ES11485: Taking BIM to the Limits for Structural Engineers & Technicians

Graham Aldwinckle and Matt Wash

Structural BIM Leaders (UKMEA and Australasia), Arup

@GrahamAld @BIM_Wash

Class summary

You can lead a structural engineer to BIM, but how do you get them to engage in it?

This class will demonstrate real efficiency gains in structural BIM

Key learning objectives

At the end of this class, you will be able to:

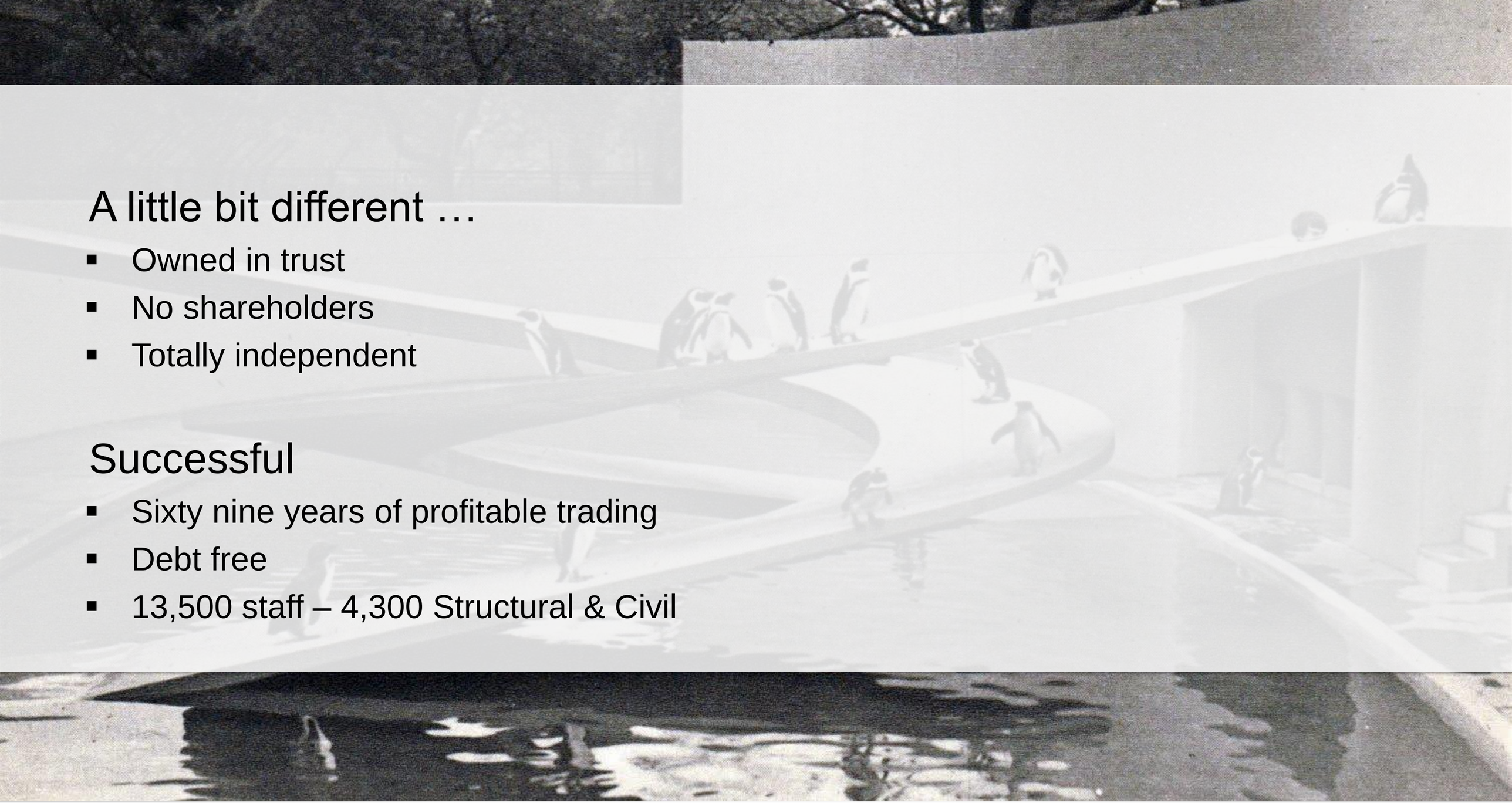
- Understand how best practice workflows can be applied to any diverse range of your projects;
- Understand how to measure your baseline in BIM adoption in your business, then track progress;
- See just how much improved your models are with well structured data. More is definitely more;
- Reap the rewards from your improved structural efficiency.

Your presenters today

- Graham Aldwinckle
  - Joined Arup 1994
  - Structural Engineer
  - Structural BIM Leader (UK)
  - Projects:
    - High Roller, Las Vegas
    - Bill & Melinda Gates Foundation HQ, Seattle
    - Leadenhall Building, London

- Matt Wash
  - Joined Arup 1996
  - Structural Engineer
  - Structural BIM Leader (AUS)
  - Projects:
    - Sports Hub, Singapore
    - Gold Coast Stadium, Australia
    - Melbourne Airport, Australia

* Belfast, Bristol, Cardiff, Edinburgh, Glasgow, Leeds, Liverpool, Manchester, Midlands Campus, Newcastle, Nottingham, Sheffield, Winchester



A little bit different …

- Owned in trust
- No shareholders
- Totally independent

Successful

- Sixty nine years of profitable trading
- Debt free
- 13,500 staff – 4,300 Structural & Civil

ARUP

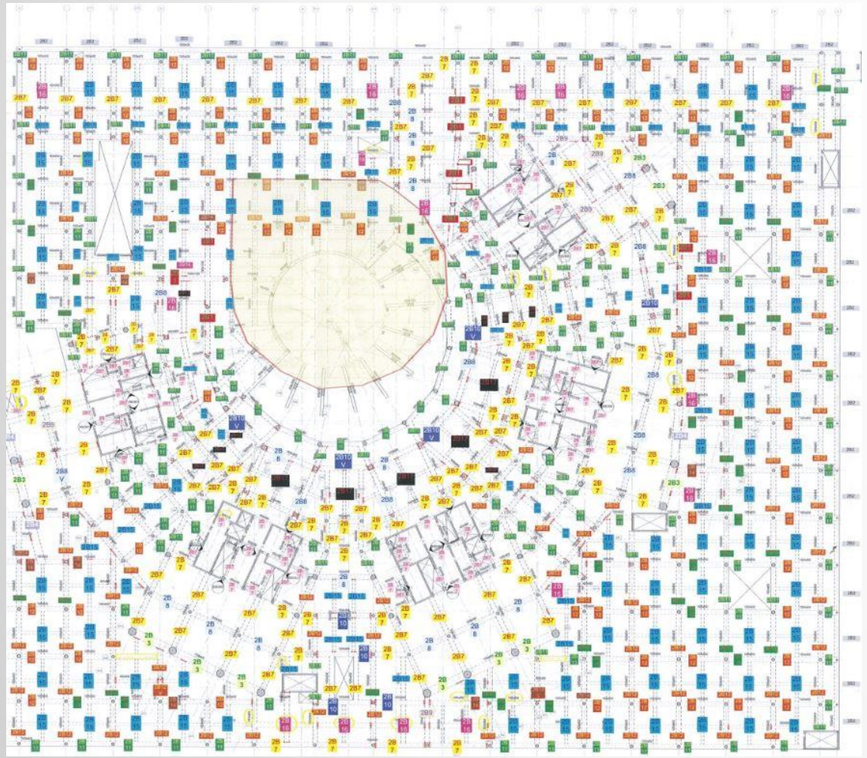
Lean Production

Lean Manufacturing and Design and Construction

Create Holistic Value and Eliminate Waste

Areas of waste in structural engineering design

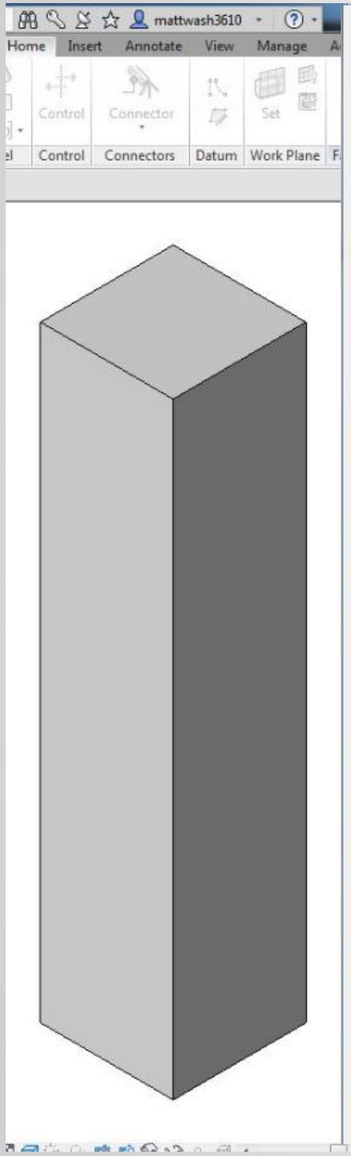
- Overproduction – Incorrect assumptions made without full stakeholder engagement
- Waiting – QS to price from drawings
- Over-processing – Tracing of engineering “mark-ups”



QCAA LEVEL 2

BEAM MARK	Beam Type
2B1	1000*1200
2B2	1000*400
2B3	1700*900
2B4	1700*900
2B5	450*550
2B6	600*800
2B7	1000*900
2B8	1000*900
2B8V	1000*900
2B9	1000*900
2B10	1000*900
2B10V	1000*900
2B11	1000*600
2B12	1000*600
2B12V	1000*600
2B13	1000*600
2B14	1000*600
2B14V	1000*600
2B15	600*600
2B16	600*600
2B17	600*900

Column Design and Documentation Workflow



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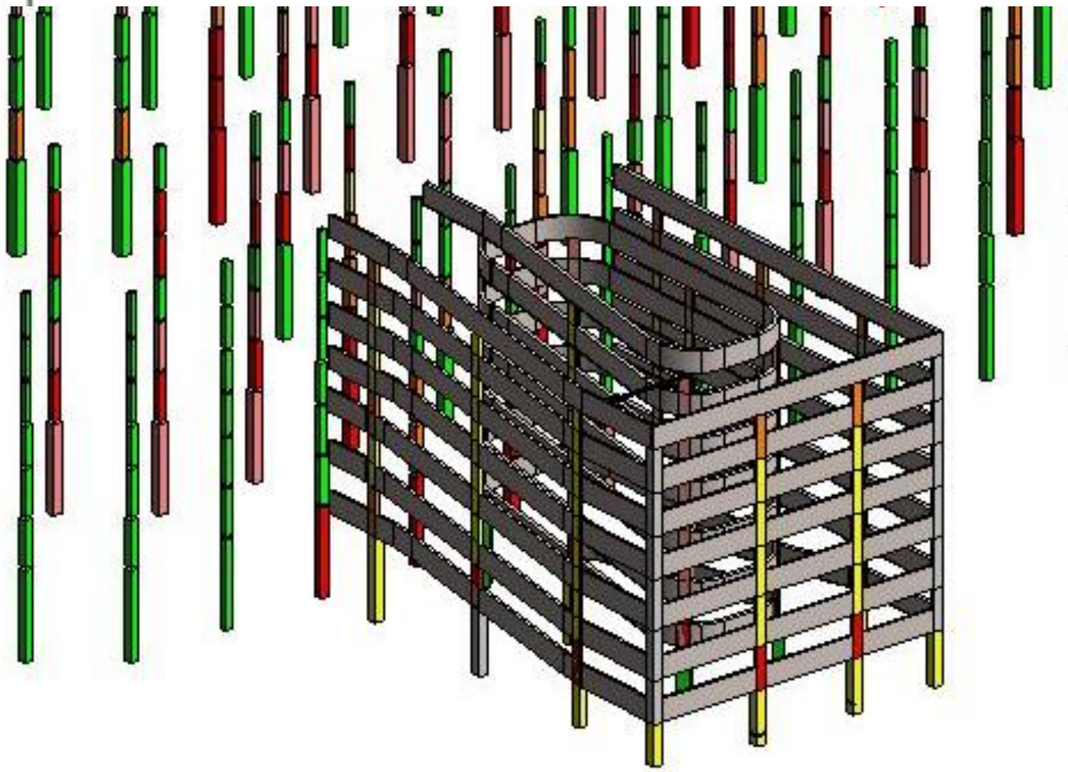
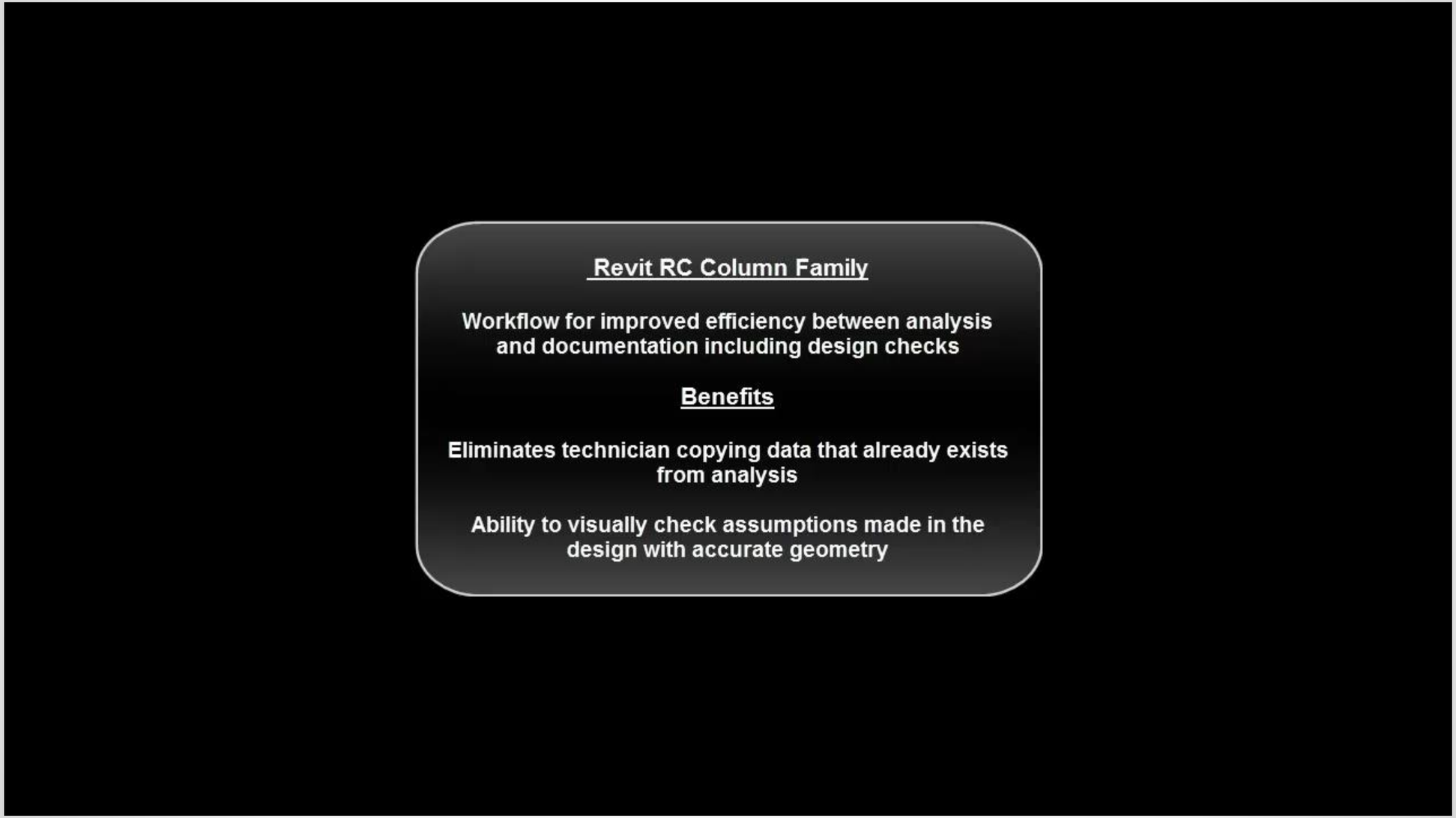
Parameter	Value	Formula
Rebar Set		
Main Bar Volume (default)	18472564.80	= ((pi() * (0.5 * Main Bar Dia.) ^ 2)) * Main Bar No. * Col Height
Main Bar No.	12.000000	=
Main Bar Dia.	28.0	=
Lig Volume (default)	3496969.61	= ((pi() * (0.5 * Lig Dia.) ^ 2)) * Lig Length * (round(Col Height / Lig Spacing) + 1) + Lig
Lig Spacing	250.0	=
Lig No. of Add h Legs	3.000000	=
Lig No. of Add b Legs	3.000000	=
Lig Length (default)	2380.0	= ((b calc * 2 + h calc * 2) - (4 * Column Cover)) + Lig Hook Length
Lig Leg Add Volume (default)	536081.37	= Lig Add Volume h + Lig Add Volume b
Lig Hook Length	300.0	=
Lig Dia.	12.0	=
Lig Add Volume h (default)	268040.69	= (((h calc) - (2 * Column Cover)) + Lig Hook Length) * ((pi() * (0.5 * Lig Dia.) ^ 2)) * Lig
Lig Add Volume b (default)	268040.69	= (((b calc) - (2 * Column Cover)) + Lig Hook Length) * ((pi() * (0.5 * Lig Dia.) ^ 2)) * Lig
Column Cover	30.0	=
Materials and Finishes		
Column Material (default)	Concrete_Insitu_Ar	=
Dimensions		
h calc (default)	550.0	= h
b	550.0	=
h	550.0	=
Column Volume (default)	756250000.00	= Col Height * b calc * h calc
b calc (default)	550.0	= b
Col Height (report)	2500.0	=
Data		
Section X-X (default)		=
Elevation Type (default)		=
Concrete Strength (Mpa) (default)		=
Other		
Total Steel Volume (default)	21969534.42	= (Main Bar Volume + Lig Volume)
Steel Weight / Cubic Metre (default)	228.047399	= (Total Steel Volume / Column Volume) * 7850
Steel Weight (main bars only) / Cubic	191.748276	= (Main Bar Volume / Column Volume) * 7850
Reo Percentage (default)	2.442653	= (Main Bar Volume / Column Volume) * 100
Identity Data		

