Central Rail Systems Alliance

Improving Passenger Journeys

Newark Crossing Renewal – August 2019

Mark Smith, Lead Engineer; Moneeb Saqlain, Project Engineer; Phil Winship, Principal Engineer.

Newark Crossing a.k.a:

Newark Flat Crossing
Newark ‘Star’
Newark ‘Diamond’

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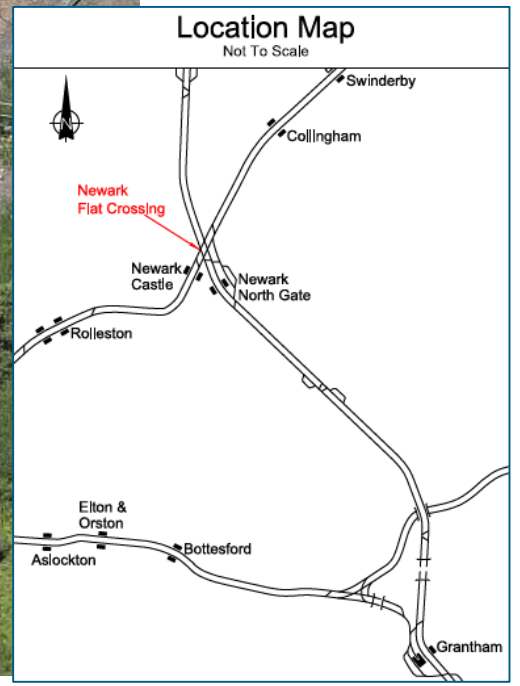
NOB1 cross ECM1 at a 44.1 degree angle



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Comprises 8 x ‘double star’ crossings on longitudinal timber structure

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Renewal History

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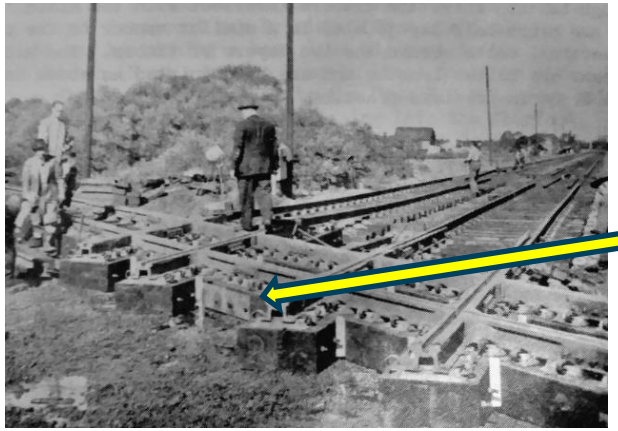
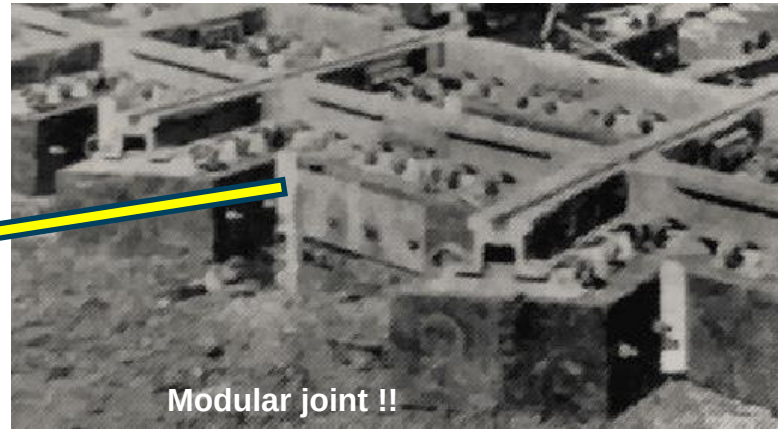
1960

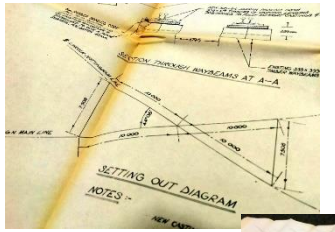


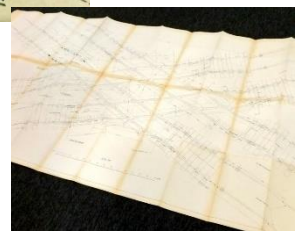


Nov 1972

Planning and execution of the installation was the responsibility of the Area Assistant Divisional Civil Engineer, Doncaster, who was in attendance throughout the two shifts with his Assistant. Remaining personnel employed over the weekend 5th/6th November, 1972, were as follows :-

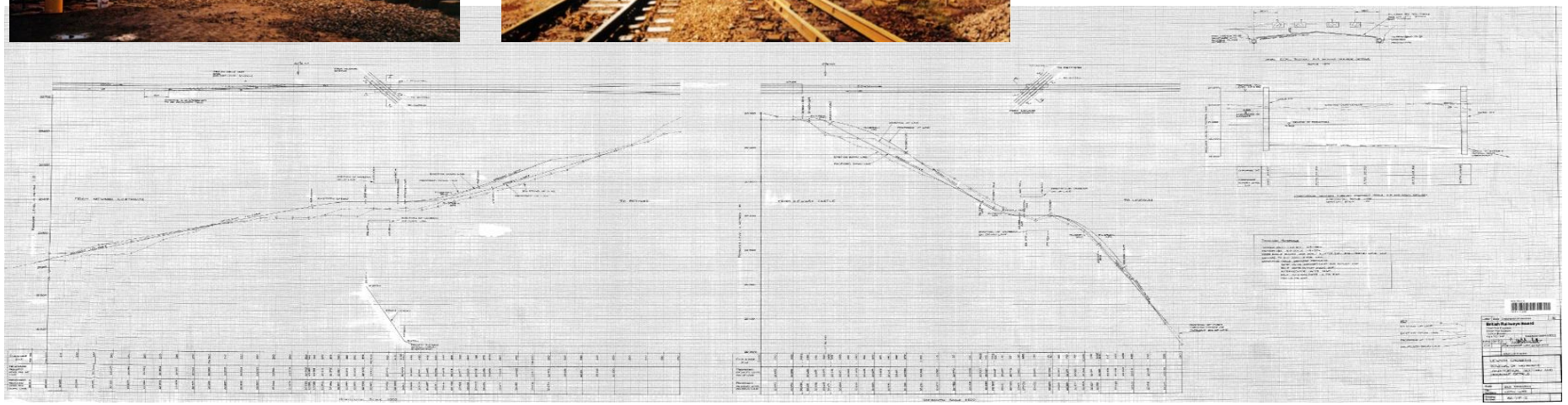
21 00 hrs. Saturday to 08 00 hrs. Sunday	26 Lengthmen, 2 Lookoutmen 2 Permanent Way Supervisors
08 00 hrs. Sunday to 18 00 hrs. Sunday	do. do. do.
23 00 hrs. Saturday to 09 00 hrs. Sunday	2 Burners
23 00 hrs. Saturday to 11 00 hrs. Sunday	8 Workshop Staff, 1 Lookoutman 1 Assistant Workshop Supervisor.
09 00 hrs. Sunday to 17 00 hrs. Sunday	2 teams of Welders
08 00 hrs. Sunday to 17 30 hrs. Sunday	8 Workshop staff
21 30 hrs. Saturday to 16 30 hrs. Sunday	2 Crane Drivers and Mates
12 00 hrs. Sunday to 21 00 hrs. Sunday	9 Lengthmen, 1 Lookoutman 2 Permanent Way Supervisors.
20 00 hrs. Saturday to 09 00 hrs. Sunday	Permanent Way Inspector
09 00 hrs. Sunday to 18 00 hrs. Sunday	do. do.





New crossings + Jarrah packing on existing timber waybeams

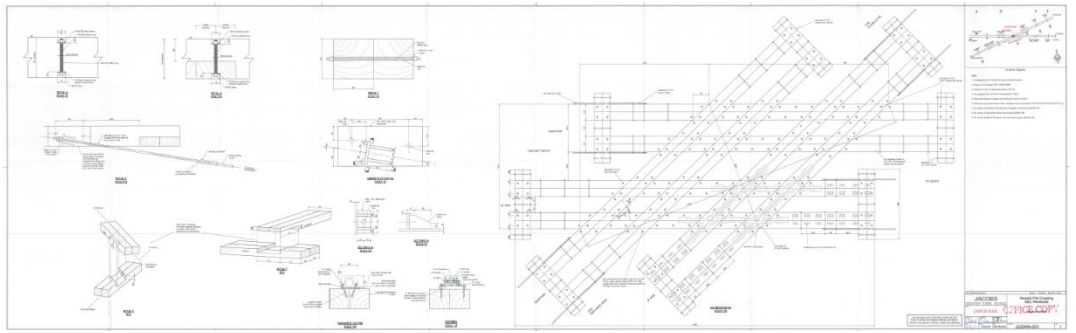
May
1986



Complete renewal using 13.65m hardwood waybeams

1986-88 ECML electrification Huntingdon to Leeds

Aug
2003



Complete renewal using 16m hardwood waybeams

2015 Crossing re-design / replacement & heavy re-furb works to remove 80mph CoT TSR

Summary

- Renewal / major intervention every 15 to 20 years.
- Track quality in the poor / very poor band soon after each renewal.
- Ballast degraded below sleeper base (Trackbed Investigation).
- Timbers now life expired / visual inspection not easy (ballast glued) and cannot be maintained – risk of CoT TSR/ESR if not renewed.

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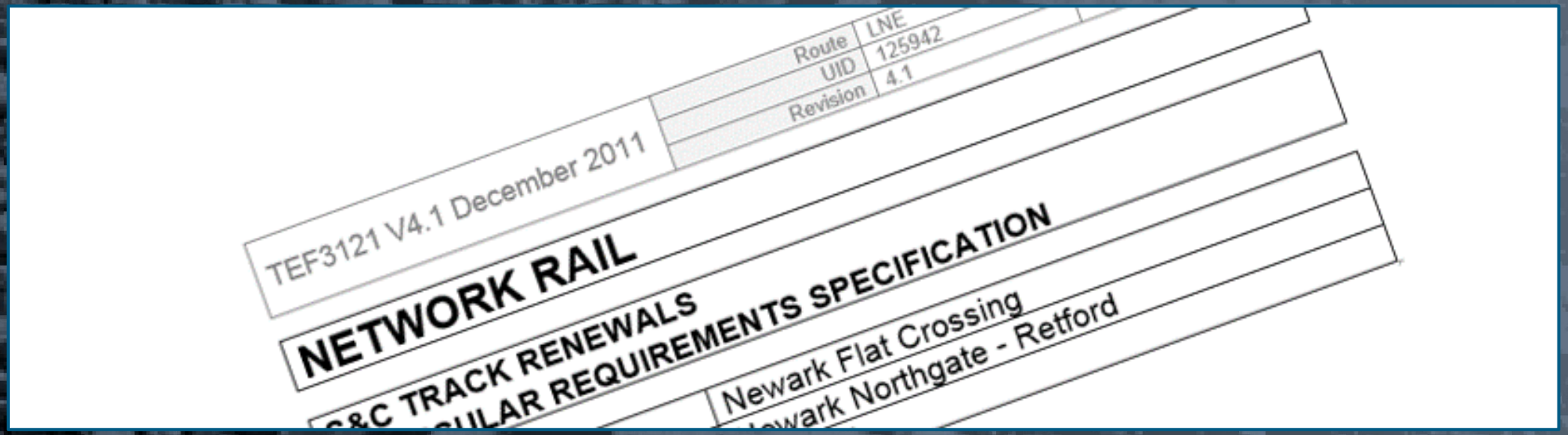
2019 Specification Timeline



Domestic Renewal – CP6 Year 1 – Life Expired Asset (timbers)

- February 2017 – 1920 LNE Start Up meeting – L4L on timber
- November 2017 – Product Acceptance for FFU (Longitudinal timbers)


NetworkRail

Certificate of Acceptance PA05/06576

Manufacturer: Sekisui Chemical GmbH

Issue : 01
Valid From : 29-11-2017

Fibre-reinforced Foamed Urethane (FFU) Longitudinal Baulks and Bridge Sleepers

- December 2017 – composite bearer option to be developed.
- January 2018 – Informed composite bearers not an option due to current product acceptance (lack of for bespoke arrangement)

Approval is for FFU Longitudinal Baulks installed in the directly fastened and cross-sleeper (bridge sleeper) configurations.

- March 2018 – Conversation at QSB with RAM [Track] : composite bearers not to be considered due to long term robustness being unknown.
- April 2018 – Advised by STE that composite bearer option 'back on' as previous barriers going away.
- May 2018 – Sekisui invited to present at LNE DCI Meeting – Request by RAM [Track] to '*take up the challenge of incorporating this technology*'.
- July 2018 – PRS (v4.1) issued (T-56).

