ensuring a smooth and timely construction process was maintained.

The Project is currently in the Commissioning and Testing phase and is planned to go operational in 2014.

Figure 16: Completed Depot Slab

Image Courtesy of the GoldLinQ consortium, delivering stage one of the Gold Coast light rail project.

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REFERENCES