Name	Visibility	Projection/Surface	
		Lines	Patterns
Reo Rate 100-150 kg/m3	☑		
Reo Rate 150-200 Kg/m3	☑		
Reo Rate 200-250 Kg/m3	☑		
Reo Rate 250-300 Kg/m3	☑		
Reo Rate 300+ Kg/m3	☑		

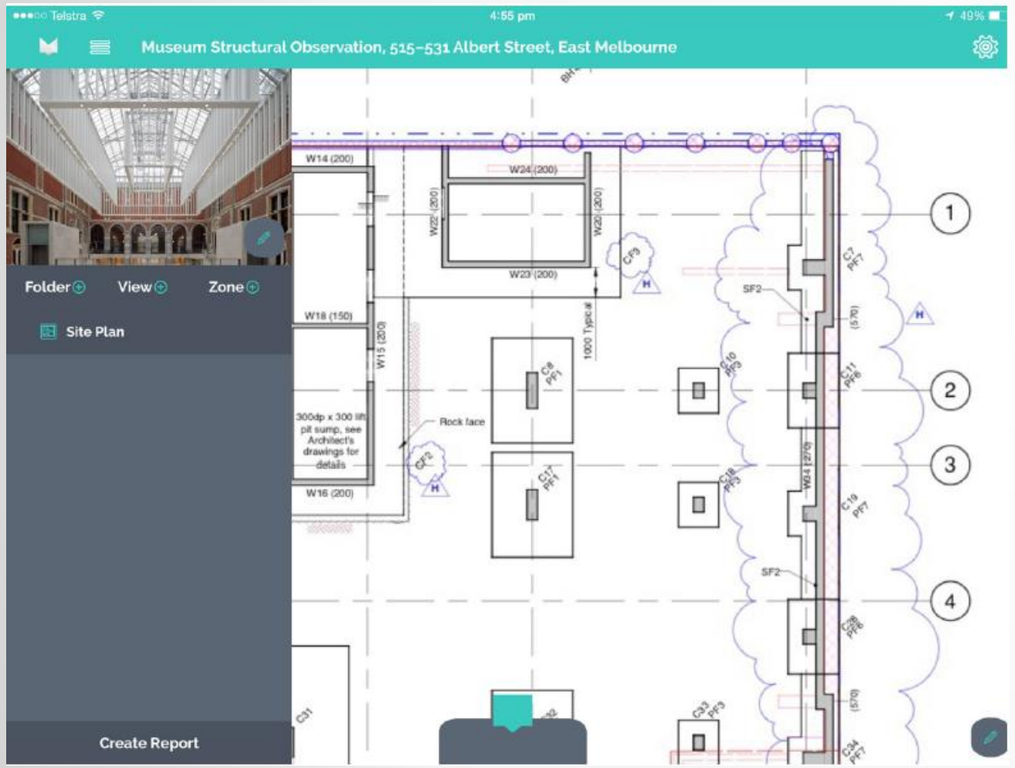


Linking Column Design with Revit – User Demo



Principles of Lean Production

- Deliver the highest quality product, in the shortest time, for the ***best value***

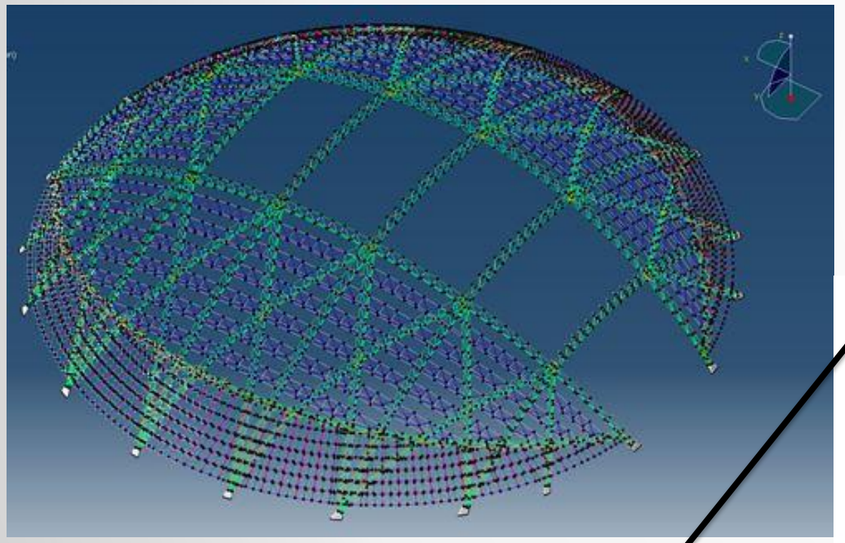


marq

- http://marqhq.com/home/support

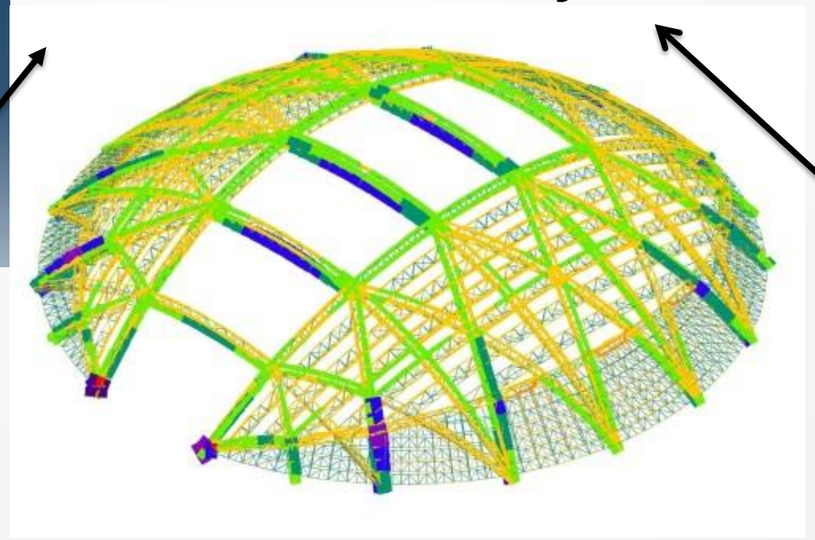
Principles of Lean Production

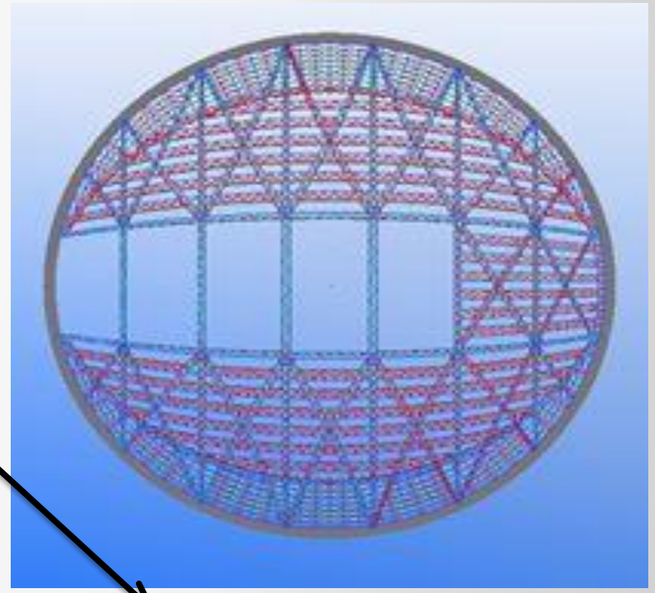
- Base decisions on a long term goal, not short term financial rewards
- Create Continuous flow



Digital Project
Parametric Modelling

Oasys GSA
Structural Analysis



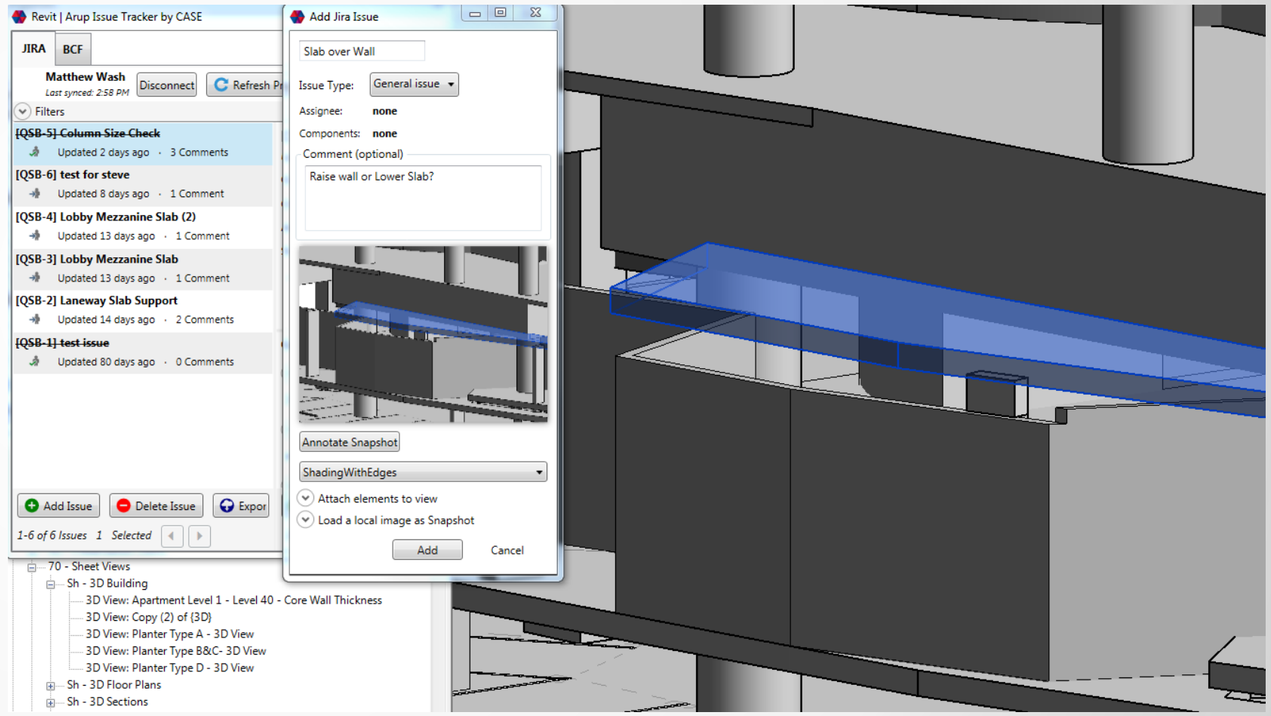


Documentation
Revit / Tekla

Singapore Sports Hub – As Built

Principles of Lean Production

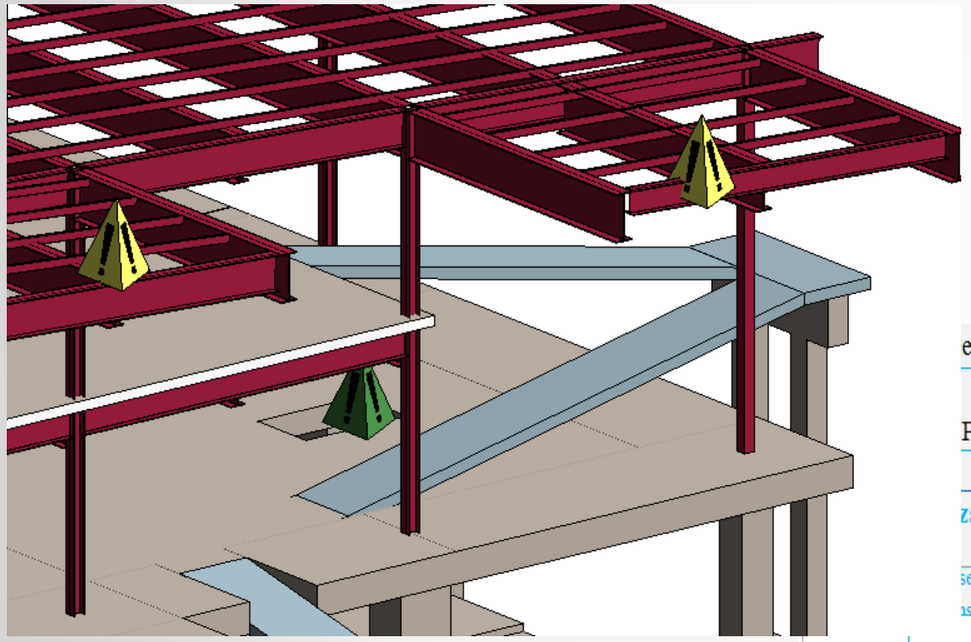
- Build a culture of stopping to fix problems to get the quality right, the first time



- Is your project correspondence littered with internal task lists buried in emails?
- Arup – Issue Tracker Plug-in

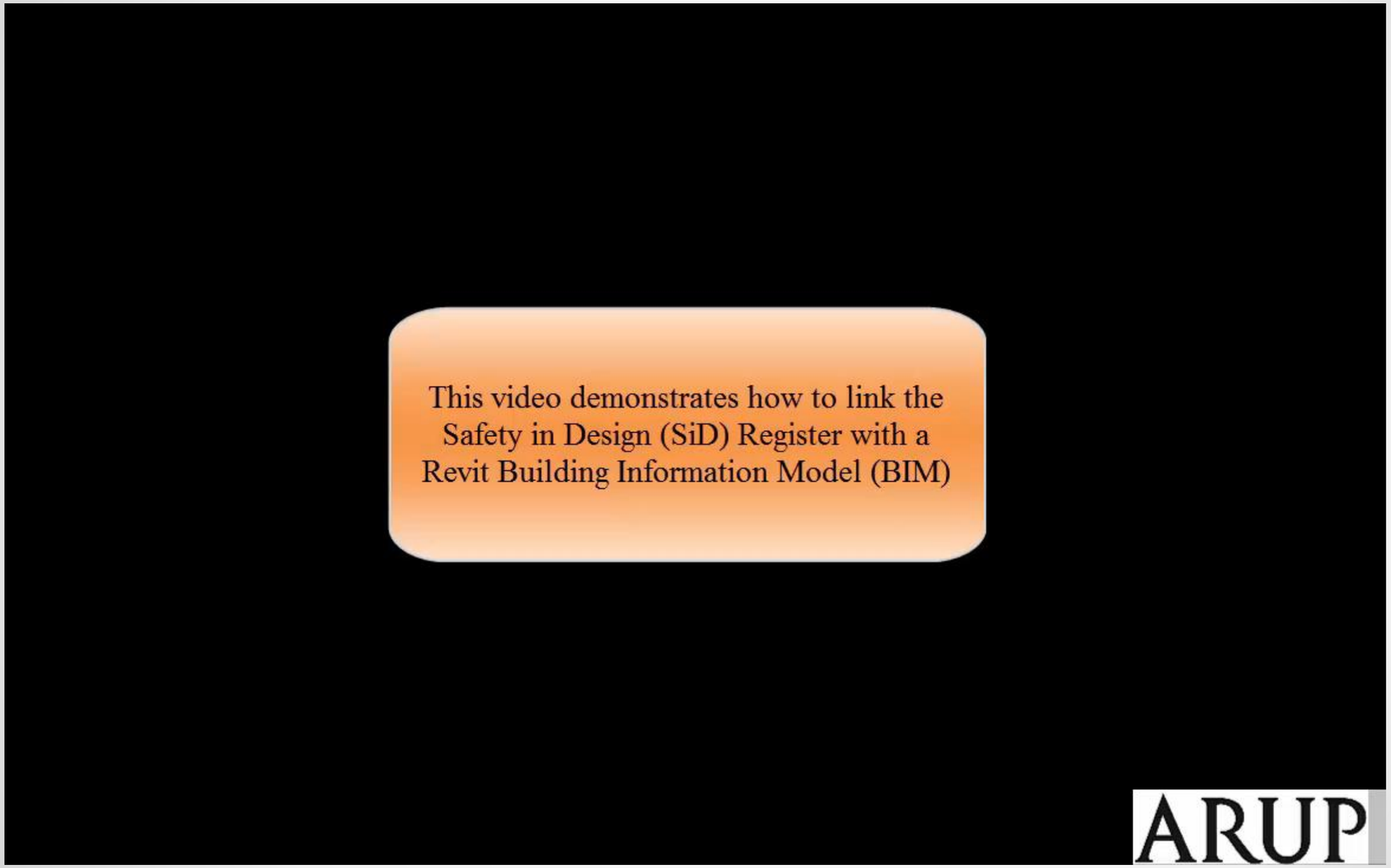
Principles of Lean Production

- Grow leaders who thoroughly understand the work, live the philosophy and teach it to others



ect Number ▶	73997-15	Project Name ▶	Safety in Design (SiD) Demo Linking BIM Model (Revit) to Excel Spreadsheet					
Project Participants ▶	Matt Wash, Al Meager, Ron Hemmick							
Client ▶	Arup	Date ▶	8/10/2015	↙ Base Risk ↘				
zard Group	Hazard	Area/Location of Risk	Description of Hazard and Risk	Likelihood	Severity	Base Risk Score	Control Measure	
se drop down ns or create your	Use drop down options or create your own						Use drop down options or create your own	
1	Falling From Height Hazards	Working at height during construction activities	Roof	Falling from height	Medium	Medium	Medium	Design includes safe access on to /across roof (e.g. designated safe walkways, work platforms) to eliminate risk of falling through fragile roof material
2	Retaining Walls and Deep Excavations	Considerations for retaining walls and deep excavation	South Elevation	Fall into excavation, temporary propping of wall	Medium	High	High	Contractor to provide method statement for construction sequence of works
3	Temporary Works and Sequencing Hazard	Temporary Crane Penetration	Level 1	Fall through opening	Low	Medium	Low	Temporary hoarding to be provided by contractor