Extract from PRS (v4.1)

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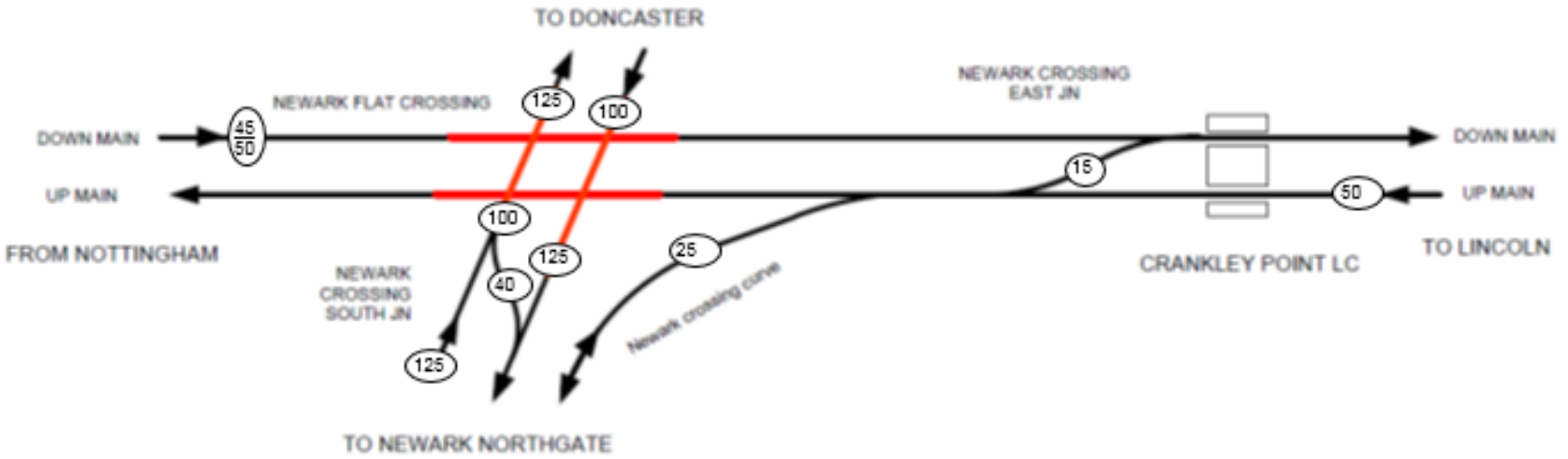
3.1 Diagram

Proposed Layout (Line Diagram; incl. line speeds):



Description (Including Operational Requirements)

'Like-for-like' layout renewal in modern equivalent form. Existing operational requirements to remain.

Fibre Reinforced Polymer bearers to be installed in lieu of Hardwood timber.

Transition from Plain Line and Flat Crossing then back to Plain Line to be explored following TBI report and modelling incorporating the composite bearers.

Existing Flat Crossing to be retained for mtce as spares. Project to liaise with mtce regarding recovery and storage location.

~~Signalling: D81 and D96 Signals: TPWS to be upgraded.~~

Composite bearers specified

FE Modelling specified

TPWS works removed

Like for Like – Based on 2003 Design Drawings

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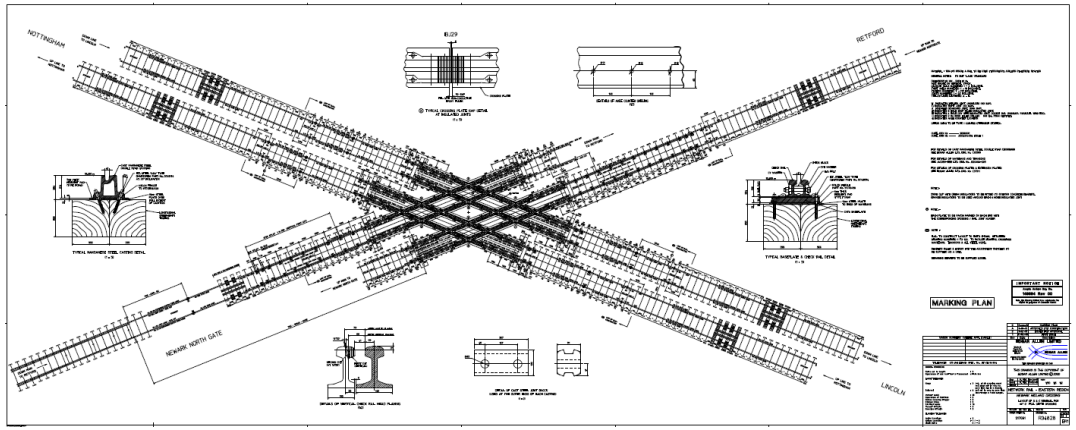

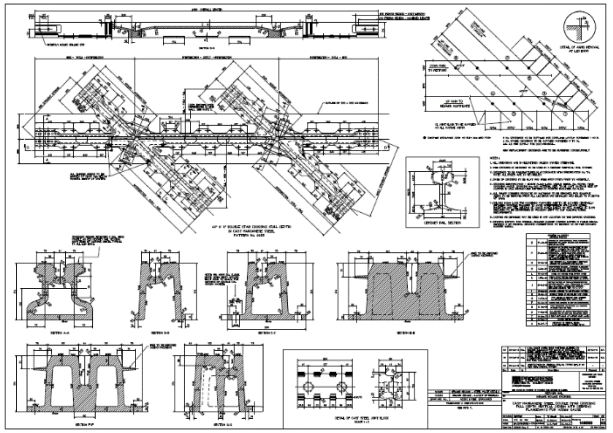

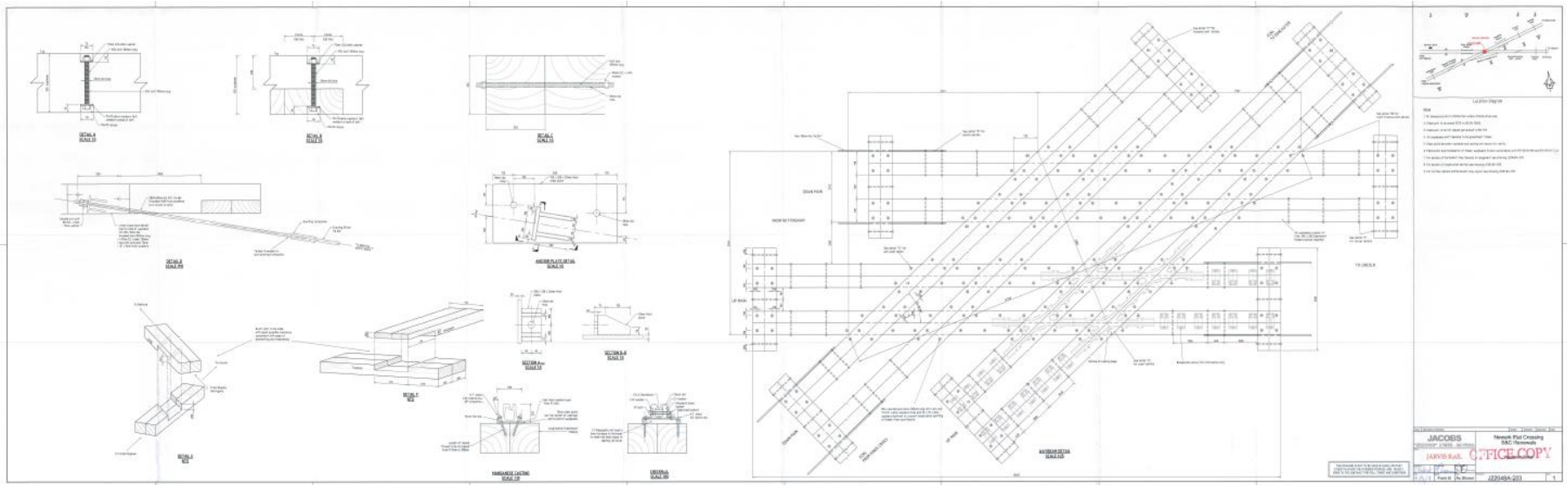

Crossing Fastening System Changes

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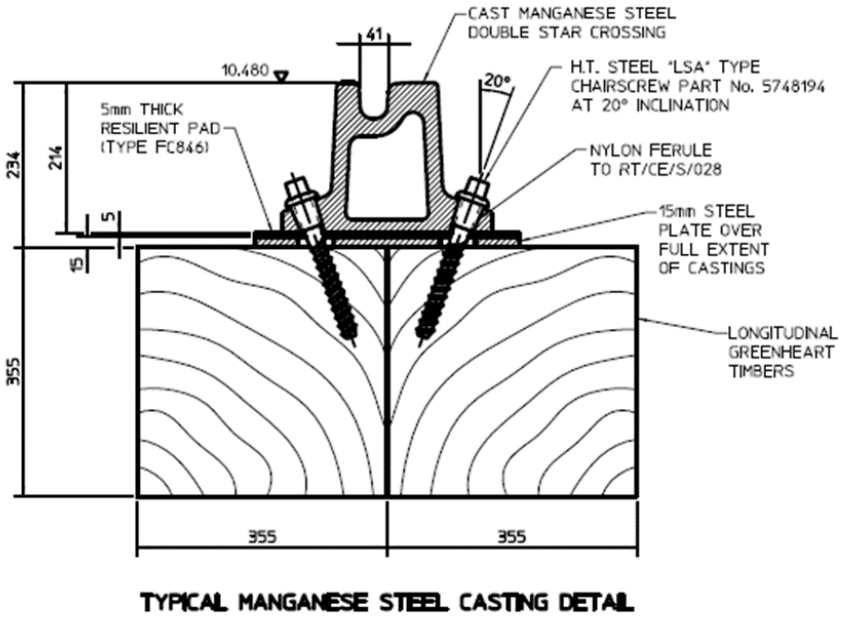
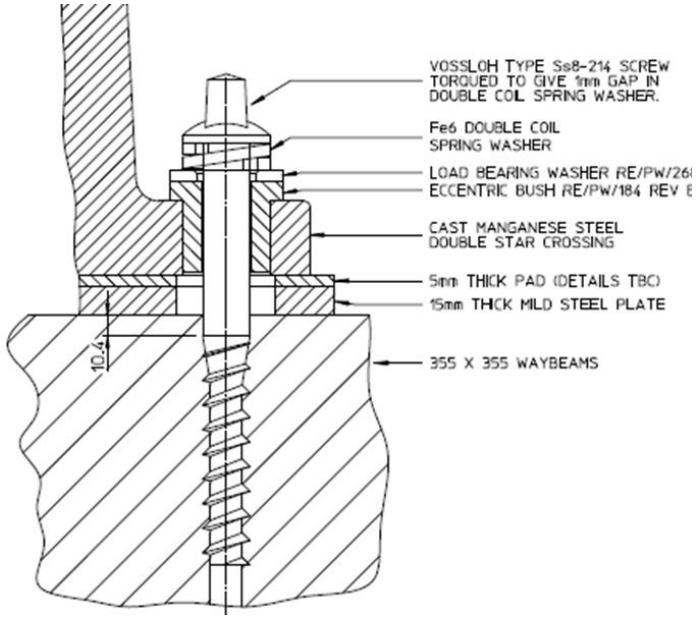
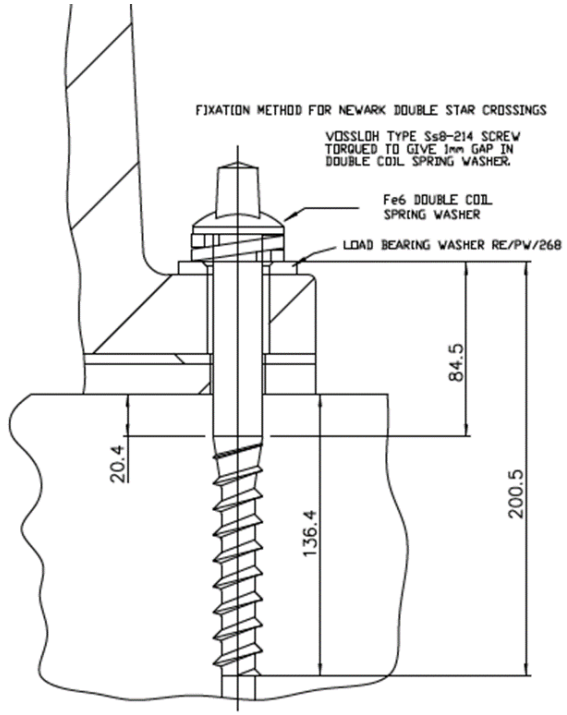


Old crossing fastening arrangement 2003



Redesigned crossing fastening arrangement 2015



Refined crossing fastening arrangement 2019

Changes Incorporated

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- Composite (FFU) bearers with under bearer pad in lieu of Greenheart timber.
- Bespoke trackbed design.
- HP rail specified including adjustment switches.
- SG iron baseplates with Pandrol e-plus clips.
- Concrete sleepers / bearers with under sleeper pads.
- Crossing profile optimisation study (Huddersfield University).
- Crossings pre-drilled for continuity bonding.

