



Temporary Works Forum (TWf)

www.twforum.org.uk

SEMINAR:

“DIGITAL COLLABORATION”

held at

SALFORD UNIVERSITY

on

29th November 2017

INTRODUCTION

On 29th November 2017 a Temporary Works Digital Collaboration Seminar was held by the Temporary Works Forum (TWf) at the University of Salford. The event was chaired by Steve Hesketh (MGF Engineering Director and TWf Director), with assistance from David Thomas (TWf Secretary and Director) and Dee Rowan (TWf Administrator).

The seminar was attended by 45 members of the TWf - with 11 speakers - representing consultants, suppliers, academia, construction and software houses.

The simple aim of the event was to allow sharing of TWf members' digital experiences, promote discussion of the issues and provide guidance to the TWf membership at large.

Eleven short presentations were made, followed by questions and answers. A summary of each presentation is contained in this publication, along with a summary of the issues and pitfalls raised.

DISCUSSION

A short discussion was held after all the presentations had been made. The consensus was that publishing the presentations and lessons learned would provide useful background to TWf members.

However, it was accepted that developing some guidance for the key stakeholders in the TWf was necessary. This should include the minimum to expect and provide when engaging. Health and safety was recognised as a key element of the process as was agreeing recognised staging and formats of providing relevant temporary works information was required, e.g. common objectives and establishing Industry Foundation Classes (IFC) for temporary works.

Concerns were particularly raised over the variety of software packages being used and the difficulty the supply chain had in complying with each project's requirements and adopting the various software packages.

Teaching undergraduates the skills required was a major issue, as was the need for TWf to engage with the BIM¹ community.

A volunteer group was required at TWf to champion 'digital'. Volunteers from the seminar were noted.

CONCLUSIONS

Digital collaboration is key to the UK Government's Construction 2025 Strategy², particularly in relation to improved productivity. There are many aspects to digital collaboration and BIM is only one of them. A lot of jargon and myths surround the subject - particularly with regards fully-developed BIM projects. It can be very confusing, but the principles are very

¹ Building Information Modeling (BIM)

² <https://www.gov.uk/government/publications/construction-2025-strategy>

simple - the collaboration and the sharing of structured information in agreed formats to reduce project timescales and costs.

The benefits of digital collaboration were demonstrably proven by every case study during the seminar. It was agreed that everyone engaged in temporary works will have to connect digitally in the future. It is not a case of if but when.

The industry desperately needs to re-organise, examine efficiencies and become less reactive (more predictive) in its approach to delivering temporary works.

All projects should be developed in 3D from the outset. Interestingly, a majority of contributors confirmed that working in 3D was actually quicker than 2D, primarily because revisions were far easier once working within a 3D model.

There is a clear divide between how BIM is viewed on major projects by consultants and main contractors and in general by the Tier 2 contractors and supply chain. This was recognised as a major issue by a number of contributors, as unless the supply chain buys in progress is impossible.

Temporary works benefits in particular from clash detection, constructability/phasing, visualisation for site teams and hazard identification.

The majority of benefits for temporary works can be achieved relatively quickly and cheaply, particularly as BIM for temporary works is much simpler than it is for permanent works. For example, producing a temporary works SketchUp model is often sufficient and can be achieved in a quarter of the time it would take in Revit.

Another issue raised by a number of suppliers was protecting their product intellectual property when providing highly detailed 3D information from which competitors could copy products.

There was a consensus that TWf needs to agree:

- Staging responsibilities for temporary works design, supply chain and construction main contractors and sub-contractors, e.g. RIBA digital overlay
- Establish key attributes needed for temporary works BIM objects
- Minimum standards for each to engage meaningfully
- Early recognition of impact of temporary works on the success of project and the complexity/risks, to allow effective management
- Agreement of key roles and responsibilities to satisfy BS 5975³, CDM2015⁴, PAS 1192⁵, etc.

12.2.18

³ BS 5975:2008+A1:2011, Code of practice for temporary works procedures and the permissible stress design of falsework

⁴ <http://www.legislation.gov.uk/ukxi/2015/51/contents/made>

⁵ <http://bim-level2.org/en/standards/>

SEMINAR: "DIGITAL COLLABORATION" - 29 th November 2017 - AGENDA			
Time	mins	Session	Speaker
10:00	30	Registration and coffee	
10:30	15	Introduction and housekeeping	Steve Hesketh MGF
10:45	60	TWf Case studies	
		Liverpool Street. Partial demolition and rebuild of existing steel structure	David Lohmann Wentworth House Partnership
		Durward Street shaft, Crossrail	Nick Boyle Balfour Beatty Major Projects
		Façade retention	Paul McLaughlin, Andrew Gascoine Mabey
		Digital collaboration for better temporary works	Angus Holdsworth Andun
11:45	15	Questions	
12:00	25	Keynote 1 Digital temporary works	Duncan Reed Trimble
12:25	25	Keynote 2 A contractor's perspective	Jill Guthrie Willmott Dixon
1:50	60	TWf Case studies	
		The use of Autodesk Navisworks for clash detection between reinforcement and temporary works cast in items	Ruth Creamer BAM Nuttall
		Revit, BIM and temporary works	Christopher Hooper dotzero Ltd
		A review of the way in which temporary works fitted into the workflows and the multi-discipline/multi-stakeholder environment of the Thames Tideway Tunnel project	Myles Bethell BAM Nuttall
		Conversion of file formats for use by different software	Andrew Jones, John Watson RMD Kwikform
		Creating CAD libraries for all products in different formats and then what are they used for	Charlie Mckillop BEIS
3:30	30	Discussion:	Led by Steve Hesketh
		What next ... ? Actions ... ?	
4:00	--	Close	

Steve Hesketh MGF Excavations Ltd.	
Case study title:	Early adopter experience
Project:	MGF temporary works design
Location:	Various
Date:	2009 to present
Role fulfilled on project:	MGF is a UK-based Tier 2 supplier/sub-contractor of excavation safety solutions, operating in the temporary works space. It completes over 4,500 engineering and design projects per year, employing over 35 design engineers and supplies approximately a third of the UK market.
What you did and how:	• MGF's BIM journey began by contributing to the full BIM model developed as part of the M25 widening. Since then, the company has contributed to a wide range of major projects, as well as developed its own approach to digital engineering. • The initial drive for BIM was based on a need to produce manufacturing drawings, technical files and develop health and safety and safer systems of work. However, MGF soon realized, that there were broader benefits related to risk management, including clash detection, capacity management, better management of certificates and permits (e.g. certificates to load and remove), improved visibility leading to better sequencing and decision support, better quality control and efficiency of business, understanding of your own components and methods, and of others, as well as 'speaking the right language to customers'. • The journey started with early investment in Autodesk, developing 3D images for technical files and an internal product library. This led to investments in using 3D images for animations and sequencing, resulting in two full time animators, and a more formal approach to the safe systems of work. As the capabilities of the company grew, this was upgraded to a full Revit offering. • A further capability is 'Scalable BIM'. Knowing that fast decision-making and agility is key, all staff are encouraged to use SketchUp, allowing working 3D sketches to be developed within 30 to 60 mins. This dramatically improves the decisions made and can be used to discuss requirements with different parties. • More recent developments have focused on broader digital engineering capability. 3 software developers were recruited with a remit to automate the design management process and create better internal systems. This includes design workflow systems to manage resources and revisions, product configurator systems to help choose solutions and generate risk registers, as well as data mining capabilities. Looking forward the aim is to be a digitally intelligent business, making use of big data to link in to existing datasets.

The issues and pitfalls:	1. <i>Develop a proactive trial and error mindset, incorporating incremental build-up of internal capability and accumulation of evidence to convince internal decision makers</i> Much of the early development work was done ‘on the side’, outside normal job descriptions using existing resources. The people doing so were passionate about making technology work for the business that a lot of the learning was done in their own time. In-house capability was developed gradually, via trial and error, including hiring people with an inclination to learn and develop digital aspects of the organization along the way. A further feature was the gradual accumulation of case studies, anecdotes and data to support the use of BIM, so that key internal decision makers could appreciate the benefits. 2. <i>Leverage in house capability, and your people</i> A striking feature was the use of internal resources. Hence, it is useful to keep in mind that outsourcing is not necessarily the answer. Digital solutions need to suit your organization, so try to get inspiration from your own people and the way that they work. 3. <i>Consider BIM within a broader digital engineering agenda</i> Recognise that BIM is part of a bigger digital engineering agenda. Hence, there is a need to think bigger than just a 3D model, reaching to see where smart digital solutions can work across your organisation. 4. <i>Developing strategic relationships with universities and best practice forums</i> For the last 5 years, MGF has been working with universities, supporting PhDs, student projects, hosting placement students, as well as giving guest lectures and participating in research projects. It also contributes to best practice studies, forums and organisations.
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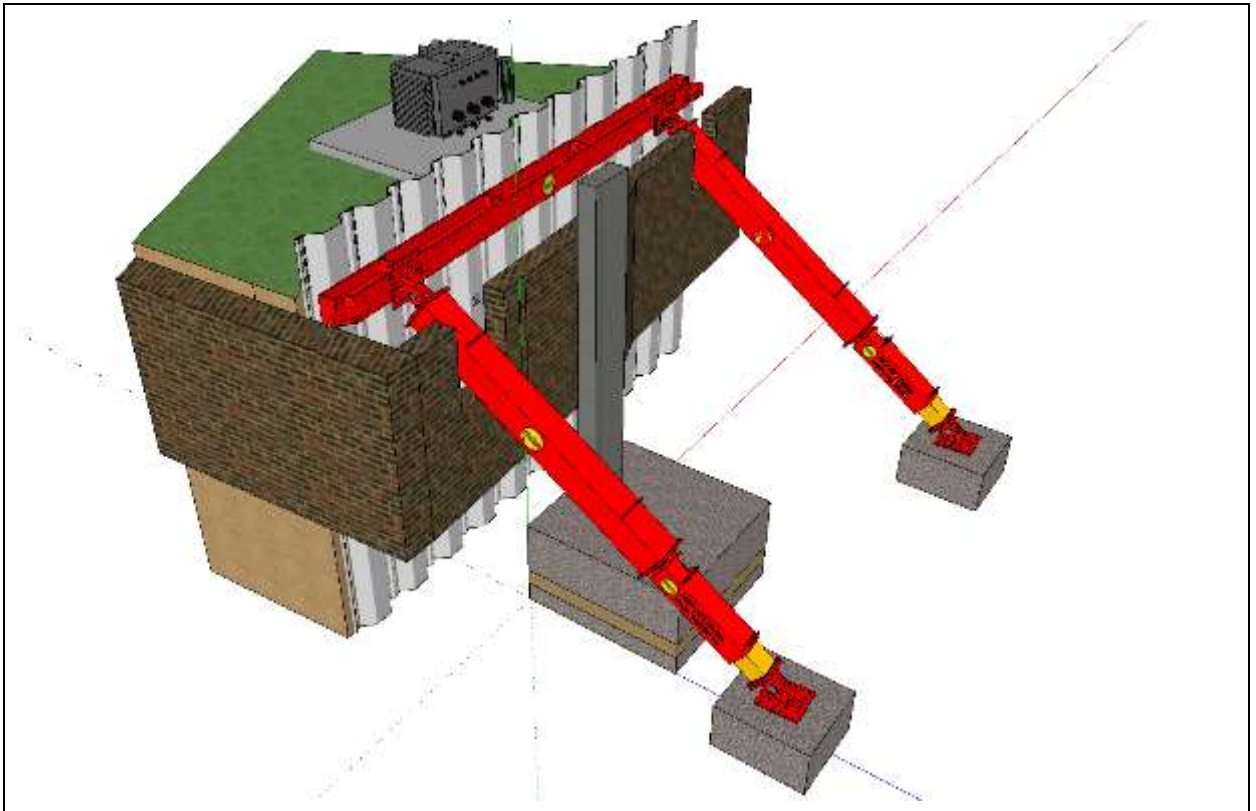


