THE PWI YOUNG ACHIEVER AWARD 2020

National level crossings upgrade: Knottingley level crossing renewals

FIRST PRIZE

PROJECT OVERVIEW (Figure 1)

Design Consultant - CAPITA Plc
Contractor - Infrasig (Carillion / Bombardier JV)
Client - Network Rail
Start Date - 2015 End Date - 2018
Contract Type - NR13B (ICC D&B Lump Sum)

The National Level Crossings Upgrade Programme is an initiative led by Network Rail to assess, manage and control risks on level crossings in the UK. Currently, more than 6,300 level crossings (1,870 on the LNE & EM Routes)[1] exist on the network. As Network Rail has a legal duty (Level Crossings Act 1983) to managing risks effectively at these crossings, improvement works have become ever more paramount.

The Knottingley Level Crossing Renewal, a sub-scheme of the programme, involved four existing Automatic Half Barrier (AHB) crossings to be upgraded (see Table 1). These sites had been previously assessed and equipment found to be life expired. Persistent unreliability of the crossing systems, increases in vehicle, train and pedestrian usage and crossing misuse all contributed towards the decision to upgrade each of the crossings to a safer alternative. To introduce further benefits, Network Rail chose to change the crossing technology to a new type of system developed by Bombardier (EBI Gate 2000 control system & EBI Gate 630 Level Crossing Barrier Machines/Booms)[2]. The aim of this was to simultaneously upgrade the crossings and iron out design issues to gain Network Rail product approval. This was an entirely new system which had not been installed in the UK before.

MY ROLE, RESPONSIBILITY & PROJECT BACKGROUND

During my employment at CAPITA, I was assigned as a dedicated level crossing design engineer for one of our main clients, Infrasig. My work involved providing design solutions for the Carillion-Bombardier joint venture client in line with an agreed framework arrangement. The core aim of my role was to develop a collaborative ongoing relationship which would introduce new technology to the market. As Lead Design Engineer I developed detailed design solutions, organised site surveys, undertook setting out and managed day to day commercial aspects for the CRE. In undertaking this role I liaised with the client daily to solve new emerging problems and deliver a successful project. At the start of the project, between "Single Option Development" (GRIP 4) and "Detailed Design" stage (GRIP 5), my work involved updating the designs to reflect the new EBI Gate 630 crossing technology. This later expanded to full GRIP 4, ground plan re-design for each crossing where I positioned every asset on each ground plan and liaised with other disciplines such as M&E, Telecoms and P-Way to develop bespoke solutions and accommodate unique challenges.

IMPROVING SAFETY: OBSTACLE DETECTION SYSTEM

On each of the four crossings, an automated obstacle detection (OD) system was to be installed to improve safety. This system has two parts, the primary being a radar scanner (POD + Reflectors) and the secondary, a IDAR scanner (complementary OD or COD). These assets work together to ensure no obstructions are on the crossing when the barriers are activated. This equipment was also integrated with the signalling system to automatically turn aspects to red if required and stop moving trains. This technology was relatively new for level crossing design and partway through GRIP 4 a revised OD standard was released by Network Rail. I was requested to amend the crossing design in line with the new standard and brief the project team. To understand the standard changes precisely, I contacted the UK's OD specialist at Network Rail and reviewed my designs with him directly before tabling them in the interdisciplinary check/ interdisciplinary review (IDC/IDR) process.

#	Site	Existing Crossing Type	New Renewed Crossing Type
1.	Selby road Level Crossing	AHBC	MCB-OD
2.	Womersley Level Crossing	AHBC	MCB-OD
3.	Cridling Stubbs Level Crossing	AHBC	MCB-OD
4.	Spring Lodge Level Crossing	AHBC	MCB-OD

AHBC = Automatic Half Barrier Crossing, MCB-OD = Manually Controlled Barrier Crossing with Obstacle Detection

Table 1: Level crossing scheme details

AUTHOR

Charles Burn is a Civil Engineer having recently passed his ICE professional charted review in Autumn 2019.

He has over seven years' relevant civils design experience and is a well-rounded designer having been involved in many varied assets such as station modifications, level crossings schemes, substations and signalling renewals.

Charles is an Alumni of Nottingham Trent University where he achieved a BSc in Civil Engineering in 2011 & MSc in Structural Engineering in 2013. After university, Charles was employed by BCS Design Ltd as a Graduate Civil Engineer. There he worked on a variety of railway infrastructure projects and developed his design skills towards the sector.