Safety in Design Register Link to Revit – User Demo

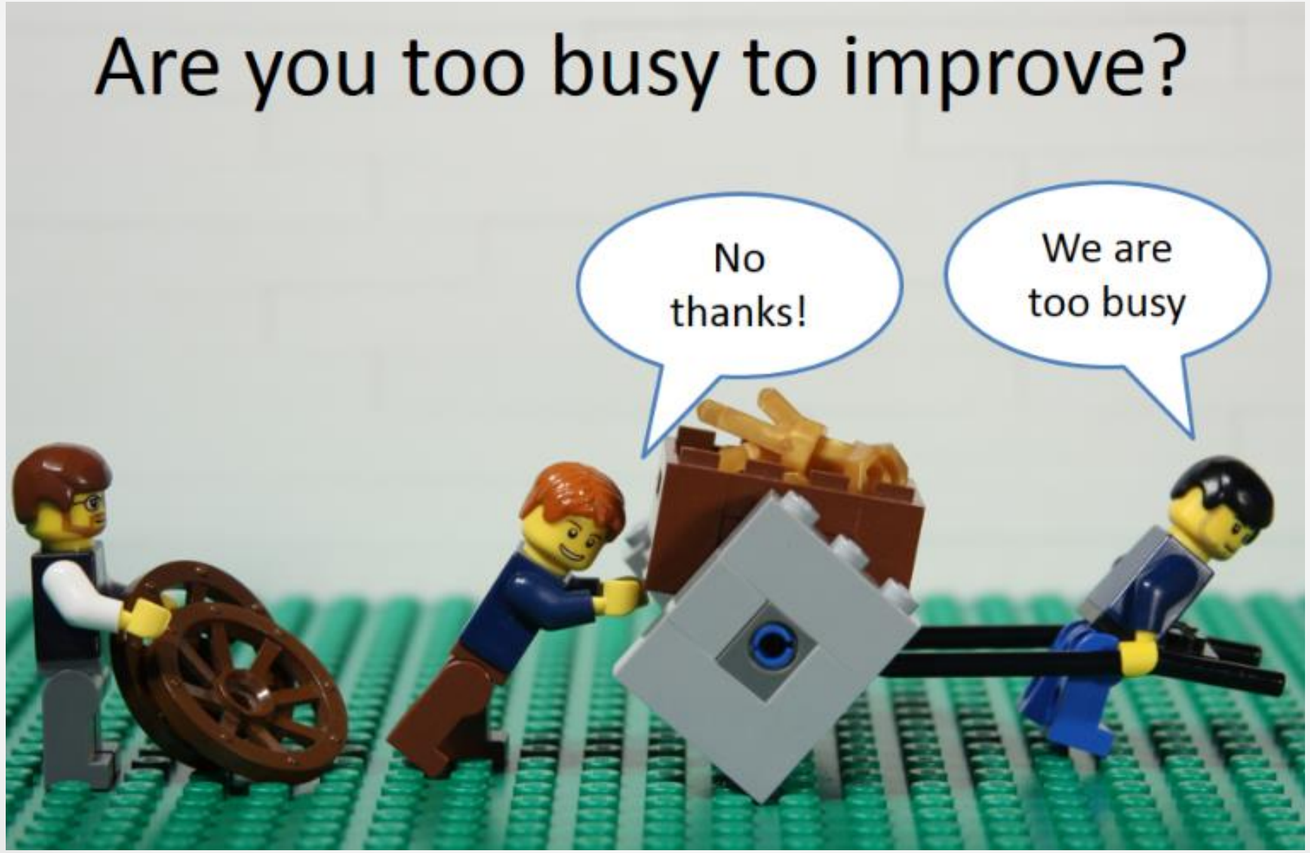


Principles of Lean Production

- Respect your extended network of partners and suppliers and help them improve
- Beware of the “supermarket effect”

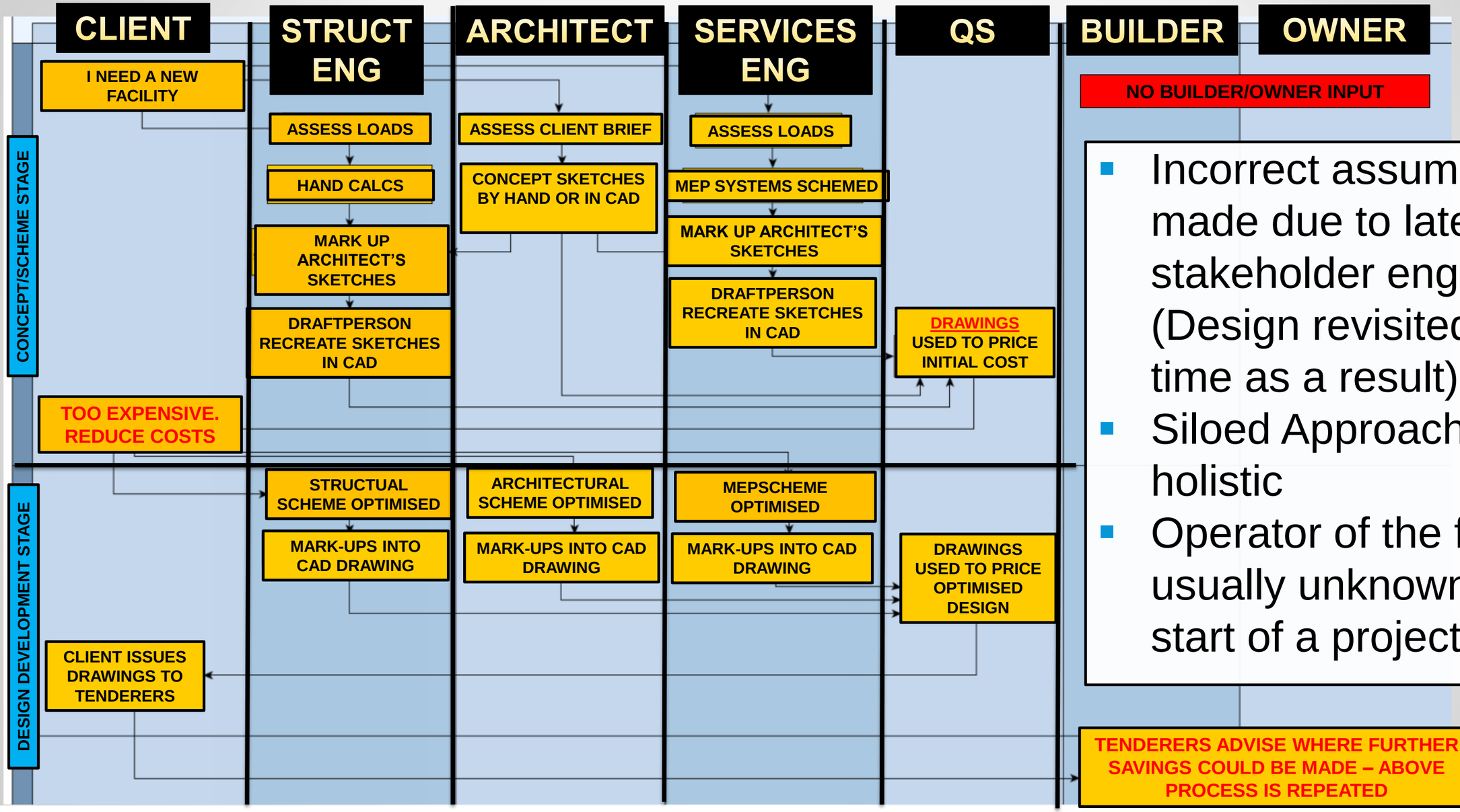
Principles of Lean Production

- Become a learning organisation through relentless reflection and continuous improvement



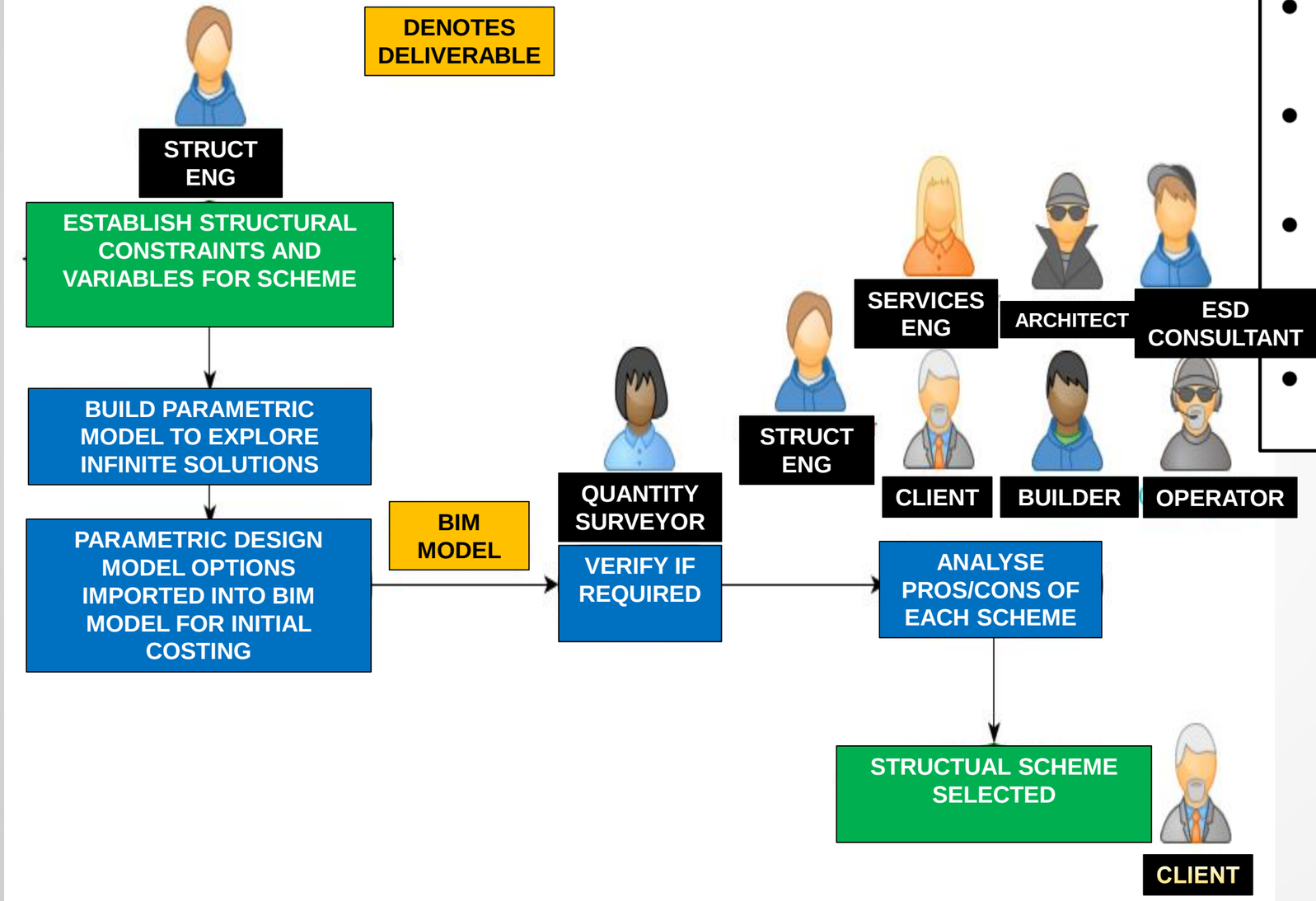
Workflow and Process

Analysis & Process Mapping – Traditional Method



- Incorrect assumptions made due to late stakeholder engagement (Design revisited each time as a result)
- Siloed Approach / Not holistic
- Operator of the facility usually unknown at the start of a project

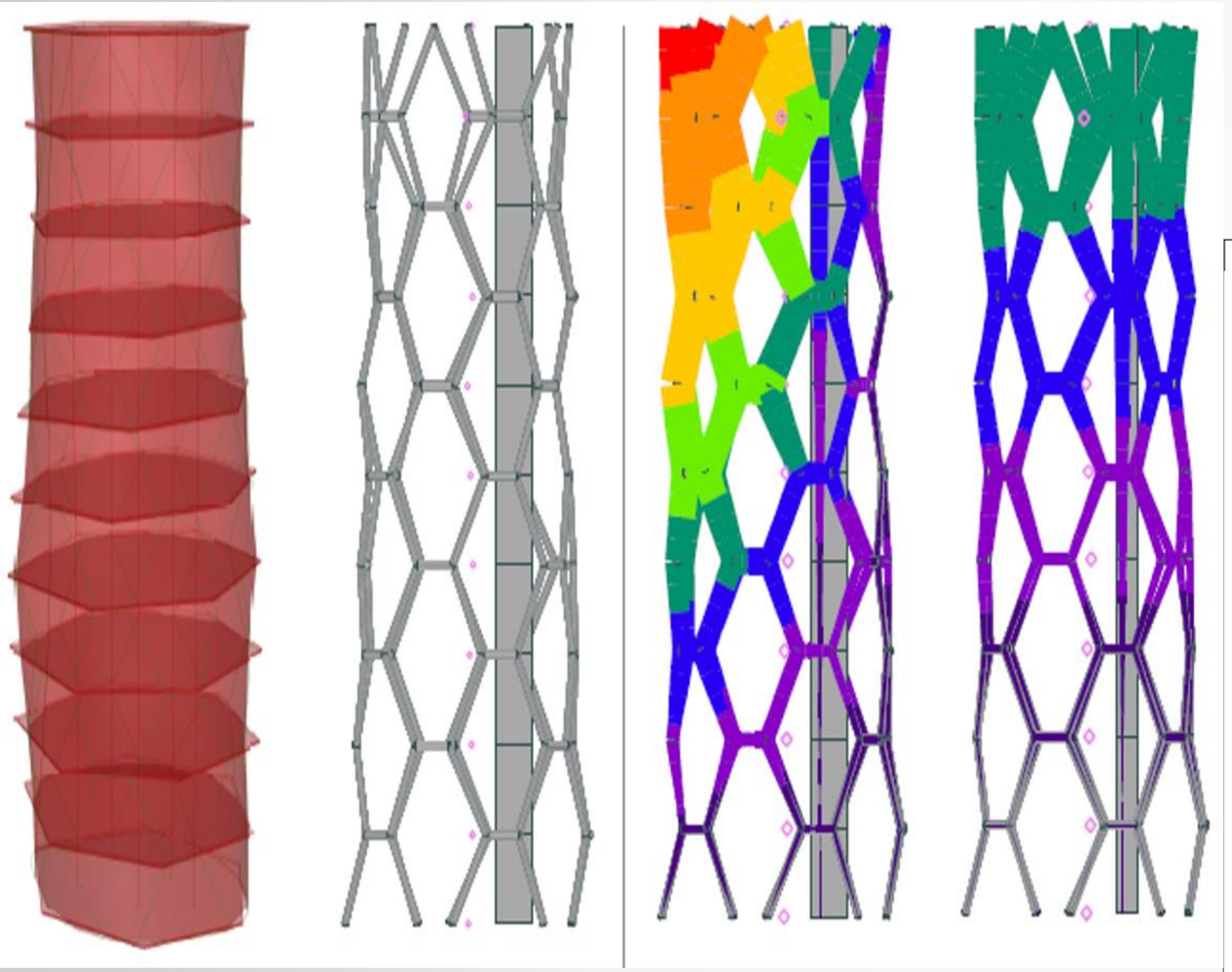
Analysis and Process Mapping – Preferred Method