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Why Composite?

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2102 clause 6.5.2
(Longitudinal Timbers)

the plane of the rails into account. Composite artificial timbers should be considered which can offer improved mechanical properties, resistance to deterioration and reduced whole-life costs.


Level 2
Specification

Design and construction of track

Endorsement and Authorisation

NetworkRail

Unable to source timber!

As discussed, I've just come off of a conference call about the current situation with the supply of timbers. We cannot get hold of any timbers over 6050mm at the moment due to the increasing civil unrest in Cameroon; the lumber mills have had to be evacuated. We also source from Brazil, however their timber is not certified over 6050mm. The only other supply option we have is not FSC certified, meaning we cannot currently accept it into our supply chain. If we were able to make a derogation and accept the uncertified timbers there would be a cost increase of between 50-150% by sourcing them through this channel.

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FFU Option

Manufacturer:
Sekisui Chemical GmbH

Issue : 01
Valid From : 29-11-2017

Fibre-reinforced Foamed Urethane (FFU) Longitudinal Baulks and Bridge Sleepers

Product Description

Sekisui Chemical GmbH Fibre-reinforced Foamed Urethane (FFU) longitudinal baulks – in the directly fastened and cross-sleeper (bridge sleeper) configurations.

Product Image

What is FFU? Fibre reinforced Foamed Urethane

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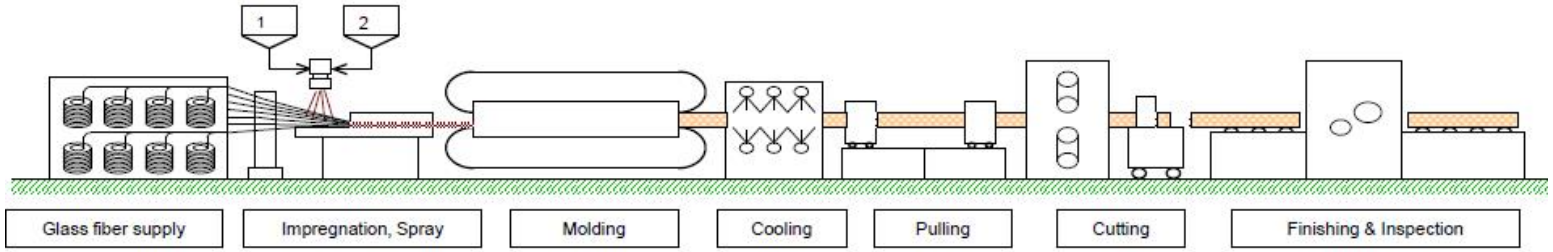
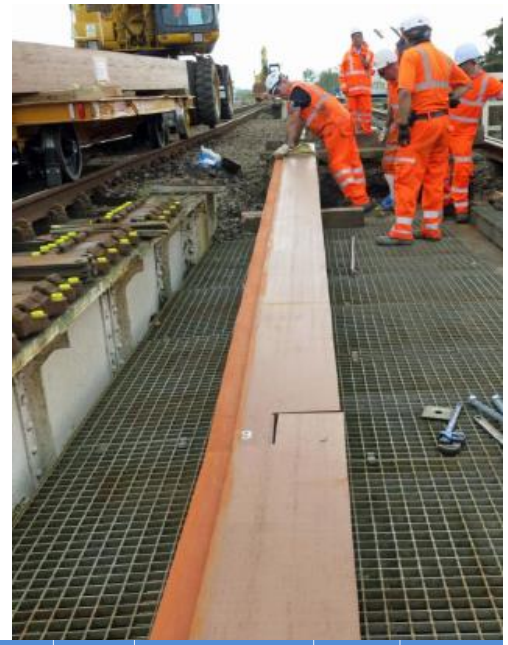
FFU synthetic wood is made up of long glass fibre strands soaked with poly-urethane and then cured at an elevated temperature. The synthetic wood can be machined and/or worked using the same techniques and tools as those used for natural wood.

FFU is a material developed for the Japanese Railways and introduced in Japan in the 1980s. FFU is much more durable than natural timber and most importantly does not rot. It has a design life in excess of 50 years which is in stark contrast to hardwood timber.





ISO 9001
Management System Certificate

ISO 14001
Environmental Management certificate

Pultrusion process

Continuous glass-fibre and Polyurethane
FFU sleepers are manufactured by Pultrusion.
Glass fibers are soaked in polyurethane and the linkage is then hardened at a raised temperature

Property	Unit	FFU74		FFU100	JIS value new sleeper
		New	30 years	New	
Density	kg/m³	740	740	1,000	740±30
Bending Strength	N/mm²	146	116	225	≥70
Flexural Modulus	N/mm²	8,100	8,414	12,000	≥6,000
Maximum Compressive Strength within the Proportional Limit (cross)	N/mm²	9	-	25	-
Shear Strength (longitudinal)	N/mm²	10	9	15	≥7
Adhesive Shear Strength (longitudinal)	N/mm²	12	9	22	≥7
Water Absorption	mg/cm²	3	-	3	≤10
Insulation Resistance (Dry)	Ω	$1.6x10^{13}$	$8.2x10^{11}$	$1.0x10^{14}$	$≥1.0x10^{10}$
Pull-out strength of screw spike	kN	65	33	125	≥30

Challenges

- NRAP re-classified project as CSM significant due to FFU & unique configuration.
- Project lacked experience of CSM significant projects.
  - STE led process
  - Ricardo Rail appointed As-Bo
- Sekisui needed design approval / order by Dec 2018.
  - STE led design approval process – RE/PW drawings will be produced
- Product acceptance needed for bespoke arrangement.
- Size of bearers needed.

Available Sizes

SEKISUI
Since 1980 | 1.400 km track

We can produce any width up to 350mm with length up to **7.0m** or 600mm width with length up to **9.4m**.

FFU is only currently manufactured in Japan, and due to shipping limitations is produced to a maximum length of 10m.

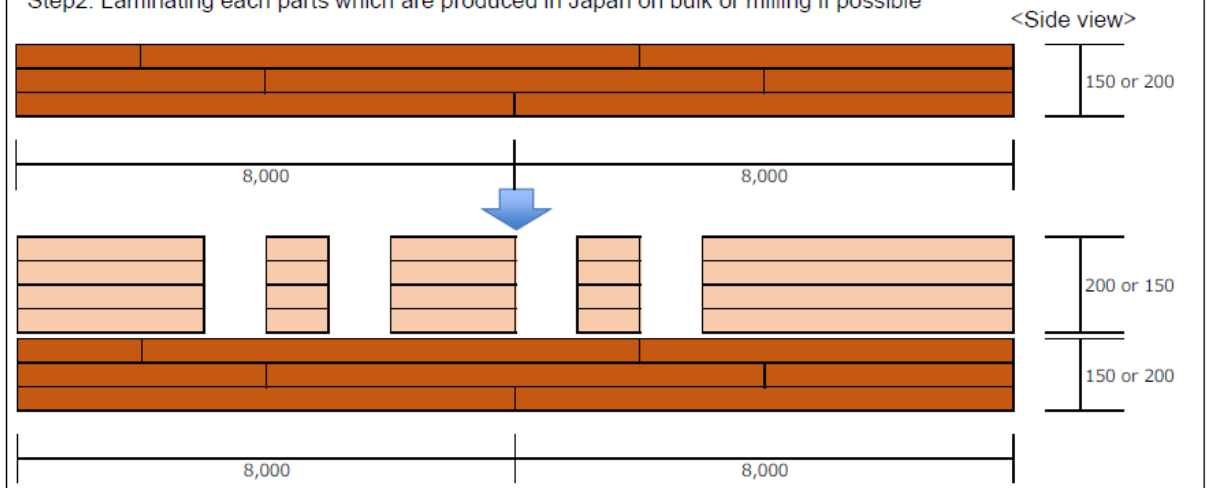
We needed 16m length x 700mm wide!

Solution:

E) Laminating on site in order to make one piece

Step1: Laminating FFU base plates for making one longer bulk

Step2: Laminating each parts which are produced in Japan on bulk or milling if possible



Advantages	Do not need to consider the joint part, you can fasten anywhere, the strongest .
Disadvantages	No experience to do this on site, preparation of lamination equipment and space

The individual pieces were shipped over to the UK and assembled at the Progress Rail Ilkeston facility in Derbyshire, to form the final matrix for the double star crossings. This was the first time they have ever been built outside of Japan.

The design was complex with interlocking designed to ensure that the construction matched that of the specification, along with having two densities of FFU layers to give increased compressive strength near the surface.

Design Example

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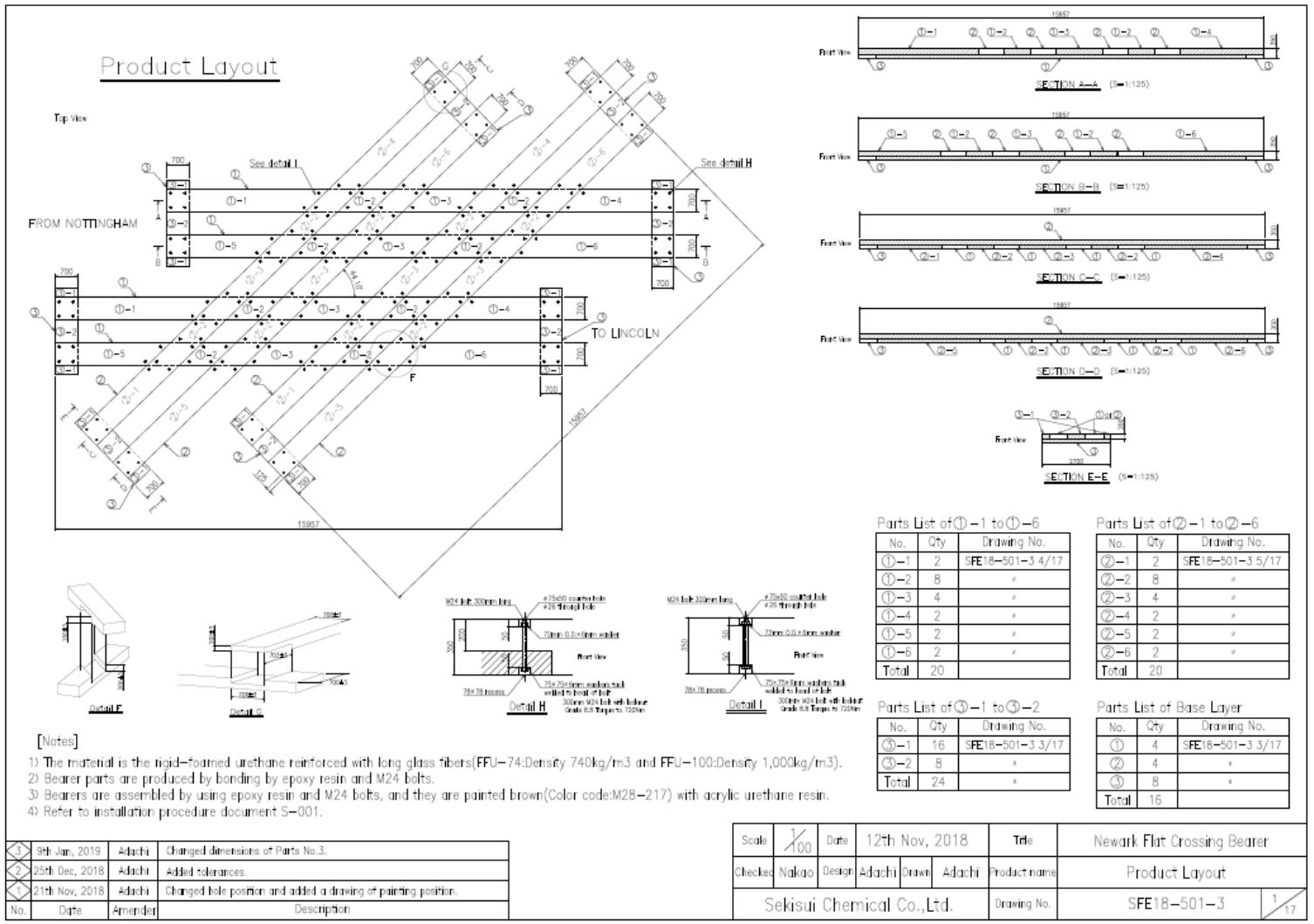