Over the years, Charles moved up to a Senior Engineer role as the company was acquired by CAPITA plc. And in 2018, Charles moved to Mott MacDonald Ltd, where he is currently undertaking a role as a Chartered Engineer and continues to contribute to the railway sector.

The POD system for Womersley Level Crossing as shown in Figure 3 required me to place the unit in close proximity to the railway (1364mm from running edge). This was necessary to achieve a compliant line of sight to the reflectors in the opposite corners, optimise positioning for barriers, chambers, crossing control systems and provide safe maintenance access. This introduced tight construction tolerances for the contractor who was keen to understand the minimum dimension for installation. To resolve this issue, I arranged a “Clear Route” analysis to be undertaken by a specialist sub-contractor and accounted for the worst-case levelling adjustment on the four holding down bolts used to match the crossings surface trend. I also attended the site to undertake setting out services for each of the equipment’s foundations and recorded as-built positions to check against my design. Figure 3 is an annotated picture of the successfully commissioned OD equipment at Womersley.

Figure 1: Aerial photograph of Commissioned Spring Lodge Level Crossing (Network Rail Route View)[3].

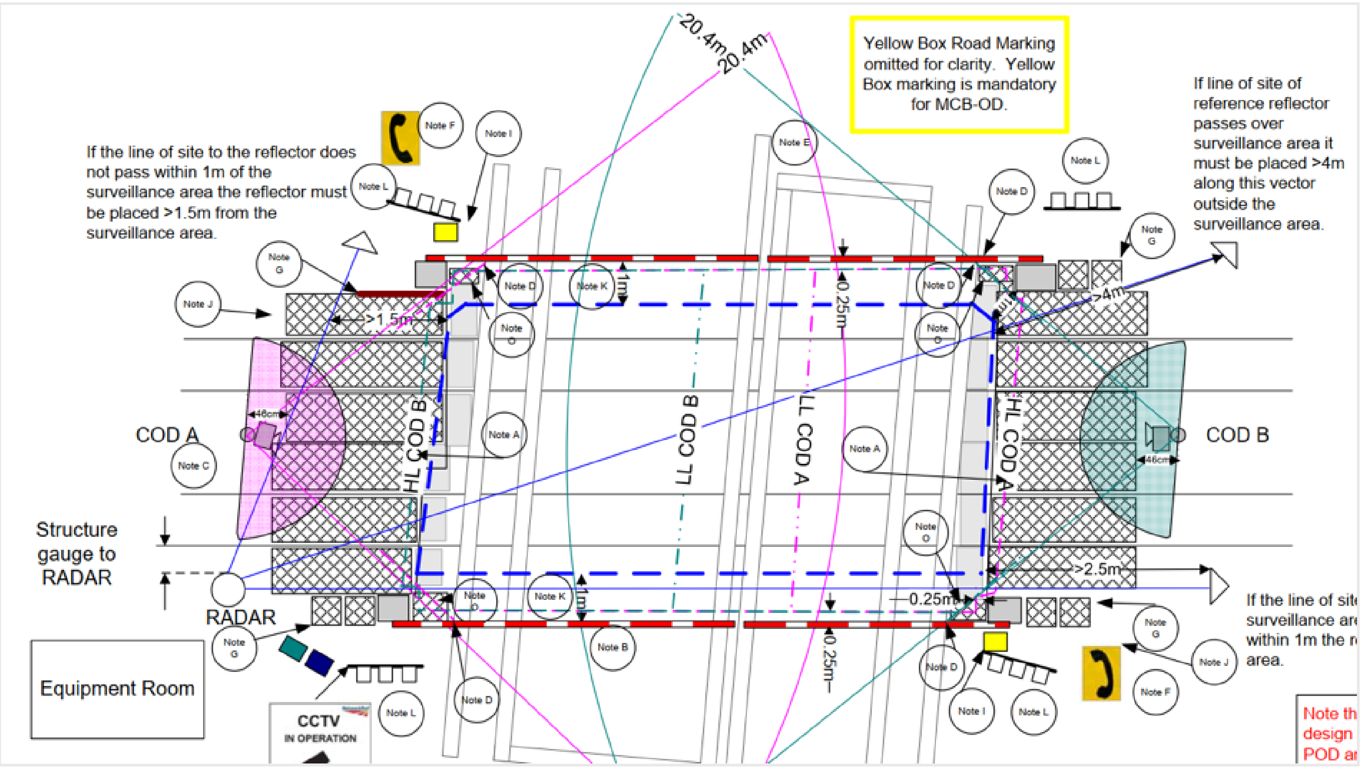

Figure 2: Extract from typical MCBOD V20 Diagram

INTRODUCING VALUE ENGINEERING: ROAD TRAFFIC LIGHT DESIGNS

For the road traffic light signal (RTLS) designs, I chose to adopt the Network Rail standard foundation design (IPS&E/EEP99/CIVILS/003) with a view of introducing value engineering to the project.

However, for three of the RTLS' at Cridling Stubbs and one at Spring Lodge, it was necessary to develop a set of bespoke shallow solutions to avoid existing and proposed buried services.