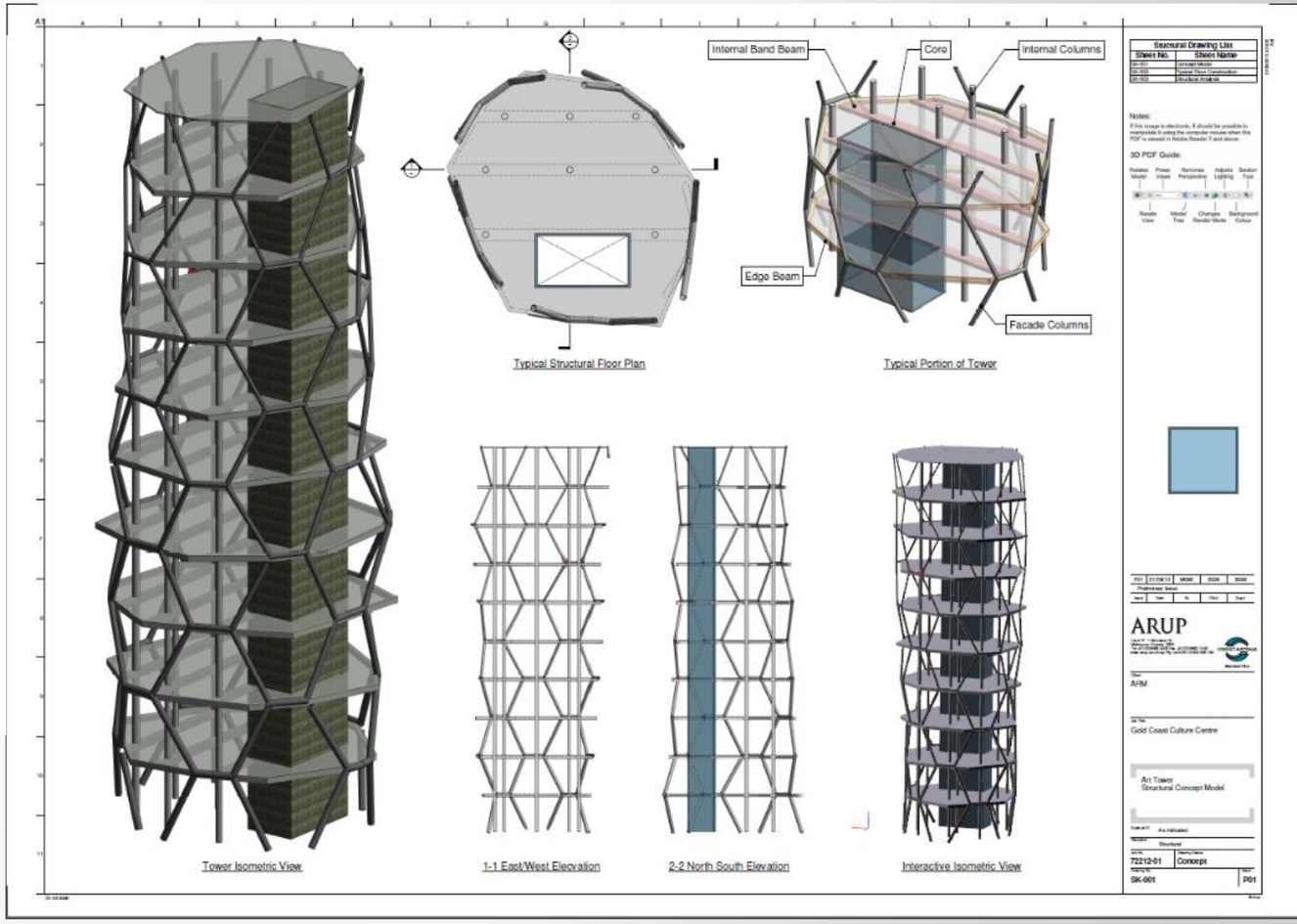


- Interoperability utilised between Engineer and Technician
- Constraints and variables established to prevent incorrect assumptions
- Optimised solution is chosen based on almost infinite possibilities with parametric modelling
- Chosen solution agreed by all after consensus is agreed

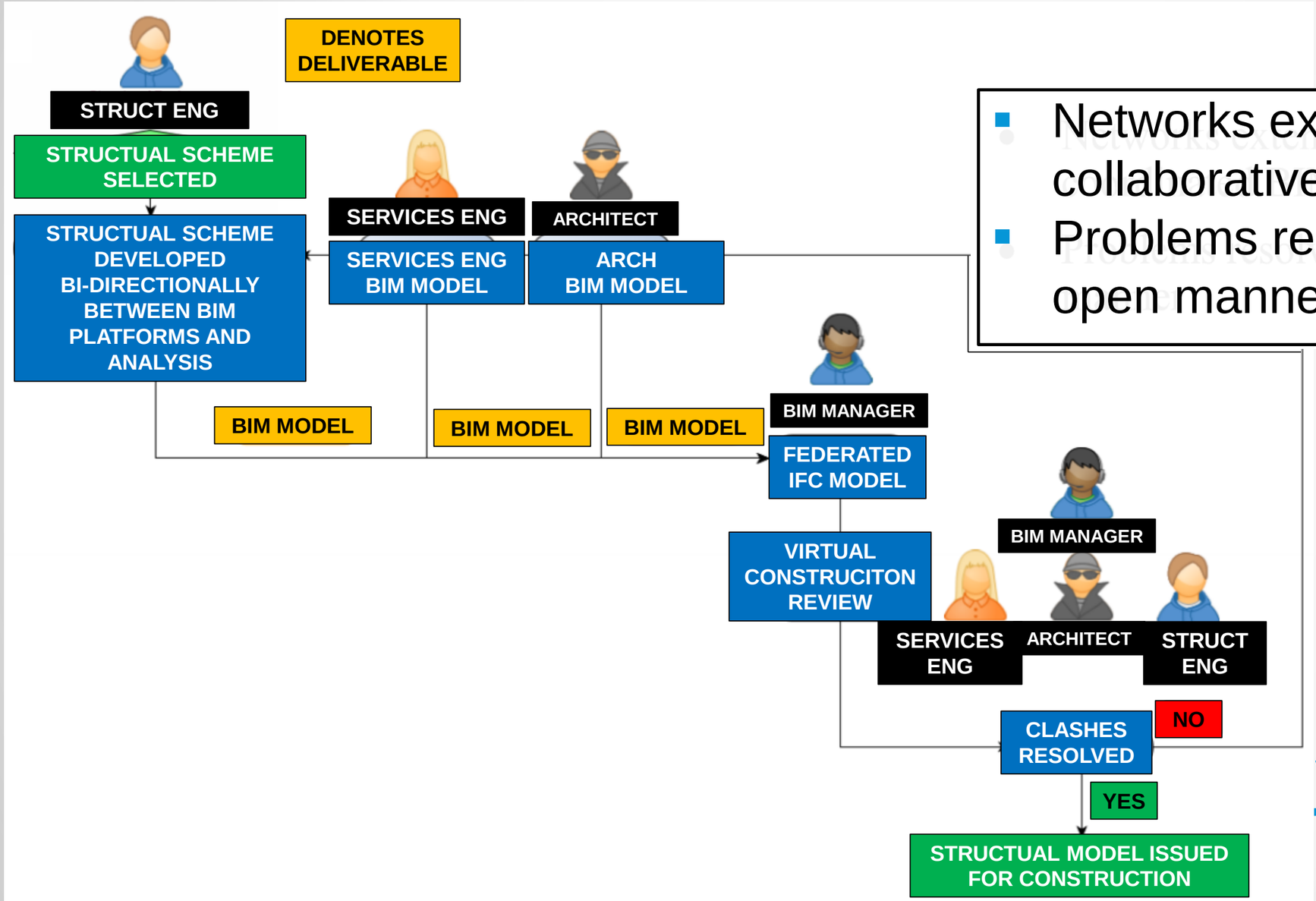
Scheme Design

Parametric – Analysis – Revit in 2 days!





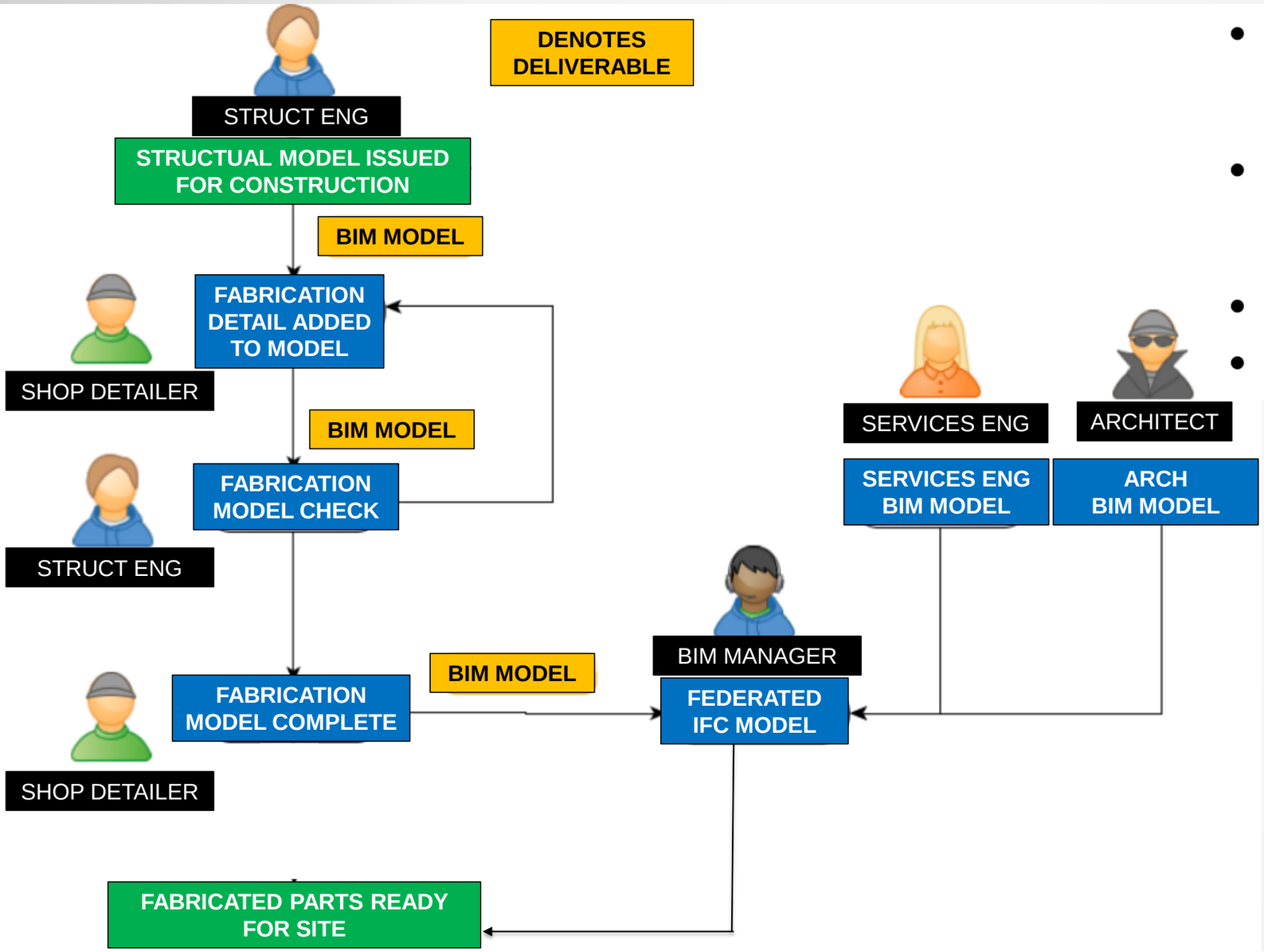
Analysis and Process Mapping – Preferred Method



- Networks extended for a shared collaborative BIM approach
- Problems resolve by all in a visual open manner

Scheme Design To Construction

Analysis and Process Mapping – Preferred Method



- Interoperability utilised with shared BIM model between structural engineer and fabricator
- Level of checking reduced as checking is done via model that originated from the engineer
- Collaboration between all parties
- Far quicker turnaround to fabrication

Construction to Fabrication

Plan, Do, Check, Adjust – Analysis Report

BACKGROUND

- How can we deliver our projects more efficiently to maximize value to the client and minimize waste?
- The problems stem from duplication of information both internally and up and downstream to external collaborators
- It is evident that there are a number of processes within the delivery of our work that are not adding value and are creating waste and unnecessary increased risk
- This A3 report aims to examine the cause and effect of the identified issues and suggest proposed solutions and how to implement them to provide greater value to the client and Arup for reduced time, effort and cost whilst maintaining or enhancing quality

CURRENT CONDITIONS

- Many projects are overspending on the agreed budget due to change in scope
- Many projects go beyond the planned duration
- Ramped up effort just before issue dates
- To win work, fees are being reduced as a result of market conditions.
- Consultants are being forced to look at becoming more efficient to be able to compete
- Construction industry is in transition between traditional and integrated project delivery
- BIM is still in its infancy but is seen as an enabler to achieve lean construction
- Confusion over new roles, responsibilities and standards with BIM

ANALYSIS

- Duplication of existing information. Information flow internally and externally is poor with many processes repeating previous steps
- Requirements of stakeholders being received too late,
- Incorrect assumptions made due to all parties not being present to agree a consensus,
- Unnecessary checking up and downstream due to rework of existing information
- Increased risk from not sharing information which already exists across teams.
- Lack of collaboration resulting in uncoordinated deliverables. Problems only realized on site when they could have been resolved in design where it is far easier to do so
- BIM enabling software is not being utilized to its potential, Information is added to drawings which already exists within the BIM model
- Designs are often revisited as a result of other stakeholder intervention
- Reluctance to share experiences, good or bad – additional work for no reward

GOAL

- Maximize value and minimize waste in the long term to arrive at the optimum solution for all our projects.

PROPOSAL (WHAT)

- Collaborate with our partners internally and externally
- To undertake a delivery inception review on all jobs before any work is carried out
- To expand our scope of work for the overall benefit of the client by utilizing the Value concept to validate and verify to arrive at the optimum solution
- Multi-skilled teams
- Minimize repetition in workflows
- Establish constraints and variables at the earliest opportunity to manage client expectations if scope changes
- Explore more options at concept whilst engaging with key stakeholders to arrive at the optimum solution

IMPLEMENTATION PLAN (HOW – People, Process, Technology)

- Utilize project delivery tool to ensure appropriate decisions are made from the start
- Define new roles and responsibilities appropriate for new relational contracts and BIM
- Discuss possible legal issues with regard to embracing BIM, IPD and lean with legal department
- Explore interoperability between analysis and documentation to prevent overproduction.
- Keep abreast of the competition. Ensure Arup are ahead of the game.
- All projects to have a BIM brief and BIM execution plan to share information with external parties in an open manner using Industry Foundation Class (IFC)
- New scope of work to be investigated including 4D, 5D opportunities
- Education of staff in BIM/IPD/Lean principles
- Creation of partnering networks across disciplines both internally and externally. Determine what is important in the BIM model for each of the key stakeholders
- Keep abreast of new technologies by allocating funding for R&D. Ensure results are shared
- Graduate Engineers to learn the basics of BIM enabled software. BIM software is not to be thought of as a tool solely for the technician
- Empower all employees to want to feedback for continuous improvement by giving them an incentive to

FOLLOW UP

- Quantifying the cost/value of these changes will be the hardest task
- Implementation of this new approach under a transactional contract will be challenging. A stepped approach will be necessary before full it can be fully embraced
- Change management will undoubtedly be the biggest obstacle to overcome in achieving these goals. For continuous improvement to be possible there are a number of large scale changes that will need to be adopted.

Prioritisation Matrix

PROBLEM	Frequency (1=low, 10=high)	Importance (1=low, 10=high)	Ease of Implementing solution (1=low, 10=high)	Total Points	SOLUTION STEP 1	SOLUTION STEP 2	OBSTACLE TO OVERCOME	Action Owner TBC	Proposed date to close out implementation TBC	Actual date of implementation TBC
Additional time to add detail to drawings that already exists within the model. Developing a model and drawings at the same time that are not linked.	10	2	4	16	Use BIM model as the deliverable until 2d is necessary. Build the models first then produce the drawings from it.	Eliminate the need for 2d documentation where information already exists in the model.	Reluctance to change. 2d drawings are industry standard. Requires training to learn new software and working in 3d environment.			
Not winning jobs due to high fees.	6	10	1	17	Demonstrate to client how overall saving will be less by providing the most appropriate solution - explain Arup differentiator.		Need to clearly identify why choose Arup over competitor. Need examples of value added to justify why we are not the cheapest.			
Poor workflow between analysis and documentation - tracing existing information from one to the other.	10	8	2	20	Minimise the amount of repetition of information by utilising interoperability between analysis and documentation packages.		The format of the deliverable may be different from the traditional standard if output directly from analysis. Funding required to test possibilities on a trial project in parallel with traditional delivery method.			
Too many RFIS.	2	2	4	8	Empower everyone in the team to highlight issues and solve before information is issued externally.		Need to reward employees for highlighting the problems. The result should not mean more work for them.			
Revisiting the design following external input.	10	10	1	21	Engage all key stakeholders requirements prior to undertaking design.		Type of contract key to the success of achieving this. Far easier in a relational type contract.			