Figure 1 – Trench sheet propping

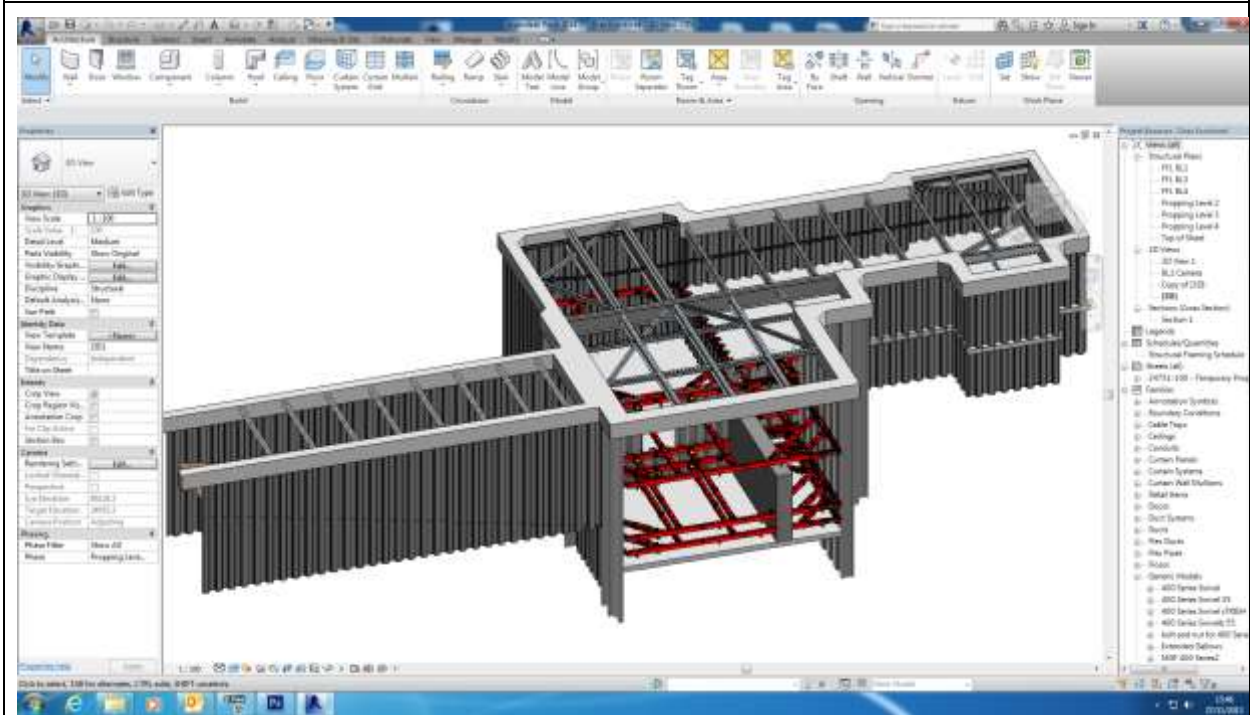


Figure 2 – Trenching solution



Figure 3 – Motorway gantry

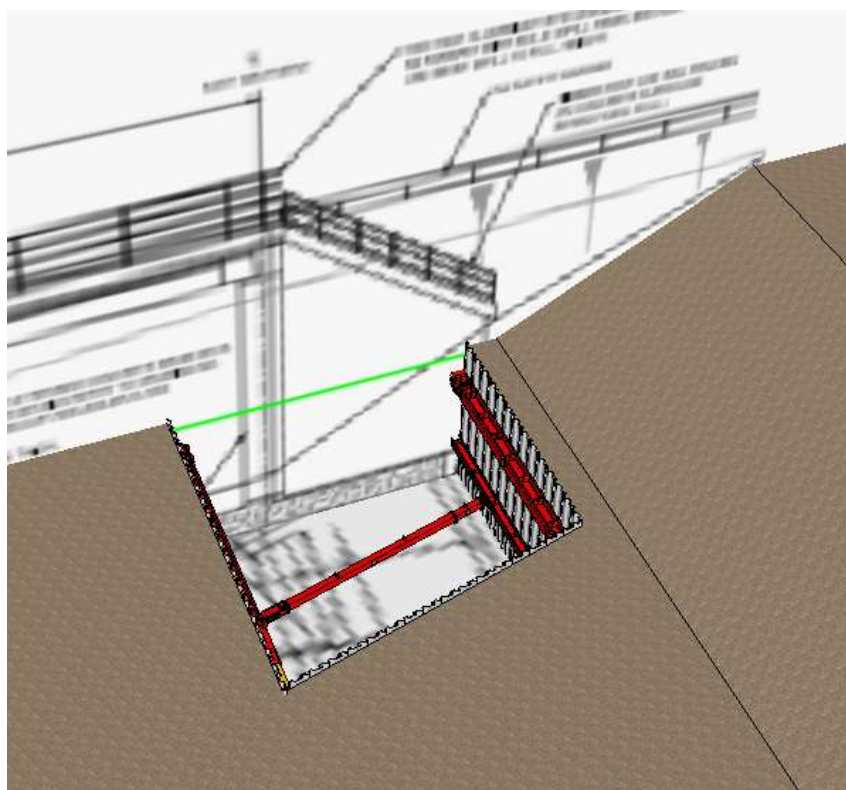


Figure 4 - Propping

David Lohmann and David Kwong Wentworth House Partnership	
Case study title:	Partial demolition and rebuild
Project and location:	Liverpool St – London
Date:	2016 - Ongoing
Role fulfilled on project:	Temporary works designer for the demolition contractor – Keltbray
What you did and how:	Wentworth House Partnership (WHP) produced a series of temporary works schemes, based upon and modeled around existing permanent works and survey models. This 3D output, coupled with calculations formed a significant part of our deliverable objectives on the job. The models produced were used not only for clash checking, but were directly turned into fabrication information for the steelwork, both site and shop fabricated by a third-party. <i>First scheme discussed:</i> Resilient crash deck – Spanning 15m above a live Network Rail asset to resist potential impact from demolition above the live pedestrian access. Access constraints to the area meant that a 3 phase scheme was required, with preparatory works being put in place to enable a rolling scaffold deck to be put in place in a single 24 hour access period. Once this scaffold deck was in place, the fabricated truss that would make up most of the resilient deck was able to be put together. The use of 3D software enabled WHP to deliver this in a manner that was easy to construct, with 6,600 individual parts being pieced together into 8 main parts, with only 3 different types of bolts across the whole scheme. <i>Second scheme discussed:</i> Stability bracing – In order to provide stability to the existing structure during demolition, WHP designed the temporary bracing to facilitate this. Locations of the temporary bracing were strategically positioned to avoid third-party interfaces such as existing bracing to the current structure, future permanent bracing and steel work for the new structure and tower crane bracing. Due to a congested site environment, a 3D model was implemented to allow for clash detections which resulted in streamlining approval methods as well as helped the site team undertaking the works visually.
The issues and pitfalls:	General The main issues faced with collaborative working and BIM were procedural. Whilst BIM is not something new to the industry, it's still not common to see early engagement. With

	this lack of early engagement, the key processes and responsibilities are rarely developed sufficiently during demolition until the main contractor gets involved in the project. On projects with multiple phases, this is sometimes more apparent, with the BIM Execution Plan (BEP)/Employer's Information Requirements (EIR) being released half way through or after a phase is complete, meaning a large volume of information has not been created or stored in an appropriate (as defined but the BEP) manner. Where elements of phases are retained through into others, this leads to reworking and reissue of information. Scheme specific WHP's Client (Keltbray) was issued a form of BEP after a portion of works had already been completed and designs delivered. This led to a change in the document control systems that were already in place. To save a WHP reissue of drawings under new document numbers, numbers were added to existing drawings by site team, which were then uploaded to the new Common Data Environment (CDE) as construction records. Truss A spatial constraint came up when fabricating the finger plates on some of the members. An 8mm fillet weld all round (FW AR) was specified. However, access to the return faces of the plates was blocked by the other plates. Of the 2 options, a partial butt weld or a larger fillet the fillet was chosen for cost. Stability bracing The stability bracing had to interact with the existing frame, which was modeled to varying degrees of accuracy due to access constraints/fireproofing making it difficult to gauge the exact locations. This was not a major concern given tolerances were understood, allowing WHP to design a scheme around the +/- 10mm expected. Issues arose when the permanent works were being developed at the same time as the temporary works, given the temporary works were to avoid the new permanent works. Changes in beam depth led to geometry changes in the temporary works. Had the scheme been delivered in 2-D, however, the workflow to adapt to the changes would have been much longer, with more potential errors through omission of details.
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Figure 1 – 100, Liverpool Street, Partial demolition and re-build of existing steel structure

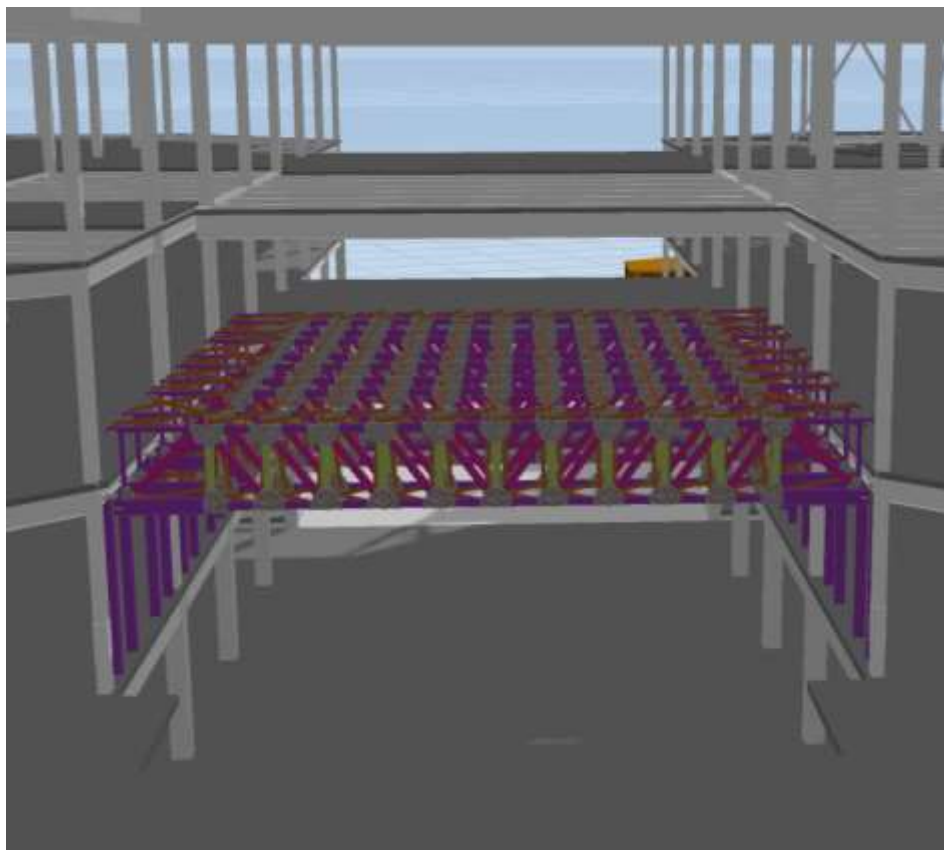


Figure 2 - Crash deck truss shown with existing structure



Figure 3 - Manual installation of truss

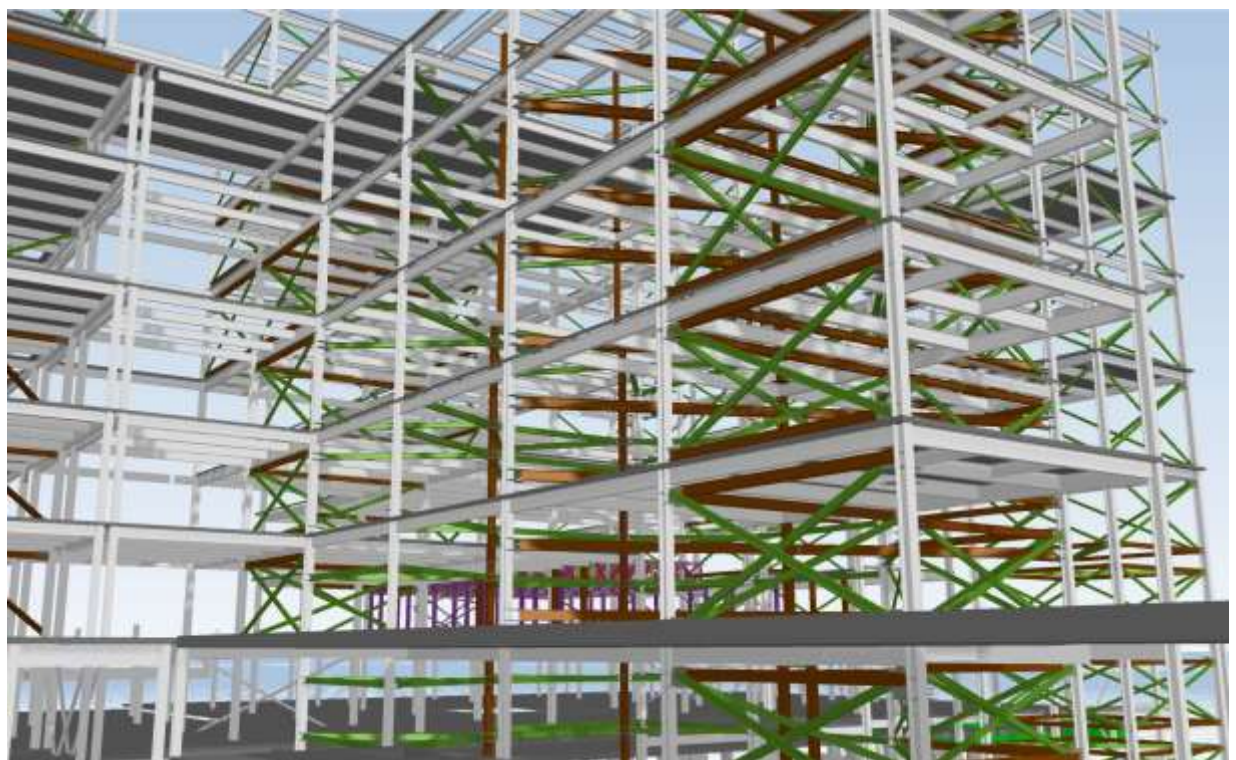
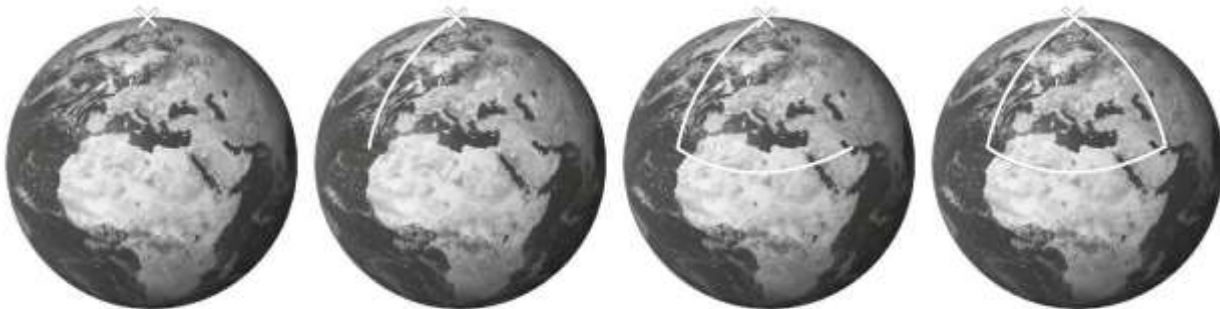