Parts List of ①−1 to ①−6

No.	Qty	Drawing No.
①−1	2	SFE18−501−3 4/17
①−2	8	〃
①−3	4	〃
①−4	2	〃
①−5	2	〃
①−6	2	〃
Total	20	

Parts List of ②−1 to ②−6

No.	Qty	Drawing No.
②−1	2	SFE18−501−3 5/17
②−2	8	〃
②−3	4	〃
②−4	2	〃
②−5	2	〃
②−6	2	〃
Total	20	

Parts List of ③−1 to ③−2

No.	Qty	Drawing No.
③−1	16	SFE18−501−3 3/17
③−2	8	〃
Total	24	

Parts List of Base Layer

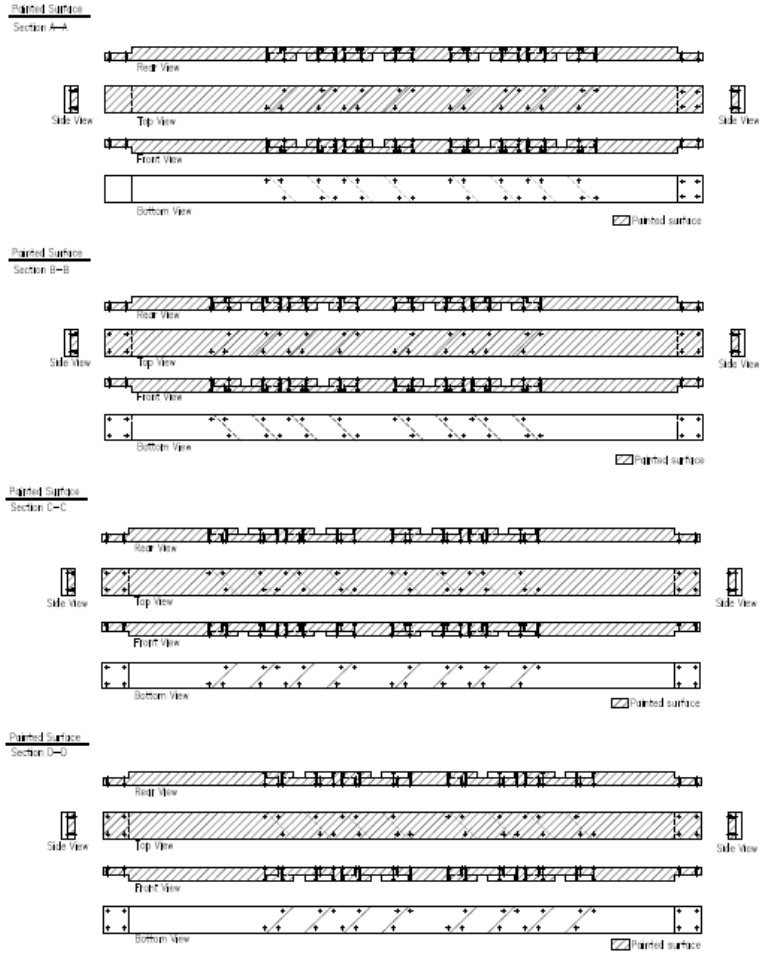
No.	Qty	Drawing No.
①	4	SFE18−501−3 3/17
②	4	〃
③	8	〃
Total	16	

[Notes]

1) The material is the rigid−foamed urethane reinforced with long glass fibers(FFU−74:Density 740kg/m3 and FFU−100:Density 1,000kg/m3).
2) Bearer parts are produced by bonding by epoxy resin and M24 bolts.
3) Bearers are assembled by using epoxy resin and M24 bolts, and they are painted brown(Color code:M28−217) with acrylic urethane resin.
4) Refer to installation procedure document S−001.

No.	Date	Amender	Description
3	9th Jan, 2019	Adachi	Changed dimensions of Parts No.3.
2	25th Dec, 2018	Adachi	Added tolerances.
1	21th Nov, 2018	Adachi	Changed hole position and added a drawing of painting position.

Scale	1/100	Date	12th Nov, 2018		Title	Newark Flat Crossing Bearer	
Checked	Nakao	Design	Adachi	Drawn	Adachi	Product name	Product Layout
Sekisui Chemical Co.,Ltd.					Drawing No.	SFE18−501−3	1/17



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Trackbed Design Solution

TBI REPORT

NetworkRail

TERRITORY	East Midlands					
PLANNED RENEWAL YEAR	N/A					
ELR	ECM1	ECM1	NOB1	NOB1		
TID	1100	2100	1100	2100		
SITE NAME	Newark Flat Crossing					
UID	N/A					

The track system at Newark is a ballasted track system, the design recommendation aims to reduce ballast settlement, future maintenance interventions and the development of significant track geometry faults.

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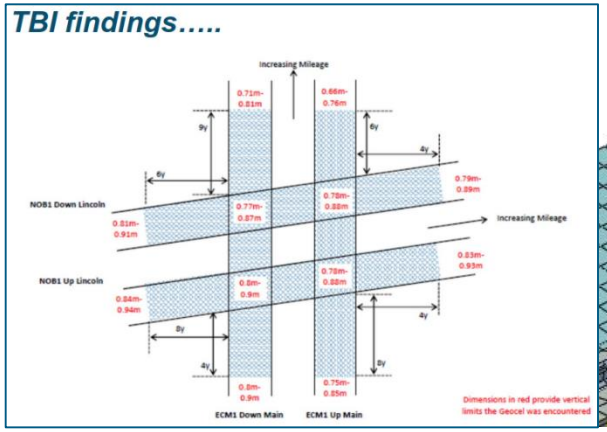
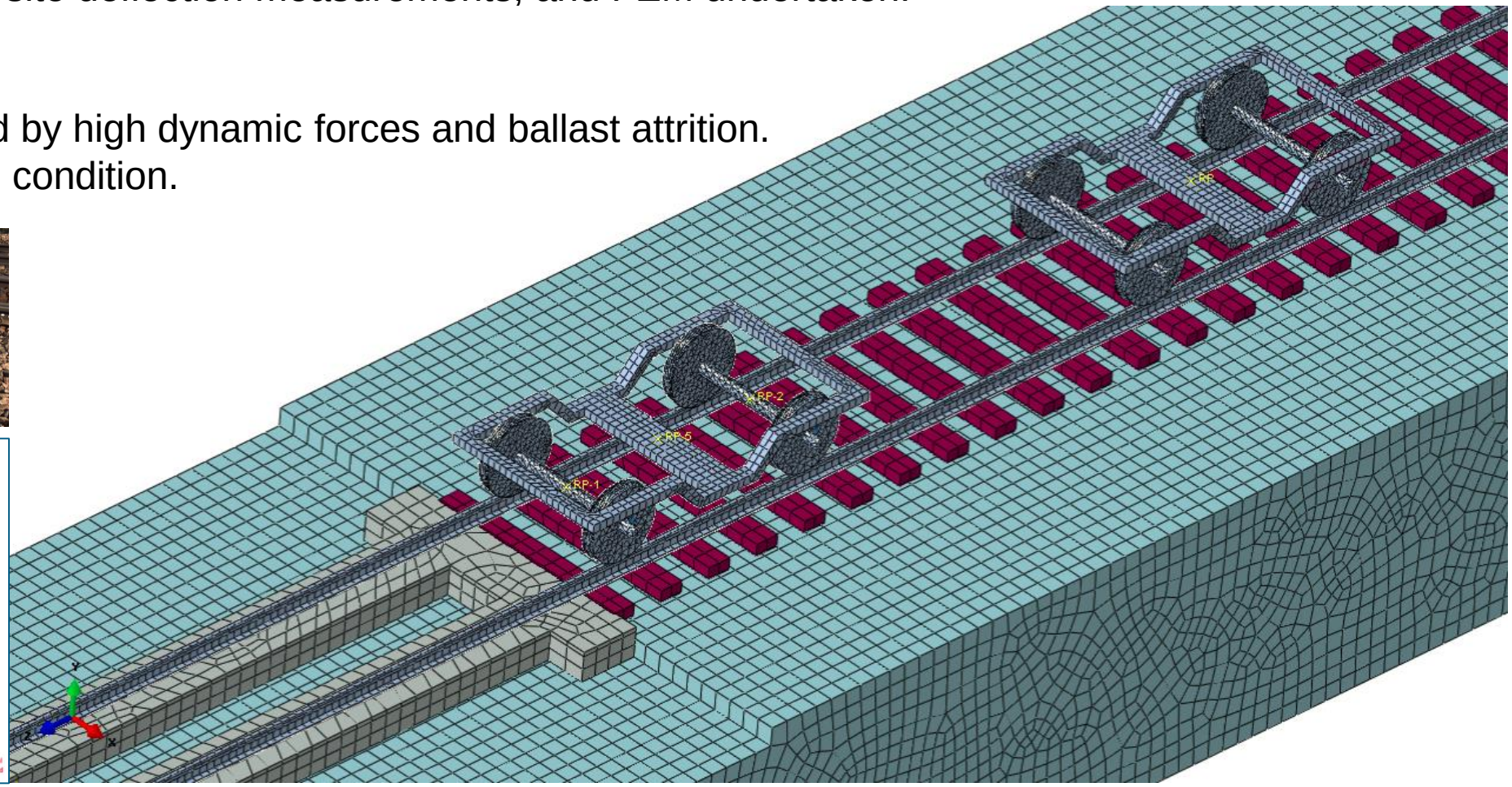
Track Bed Investigation, on site deflection measurements, and FEM undertaken.

Results have determined:

- Poor track quality caused by high dynamic forces and ballast attrition.
- Existing geocells in good condition.





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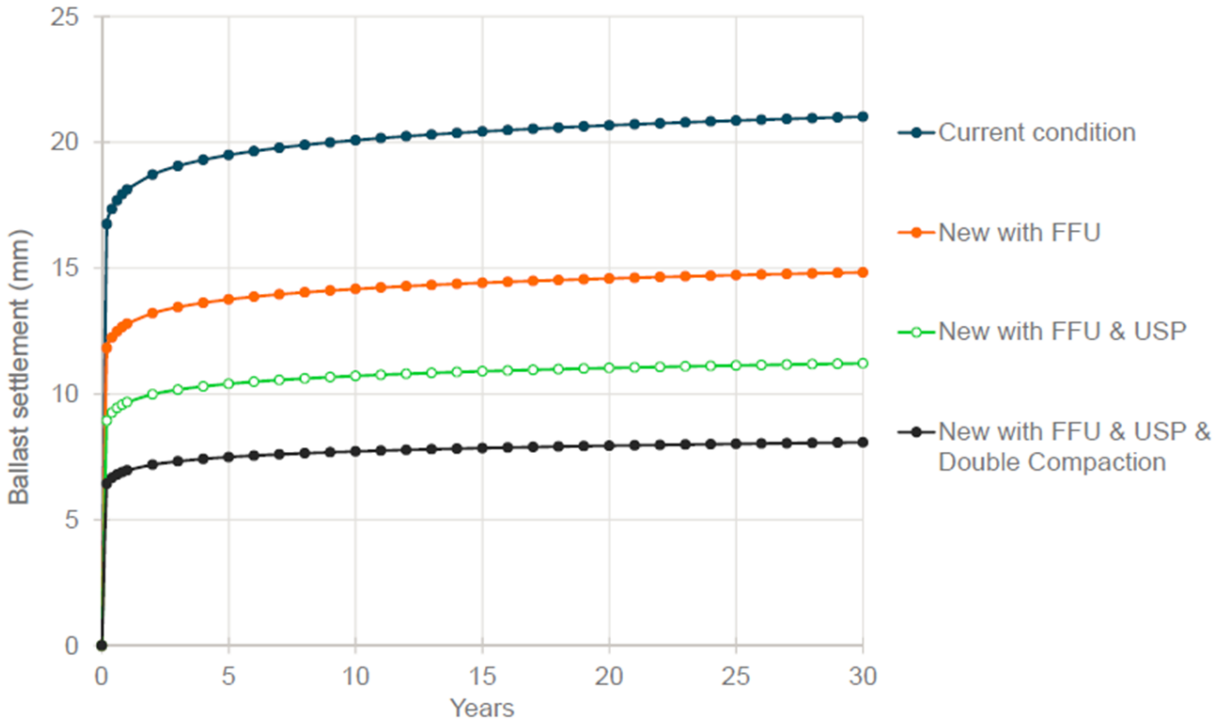
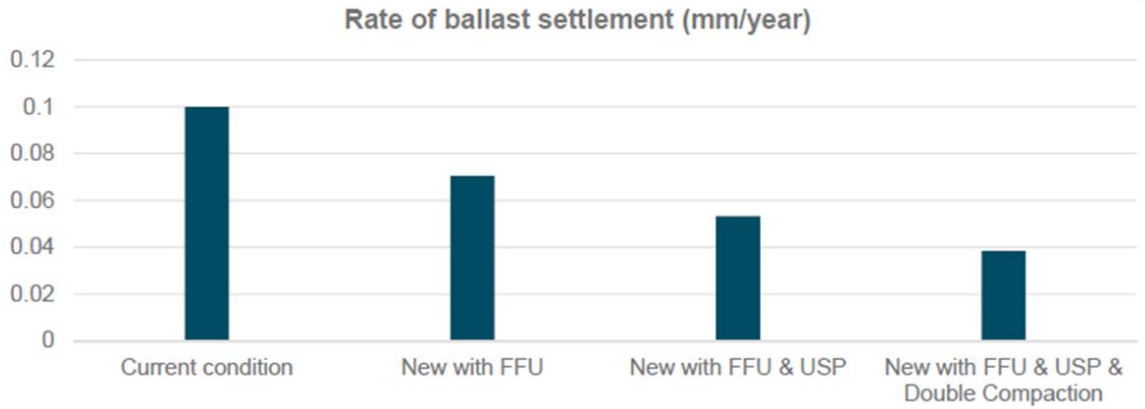
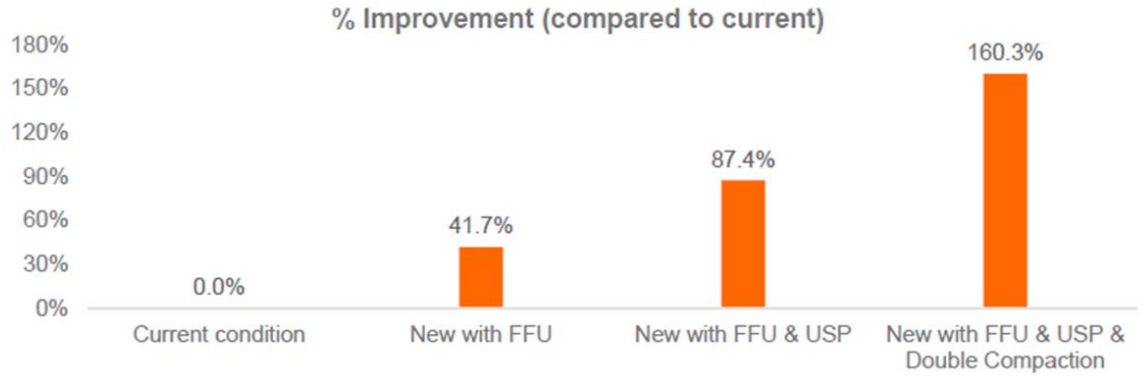
Ballast Degradation analysis