HOW OFTEN DOES THE PROBLEM OCCUR

HOW IMPORTANT IS IT TO FIX THE PROBLEM

HOW EASY WILL IT BE TO FIX THE PROBLEM

OVERALL SCORE

WHO WILL LEAD IMPLEMENTING THE CHANGE

TARGET COMPLETION DATE

ACTUAL COMPLETION DATE

Tips for Implementation

- Technical then cultural change
- Select a sample project and involve those who are aware of the principles, then train others
- Provide a 'go and see' model
- Use flowcharts to develop future vision
- Improvement workshops, implement quickly
- Make it mandatory
- Do not give up for short term goals
- Look for opportunities for the bigger picture
- Realign with flowchart vision
- Develop leaders who want to develop the company based on lean
- Use experts for teaching to get quick results

Measuring BIM

(see AU2014 class: BM6460 - How to Measure the Impact of Building Information Modelling on Your Business)

BIM Maturity Measure (BIMmm)

- Comprehensive
- Project level interrogation
- User-friendly
- Multiple-choice responses
- Objective
- Collatable
- Shareable

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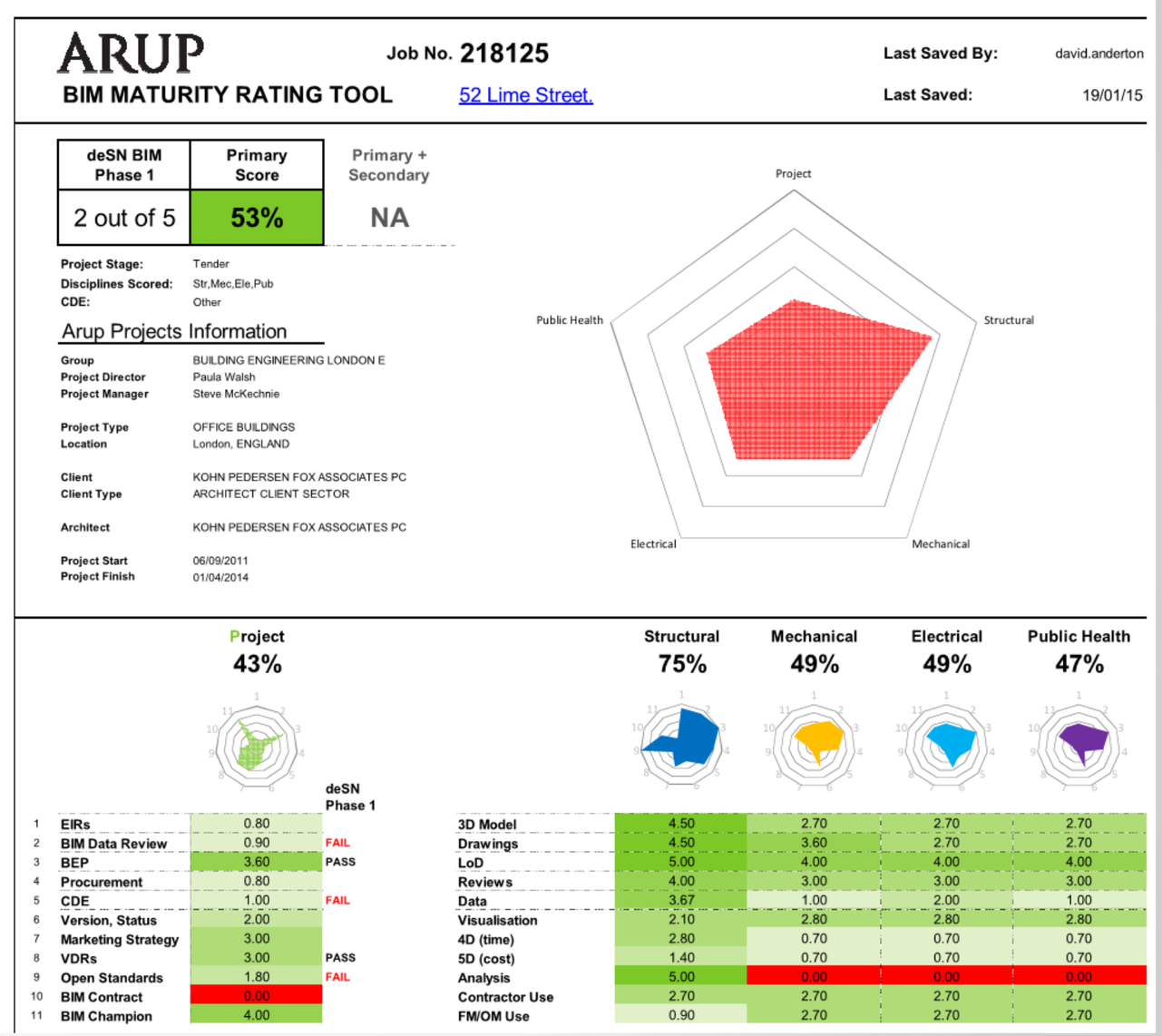


ARUP

BIM MATURITY RATING TOOL

Job No. 218125

52 Lime Street.

Last Saved By: david.anderton

Last Saved: 19/01/15

deSN BIM Phase 1	Primary Score	Primary + Secondary
2 out of 5	53%	NA

Project Stage: Tender
Disciplines Scored: Str,Mec,Ele,Pub
CDE: Other

Arup Projects Information

Group: BUILDING ENGINEERING LONDON E
Project Director: Paula Walsh
Project Manager: Steve McKechnie

Project Type: OFFICE BUILDINGS
Location: London, ENGLAND

Client: KOHN PEDERSEN FOX ASSOCIATES PC
Client Type: ARCHITECT CLIENT SECTOR

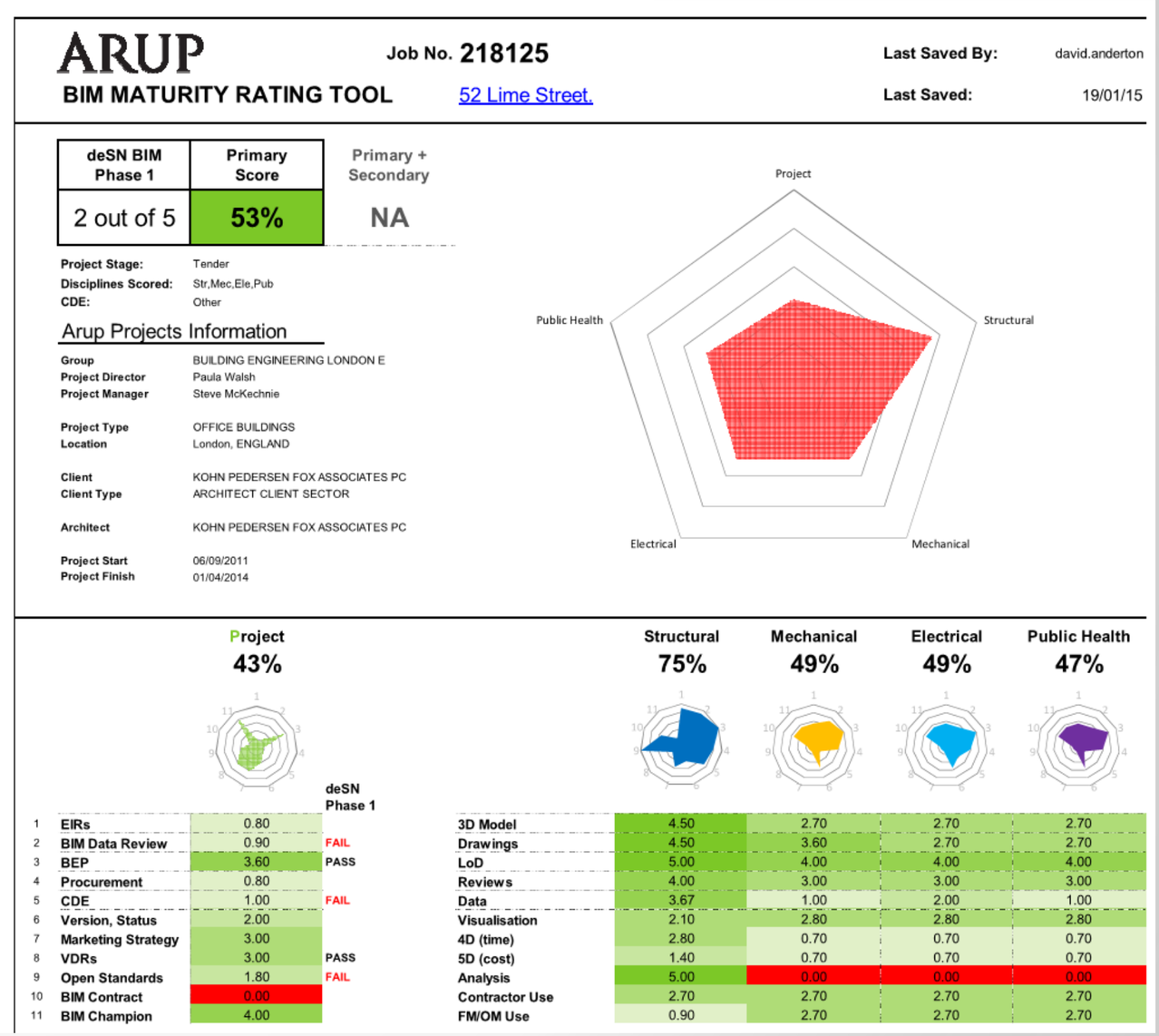
Architect: KOHN PEDERSEN FOX ASSOCIATES PC

Project Start: 06/09/2011
Project Finish: 01/04/2014

	Project 43%	deSN Phase 1	Structural 75%	Mechanical 49%	Electrical 49%	Public Health 47%
1	EIRs 0.80		3D Model 4.50	2.70	2.70	2.70
2	BIM Data Review 0.90	FAIL	Drawings 4.50	3.60	2.70	2.70
3	BEP 3.60	PASS	LoD 5.00	4.00	4.00	4.00
4	Procurement 0.80		Reviews 4.00	3.00	3.00	3.00
5	CDE 1.00	FAIL	Data 3.67	1.00	2.00	1.00
6	Version, Status 2.00		Visualisation 2.10	2.80	2.80	2.80
7	Marketing Strategy 3.00		4D (time) 2.80	0.70	0.70	0.70
8	VDRs 3.00	PASS	5D (cost) 1.40	0.70	0.70	0.70
9	Open Standards 1.80	FAIL	Analysis 5.00	0.00	0.00	0.00
10	BIM Contract 0.00		Contractor Use 2.70	2.70	2.70	2.70
11	BIM Champion 4.00		FM/OM Use 0.90	2.70	2.70	2.70

BIM Maturity Measure (BIMmm)

- Available on
  - Arup.com
  - Institution of Civil Engineers
    - https://www.ice.org.uk/news/bim-maturity-tool
  - BIM4SME
    - http://www.bim4sme.org/resources/bim-maturity-measurement/
  - And soon on BuildingSmart



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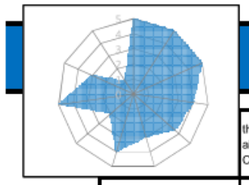
1	EIRs	0.80	
2	BIM Data Review	0.90	FAIL
3	BEP	3.60	PASS
4	Procurement	0.80	
5	CDE	1.00	FAIL
6	Version, Status	2.00	
7	Marketing Strategy	3.00	
8	VDRs	3.00	PASS
9	Open Standards	1.80	FAIL
10	BIM Contract	0.00	
11	BIM Champion	4.00	

	Structural 75%	Mechanical 49%	Electrical 49%	Public Health 47%
3D Model	4.50	2.70	2.70	2.70
Drawings	4.50	3.60	2.70	2.70
LoD	5.00	4.00	4.00	4.00
Reviews	4.00	3.00	3.00	3.00
Data	3.67	1.00	2.00	1.00
Visualisation	2.10	2.80	2.80	2.80
4D (time)	2.80	0.70	0.70	0.70
5D (cost)	1.40	0.70	0.70	0.70
Analysis	5.00	0.00	0.00	0.00
Contractor Use	2.70	2.70	2.70	2.70
FM/OM Use	0.90	2.70	2.70	2.70

BIM Maturity Measure (BIMmm)

ARUP

218125 52 Lime Street.

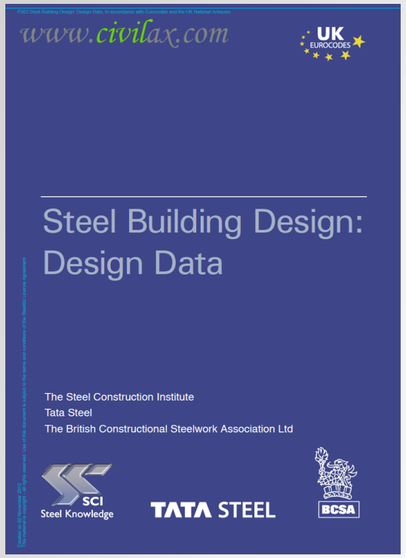


Structural BIM Maturity

3.32 | 75%

		the Mission, Vision, Goals, and Objectives, along with management support, BIM Champions.	0 Non-Existent	1 Initial	2 Managed	3 Defined	4 Measured	5 Optimizing	Target Level	Current Level	Adjusted Score	Weighting
EASY WINS	3D Coordination	Model used to inform coordination across disciplines, and during Construction	None considered		Majority of Project 3D, adhoc 3D coordination	Majority of Project 3D, 3D coordination reviews held regularly & recorded		Whole project 3D, all components modelled & coordinated between disciplines	5	5	4.5	0.9
	Drawings	BIMs should be linked to documentation, including drawings	Model not Linked to Drawings	Model partially Linked to Drawings (some 2D)	Model used for some GAs, Sections, etc	Model Used for majority of GAs, Sections etc	Model used for all GAs, Sections, etc	Models used for all GAs, Sections and Schedules	5	5	4.5	0.9
	Level of Development	LOD represents how developed elements within a model are. This also conveys to others, via a BEP, what it can be used for.	No LODs considered		Consistent LODs for some similar elements, but other elements over/under modelled		Consistent LODs for most similar elements, aligned with BIM Execution Plan	All elements in model comply with stated LODs in BEP	4	5	5	1
	Discipline Model Reviews	A significant step-change is required in verification and reviewing of models, as they become standard deliverables.	No checking of models	Self-checking of models by technicians only	Engineer checking of parts of models	Engineer-led reviewing of whole of models	Full checking and QA verification of models	Full QA cross checking of model and any documentation including verfication signoff	4	4	4	1
	Discipline Specific **Target & Current Level to be filledin for all lines** Line below provides average of section	Framing Schedules linked to model		Internal	Deliverable				2	2	2	
		Foundation Schedules linked to model					Internal	Deliverable	4	5	5	
		Material Grades linked to model				Internal	Deliverable		3	4	4	
		To be determined										
		To be determined										
	Embedded Data, Schedules and Specifications	The 'I' in BIM, the ability to embed all relevant data into the model, to extract and use for all design and documentation aspects.							3	3.66666667	3.66666667	1
	Visualisation	To assist with Coordination and Client/Contractor understanding of the model.	None considered	Basic screenshots taken from Model for reports etc	Model used to inform Design team through basic visualisations.	Model used to inform Design team through 3D walkthroughs.	Model used to inform Client through 3D presentations	Advanced photorealistic renderings/animations taken from Model	2	3	2.1	0.7
	4D (Construction Sequencing)	Construction Sequencing, or analysis from the model	None considered	Model used for simplified phasing using hide/show only	Design Model used for sequencing by Arup only		Majority of Design Model used or evolved by Contractor to inform 4D	Design model used by Arup to inform Contractor/Client	1	4	2.8	0.7
	5D (Quantity and Cost)	The ability to extract cost and quantity information is truly collaborative.	Model not suitable for costing	Model used for some internal quantity information/checking	Schedules produced from Model, and Model informally shared with QS with caveat		Model formally issued to QS and cross-checked by Arup	Cost optimisation by linking cost data directly to the model	1	2	1.4	0.7
	Links to Engineering Analysis Tools	An essential efficiency gain	None considered		One way export to or from Analysis & Design Tools		Whole model linked bi-directionally to Analysis & Design Tools	Full round-tripping between Model and Analysis/Design tools, to optimise design	4	5	5	1
	Handover to Contractor	Part of the collaborative process involves sharing the model with the Contractor	Not possible	Model for design team internal use only	Informal issue of model to Contractor with disclaimer	Formal issue of Model to Contractor with disclaimer	Formal issue of Model to Contractor, with signed BIM contract	Formal handover of Model to Contractor for use in Construction and FM.	3	3	2.7	0.9
HARDER!	Use in Operations and FM	An early understanding of the downstream uses of the model is essential to gain the maximum benefits for the Client.	None considered	Employers Information Requirements not implemented		Employers Information Requirements implemented but Model not used for FM		Employers Information Requirements considered from outset and model used for FM	3	1	0.9	0.9