Figure 4 – WHP bracing (Green) with retained (Grey) - Synchro

Nick Boyle Technical Solutions Director, Balfour Beatty Major Projects	
Case study title:	Smarter ways of working – the use of digital tools
Project:	Speaking in a common language – the use of digital techniques in construction methodologies
Location:	Crossrail, Highways & Tideway
Date:	2015 to 2018
Role fulfilled on project:	Design and Construction
What you did and how:	The secret of communicating is to understand what is to be constructed, how the works are planned, integrated into the permanent works design and the temporary works design, the methodology, and the role of the supply chain; in order that we all talk in a common language between the disciplines. The adage “a picture is worth a thousand words” says it all - visualisation is the common communication tool. An old riddle that demonstrates the value of visualisation goes something like this. To demonstrate communication, consider in your mind: “Drive 1 mile south, 1 mile east, 1 mile north.” Are you back where you started? The initial answer might be, “No, of course not, as we live in a 2-D world”. However, if this is illustrated (see Figure 1) using a 3D model it depends entirely on where you started and, by a simple trick, we instantly understand and there is no confusion.
 Figure 1 – A 3D world	
	Various case studies were shared. One example was at Whitechapel station, where a large trapezoidal shaft was to be constructed at Durward Street. The permanent works design had been carried out, complete with an illustrative temporary works design that had significant resilience/redundancy due to the requirement to design for a catastrophic event involving removal of any

	prop on a scheme incorporating three levels of propping, with loads on the walings of circa 3000kN/m. An alternative propping arrangement was developed that reduced the number of props and mitigated the risk of elimination of a prop at the same time. The visualisation concept was completed in Trimble SketchUp (see Figures 2 to 5), which improved all the design and site staff's understanding of the complexity and, importantly, enabled early agreement to the principles. Any changes to the model would instantly reflect through into all the layout drawings and sequencing at the click of a mouse. We are also seeing rapid development of the latest technologies which literally immerse the viewer into future scenarios: • In virtual reality, the viewer experiences the full 3D space in a virtual world. This technique can be used with devices such as VIVE and Oculus Rift and other developing devices and can bring the site into the office. The use of multiple wrap-around screens in a 'BIM cave' can give a full immersive experience. • In augmented reality, we can design the piece of plant/temporary works equipment and share with the project team on site to ensure it works virtually, before it works in reality. For example, Balfour Beatty Ground Engineering designed a piling casing extractor that was shared on site through augmented reality, which could be critically reviewed and then implemented. In mixed reality, we combine the experience of the actual site with the virtual construction and by using survey points we can show the temporary works on a real site in context, with the actual building site. This uses devices such as HoloLens - a head up display unit that knows where it is geospatially, xyz in space.
The issues and pitfalls:	Tools need to be easy to learn and easy to use; ensuring that the right tools can be used by the right people with the right training. Not all tools are interoperable –and this space is continually developing.
Reference:	This is an extract from larger document that has been put forward for a new chapter in a 2nd edition of the successful ICE Temporary Works: Principles of Design and Construction, "Visual Planning and BIM" (due for publication in the autumn of 2018) www.icebookshop.co.uk/bookshop_main.asp?ISBN=9780727741776&BookTitle=Temporary%20Works
Figures:	Crossrail – simple illustration in 3D of alternative propping scheme and methodology of installation.



Figure 2 – Excavation to Level 4



Figure 3 – Installation of Level 4 props and concrete arch

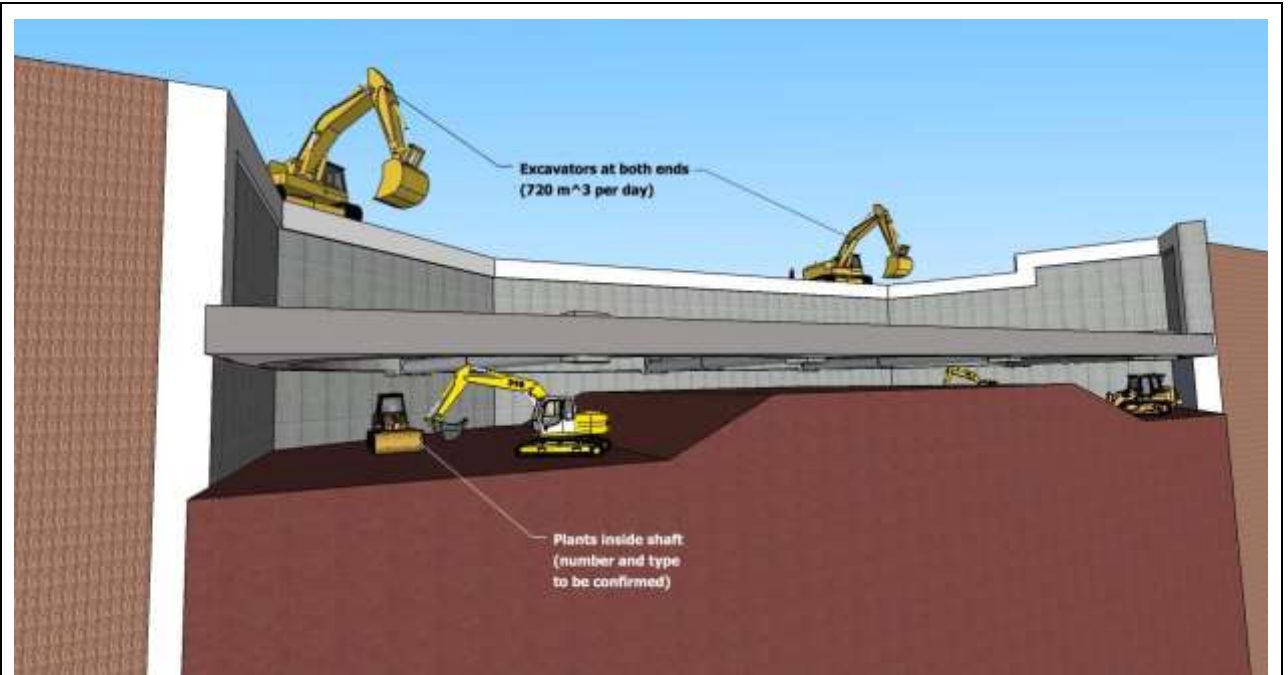


Figure 4 – Excavation from Level 4

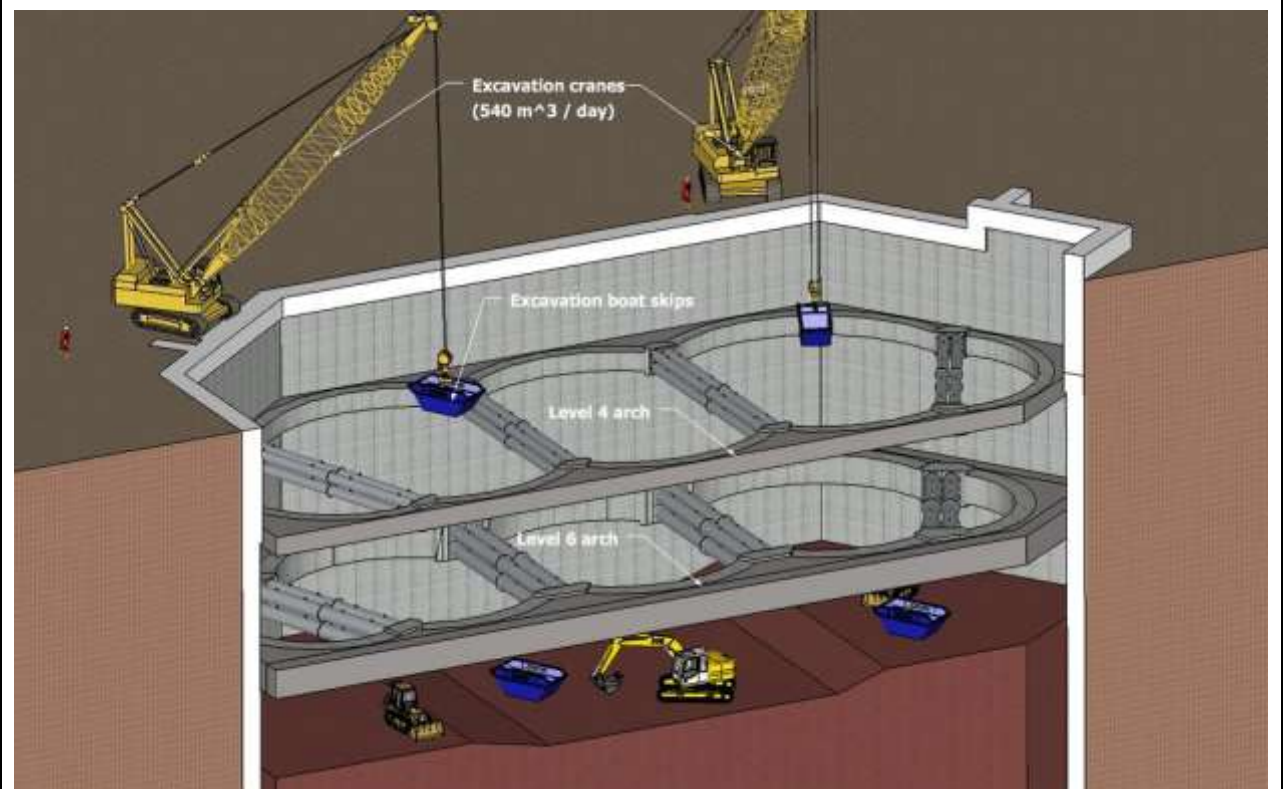


Figure 5 – Excavation below Level 6

Paul McLaughlin Mabey	
Case study title:	"Project Pacific"
Project:	Façade retention
Location:	Glasgow
Date:	October 2017
Role fulfilled on project:	Specialist sub-contractor (manufacturer, supplier, designer and installer) of temporary works equipment.
What you did and how:	We're currently working on a large project with BAM Nuttall for a façade temporary restraint system in Glasgow. The façade is currently being restrained by structural steel; however, this steel is being removed for the permanent steelwork to be installed, and in the interim period; our temporary system will take over the role of restraining the façade. A BIM Execution Plan (BEP) was provided by BAM Nuttall in June with an on-site date in October 2017. A list of actions and benefits were established and allowed the lead project team and digital engineering team to define a suitable workflow. A BIM model was created to identify any clashes between our temporary system and the structures already in place, and the future permanent steelwork. The client provided all existing models to allow us to produce a federated model. A clash detection report was produced. Prior to resolving the clashes, the model was exported to our Virtual Reality (VR) system, where the Lead Project Engineer reviewed the model visually to establish the best way of resolving the clashes. Once all clashes were resolved, the model was again exported to the VR System for review to allow the site installation team leader to assist with the installation methodology and define any further design changes required before producing a Safe System of Work document.
Benefits and improvements achieved:	Using BIM and VR on this project and in general has provided the following benefits: 1. New software and hardware providing new capabilities including BIM, VR & Augmented Reality (AR). 2. Digital content of all our products for BIM projects. 3. Internal BIM training developed focusing on temporary works. 4. BSI BIM Level 2 certification. 5. Improved certainty and confidence in the complicated design and programme. 6. Design changes are quicker and more efficient.