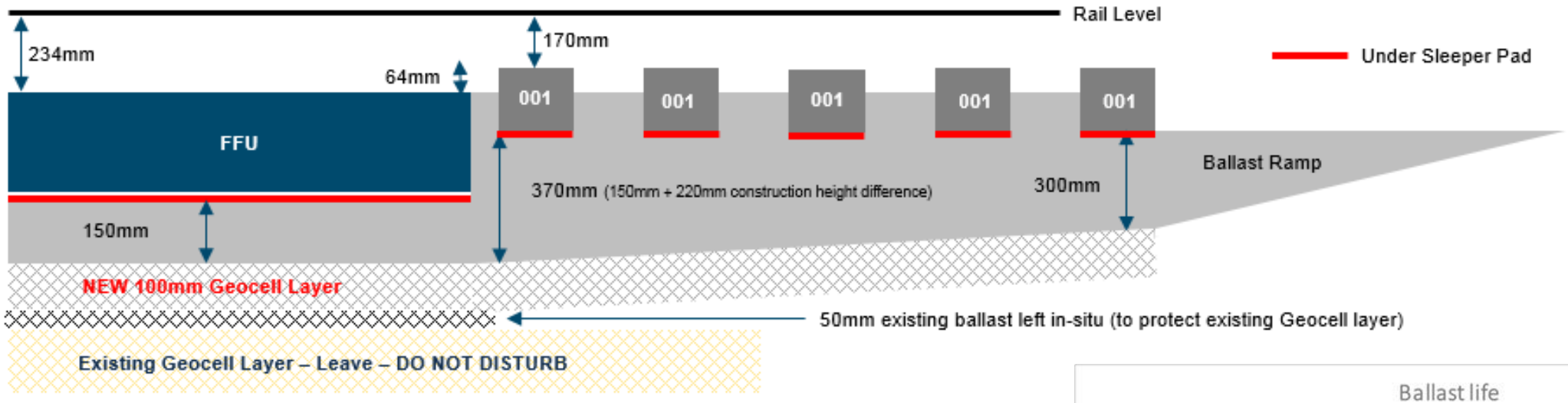
Ballast degradation analysis

NetworkRail

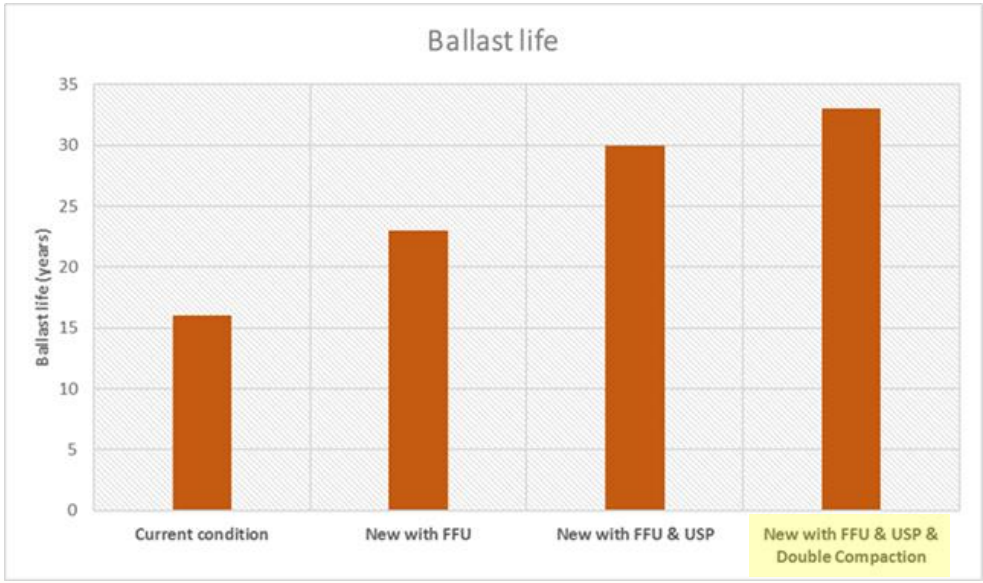


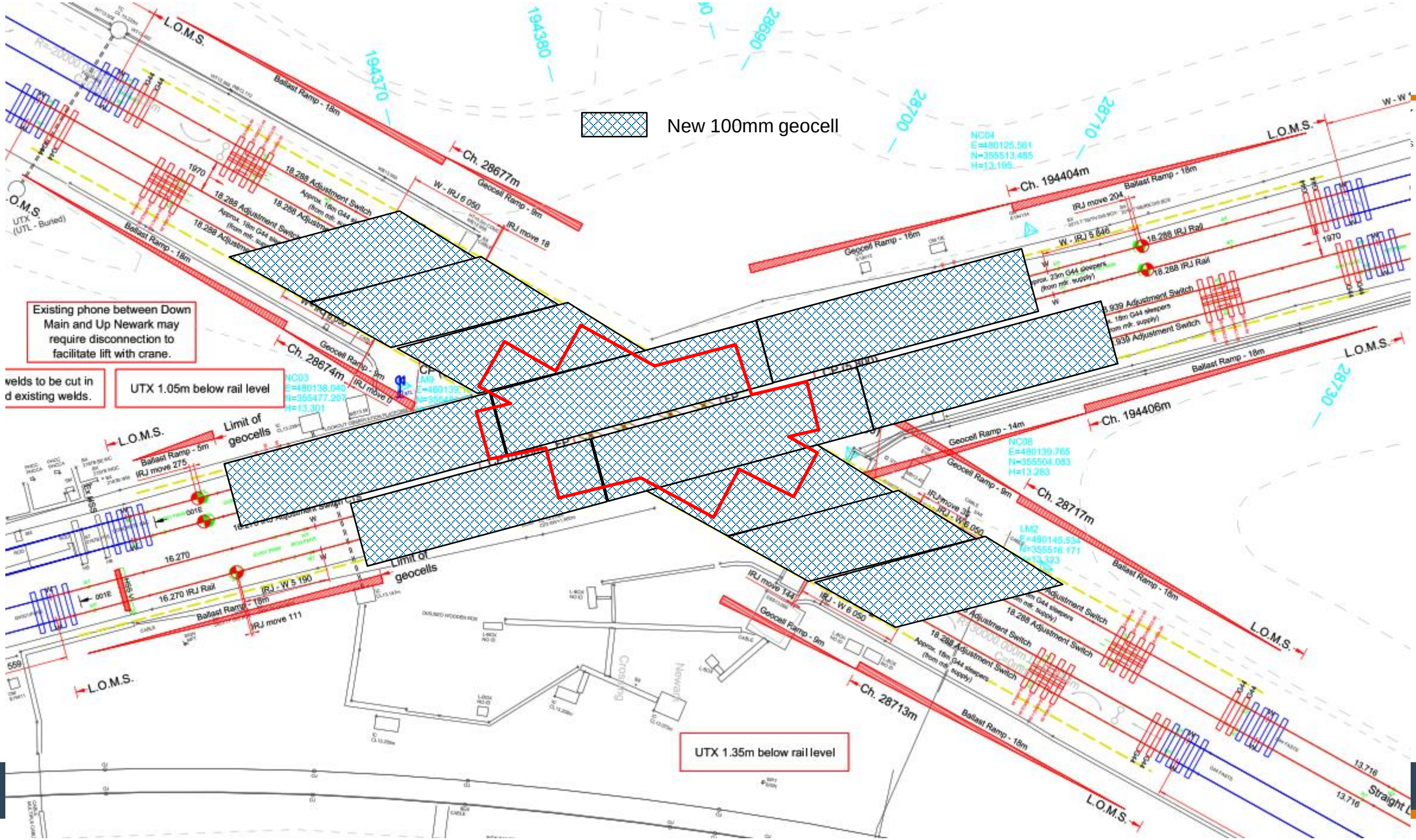


Option chosen



- Under Sleeper Pads to reduce ballast deterioration especially in ‘top’ layer
- Ballast compacted in 2 layers
- Additional geocell layer on to of existing geocells to minimise ballast deterioration in ‘bottom’ layer.
- Dependent on high accuracy of installation.
- Deterioration is expected as it is a ballasted system and settlement cannot be entirely eliminated.




New 100mm geocell
Existing phone between Down Main and Up Newark may require disconnection to facilitate lift with crane.
UTX 1.05m below rail level
UTX 1.35m below rail level
L.O.M.S.
Ballast Ramp - 18m
Ballast Ramp - 5m
Geocell Ramp - 9m
Geocell Ramp - 14m
Geocell Ramp - 16m
Ch. 28677m
Ch. 28674m
Ch. 194404m
Ch. 194406m
Ch. 28717m
Ch. 28713m
Limit of geocells
IRJ move 275
IRJ move 111
IRJ move 144
IRJ move 204
IRJ - W 5 190
IRJ - W 6 050
W - IRJ 6 050
W - IRJ 5 846
16.270
16.270 IRJ Rail
18.288 Adjustment Switch
18.288 IRJ Rail
Approx. 18m G44 sleepers (from mfr. supply)
Approx. 23m G44 sleepers (from mfr. supply)
1970
194370
194380
28690
28700
28710
28730

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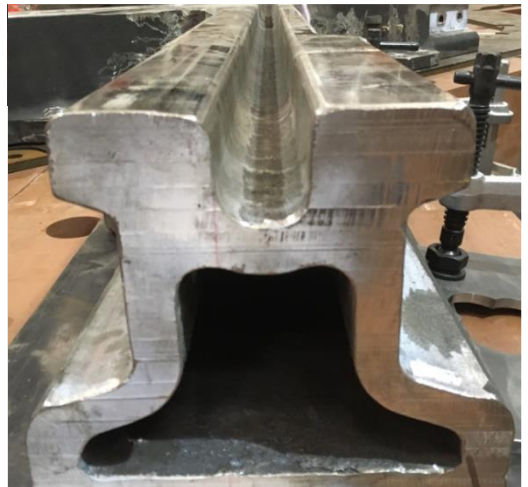
Supply & Manufacture

Scope

Route Services placed a contract with Progress Rail to:

- Supply new double star crossings (EDH'd).
- Sub-contract with Sekisui to supply, laminate, and assemble FFU bearers in UK (PRS facility at Ilkeston) including supply of tooling etc. First time this has been undertaken outside of Japan.
- Facilitate demonstrations of workability of FFU material etc.
- Assemble complete layout at PRS.
- Deliver layout and re-assemble lineside with assistance from CRSA.
- Build all external panels including adjustment switches and slave panels.
- Sub-contract with Huddersfield University to undertake wheel rail interface study to optimise crossing profile.