Arup’s Revit Template

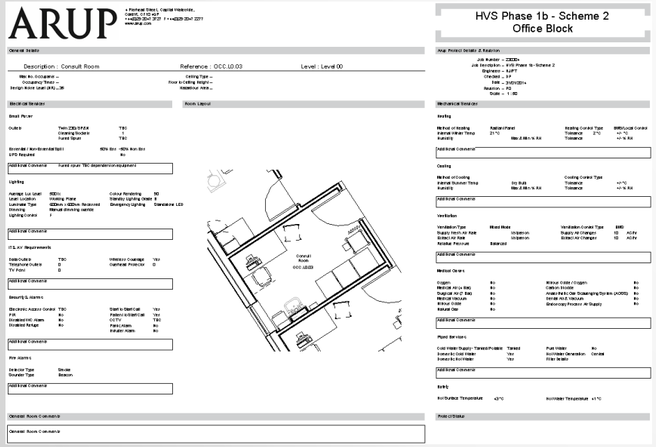


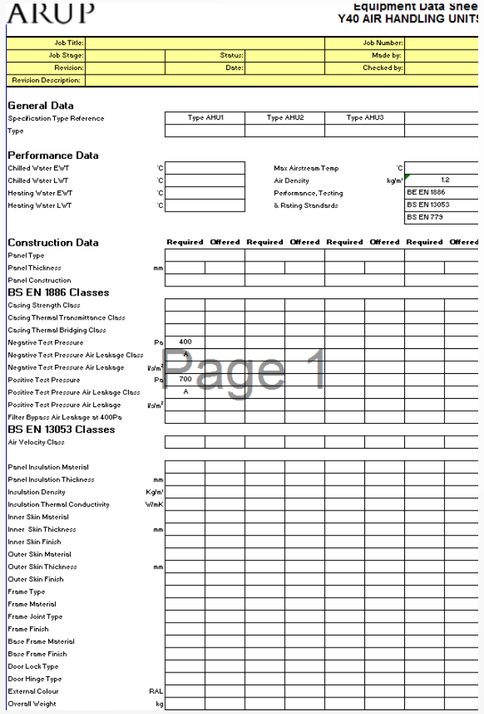
BLUE BOOK

DESIGN Information

EDS

Room Data Sheet

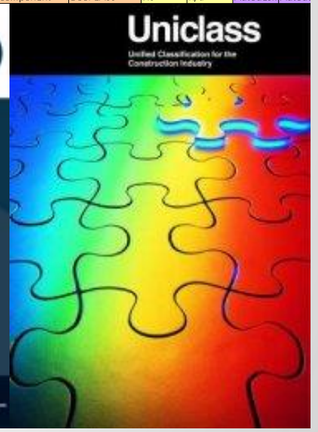




BIM

INFORMATION

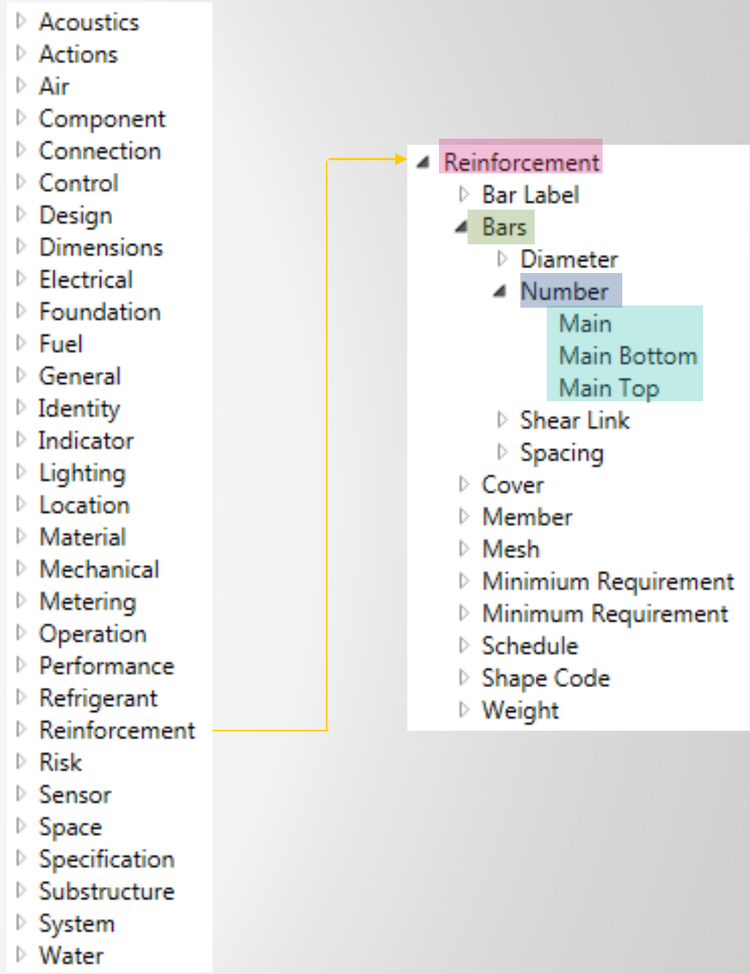
	A	B	C	D	E	F	G	H	I	J
1	Name	CreatedBy	CreatedOn	Category	SheetName	RoomName	Value	Unit	ExtSystem	ExtObject
8327	Threshold	rich.mitre	2012-12-1	Requirement	Component	Door 2A05	T	n/a	Autodesk	Autode
8328	DoorFrame	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	ALUMINIU	n/a	Autodesk	Autode
8329	HardwareSet	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	109	n/a	Autodesk	Autode
8330	WeatherStrpping	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	n/a	n/a	Autodesk	Autode
8331	JambNumber	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	J11, J10	n/a	Autodesk	Autode
8332	SoundProof	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	n/a	n/a	Autodesk	Autode
8333	DoorThickness	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	45 mm	n/a	Autodesk	Autode
8334	DoorWidth	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	915 mm	n/a	Autodesk	Autode
8335	HeadNumber	rich.mitre	2012-12-1	Requirement	Component	Door 2A06	H8	n/a	Autodesk	Autode



Arup's Shared Parameters

Reinforcement_Bars_Number_Main
Reinforcement_Bars_Number_Main Bottom
Reinforcement_Bars_Number_Main Top

- 1900+ Parameters
- Use of Autodesk COBie parameters
- Hierarchical format
- Organised into standard Revit groups
- Using engineering types where possible
- Same for all Revit versions



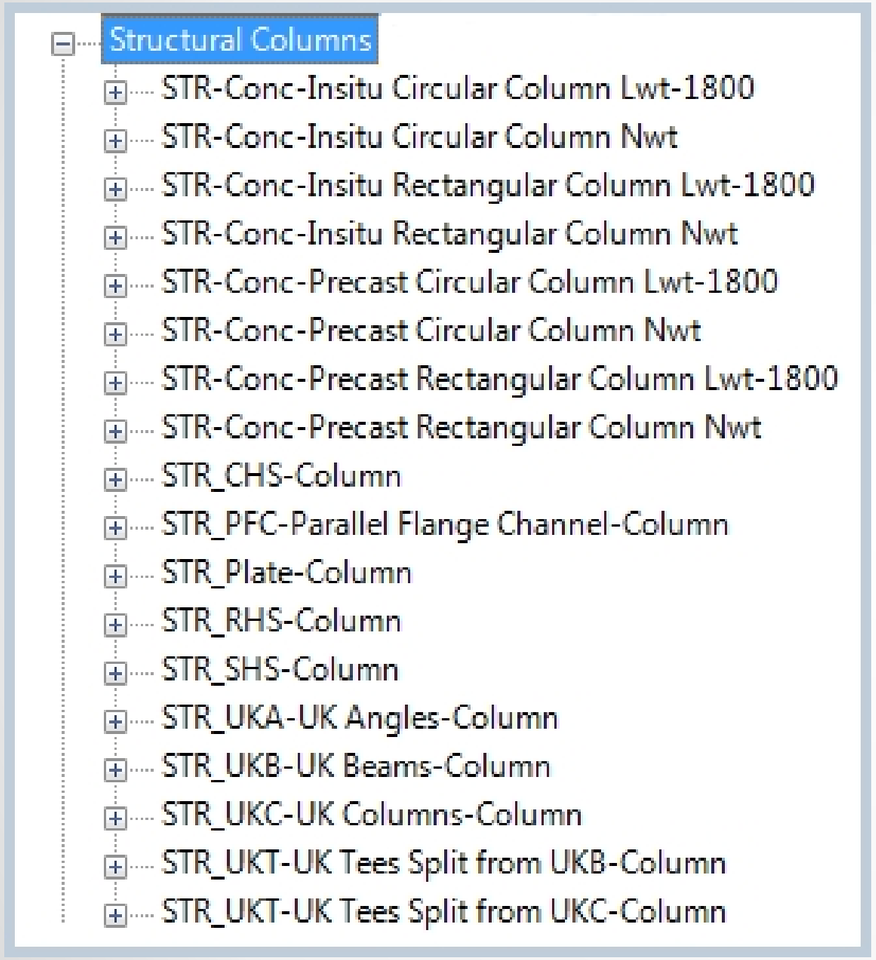
Shared Parameters & New Families

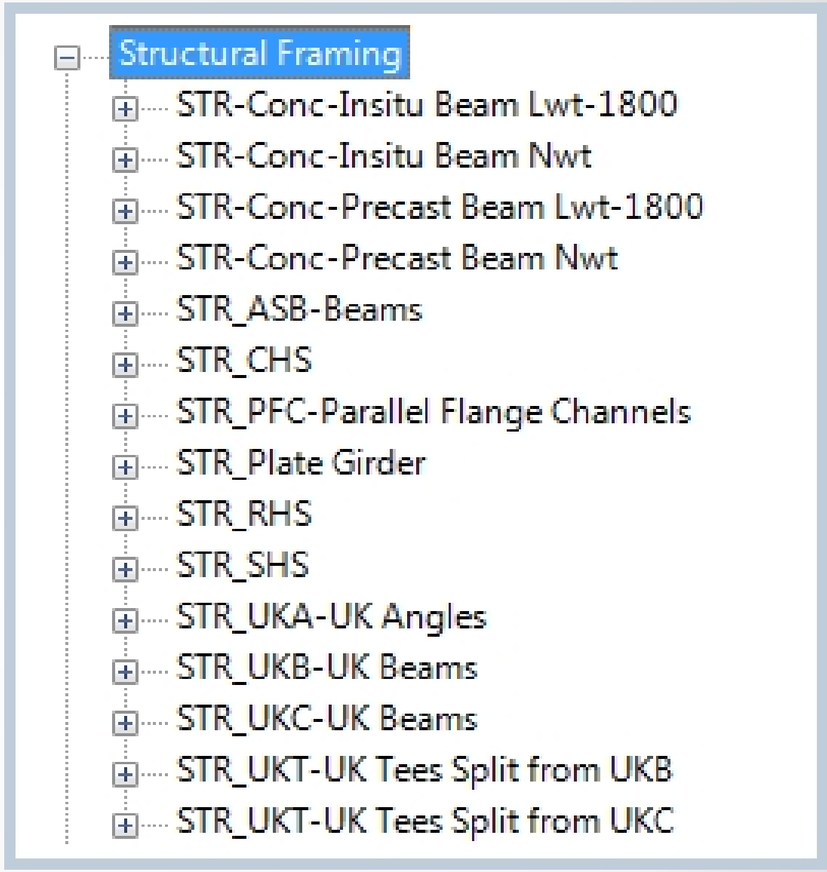
GUID	NAME	DATATYPE	GROUP
d758b80d-3e78-4ace-aa0e-f7250dbd7ae5	Reinforcement_Bars_Diameter_B1	Bar_diameter	32
8d05b5ae-372b-4c35-b0bc-0127d910a35a	Reinforcement_Bars_Diameter_B2	Bar_diameter	32
d7047984-b458-447f-ba70-7732756d2ce9	Reinforcement_Bars_Diameter_FF1	BAR_DIAMETER	32
4baccf5b-d4bb-4256-b37c-3c8fd017363d	Reinforcement_Bars_Diameter_FF2	BAR_DIAMETER	32
e441f204-e453-4e9a-b49b-5f792355095a	Reinforcement_Bars_Diameter_Loose	Bar_diameter	32
7db2a2b6-26aa-4c29-bb05-d85de822fd2c	Reinforcement_Bars_Diameter_Main	Bar_diameter	32
eb888b09-b260-4d9f-9be2-06961857fd98	Reinforcement_Bars_Diameter_Main Bottom	Bar_diameter	32
54f821cb-42bf-45e1-9ea9-02ef25bc625d	Reinforcement_Bars_Diameter_Main Top	Bar_diameter	32

GUID	NAME	DATATYPE	GROUP
d4743400-45de-40e8-94e2-24a66290415a	Foundation_Pad_SLS_Horizontal Load	FORCE	36
7a927a9f-2410-4680-9caa-cdea206171f2	Foundation_Pad_SLS_Vertical Load	FORCE	36
2a18f39a-837b-48bc-b0b2-b74e2e431f4e	Foundation_Pile_Design Force_Horizontal	Force	36
a54d06ea-ee13-436c-92a6-c966c9474ca3	Foundation_Pile_Design Force_Tension	Force	36
e3b9a3bf-acb2-4a84-b535-318a53824da2	Foundation_Pile_Design Force_Vertical	Force	36

GUID	NAME	DATATYPE	GROUP
f33e83ee-4c0b-4458-b04e-55258c5bd50b	Design_Concrete_Is Post Tensioned	YESNO	5
eb935d54-a642-4b0d-bcea-ad910878ccf6	Design_Concrete_Is Prestressed	YESNO	5
049dccd3-f09a-4537-acdf-beedc854170e	Design_Concrete_Is Reinforced	YESNO	35
3d42967d-47da-422b-9fbb-fac7571d684f	Design_Concrete_Kicker_Is Required	YESNO	5
95c4367c-3020-4bac-b499-2277df944e1c	Design_Concrete_Propping_Is Required	YESNO	5
9ac21e70-9e4a-4b6a-8659-658e2c0cbb41	Design_Element_Is Composite	YESNO	35
184f3526-2cb7-4f1f-9b9b-c240d8dd2aba	Design_Element_Is Contractor Designed	YESNO	5
fac207ec-ce41-4de3-b130-391d9d950e16	Design_Element_Is Key Element	YESNO	35

Shared Parameters & New Families





Shared Parameters & New Families

Section Designation			Mass per Metre	Radius		Area of Section	Distance to Centroid	Second Moment of Area			Radius of Gyration			Elastic Modulus	Torsional Constants	Equivalent Slenderness Coefficient
Size	Thickness			Root	Toe			y-y, z-z	u-u	v-v	y-y, z-z	u-u	v-v	y-y, z-z		
h x h	t			r_1	r_2		c								I_T	φ_a
mm	mm		kg/m	mm	mm	cm^2	cm	cm^4	cm^4	cm^4	cm	cm	cm	cm^3	cm^4	
200 x 200	24.0		71.1	18.0	9.00	90.6	5.84	3330	5280	1380	6.06	7.64	3.90	235	182	2.50
	20.0		59.9	18.0	9.00	76.3	5.68	2850	4530	1170	6.11	7.70	3.92	199	107	3.05
	18.0		54.3	18.0	9.00	69.1	5.60	2600	4150	1050	6.13	7.75	3.90	181	78.9	3.43
	16.0		48.5	18.0	9.00	61.8	5.52	2340	3720	960	6.16	7.76	3.94	162	56.1	3.85
150 x 150	18.0	+	40.1	16.0	8.00	51.2	4.38	1060	1680	440	4.55	5.73	2.93	99.8	58.6	2.48
	15.0		33.8	16.0	8.00	43.0	4.25	898	1430	370	4.57	5.76	2.93	83.5	34.6	3.01
	12.0		27.3	16.0	8.00	34.8	4.12	737	1170	303	4.60	5.80	2.95	67.7	18.2	3.77
	10.0		23.0	16.0	8.00	29.3	4.03	624	990	258	4.62	5.82	2.97	56.9	10.8	4.51
120 x 120	15.0	+	26.6	13.0	6.50	34.0	3.52	448	710	186	3.63	4.57	2.34	52.8	27.0	2.37
	12.0		21.6	13.0	6.50	27.5	3.40	368	584	152	3.65	4.60	2.35	42.7	14.2	2.99
	10.0		18.2	13.0	6.50	23.2	3.31	313	497	129	3.67	4.63	2.36	36.0	8.41	3.61
	8.0	+	14.7	13.0	6.50	18.8	3.24	259	411	107	3.71	4.67	2.38	29.5	4.44	4.56
100 x 100	15.0	+	21.9	12.0	6.00	28.0	3.02	250	395	105	2.99	3.76	1.94	35.8	22.3	1.92
	12.0		17.8	12.0	6.00	22.7	2.90	207	328	85.7	3.02	3.80	1.94	29.1	11.8	2.44
	10.0		15.0	12.0	6.00	19.2	2.82	177	280	73.0	3.04	3.83	1.95	24.6	6.97	2.94
	8.0		12.2	12.0	6.00	15.5	2.74	145	230	59.9	3.06	3.85	1.96	19.9	3.68	3.70
90 x 90	12.0	+	15.9	11.0	5.50	20.3	2.66	149	235	62.0	2.71	3.40	1.75	23.5	10.5	2.17
	10.0		13.4	11.0	5.50	17.1	2.58	127	201	52.6	2.72	3.42	1.75	19.8	6.20	2.64
	8.0		10.9	11.0	5.50	13.9	2.50	104	166	43.1	2.74	3.45	1.76	16.1	3.28	3.33
	7.0		9.61	11.0	5.50	12.2	2.45	92.6	147	38.3	2.75	3.46	1.77	14.1	2.24	3.80

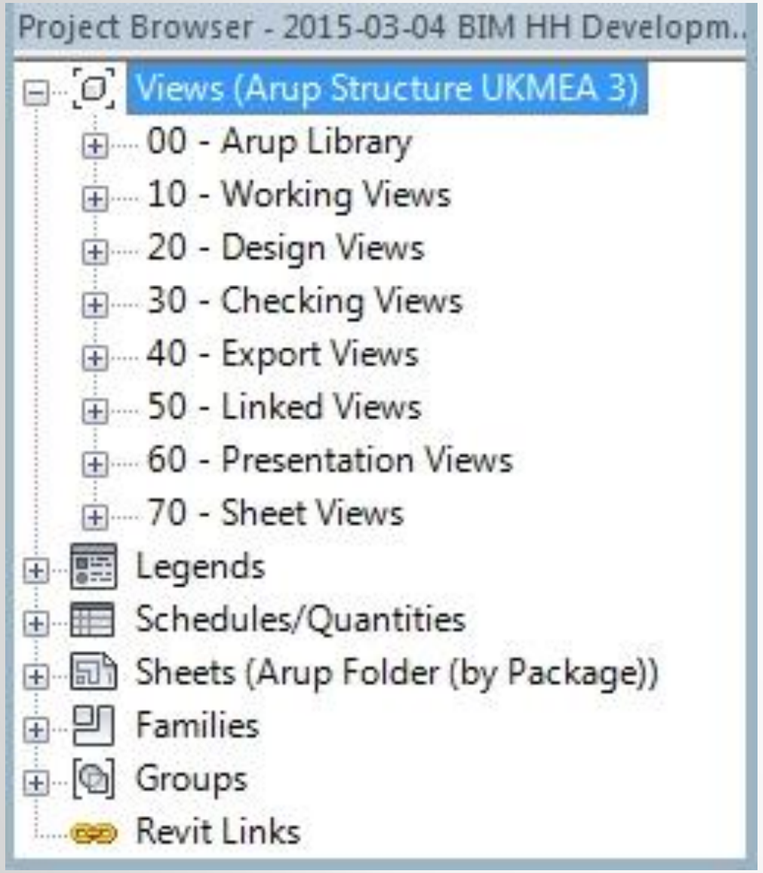
Section Properties of Advance® UKA - Equal