The reinforced concrete foundations I designed allowed for posts to be positioned eccentrically if required. Using the loads stated on the Network Rail standard design, I checked the foundation for bearing, sliding and overturning by calculation in accordance with Eurocode principles.

To push my designs further, I incorporated retention sockets within my bespoke foundation solutions. These retention sockets are a common solution for signage in the highways sector, however are rarely used in rail. For the posts, I specified the standard root mounted product from "UNIPART" which could be modified (bottom section cut off) to ensure availability and reduce fabrication cost.

The main benefit of this system was that existing foundations can be reused if posts are struck by vehicles, damaged by vandalism or life expired. Network Rail is also able to quickly swap-out posts using a specialist trolley which locks into the retention socket removing working at height during maintenance.

Figure 3: Annotated Photograph of Womersley LX OD System.

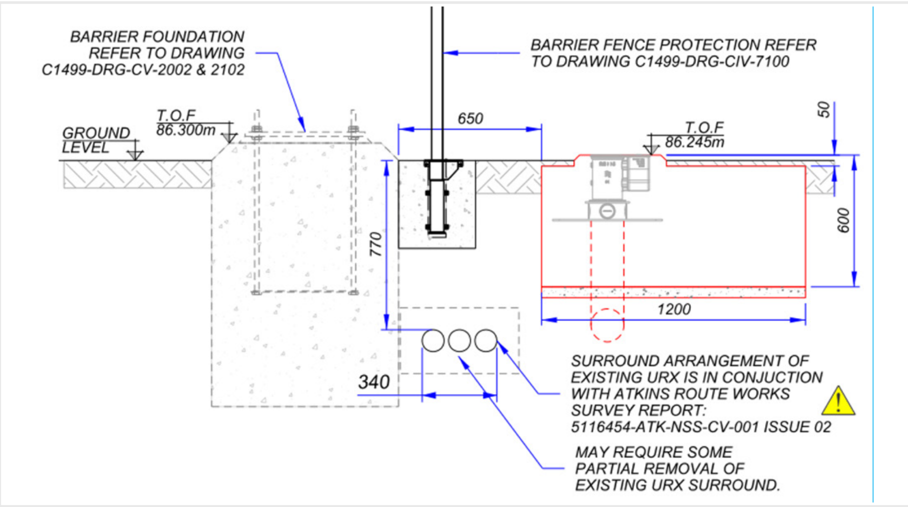

Figure 4: Extract from "Cridling Stubbs RTLS General Arrangement".

EBI GATE 630 TECHNOLOGY IMPROVEMENTS

The Bombardier EBI Gate technology included lightweight barrier machines (EBI Gate 630) and signalling equipment (EBI Gate 2000) run from a small equipment building also known as a "Level Crossing Hut". This hut was pre-installed with crossing control equipment for a "Plug and Play" solution which reduces installation time on site. To ensure routeworks and foundations would align correctly, I formally requested the building's schematics and standard designs from Bombardier.

To do so, I issued a "Request for Information" (RFI) and received design drawings from Poland. After an initial review, I noticed the section detailed had a buried pad foundation with a bolted steel column detail. My main concern with this detail was the buried bolt connection, which would have deteriorated over time and wouldn't be accessible for inspection / maintenance.