	7. Automated parts list generated saving engineering time. 8. Reduced risks on site with a clear view on installation methodology, aiding health and safety. 9. Less potential delays on site, minimizing additional costs and penalties. 10. Added Bonus – shortlisted in the CN Specialist Awards for Digital Construction Excellence.
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The issues and pitfalls:	Not too many, as we are getting used to working on these kinds of projects. Some issues experienced however: 1. Transfer of the Point Cloud into VR was not possible. The point cloud had to be converted into a solid model for this. 2. The Tier 1 Contractor (BAM Nuttall) was mature in their use of BIM, but our client was not. This created an extra layer of communication, difficulties in understandings and delays in transferring files. 3. Making sure we have early engagement with clients and they know what we can do. 4. Client models often do not consider temporary works. 5. Embedding it into the project teams fully is a difficult process. 6. Additional costs for software and training.
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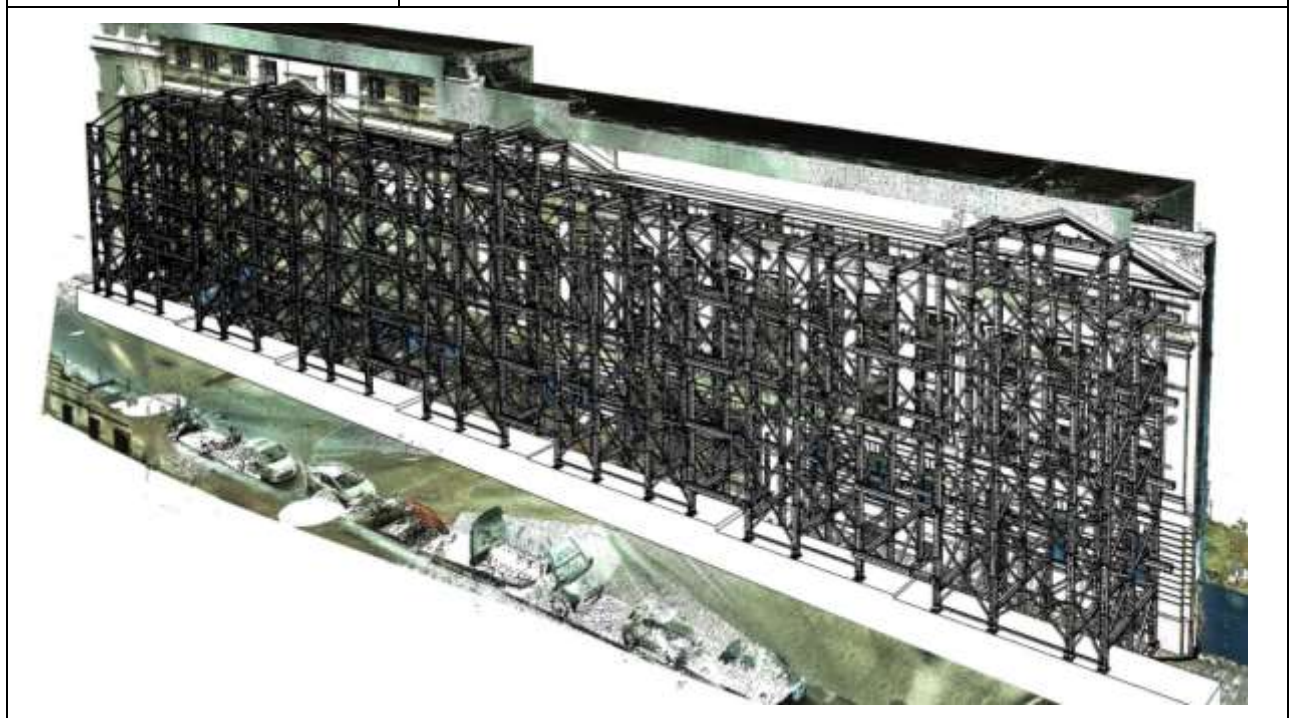


Figure 1 – Façade retention scheme

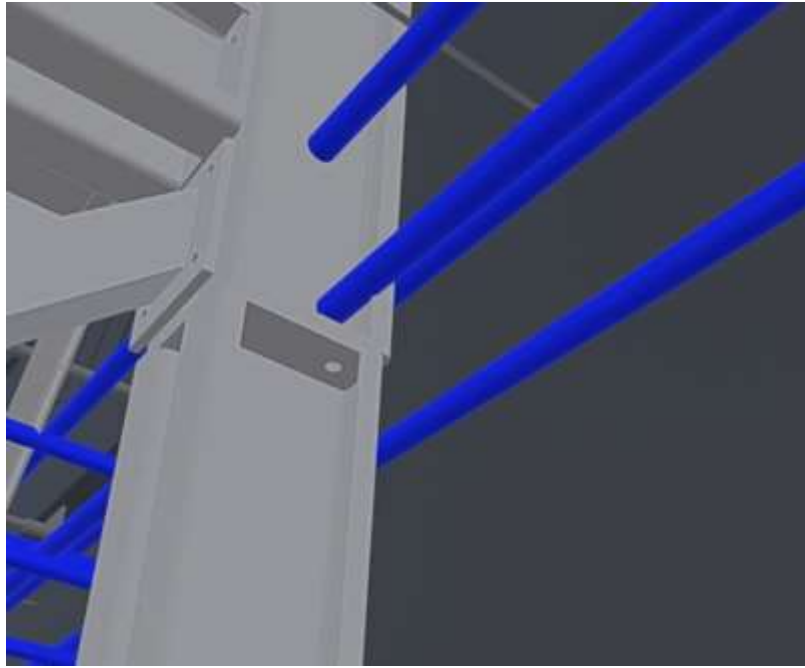


Figure 2 – Clash detection



Figure 3 – Façade retention - bracing

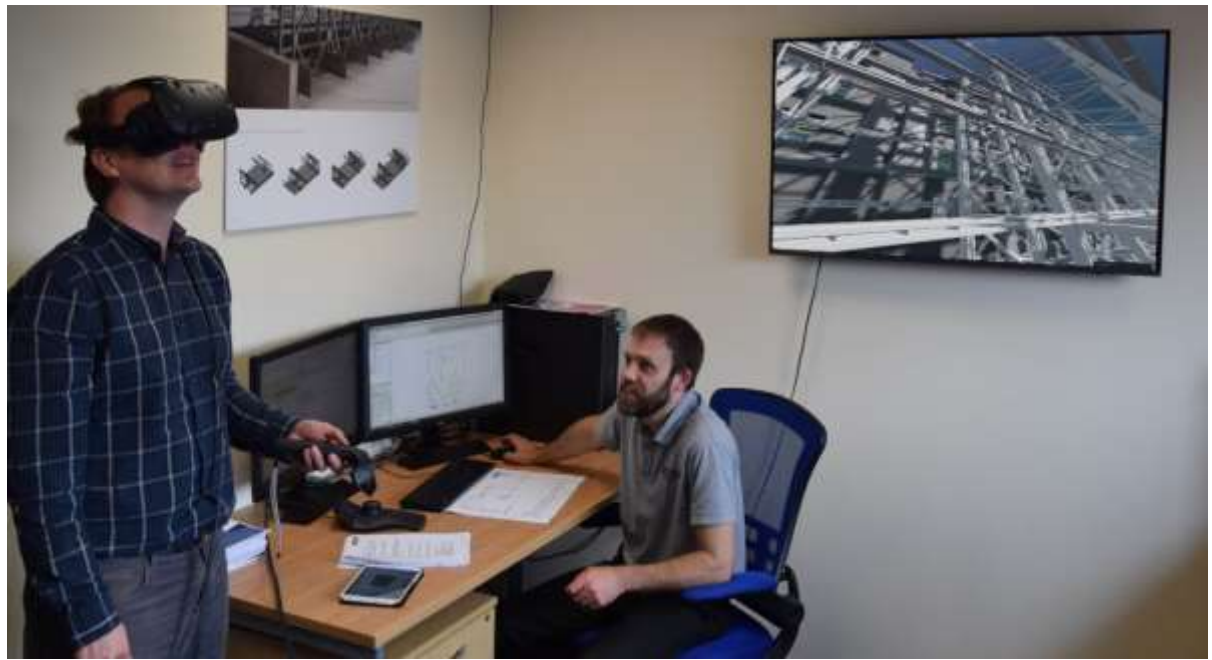


Figure 4 – Virtual reality goggles

Angus Holdsworth Andun Ltd.	
Case study title:	Digital collaboration for better temporary works
Project:	LOCROS; Landmark; The Majestic; Crossrail
Location:	London; Manchester; Leeds and London, respectively
Date:	2016/2017
Role fulfilled on project:	Temporary works designer
What you did and how:	LOCROS, London – Providing step free access to 3 stations, namely; Manor Park, Maryland and Seven Kings: • 3D model used for clash detection and signal sighting; • All temporary works in 3d in correct spatial position; • All temporary works fit first time, signal sighting was as per agreements, no clashes onsite; • AutoCAD and MicroStation used; • Navisworks for clash detection. Landmark, Manchester – Basement Propping: • Majority in Revit; • Fabrication drawings in AutoCAD; • Model shared freely with client and permanent works designer; • Majority of temporary works fit first time; • Clash detection of significant TW encast items with permanent works model undertaken using Navisworks and Revit. Worked successfully with no rebar clashes. • Showed the true value of collaborative working. We made changes to suit permanent works (PW) design, PW made changes to suit temporary works (TW) design. The result is a system that can be built whilst maintaining the PW designer's intent. Collaboration is the key; • Free exchange of information between all parties in useable formats. The Majestic, Leeds – Facade retention and basement propping: • PW designer working in Revit; • Our works in Tekla, with a little bit of AutoCAD; • Steelwork model will be shared directly with fabricator; • Clash detection undertaken within Tekla/BIMsight. Whitechapel

	• Used 3D models to gain stakeholder approval for a novel lifting frame design; • In house 3D printer used to make a physical model. Very useful when convincing stakeholders of the proposal.
What were the benefits:	• Streamlined workflow; • Analysis, design, connection design, fabrication model/drawings all in house; thereby ensuring design intent is realised; • Ability to handle most file types, and more importantly use them productively; • Increase productivity, automated take-offs, schedules, etc.; • Clash detection; • Temporary works generally fit first time.
The issues and pitfalls:	• A Lot of licenses required; significant investment; • A lot of time spent training; significant investment; • Decreased productivity; a sledge hammer to crack an egg! It is not always cost effective to produce a 3D design, however some clients insist; • We are often asked to coordinate our works with others models. They are then updated without any feedback to us, meaning that our works don't fit; • Companies insist on sharing files in formats that can't be readily used; this slows down the workflow; • Sharing of our intellectual property when we work collaboratively, i.e. we have spent time producing 3D blocks of TW components for our own use that we then end up sharing for free; • One size fits all standards; there is no flexibility within standards, particularly those from client such as TFL and Network Rail. Often written for permanent works with no thought about demolition or temporary works. Very difficult to challenge.