\+ These sections are in addition to the range of BS EN 10056-1 sections

c Is the distance from the back of the leg to the centre of gravity

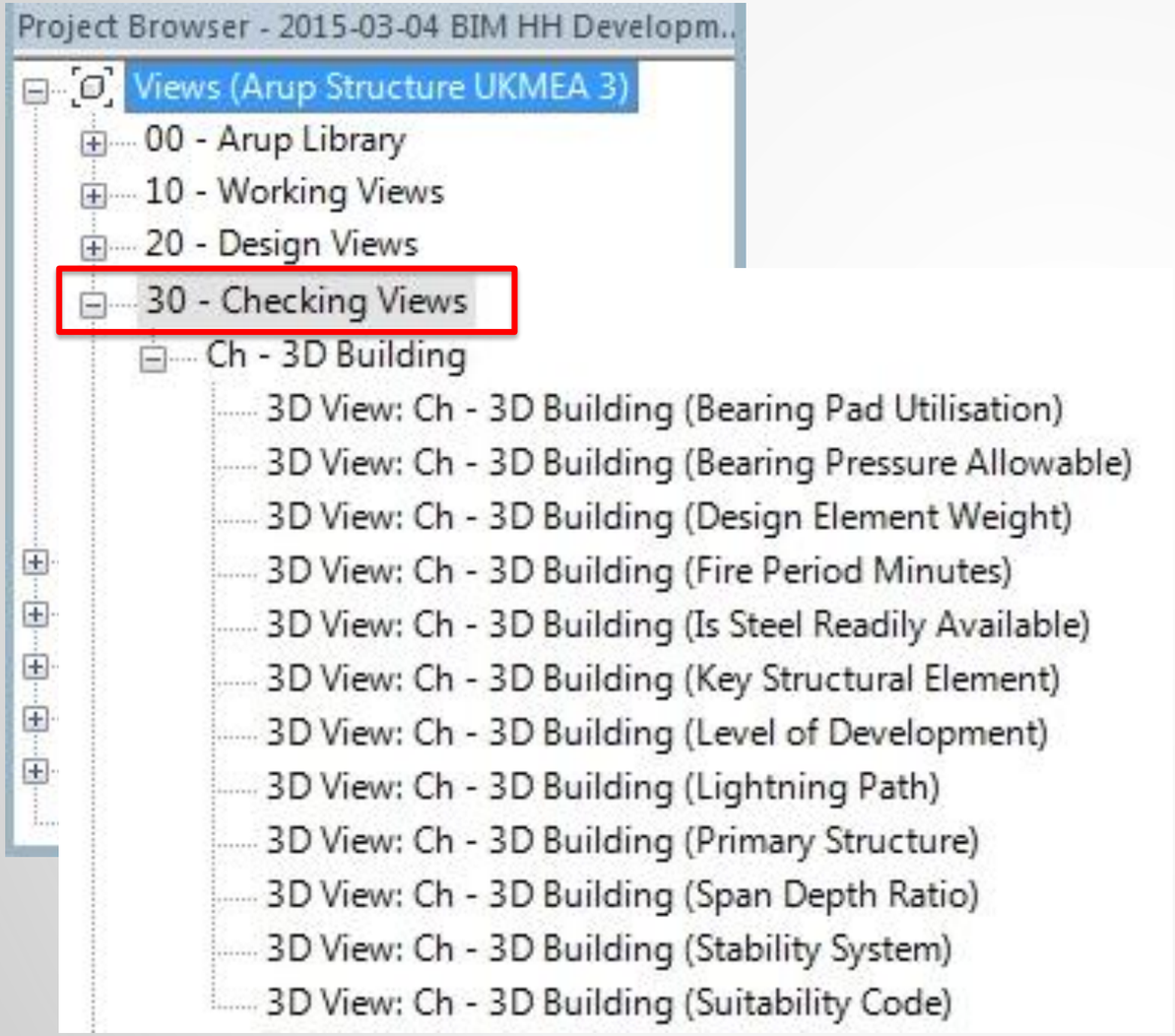
Get more from your models

Project Browser



- **00 – Arup Library**
  Documentation & Graphics
- **10 – Working Views:**
  User controlled Views
- **20 – Design Views:**
  Analytical Views
- **30 – Checking Views:**
  Filters pre-set to assist checking
- **40 – Export Views:**
  Views for Exporting
- **50 – Linked Views:**
  Linked Models
- **60 – Presentation Views:**
  Renders etc.
- **70 – Sheet Views:**
  Views dropped onto Sheets

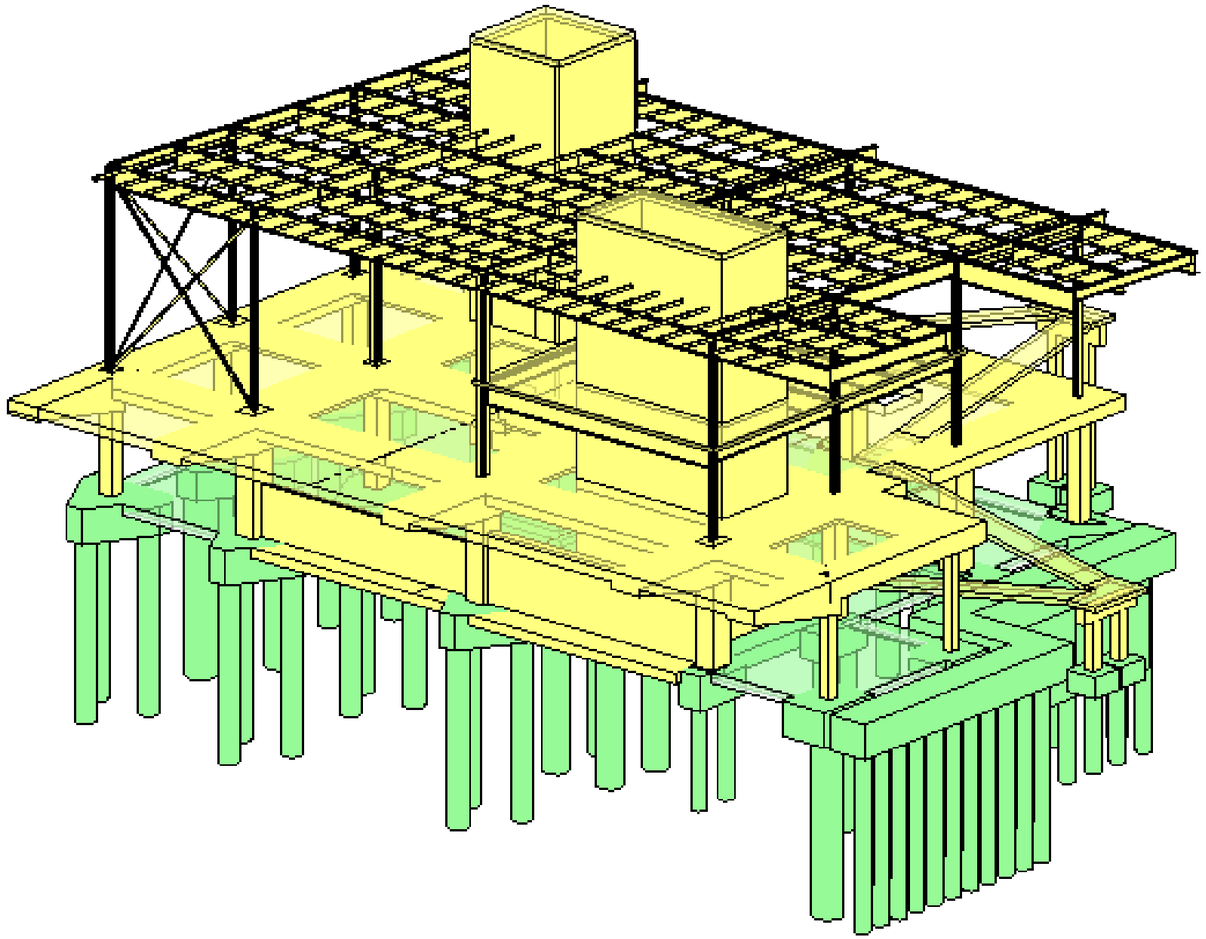
Checking Views for Engineers



Level of Development

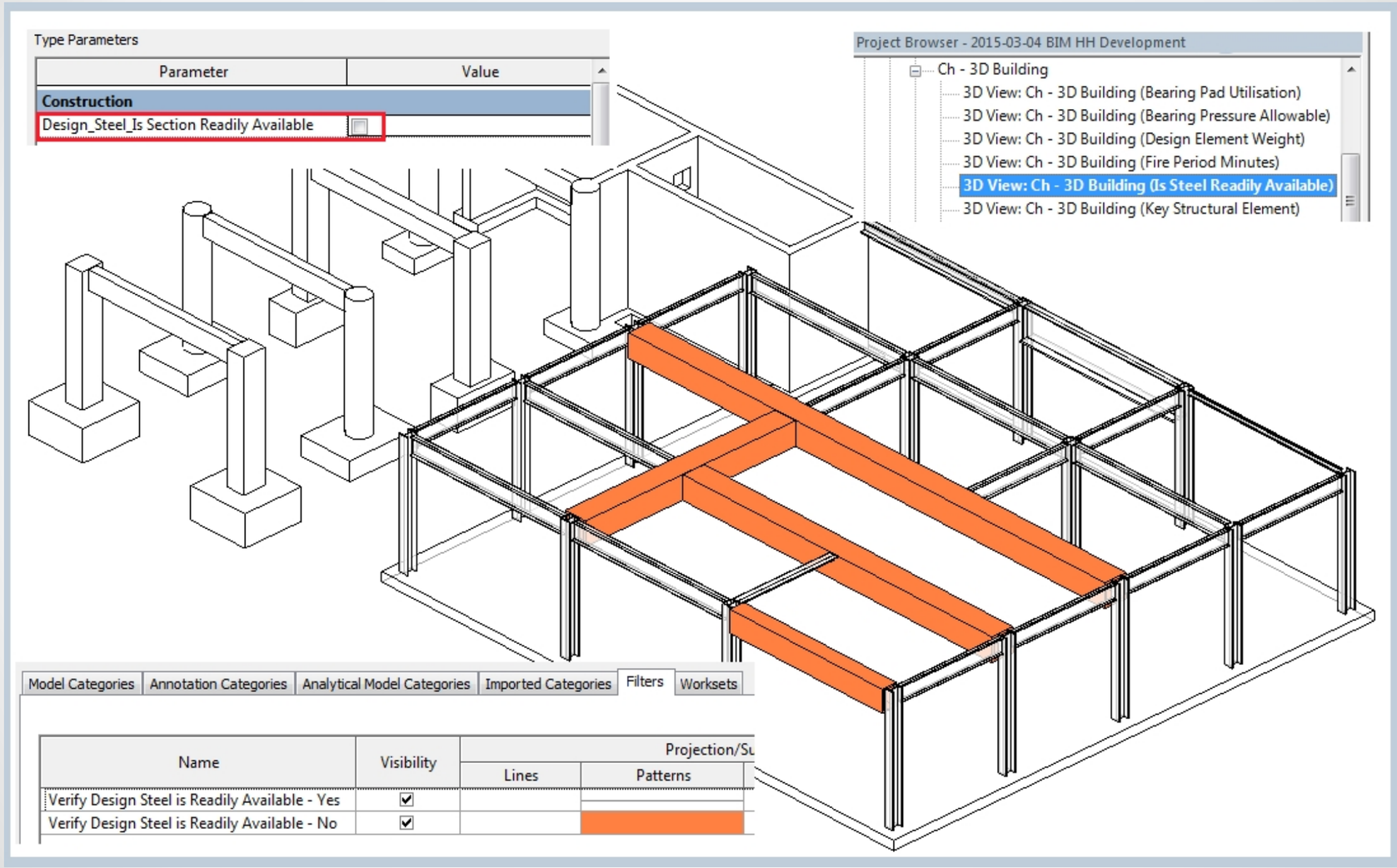
LOD	Description
100	The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e., cost per square foot) can be derived from other Model Elements.
200	The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location and orientation. Non-graphic information may also be attached to the Model Element.
300	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.
350	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, orientation and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.
400	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.
500	The Model Element is a field verified representation in terms of size, shape, location, quantity and orientation. Non-graphic information may also be attached to the Model Element.

Level of Development

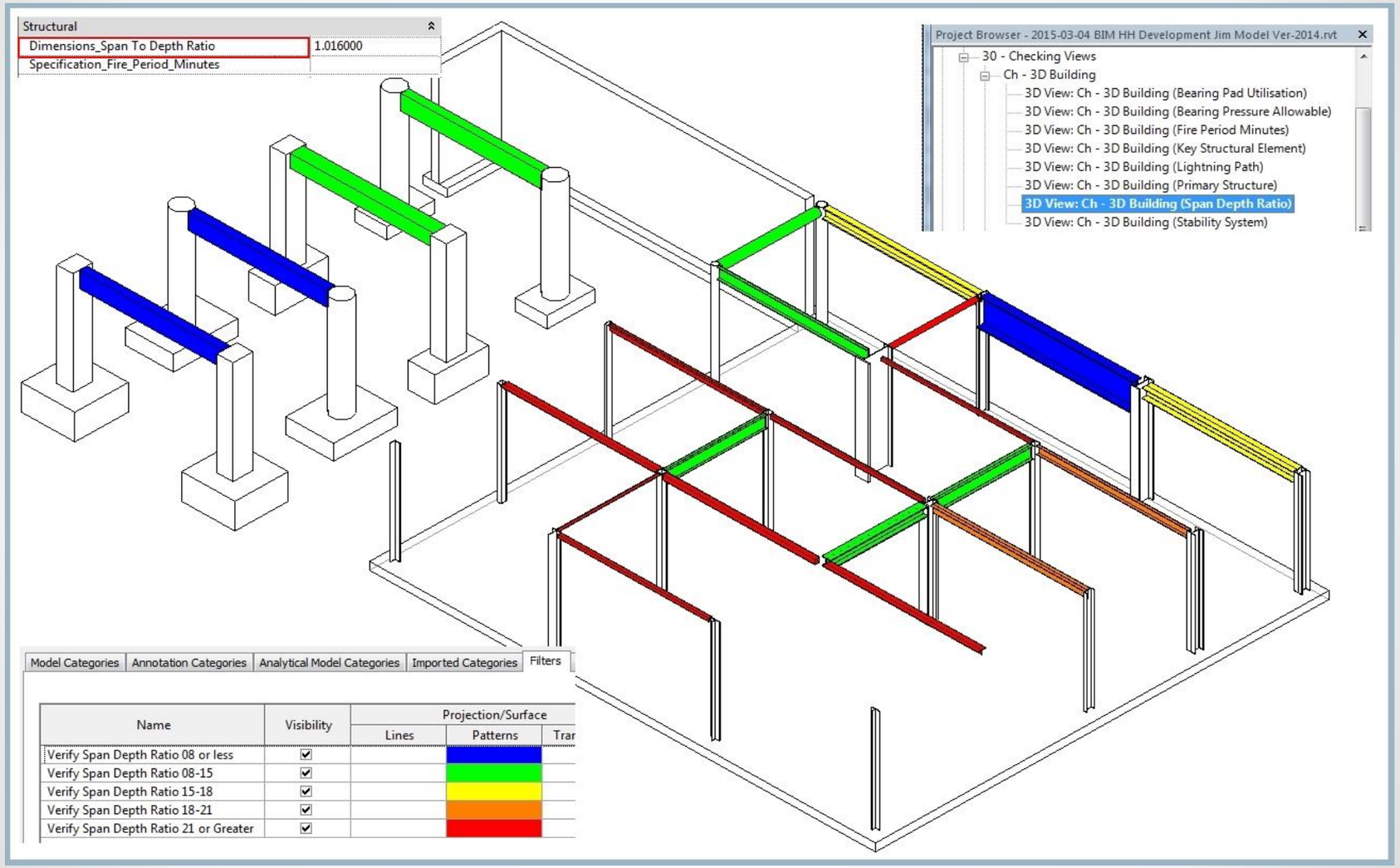


3D Building (Level of Development)