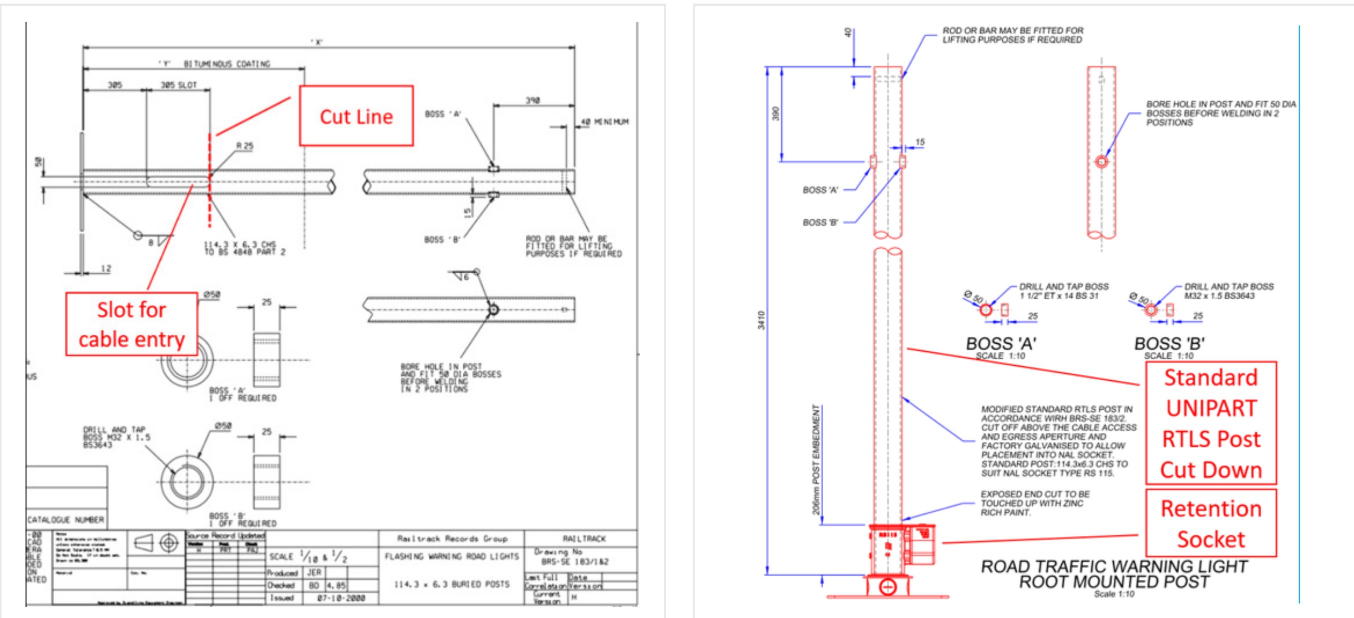

Figure 5: BRS-SE-183/1&2 & Extract from "RTLS Foundation General Arrangement".

After further research, I discovered Bombardier used this solution in Poland due to the effects of ground freezing.

During a design review with the Infrasig team, I tabled my findings to the Civils Construction CRE and suggested I could improve this detail by specifying bespoke shorter support legs and shallower foundations. This would reduce excavations and improve installation. For my design to satisfy the Eurocode 7 (BS EN 1997-1:2004) Clause 6.4 requirements, I detailed 250mm deep foundations with a minimum 225mm thick Type 1 granular subbase.

CONSTRUCTION METHODOLOGY

As level crossings affect both the highway and rail networks, minimising disruption during improvements is crucial. To achieve this, I specified precast foundations and positioned new infrastructure such that the existing crossing systems could remain operational until commissioning. My choice of a prefabrication method also minimised disruption by undertaking works off-site in a safer more controlled environment. This often results in higher degrees of quality, although inherently generates transportation and installation challenges. In circumstances where clashes between new and existing assets were unavoidable, I designed bespoke solutions which took into account buildability, safety and long term operation.

At Spring Lodge the level crossing barrier in the "YO" corner*4 interfaced with an existing under road crossing (URX) which had been confirmed following a ground-penetrating radar survey. The barrier position was restricted by crossing skew, barrier length and proximity to track. My solution involved excavating either side of the URX to install mass concrete fill and a bespoke shallow precast foundation which would span over the existing URX.