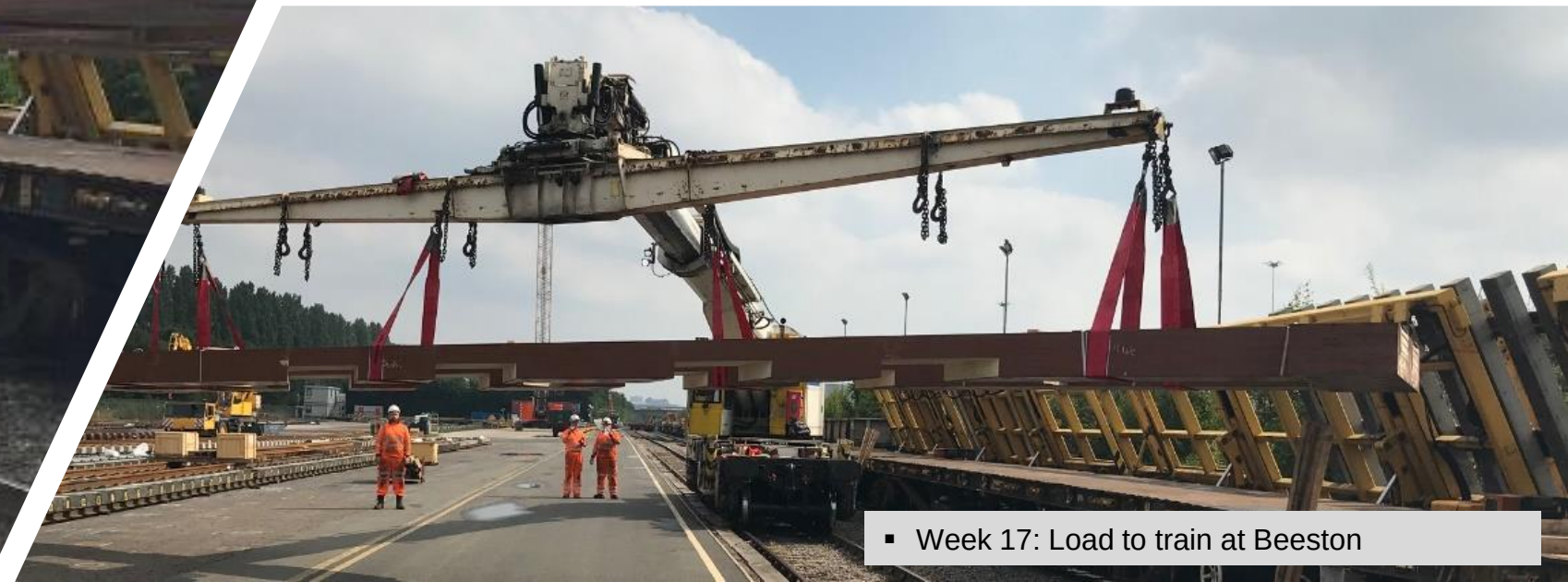

NEWARK
XING X1




IBJ6
IBJ6
IBJ6

Build Programme:

- Week 05: FFU starts arriving at Ilkeston
- Week 07: Start lamination process
- Week 13: Complete bearer assembly
- Week 15: Start fitting crossings etc.
- Week 16: Complete fitting crossings etc.
- Week 17: Strip layout and send to Beeston for loading to train.



- Week 17: Load to train at Beeston

- Plain line panels ready for loading

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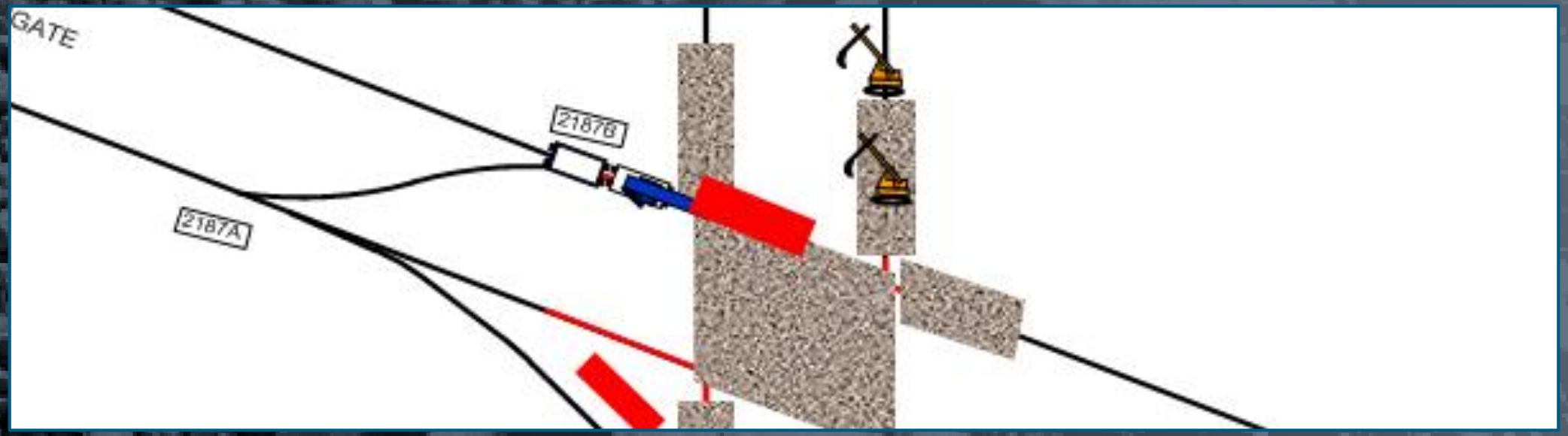
Development Plan



Considerations

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- Keep ‘Business As Usual’ using our standard methodologies as much as possible
- Site build area and land requirements
- Kirow crane(s) or mobile crane. Kirow 1200’s chosen due to:
  - no need to take OLE down
  - limited space – land sold off
  - more resilience to weather (high winds)
  - contingency options – able to lift with 1 crane
- Removal of old flat crossing – saving cast crossings / how to lift / space constraints.
- Temporary track panels for haul road(s).
- Construction height differences between adjacent plain line and crossing area.
- Slave rails.
- Temporary clamping of joints during construction & check rails.
- Continuity bonding of crossings.
- Staged possession handback – Newark Chord.

Plan for lifting old crossing

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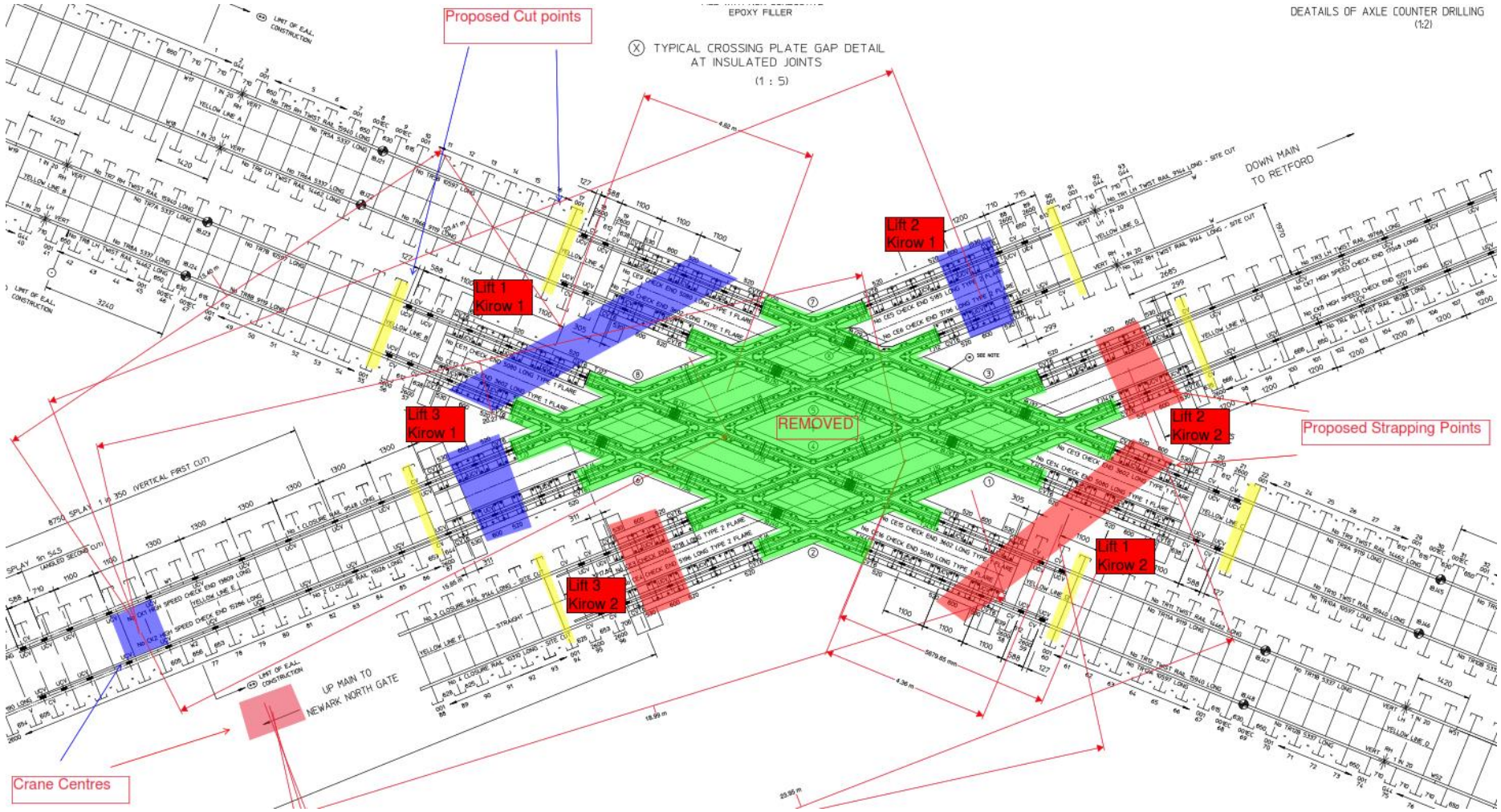
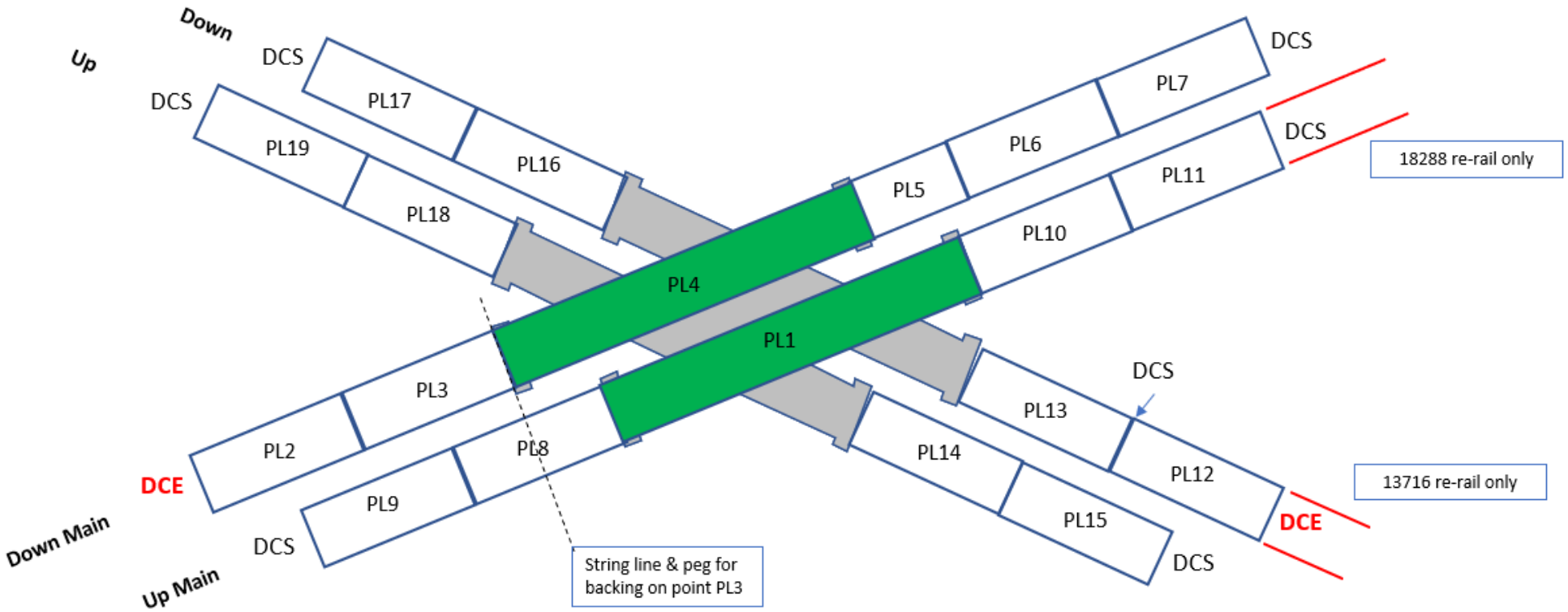