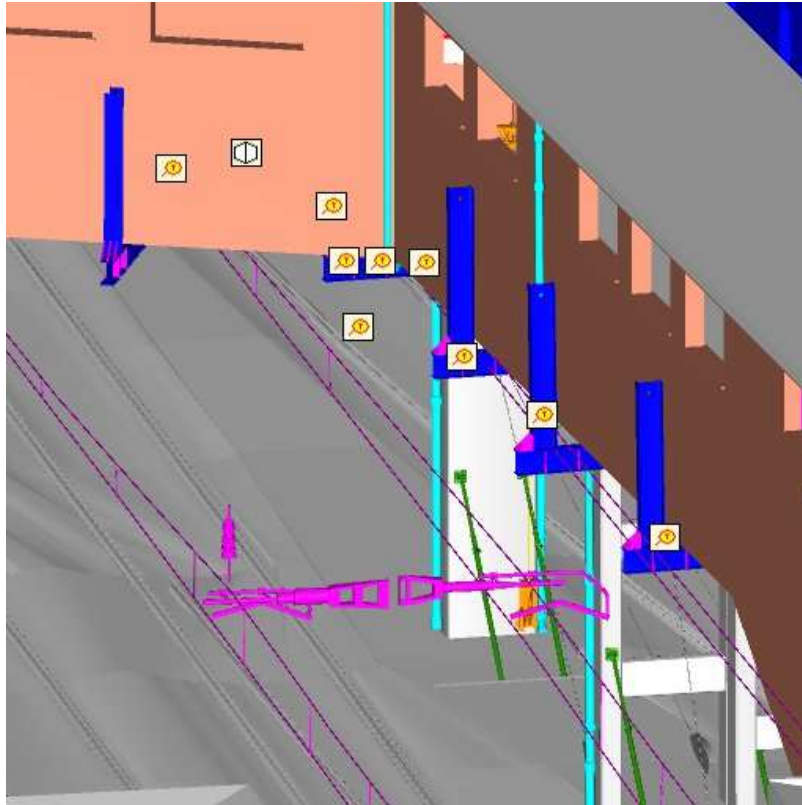


Figure 1 – LOCROS, London – Clash detection

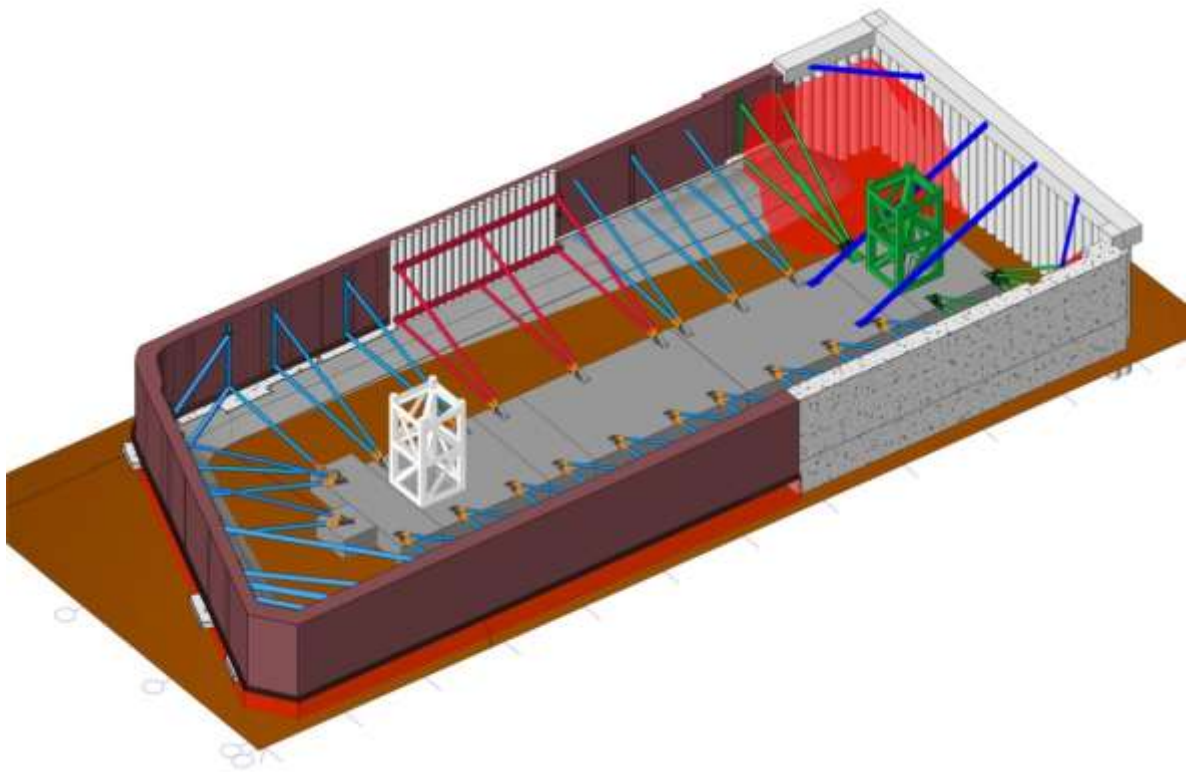


Figure 2 - Landmark, Manchester- Basement propping

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Duncan Reed Trimble Solutions (UK) Ltd	
Case study title:	Presentation - Digital Temporary Works
Project and location:	---
Date:	Various
Role fulfilled on project:	Software Vendor - https://www.tekla.com/uk
What you did and how:	Trimble Solutions offer world class structural design and modelling capabilities with products that can be applied to temporary works design and installation too: • Model, schedule and order temporary works materials in confidence; • Iterate multiple pour options to deliver the most economic solutions for your site conditions and constraints; • Automate temporary works calculations for formwork, falsework, propping and other contractor design portions with code-compliant solutions; • Analyse complex falsework designs with confidence, share the outputs from these designs directly into fabrication level software solutions; • Download best-in-class objects and plug-ins to enhance, simplify and speed up your modelling processes to develop as-will-be built models that are ready to go to site. Trimble Solutions, through our product portfolio of Tekla Structures, Tekla Structural Designer and Tekla Tedds can offer you all of this and more. See our webinar: https://www.tekla.com/about/webinars/plan-and-quantify-formwork-quickly-and-easily
The issues and pitfalls:	In the current business climate we see issues through lack of adoption or the inappropriate use of tools to try and deliver the wrong solution. Aligning BIM workflows to temporary works procedure will assist these issues greatly. In order to help both TWf members and the wider industry understand how to adopt temporary works digitally we suggest that a “temporary works overlay” to the digital plan of work (DPoW) be created. This was proposed in the presentation with a possible start to an overview based upon aligning the DPoW stages to those required in BS 5975 (see Figure 1, below).

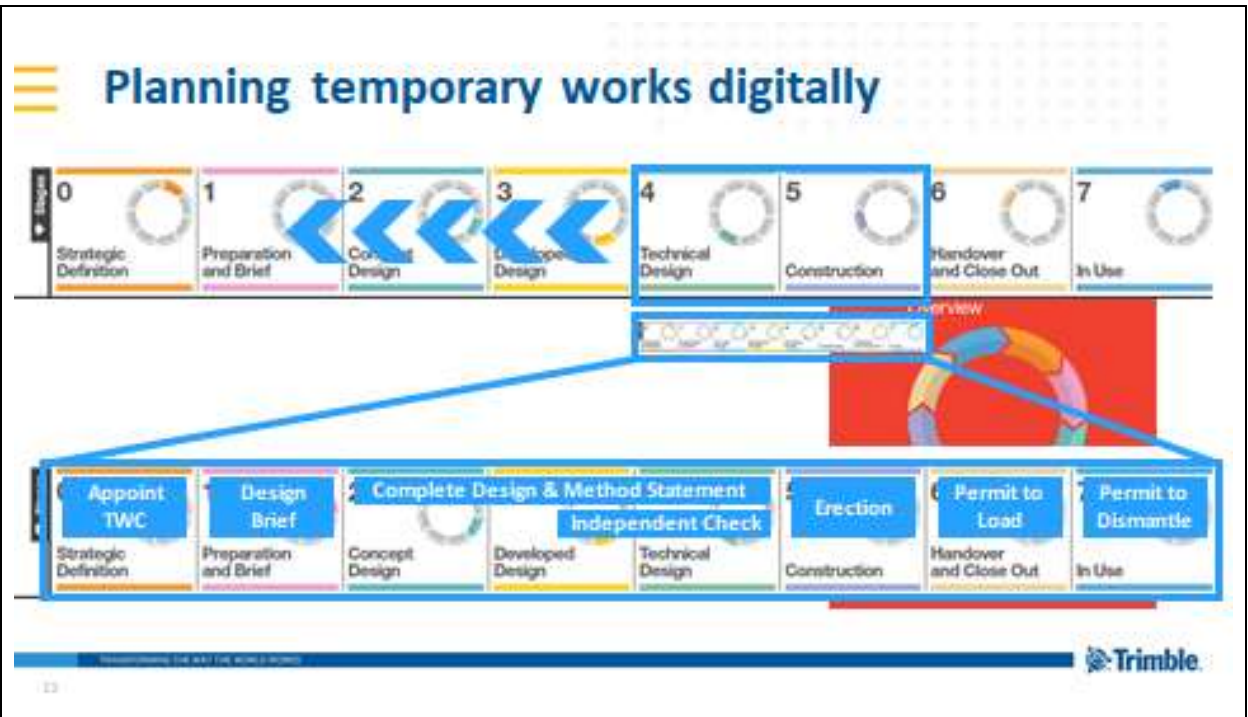


Figure 1 - Possible start to an overview based upon aligning the DPoW stages to those required in BS 5975

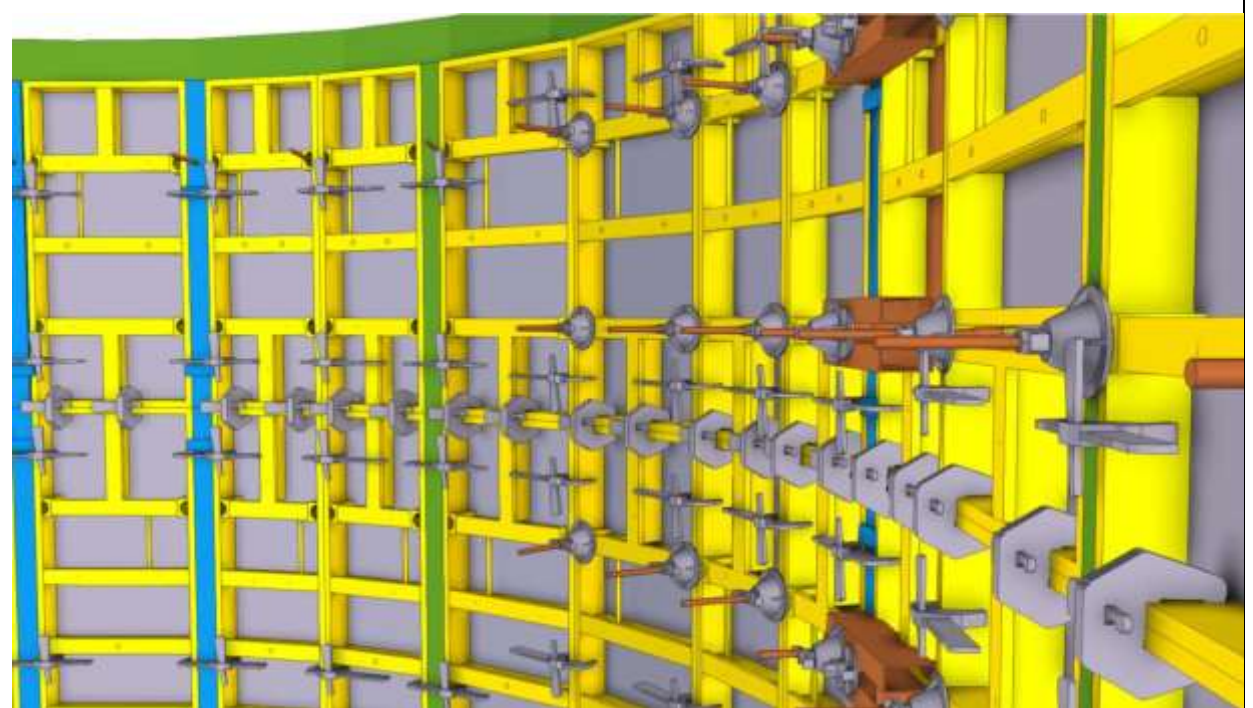


Figure 2 – Formwork detailing

 Tekla Tedds Trimble Solutions (UK) Ltd Trimble House Leeds LS27 7JP	Project				Job Ref.	
	Section				Sheet no./rev.	
					1	
Calc. by	Date	Chk'd by	Date	App'd by	Date	
SC	31/10/2017					

STEEL SHEET PILING DESIGN

In accordance with BS 8002:1994 - Code of practice for earth retaining structures Tedds calculation version 1.0.07

Cantilever wall

Geometry

Length of sheet pile for equilibrium (for analysis); $H = 11869$ mm

Total length of sheet pile provided; $H_{\text{max}} = 13150$ mm

Number of different types of soil; $N_s = 2$

Retained height; $d_{\text{ret}} = 3500$ mm

Depth of unplanned excavation; $d_{\text{exc}} = 500$ mm

Total retained height; $d_s = d_{\text{ret}} + d_{\text{exc}} = 4000$ mm

Angle of retained slope; $\beta = 5.0$ deg

Depth from GL to top of water table retained side; $d_{\text{wt}} = 2000$ mm

Depth from GL to top of water table retaining side; $d_{\text{wrt}} = 4000$ mm

Soil layer 1

Moist density of soil; $\gamma_{m1} = 18.0$ kN/m³

Dry density of soil; $\gamma_{d1} = 11.2$ kN/m³

Mobilization factor; $M_{\text{act1}} = 1.2$

Design shear strength; $\phi'_1 = 29.3$ deg

Active pressure coefficient; $K_{a1} = \cos(\phi'_1)^2 / (1 + \sqrt{(\sin(\phi'_1) \times \sin(\phi'_1 - \beta) / \cos(\beta))})^2 = 0.362$

Passive pressure coefficient; $K_{p1} = \cos(\phi'_1)^2 / (1 - \sqrt{(\sin(\phi'_1) \times \sin(\phi'_1))})^2 = 2.917$

Height of soil layer 1; $h_1 = 6000$ mm

Depth from GL to bottom of layer1; $d_1 = 6000$ mm

Soil layer 2

Moist density of soil; $\gamma_{m2} = 18.0$ kN/m³

Dry density of soil; $\gamma_{d2} = 11.2$ kN/m³

Mobilization factor; $M_{\text{act2}} = 1.2$

Design shear strength; $\phi'_2 = 27.5$ deg

Active pressure coefficient; $K_{a2} = \cos(\phi'_2)^2 / (1 + \sqrt{(\sin(\phi'_2) \times \sin(\phi'_2 - \beta) / \cos(\beta))})^2 = 0.390$

Passive pressure coefficient; $K_{p2} = \cos(\phi'_2)^2 / (1 - \sqrt{(\sin(\phi'_2) \times \sin(\phi'_2))})^2 = 2.716$

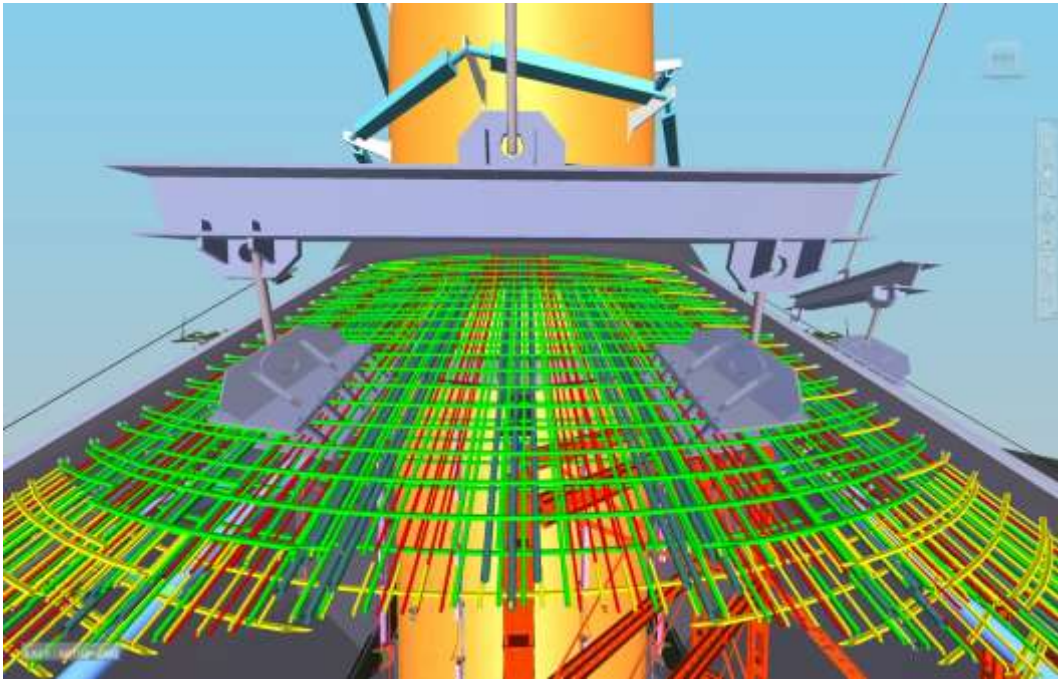
Height of soil layer 2; $h_2 = 5869$ mm

Figure 3 – Calculations for an earth retaining structure (to BS 8002:1994)

Jill Guthrie Willmott Dixon	
Case study title:	BIM and Temporary Works – A Contractor’s Perspective
Project:	Various
Location and Date:	----
Role fulfilled on project:	Senior BIM Manager for Willmott Dixon – Responsible for BIM implementation across the northern region.
What you did and how:	Jill’s presentation explained the role Willmott Dixon (WD) undertook in upskilling its supply chain and lesson learnt which can be implemented when working with temporary works; reviewing a contractor’s requirements and its expectations for temporary works in terms of clash detection, health and safety, construction sequencing and managing temporary works in the field.
What were the benefits:	Benefits with the supply chain included upskilling workshops based on both specific workshops and general BIM process; the supply chain then provided information in the correct format, on time and contributed to clash detection workshops.
The issues and pitfalls:	Initial limitations were WD providing too much information which the supply chain didn’t understand. Upon reviewing this WD now produce a supply-chain specific document that only includes information relating to their package of works.