HEALTH, SAFETY & "SAFE BY DESIGN" IMPROVEMENTS

I was keen to improve our safe by design involvement on the project and I quickly became proficient in assessing ground plans for optimised accessibility, visibility and operation. My fencing design in particular involved me critiquing against these elements in detail. I gave particular consideration to operation and construction safety. The protective fencing had to be compliant for the Obstacle Detection (OD) system & ISO 14120 "Safety of Machinery – Guards – General requirements of the design and construction of fixed and movable guards". The ISO 14120 standard included references to other applicable European Standards which also had to be assessed. I produced a report which outlined the minimum distance requirements to achieve a compliant design based on a review of these standards. I then developed a glass-reinforced plastic (GRP) fencing system which was successfully reviewed by an HSE machine guard specialist following a prototype build at the Rail Operating Centre (ROC) in York.

For all my designs I reviewed potential hazards for design applicable risks. When a design risk became apparent, I recorded the issue within a Design Risk Assessment (DRA). This aligns

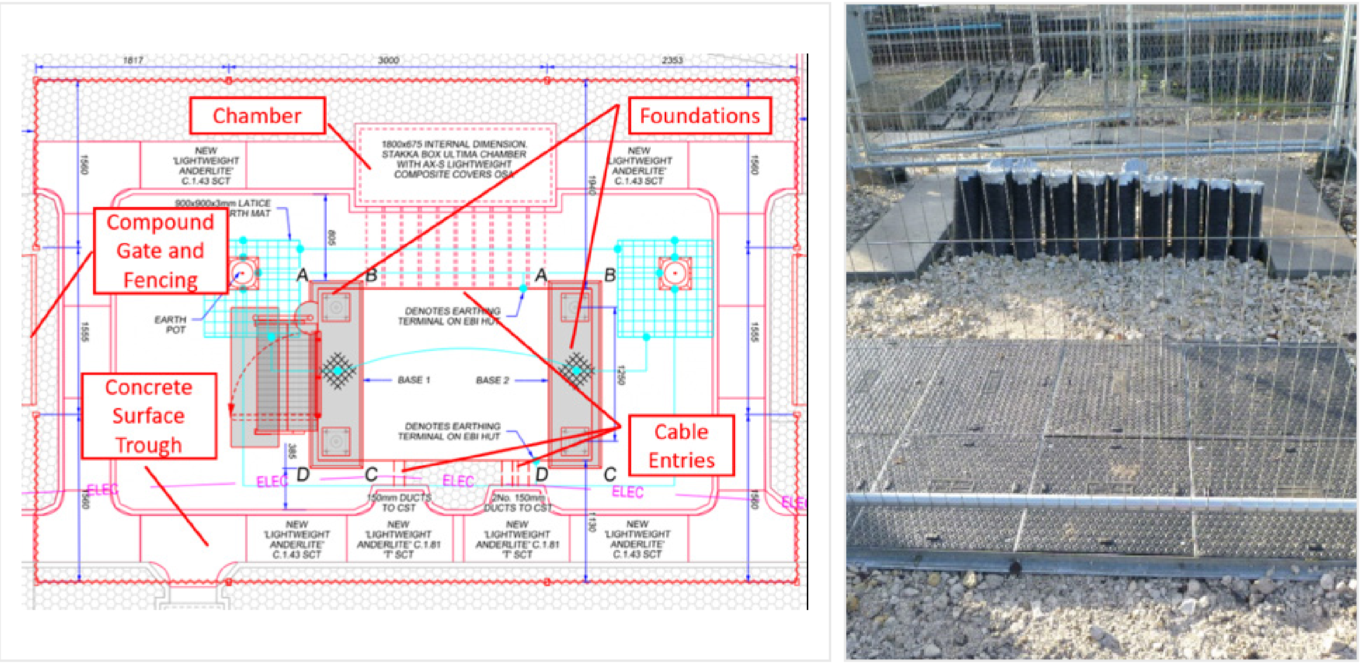

Figure 6: Extract from Detailed Design Drawing and photo of constructed Hut Foundations.