Panel Arrangement incl. temporary panels



PL1 – 17935mm Temp vertical	PL6 – 13778mm Adj Sw	PL11 – **18791**mm Adj Sw	PL16 – 16650mm Check/Twist/IRJ
PL2 – **11260**mm Vert IRJ/Adj Sw (slave rails)	PL7 – **18162**mm IRJ	PL12 – **17756**mm Adj Sw	PL17 – **17633**mm Adj Sw
PL3 – 10132mm Vert Check (slave rails)	PL8 – 18288mm Vert check	PL13 – 16650mm Check/Twist/IRJ (AC)	PL18 – 16650mm Check/Twist/Adj Sw (AC)
PL4 – 16250mm Temp vert timber bespoke	PL9 – **15282**mm Vert single IRJ incl HSS	PL14 – 16650mm Check/Twist/IRJ	PL19 – **17638**mm Adj Sw
PL5 – 5193mm Check/Twist (slave rails)	PL10 – 19766mm Check/Twist	PL15 – **17728**mm Adj Sw	Numbers in bold are adjusted lengths following setting out.

Bespoke panel to cater for height differences

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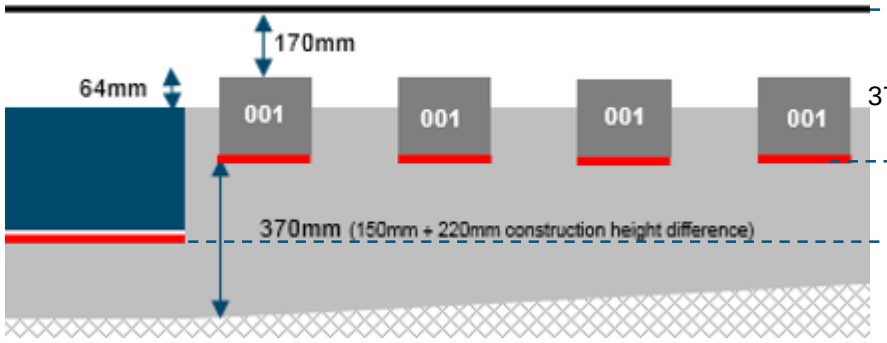
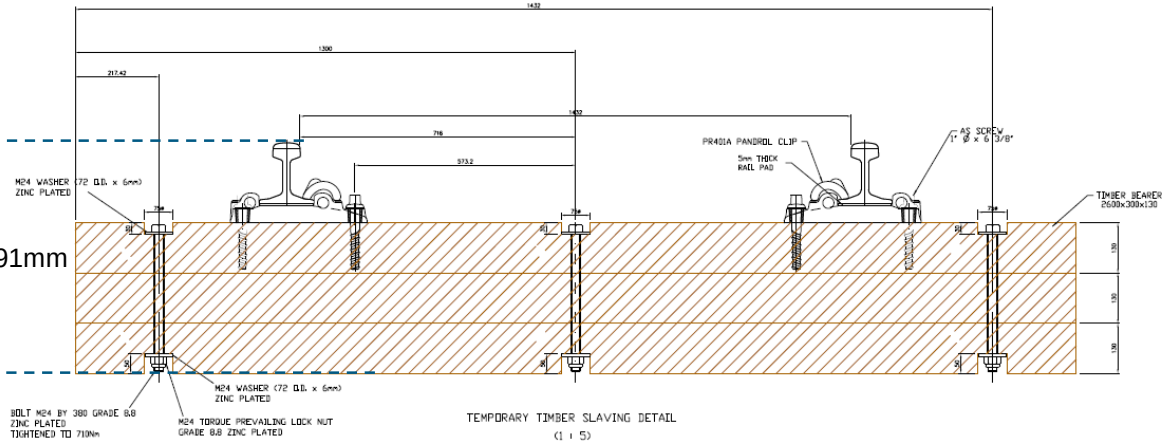
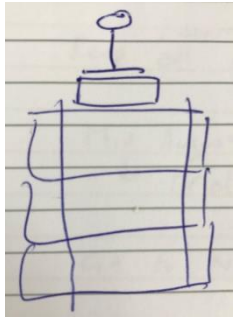


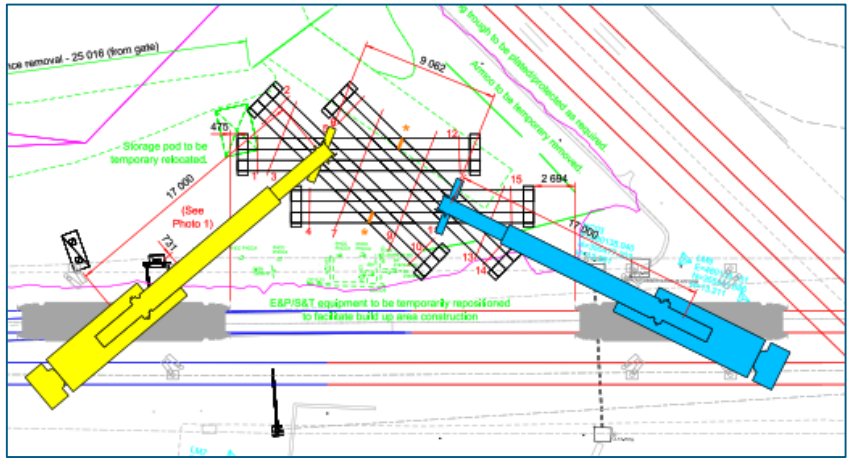
371mm

591mm

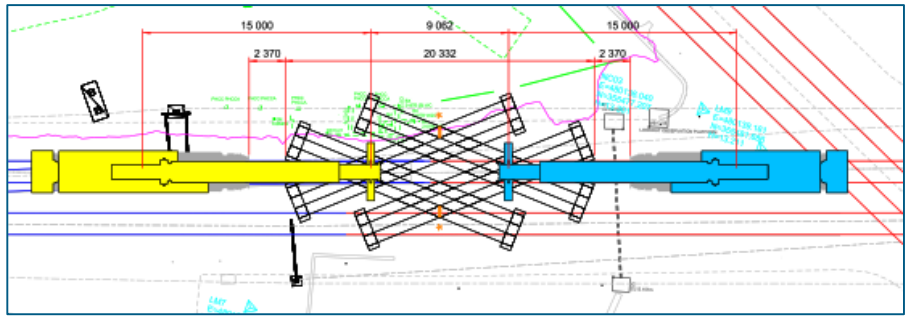




Lifting of new crossing

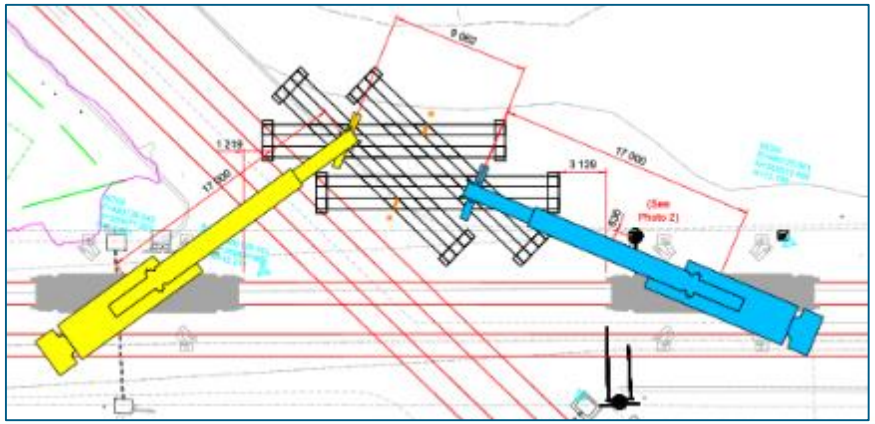


Initial lift from build area



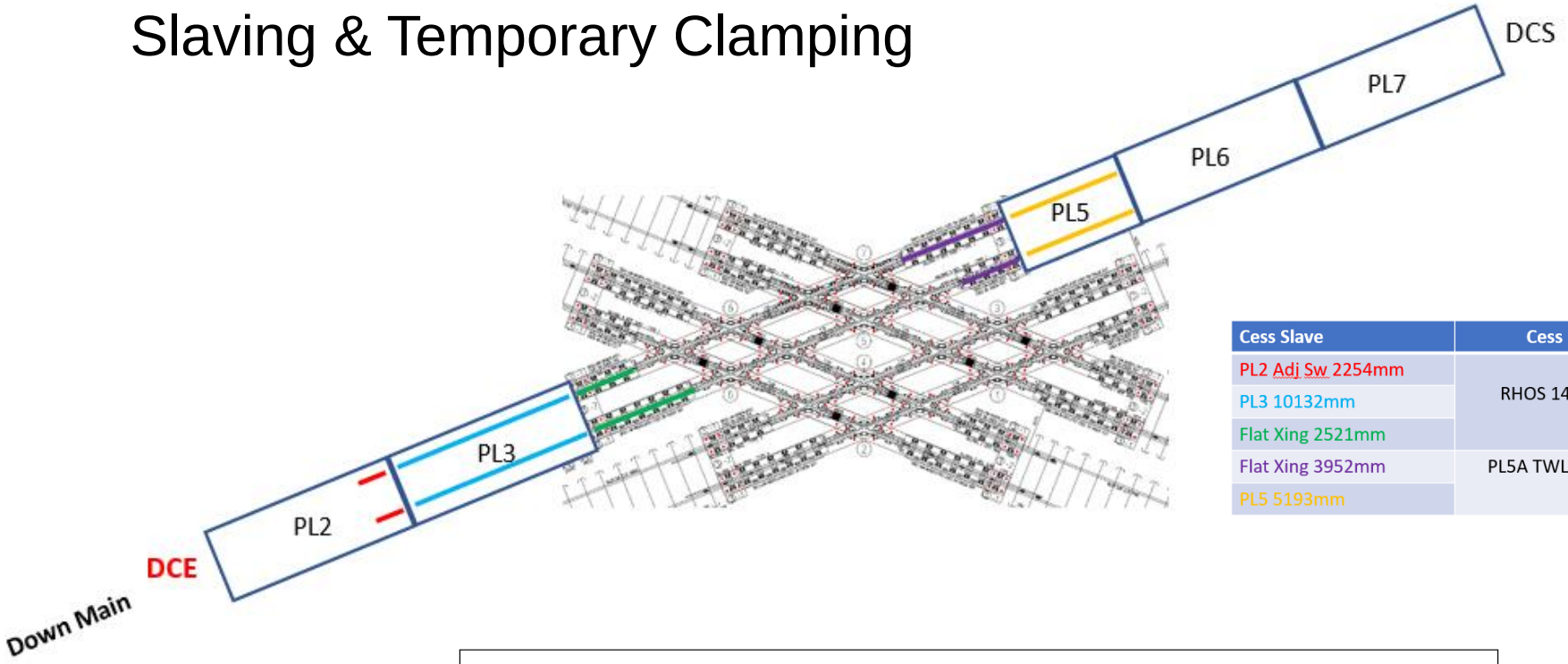
Travelling

To/from temp laydown area

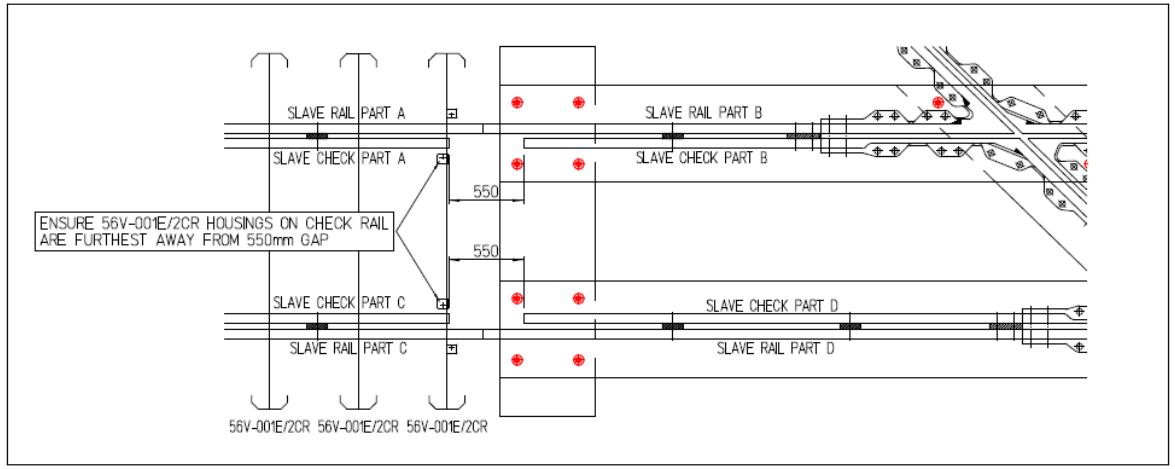


Changes in the position of the centre of gravity of the layout, proved challenging during the lift as can be seen in later photo's !