Figure 1 – Completed projects

Ruth Creamer BAM Nuttall	
Case study title:	The use of Autodesk Navisworks for clash detection between permanent and temporary works cast-in Items
Project and location:	----
Date:	2017
Role fulfilled on project:	Temporary Works Designer
What you did and how:	The task was to lift and rotate a 140 Te precast concrete unit. The unit was heavily reinforced and the bolt group and backing plate for the substantial lifting lug had to be in place at the time of casting the concrete. The challenge was to arrange these around the reinforcement so as not to affect the permanent works design. The chosen method was to compare the 3D model for the permanent works and a separate model for the temporary works using clash detection techniques in Navisworks.
The issues and pitfalls:	The initial challenge was combining 3D models from various sources and file types. Once in Navisworks, it was possible to clash detect one model with another either by sectioning or by using built in clash detection facility. A drawback was the lack of accurate dimension in Navisworks.
	
Figure 1 – Lifting brackets	

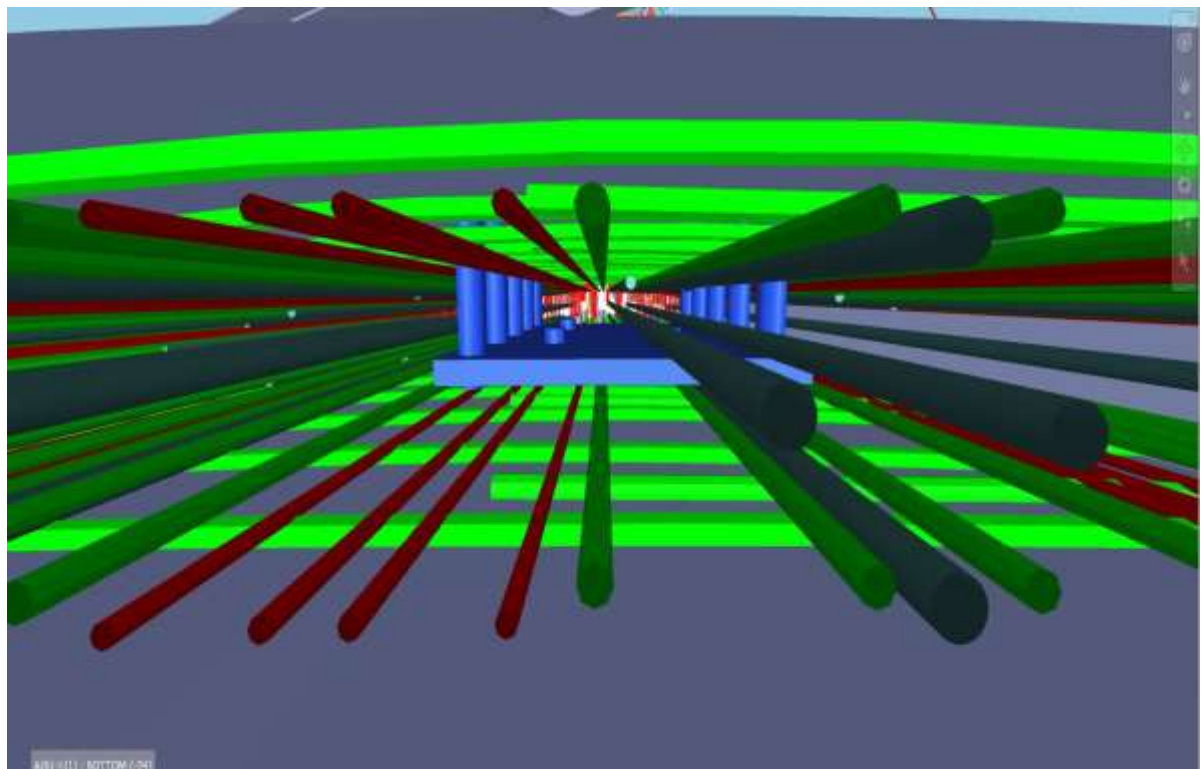


Figure 2 – Clash detection

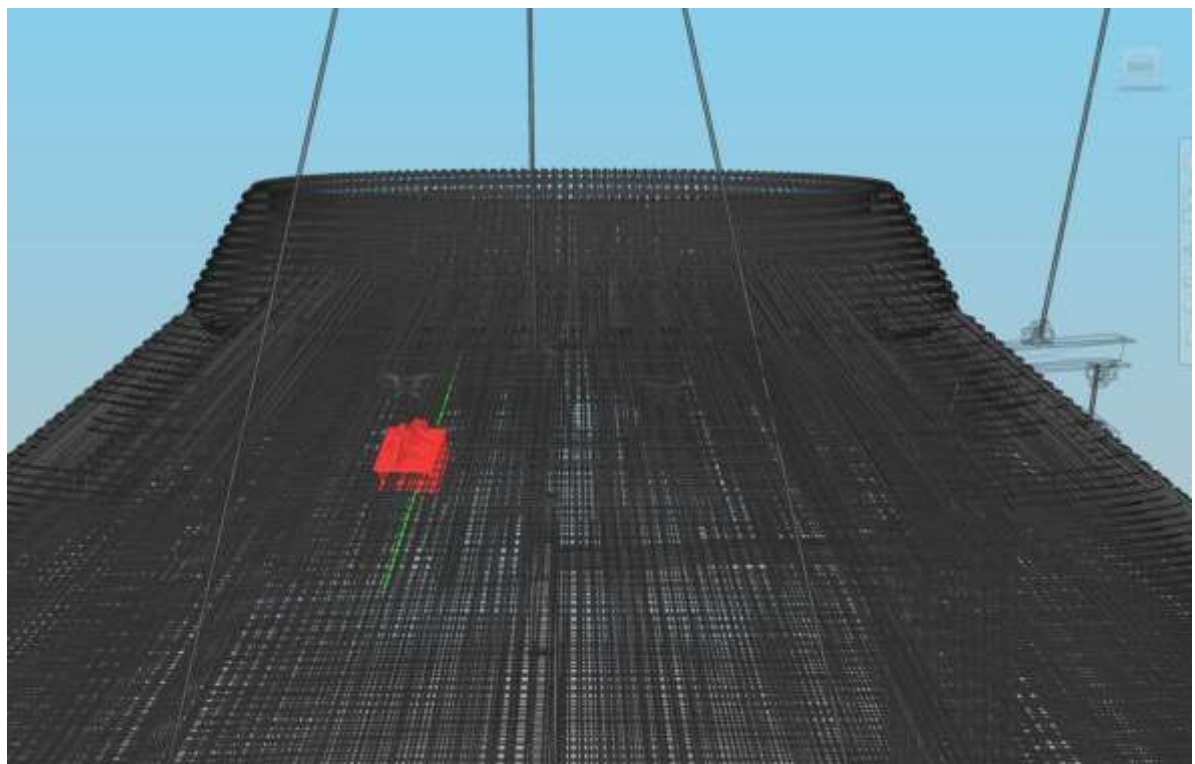


Figure 3 – Rebar detailing

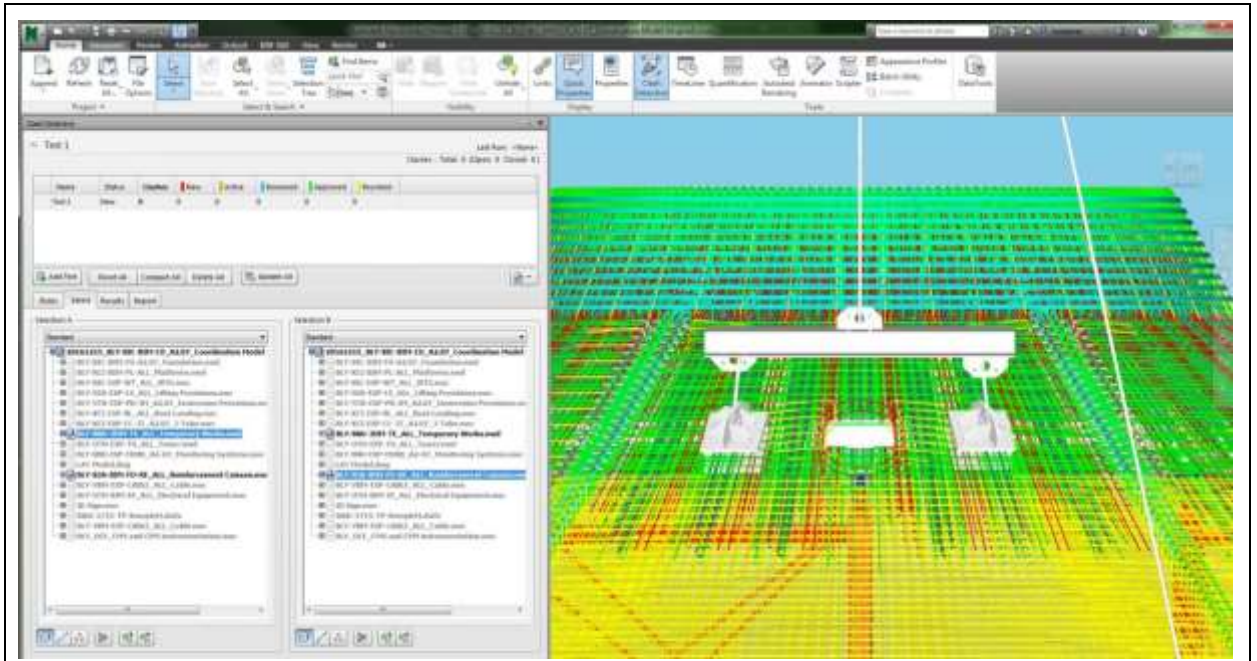


Figure 4 – Clash detective

Chris Hooper dotzero Ltd.	
Case study title:	Revit, BIM and Temporary Works
Project s and locations:	Various - Stanmore, Birmingham and Coventry
Date:	----
Role fulfilled on project:	Revit Technician
What you did and how:	Revit and BIM were used to model temporary works on three projects: • Level 1 BIM: Avanti House Primary School - Propping to Blockwork in Main Hall (Figure 1) • Level 1 BIM: 104-106 Hagley Road - Refurbishment of office blocks into student accommodation (Figure 2) • Level 2 BIM: Tiverton CEN School, Coventry - Structural Revit model from client (Figure 3)
What were the benefits:	Advantages of using BIM within temporary works: • BIM compliance • Fast, easy clash detection • Ease of producing quantity take-offs • Can be used to show project timescale (4D) • Temporary works components have to be installed correctly.
The issues and pitfalls:	The disadvantages of using BIM within temporary works: • The need for skilled technicians • Contractors not providing Revit models • Attitudes to BIM/Revit • Some modelling of components may be needed