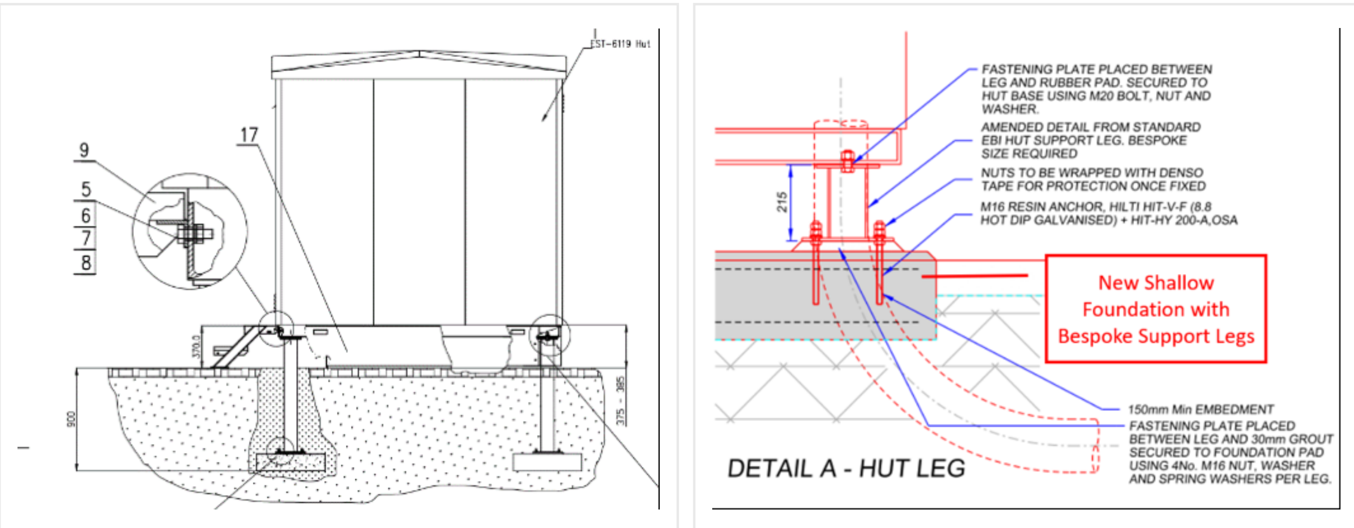

Figure 1.7: Extract from Detailed Design Drawing & "EBI Hut General Arrangement"

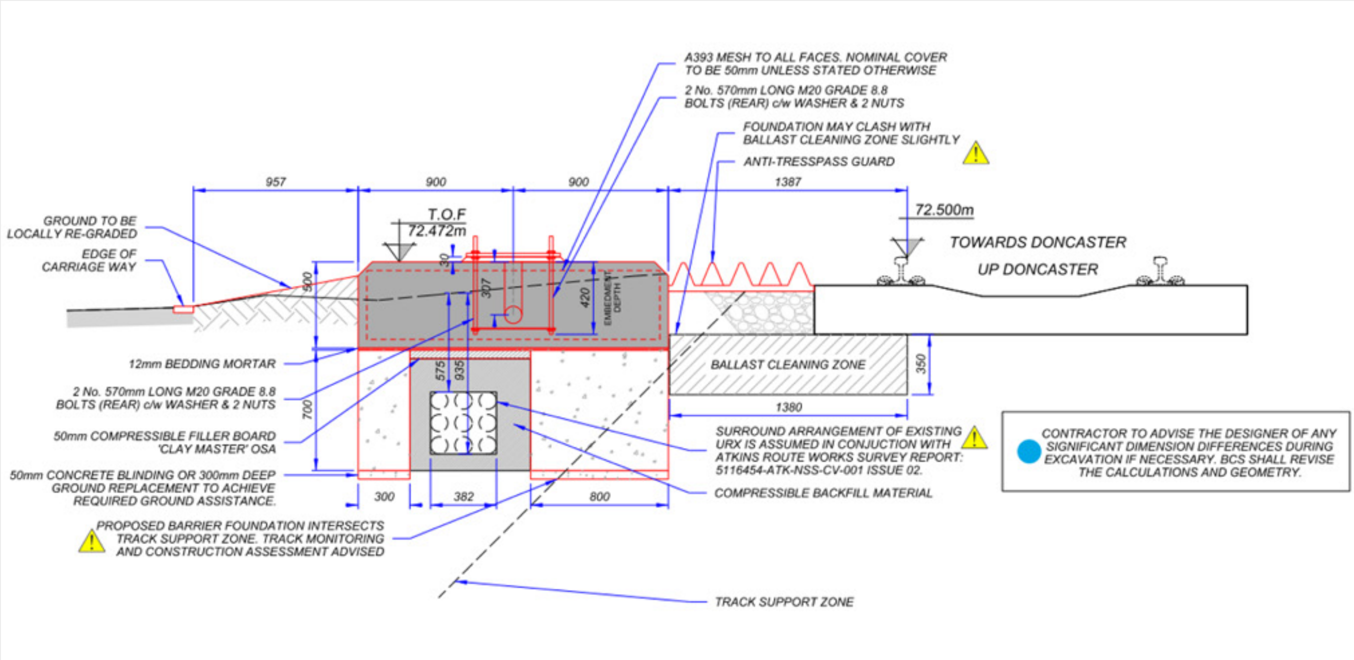

Figure 8: Extracts from drawing C1499-DRG-CIV-4102 and photograph of commissioned Spring Lodge YO Barrier