Slaving & Temporary Clamping



Cess Slave	Cess Final	6ft Slave	6ft Final
PL2 Adj Sw 2254mm	RHOS 14907mm	PL2 Adj Sw 2254mm	LHOS 16385mm
PL3 10132mm		PL3 10132mm	
Flat Xing 2521mm		Flat Xing 3999mm	
Flat Xing 3952mm	PL5A TWL 9144mm	Flat Xing 2474mm	PL5B TWR 7666
PL5 5193mm		PL5 5193mm	



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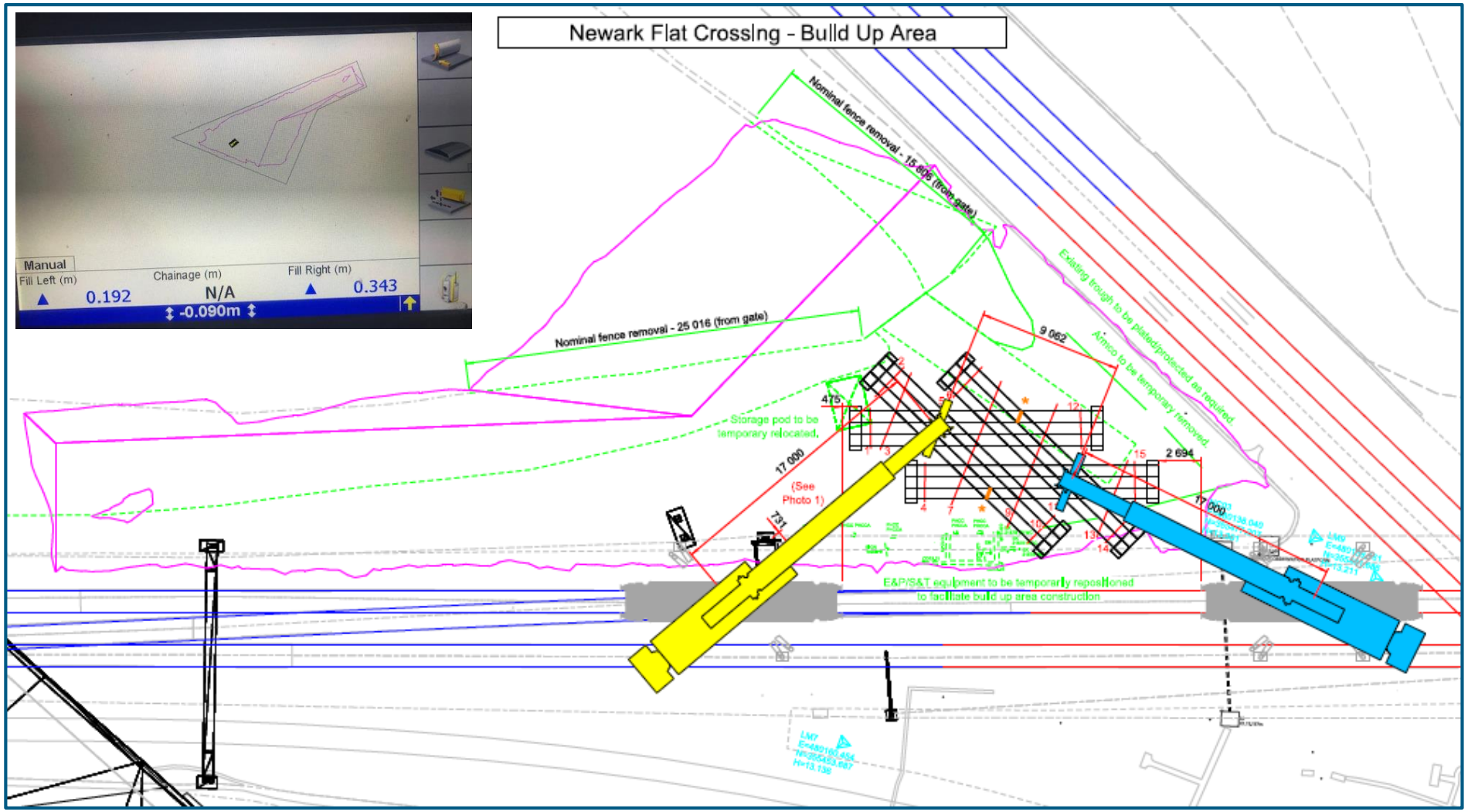
Prep Works

Build Area & Temporary Laydown Area



- Week 12 to 15: Prep build area

- Week 18: Offload bearers on site

- Week 18 & 19: Lineside rebuild

- 09/08/19 (Wk19) – Layout complete & inspected

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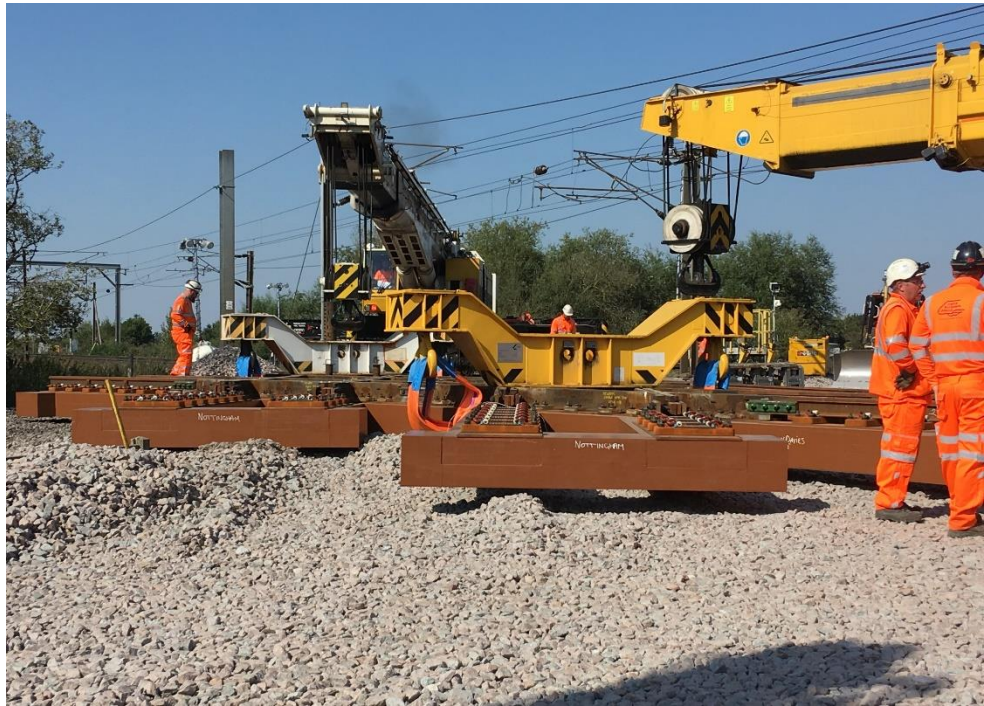
Core Works August Bank Holiday
24th – 27th August 2019


R.P. Webb
Plant Hire
01785 241331
COSTAIN
COSTAIN


HEAVY LIFT
A.P.Webb
Plant Hire
01785 241335


MULTI




THIS MACHINE IS NOT PERMITTED
TO SELF PROPEL OUTSIDE
POSSESSIONS!


KIROW


Championing Great British Quality
LNER


LNER


Trimble

- Possession Handback Tuesday 27/08/2019

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Follow Up & Monitoring

Getting back to Linespeed:

- Opened with 50mph TSR as per the Product Acceptance
- T+1 tamp Tue night [ECML] & Thu night [NOB1] week 23 – We consciously left the plain line low to allow settlement of the crossing to occur without compromising the vertical design. We didn't want to be in the same position as prior to the renewal where the crossing is in a 'hole'
- Visual inspection of crossing under traffic with STE / TME reps Friday week 23. Voiding evident & crossings were heavily deformed, Track Recording Train reports track as 'Super Red'
- TSR eased to 80mph weekend 24 after follow up works:
  - grinding / Inspection of crossings (crossings were **not** EDH'd)
  - Robel hand tamping of flat crossing
- Visual inspection Monday week 24 – minimal voiding following Robel hand tamping and trains appear to traverse the crossing better at higher seed

Getting back to Linespeed / Working Towards Taking Over

- Further visual inspection of crossing under traffic with STE / TME reps Friday week 25.
- Site monitoring results compiled and analysed for settlement
- T+4 tamp weekend 26 – Raised back to linespeed [100mph].
- Site inspected under traffic midweek 26 – Again trains traverse the crossing even better at higher linespeed
- T+7 Tamp - Due to the uniqueness of the site we have carried out remedial works on the lead up and away from the crossing with Jacks & Total Station – going sleeper by sleeper to get the best possible vertical alignment then tamping afterwards to fully pack the sleepers
- T+13 Tamp – Analysis of multiple weeks ‘As Builts’ carried out to check crossing settlement. Decision was finally made to lift the plain line to be fully coplanar with the crossing. 102 Compliant ‘As Builts’ Submitted
- Track Recorder now showing ‘Satisfactory’ The best it’s been in recent history!

Track Quality Summary

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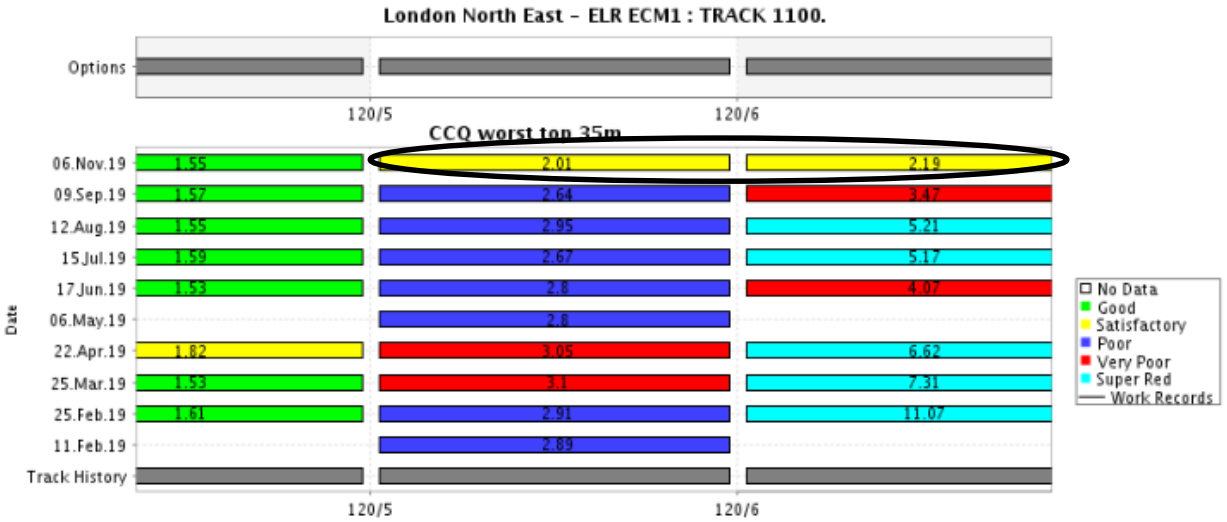
Historic TQ trend

Post Installation TQ




LNER

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Spot the difference……

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After

Thank You!

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VolkerRail

SEKISUI

Progress Rail
A Caterpillar Company

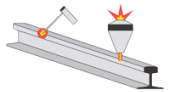
A.P. Webb Plant Hire Ltd.
THE SPECIALIST RAIL PLANT SUPPLIER

NetworkRail

Torrent Trackside
Railway Plant. Railway People

vital

WELD-A-RAIL LTD



NetworkRail

RAM Support & Maintenance