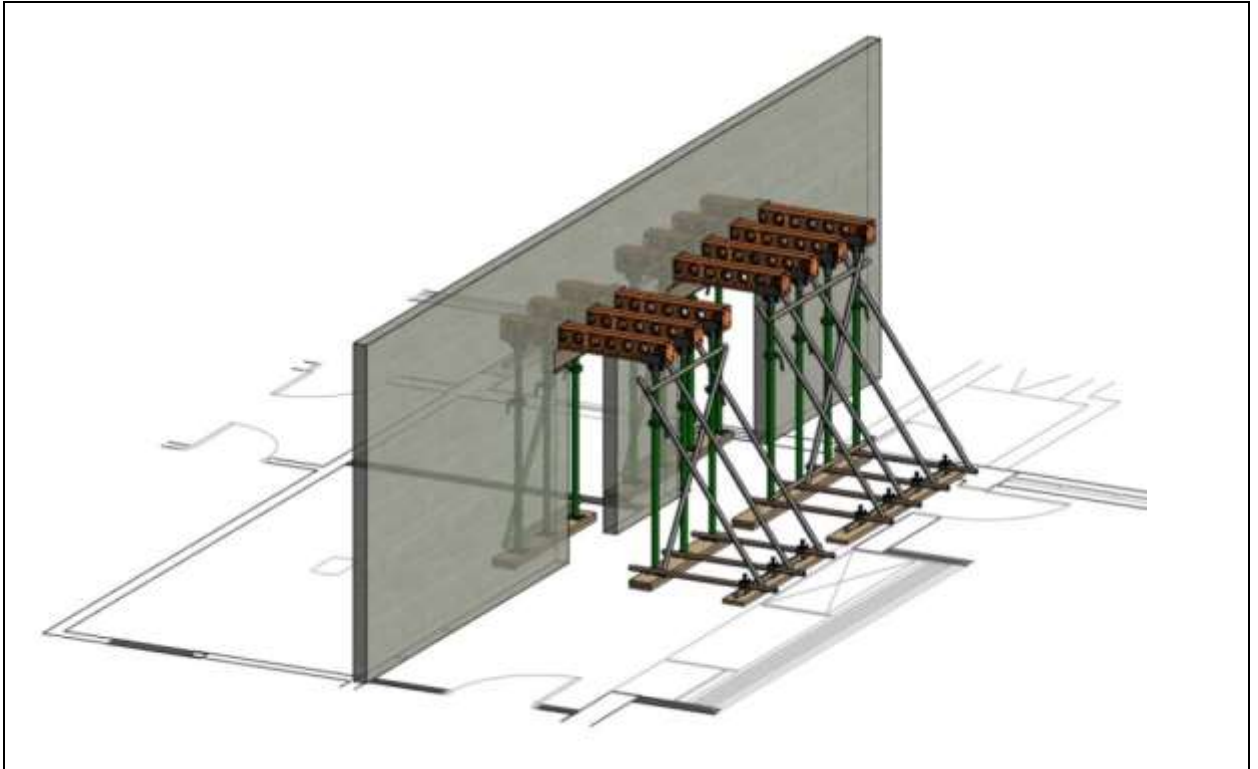


Figure 1 – Level 1 BIM: Avanti House Primary School - Propping to blockwork in main hall

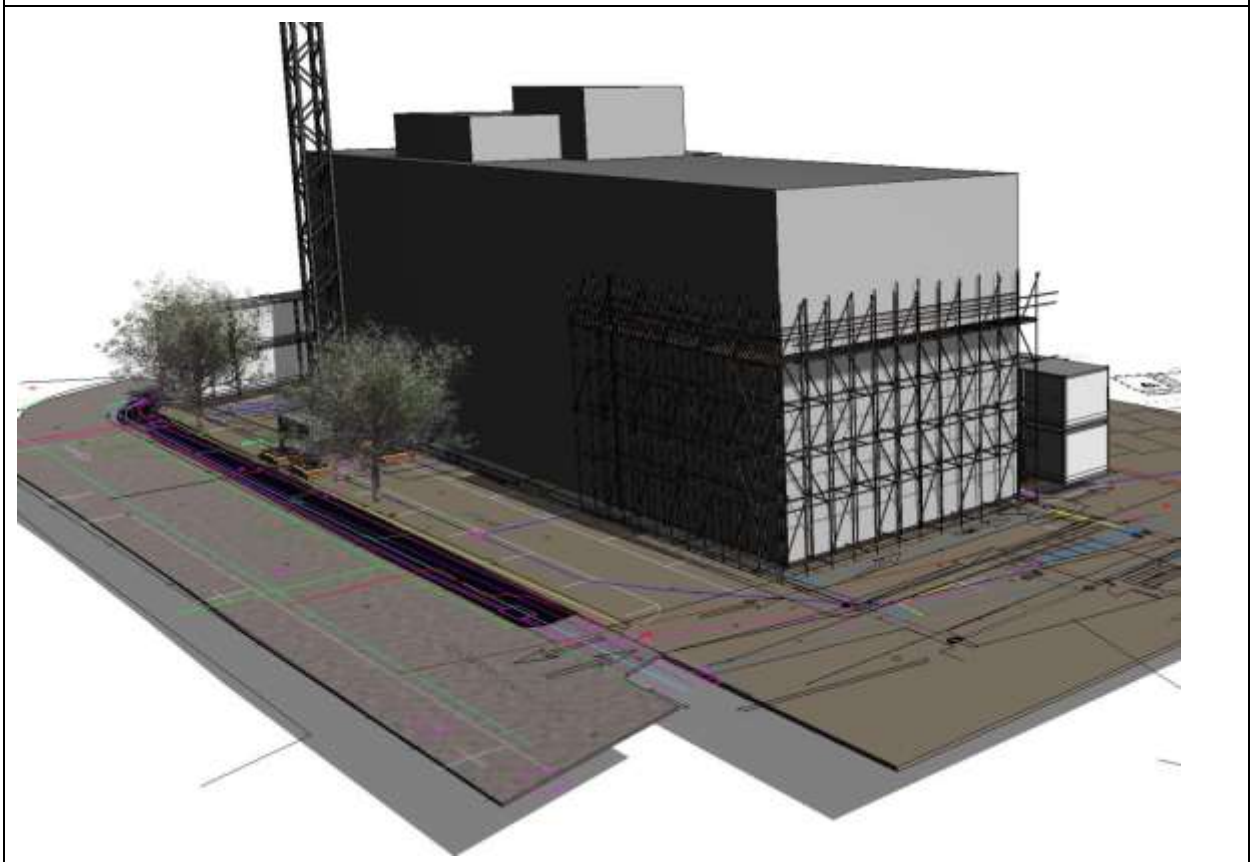


Figure 2 – Level 1 BIM: 104-106 Hagley Road - Refurbishment of office blocks into student accommodation

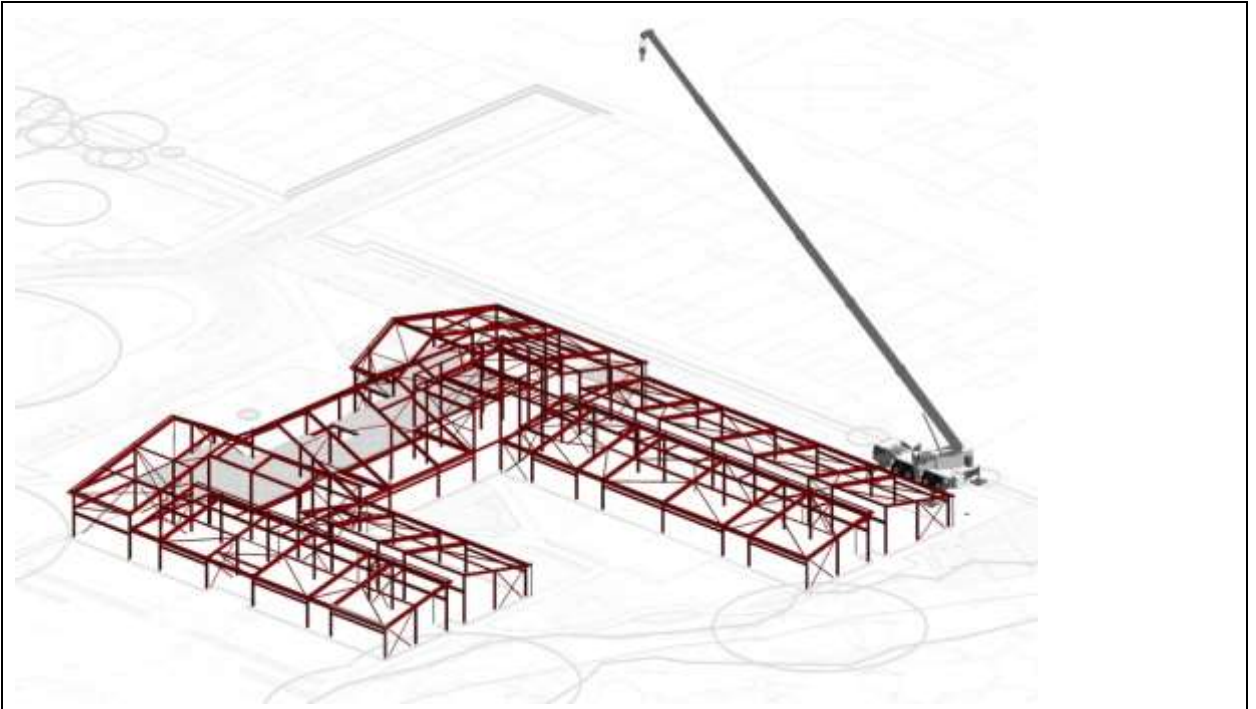


Figure 3 – Level 2 BIM: Tiverton CEN School, Coventry - Structural Revit model from client

Myles Bethell BAM Nuttall Ltd.	
Case study title:	A review of the way in which temporary works fitted into the workflows and the multi-discipline/multi-stakeholder environment of the Thames Tideway Tunnel project
Project:	Thames Tideway Tunnel
Location:	London
Date:	2016 - Present
Role fulfilled on project:	Primary role as Design Engineer for temporary works on projects at: • Putney (Embankment Foreshore); and • Hammersmith (Pumping Station) In addition, acting as BAM Temporary Works BIM coordinator.
What you did and how:	Working as part of the BMB (BAM Nuttall Ltd, Morgan Sindall plc and Balfour Beatty) joint venture, the BAM Nuttall Design Department undertook various elements of temporary works design. As the Design Department it was necessary to undertake a steep learning curve on client specified software (ProjectWise and AecoSim) which was facilitated through a multi-party collaborative approach to the project. Further liaison with the project BIM Manager and Support Team developed an understanding of the critical role of 'Temporary Works' within the project workflow, with the 'non-linear' aspect to the temporary works programme, development and an approval schedule requiring concurrent development alongside the permanent works. Regular coordination meetings, and the sharing of QA and software issues specifically relating to temporary works; enabled close interface and sharing with the development of BAM systems. As a project, the permanent and temporary works included sensitive asset interaction, rigorously controlled change management developing and changing permanent works design, multi-stakeholder involvement and specified levels of data; all managed through the workflow and collaborative approach which enabled the sharing of information – right information at the right time - and the legacy of relevant information for the project team. The collaborative approach to Digital Construction/BIM as a process for creating and managing information across the complete lifecycle resulted in several clearly visible benefits.

	Issues of constructability with both permanent works, temporary works and their interactions, were visible very early in the project cycle with all parties involved (designers, construction team, etc.) able to see, and interrogate, the digital information and raise any questions early as part of the established Gateway submission process. This allowed potential solutions to be investigated, discussed and developed by the most appropriate provider, i.e. permanent works, construction programme or temporary works. Similarly, and as design developed, changes would be highlighted with outdated revisions flagged as the user opened the file whilst the use of combined and federated models enable errors and clashes to be visible and 'system' checked. With all parties working aligned and in accordance with workflow, the system reduced abortive work and minimised the level of 'unknowns' often encountered with temporary works design. The use of models as a basis of all drawings, with the referencing in of approved permanent works models, led to less reproductive work in creating multiple sections/plans/details or sequences with everything taken from the master model. This resulted in significantly less drafting errors or incorrect representation.
The issues and pitfalls:	Initially there was a lack of specific software knowledge, both in terms of general use but also in terms of Thames Tideway setup. This meant it was a slow initial process with reliance on limited resources within the Department whilst a wider knowledge base was developed. As an industry, and more so across temporary works, this will often be the case with software and systems being specified by clients or others. The overlap between permanent and temporary works design was initially an issue, with the workflow having been developed for the ideal approach to design, with Temporary following the permanent design development. As part of this concurrent workflow, the restricted visibility of other stakeholder information (specifically the permanent works design) created occasional instances where the temporary works were based on a permanent works design model that was in the process of being revised. The flagging of this revision was not made until the revised design had been shared or approved so at times the revisions resulted in developed or temporary works no longer being appropriate. The automated clash detection would highlight instances of permanent and temporary works clashing, which in reality would not due to programme sequencing. However, due to modeling approaches this was not always able to be avoided and would have to be manually reviewed or supported by additional sequencing models.