with a designer's responsibilities in accordance with CDM 2015 Regulations by using the "ERIC" HSE method used in my designer's risk assessment. The abbreviation stands for, Eliminate, Reduce, Inform & Control. To inform the contractor and or client of a potential risk, I would not only document it within the DRA but add a note to my design drawings.

This was in the form of a Safety, Health & Environment Residual Hazards Box also known as a "SHE Box". The most commonly recurring risk was related to buried services within close proximity to new assets. While I presented the results of a ground-penetrating radar survey on the detailed design drawings and ground plan, I knew that the precise location of the service could vary substantially in both plan and elevation. An example of how I communicated these residual hazards on the drawings is shown in Figure 10. I used a mixture of zoomed-in plan views and cross-sections to make it obvious to the contractor. The contractor later managed these residual risks by undertaking trial pits before installation works.

QUALITY, PROGRAMME & MANAGEMENT

Throughout the project, I was responsible for checking ground plans and detailed designs to ensure compliance with Network Rail and Highways Standards. The standards I used most frequently were "Railway Safety Publication 7 (2011): A guide for managers, designers and operators" and "Traffic Signs Manual: Chapters 4 & 5". To maintain quality and prevent recurring errors, I developed a checklist and Document Review Notice (DRN)

Figure 9: Constructed and operational Spring Lodge Level Crossing Barrier Cage System

"styled" comments sheet which could be read in conjunction with a marked-up ground plan. This allowed me to communicate effectively with my CAD team and produce evidence of checking for an audit trail. I found this to be quicker when done by hand and passed hardcopies over to the technicians so they could add their comments before scanning to the CAPITA server.

As the project progressed, I kept the client up to date weekly via email, telephone and formal progress reports. When variations to the scope of work arose, I produced revised programmes using Microsoft Project. This included key milestones for project delivery. I also considered the resourcing requirements for each of the activities within the programme to ensure sufficient availability. As I managed a dedicated CAD team I was able to allocate and assess workload daily. This allowed me to prioritise deliverables for the client swiftly. I tracked project team deadlines, annual leave, sick leave and training days using my calendar on Outlook which was shared with the rest of the design team.

I attended numerous technical meetings (Interdisciplinary Design Checks & Interdisciplinary Design Reviews), sent emails and answered daily telephone calls from Infrasig and Network Rail. I was often the first point of contact for technical queries and would advise them on aspects of my designs by referencing standards and presenting engineering justifications. Typically, this involved explaining why infrastructure such as RTLS, Barriers, Stop Lines, Telephones etc had been located where they had. In developing a new protective fencing system around the level crossing barrier, I gave a PowerPoint presentation to the Network Rail team. This engagement was successful as I was able to accommodate the Network Rail's Route Access Manager (RAM) and maintainer's concerns.

FINAL OUTCOME

The Knottingley LX Renewals project incorporated numerous new level crossing civils design innovations and improvements which brought about a safer, more reliable set of crossings for Network Rail and the general public. The lessons learnt from the project have since influenced other schemes and contributed to more sustainable solutions for the sector.

PERSONAL NOTE

With any engineering project it takes a team of dedicated people working collaboratively to solve a problem. More so to drive continuous improvement and innovation. I would like to thank everyone involved and the knowledge shared while working together.

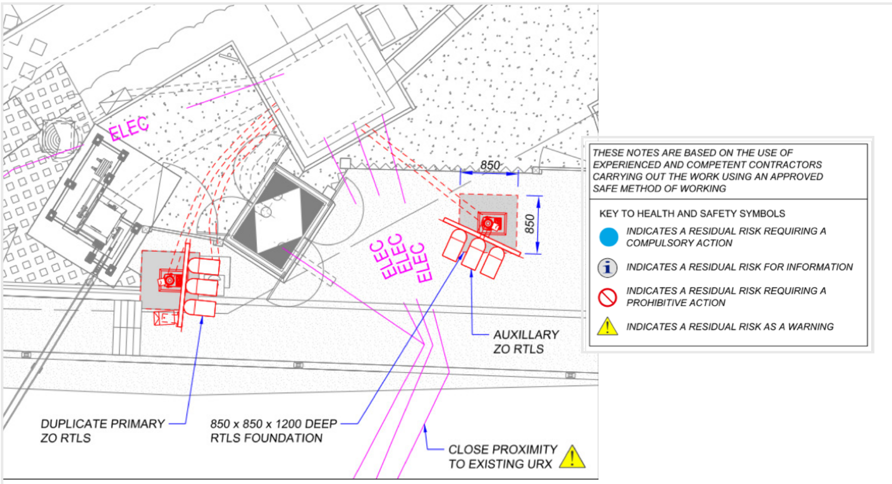

Figure 10: Extracts from drawing C1499-DRG-CIV-4103-C01, Spring Lodge RTLS Detailed Design.

Figure 11: Barrier protection PowerPoint presentation.

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1. WOMERSLEY PARISH COUNCIL. 18 Sept 2017. Spring Lodge. [Online]. [30 January 2020]. Available from: http://www.womersleyparishcouncil.gov.uk/_UserFiles/Files/_Other/15877-Womersley_PC_-_presentation_11.9.17.pdf **2. WIKIPEDIA. 23 January 2020.** Level crossings in the United Kingdom. [Online]. [30 January 2020]. Available from: https://en.wikipedia.org/wiki/Level_crossings_in_the_United_Kingdom. **3. Network Rail RouteView, (2018).** Aerial Photograph of Commissioned Spring Lodge Level Crossing. Available at: https://routeview.visivi.com/nr-routeview/?mode=deepzoom&id=1088285#m%7C-1.21124%2C53.67812%2C15 [Accessed 7 May 2020]. **4. Diagram included (below) in NR/L2/SIG/11201/MOD X02, 2012.** Signalling Design: Module X02 - Level Crossings: Common Design Requirements. 2nd ed. Kings Place, 90 York Way, London. N1 9AG: Network Rail. **5. Davison, S., 2013.** NR/IP/SDG York/MCB-OD/RADAR/02: Typical MCB-OD Arrangement. v.20. Network Rail: Kings Place, 90 York Way, London. N1 9AG.

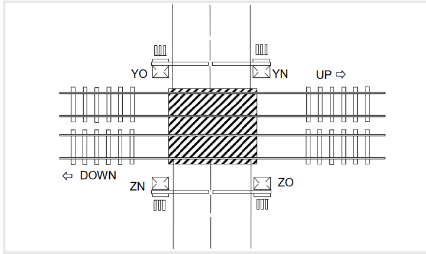

Figure 12: Photo of Commissioned Level Crossing Hut at Spring Lodge LX.

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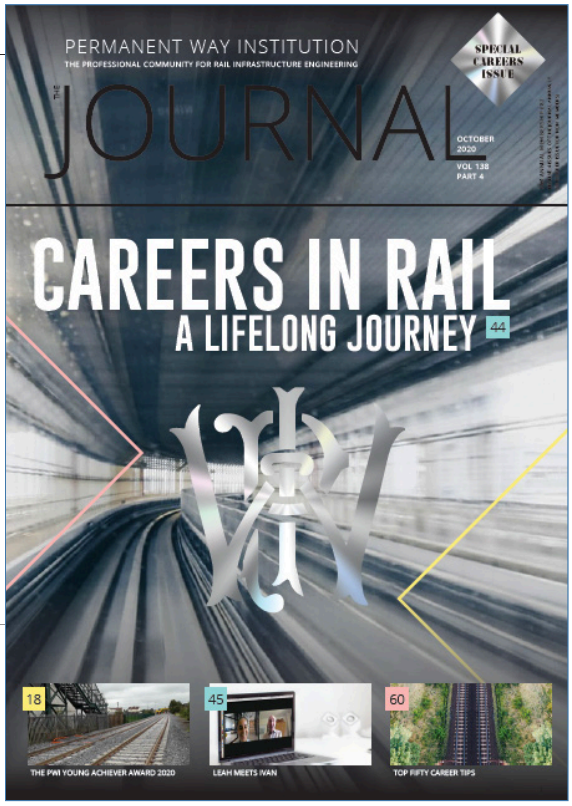

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