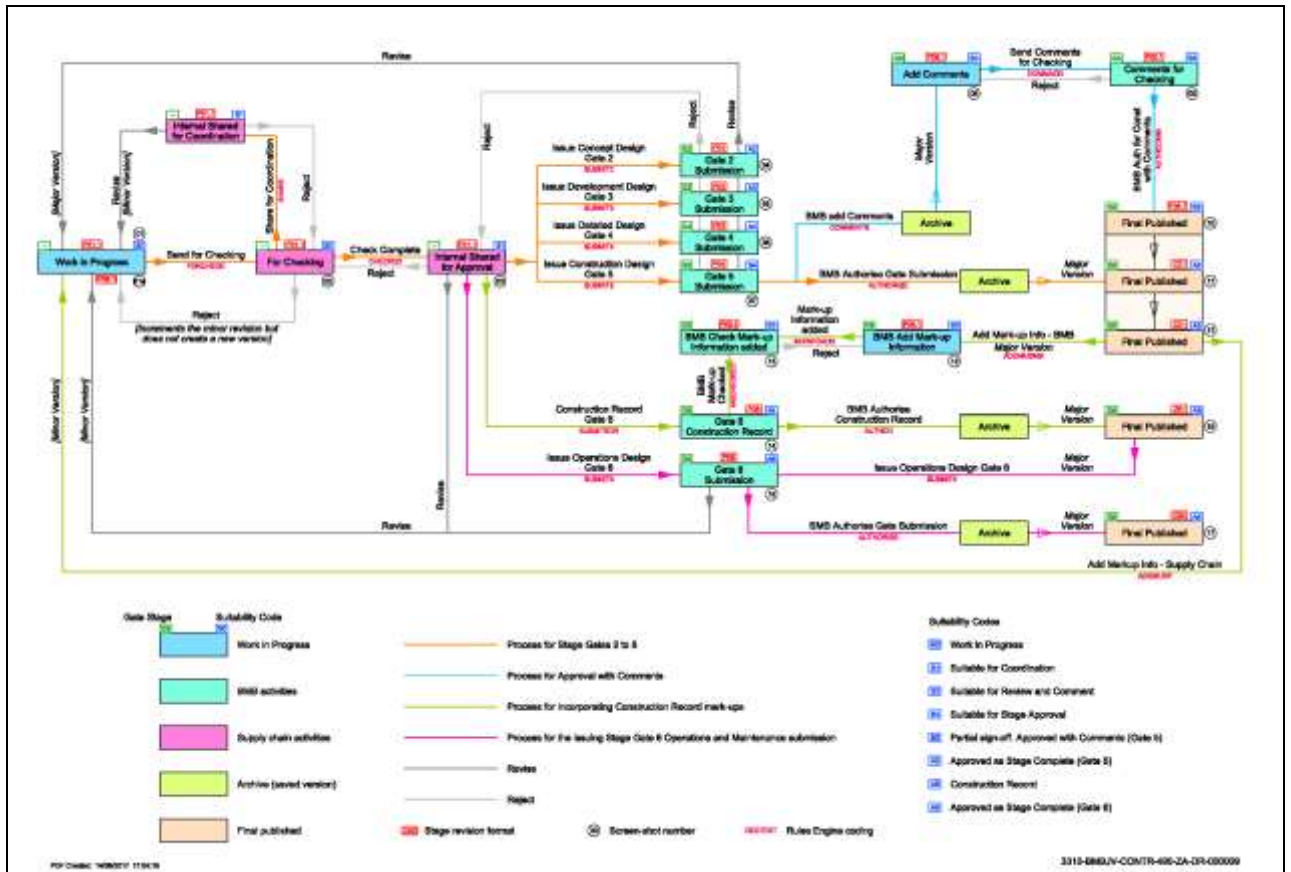


Figure 1 – Work process

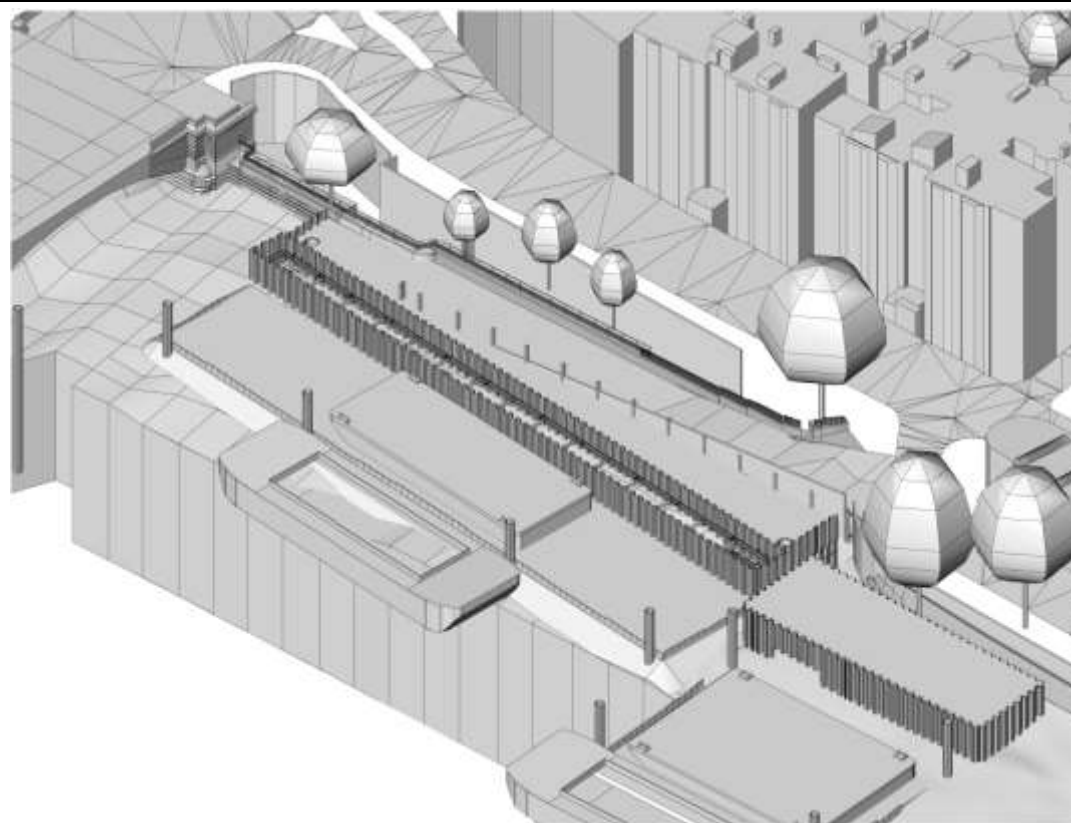


Figure 2 – Project screen-shot

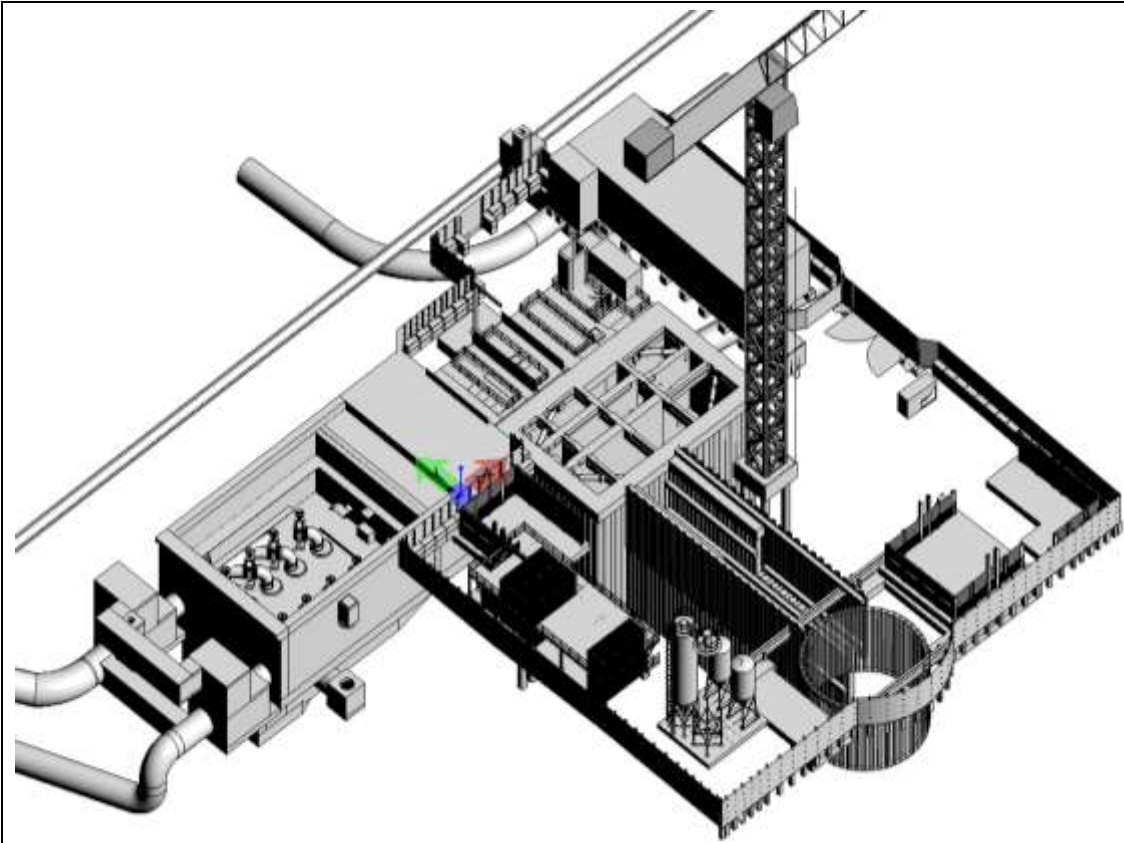


Figure 3– Project screen-shot

Andrew Jones and John Watson RMD Kwikform	
Case study title:	Conversion of file formats for use by different software
Project:	Use of LocusEye for 3D Visualisation
Date:	Internal launch date: February 2017
Role fulfilled on project:	Equipment supplier
What you did and how:	Developed 3D visualization software that extracts data from AutoCAD 3D models into a user friendly environment that allows: • easily navigation and viewing of complex models; • identification of components and viewing of basic information and dimensions; • provides bill of materials for equipment shown; and • enhances communication and collaboration.
The issues and pitfalls:	Within the developing digital environment there are two common issues are: 1. Moving of data between software platforms; and 2. Providing access to complex 3D information in a user friendly format. 1. Moving of data between software platforms A large number of software platforms have been developed for carrying out 3D modeling of construction projects. These have generally been developed in isolation and have focused on different parts of the construction sector. It is almost always difficult to transfer data seamlessly between programs. The industry is trying to develop robust protocols but it is unlikely that it will be easy to transfer fully functioning models. This stifles collaboration and can force organizations to invest in multiple platforms. Having to use multiple platforms dilutes people's skills, requires more highly skilled and trained people and reduces the number of people who can access the information. 2. Providing access 3D models can be time consuming and expensive to generate and so once generated they need to be used as much as possible. They provide benefits to the designers and planners but then they can come to a dead end. For temporary works applications the amount of effort required to generate them currently does not always justify the benefit that is derived from them. RMD Kwikform LocusEye extends the use of an AutoCAD 3D model by making it accessible to anyone involved in the project via a phone or tablet app. The navigation tools allow users with limited IT and 3D skills easy access to the model via a variety of navigation methods including augmented reality. This extends the usefulness of the model and makes it available for all to access it and not just those with expensive software and advanced skills. It is currently being used internally by RMD Kwikform and we are planning how to make it accessible across the industry.



Figure 1 – LocusEye: Formwork and Falsework Visualisation Software

Paul Hyde and Charlie McKillop Hünnebeck Forming and Shoring	
Case study title:	BIM and the request for Blocks in multiple formats
Project:	Non-specific
Location:	Europe (particularly UK and Germany)
Date:	----
Role fulfilled on project:	Equipment supplier
What you did and how:	Hünnebeck prepare designs for pricing and showing the safe use of its proprietary forming and shoring equipment. Over the years, products and drafting systems have been developed, with updates to Computer-aided Design (CAD) capability year after year. The need to maintain CAD libraries has grown as software and hardware has improved; both in number and detail. Software has been developed that can develop working details of systems; some can undertake structural analysis within the CAD model or schedule the material and check stock.
The issues and pitfalls:	The push for BIM reveals ignorance by the Promoters of the work and sophistication of the supply chain; instead they demand 3D images or CAD blocks without any comprehension of the task. Models are too large and not up to date. No clear instruction issued, you are expected to search and find information. Document control is left to administrators with no construction knowledge but they have an audit trail. Software, multiple types and not compatible. Cost, huge extra time and licenses to pay for. Break in the supply chain, smaller subcontractors hire or purchase the equipment but do not carry engineering or CAD staff to model the project. Conversion of files results in lost data. CAD files from suppliers can be large far bigger than the basic structure they are forming. MVD (model view definition) industry standard required to enable swift Data transfer. Temporary works categories for relationship modelling.



Figure 1 - Developing a full library of Tekla blocks

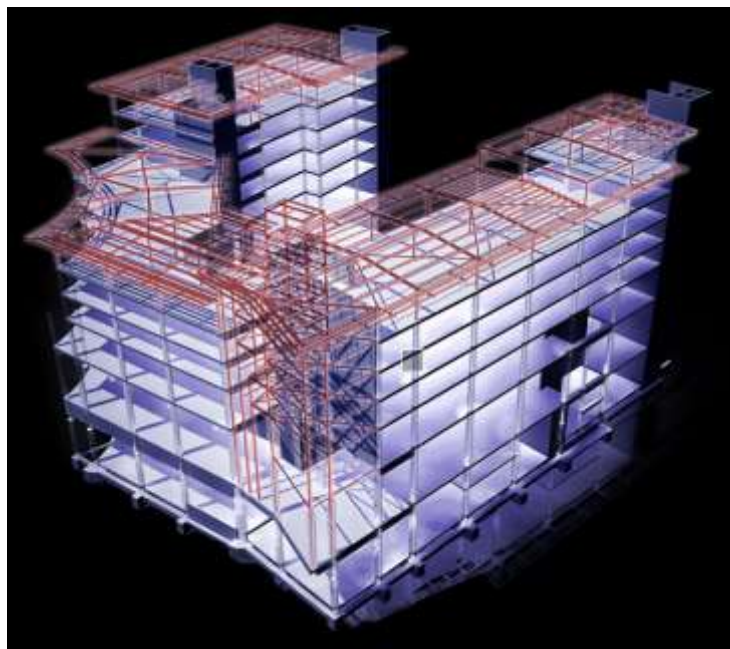


Figure 2 - Multi-view model

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