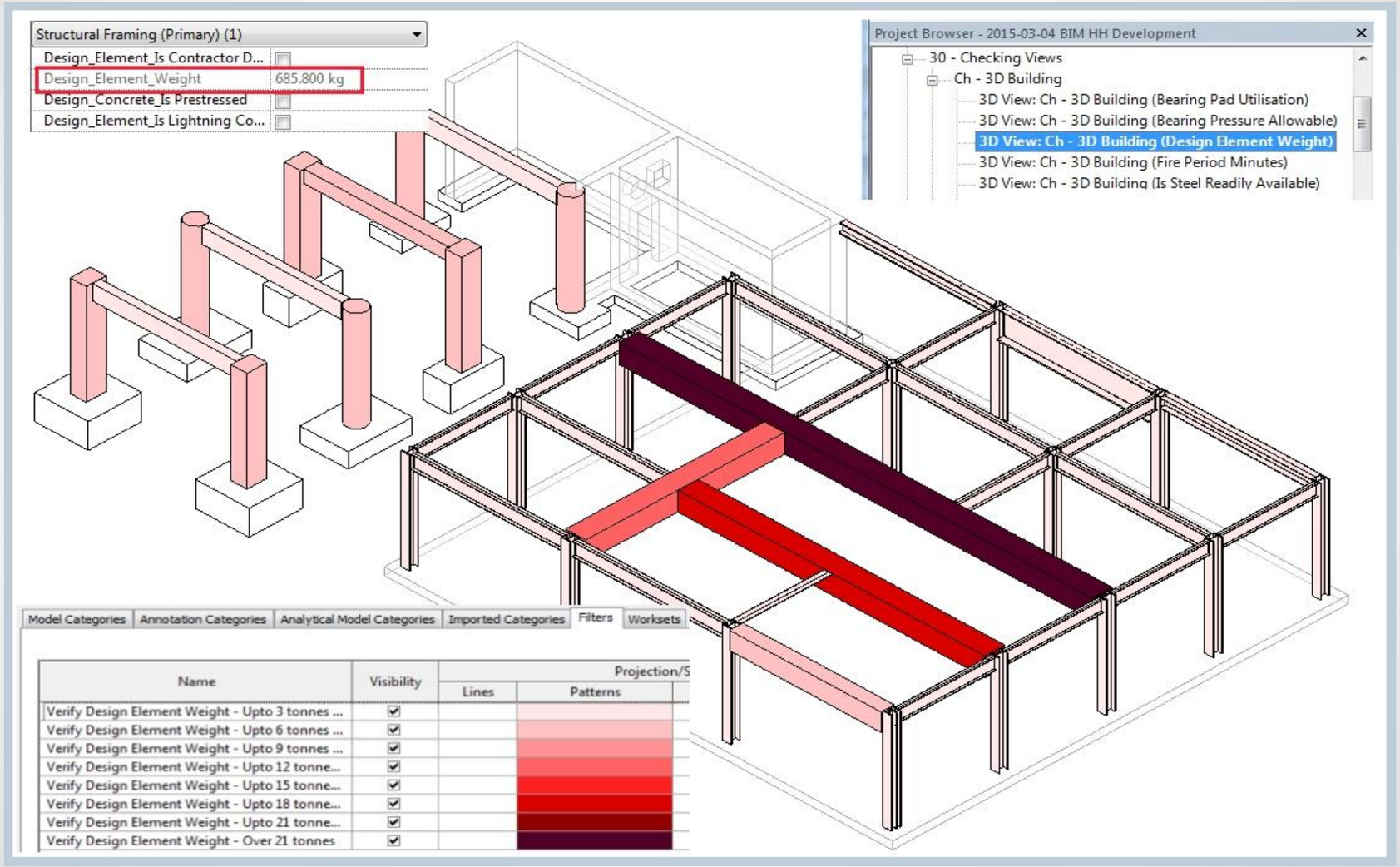
Is Section Readily Available ?



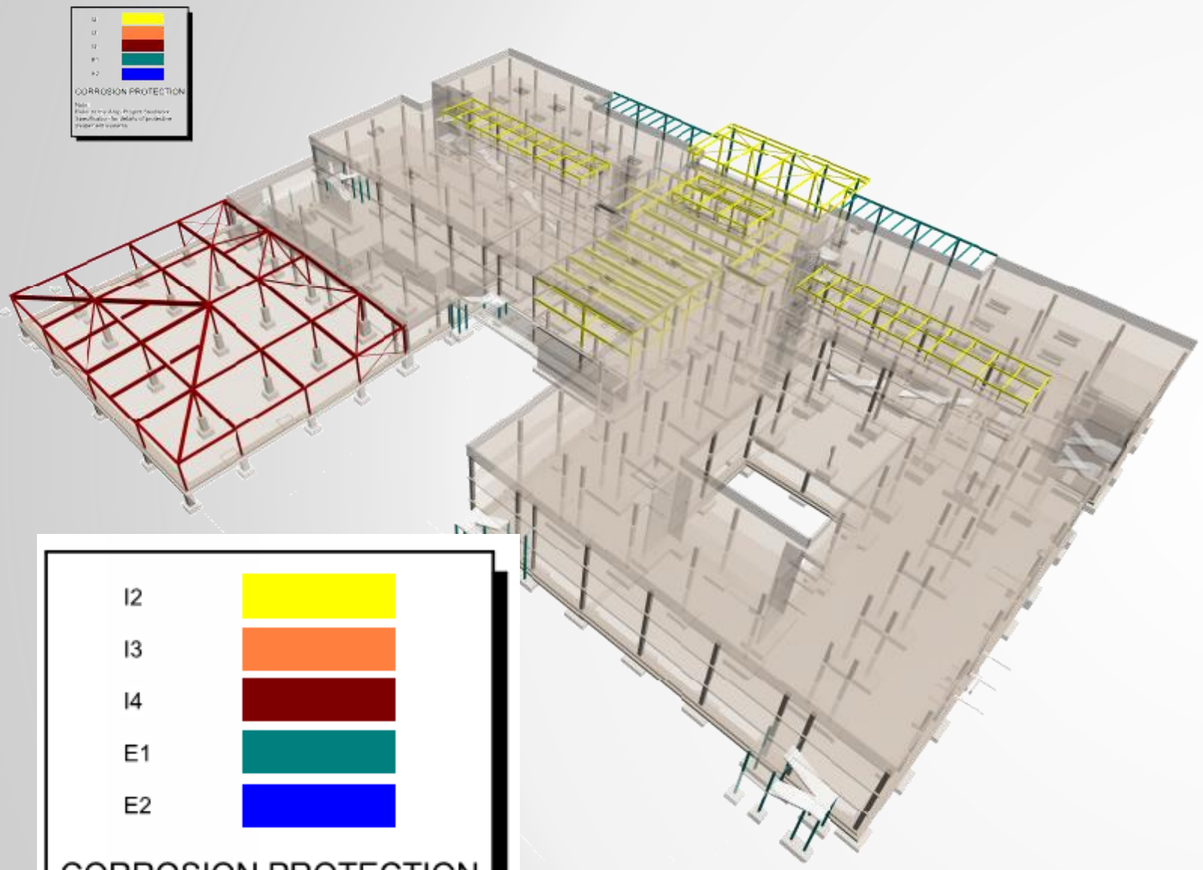
Span to Depth Ratio

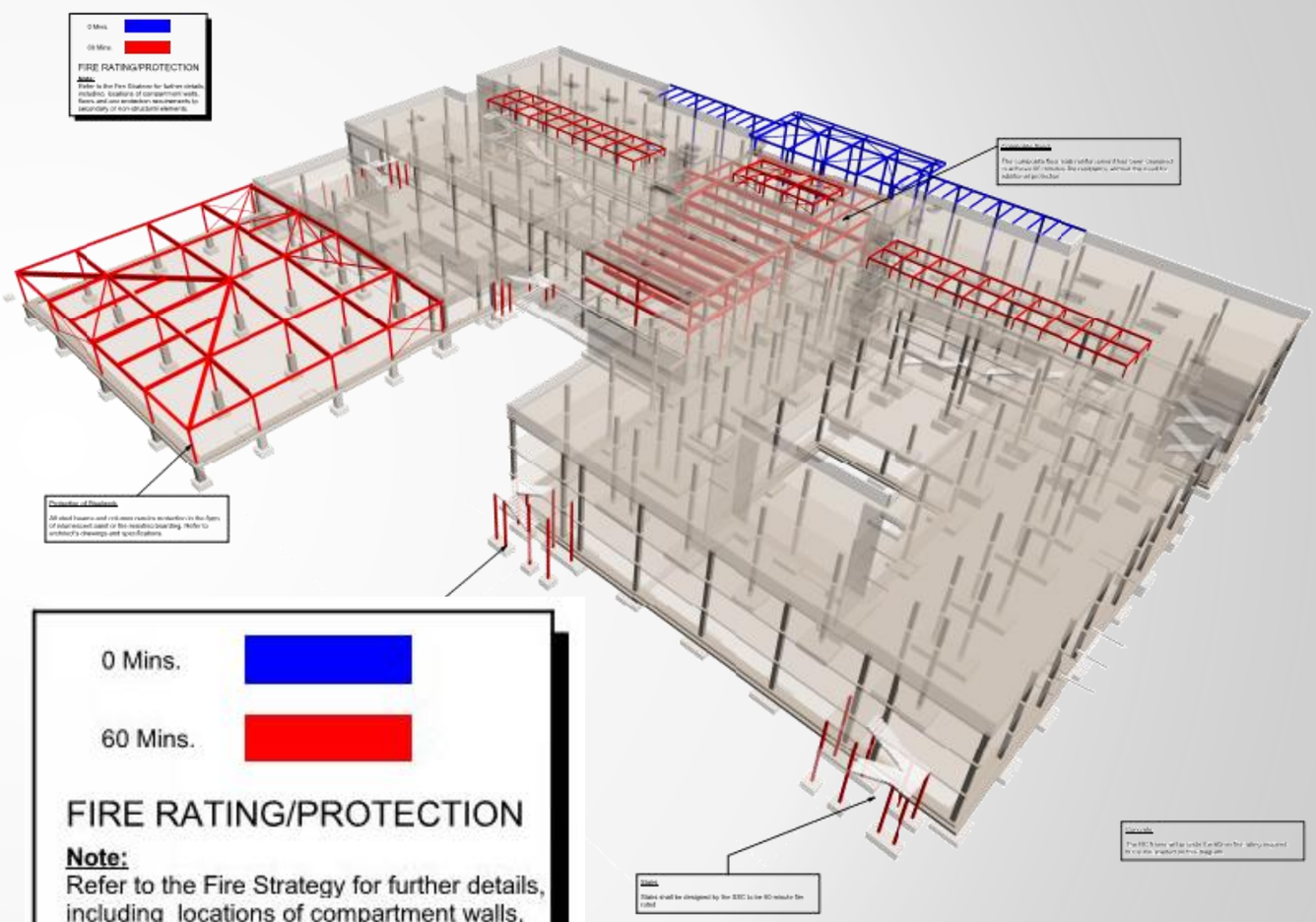


Design Element Weight

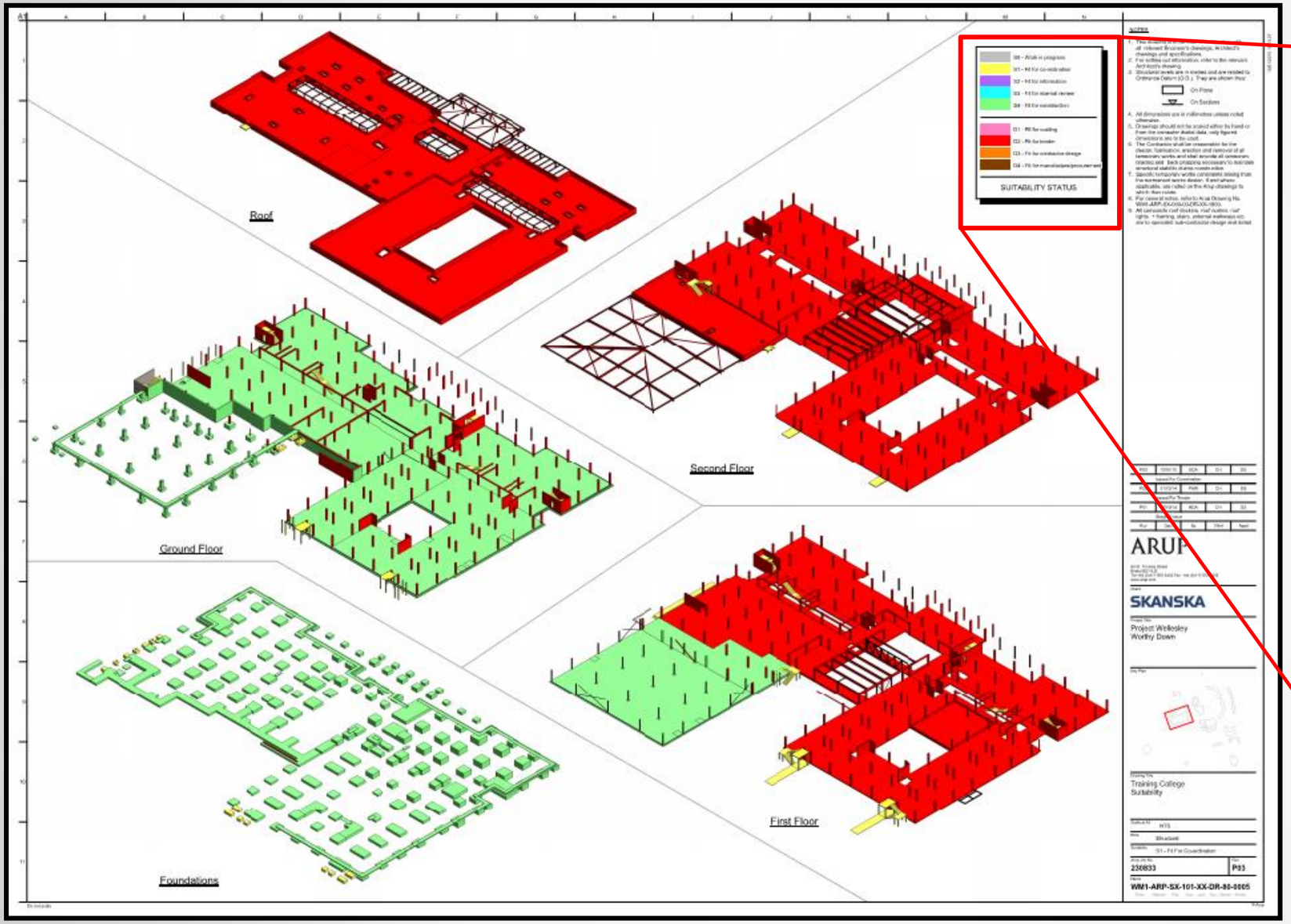


QA/QC – Get more out of our models



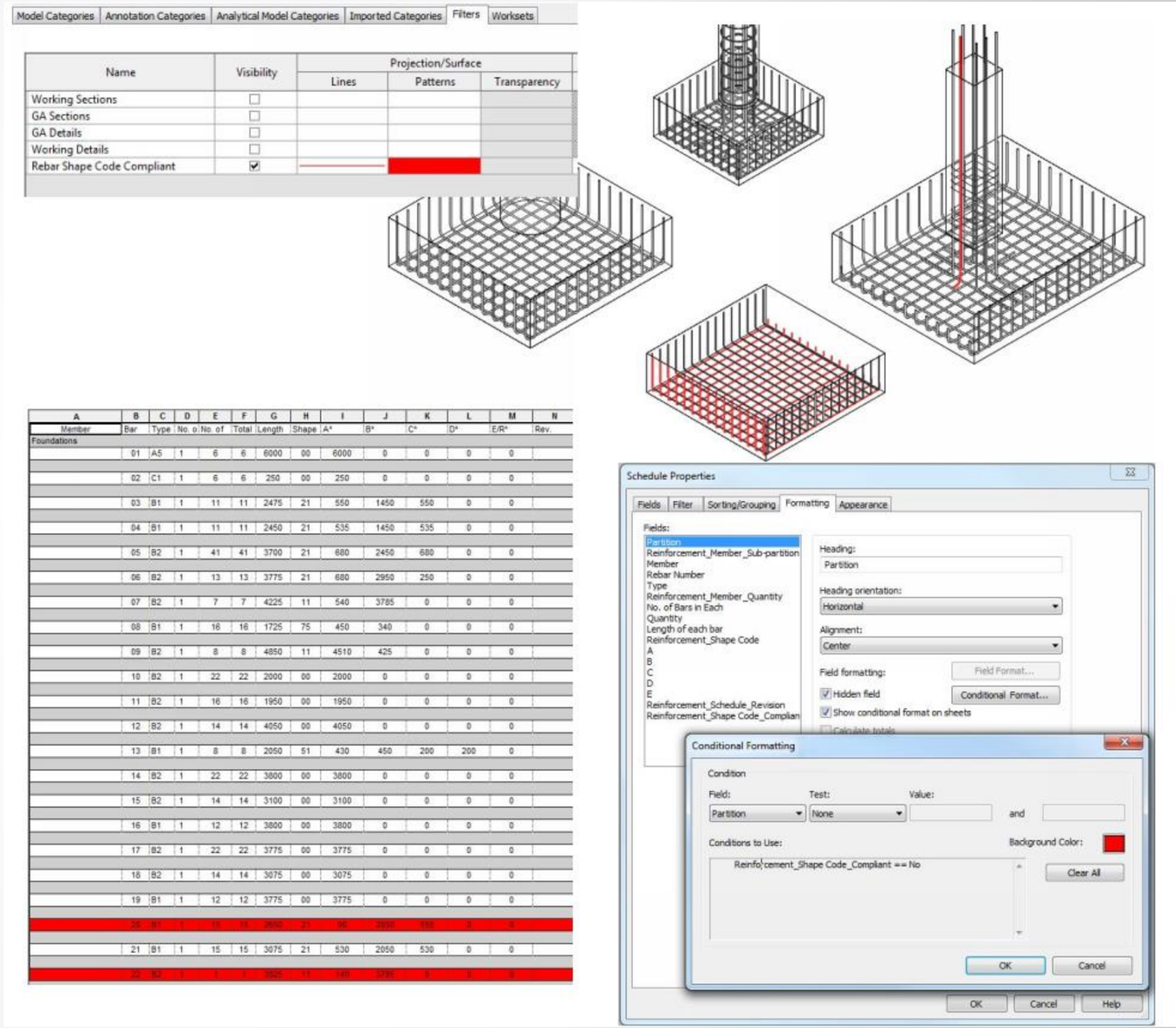


QA/QC – Suitability code (BS 1192)

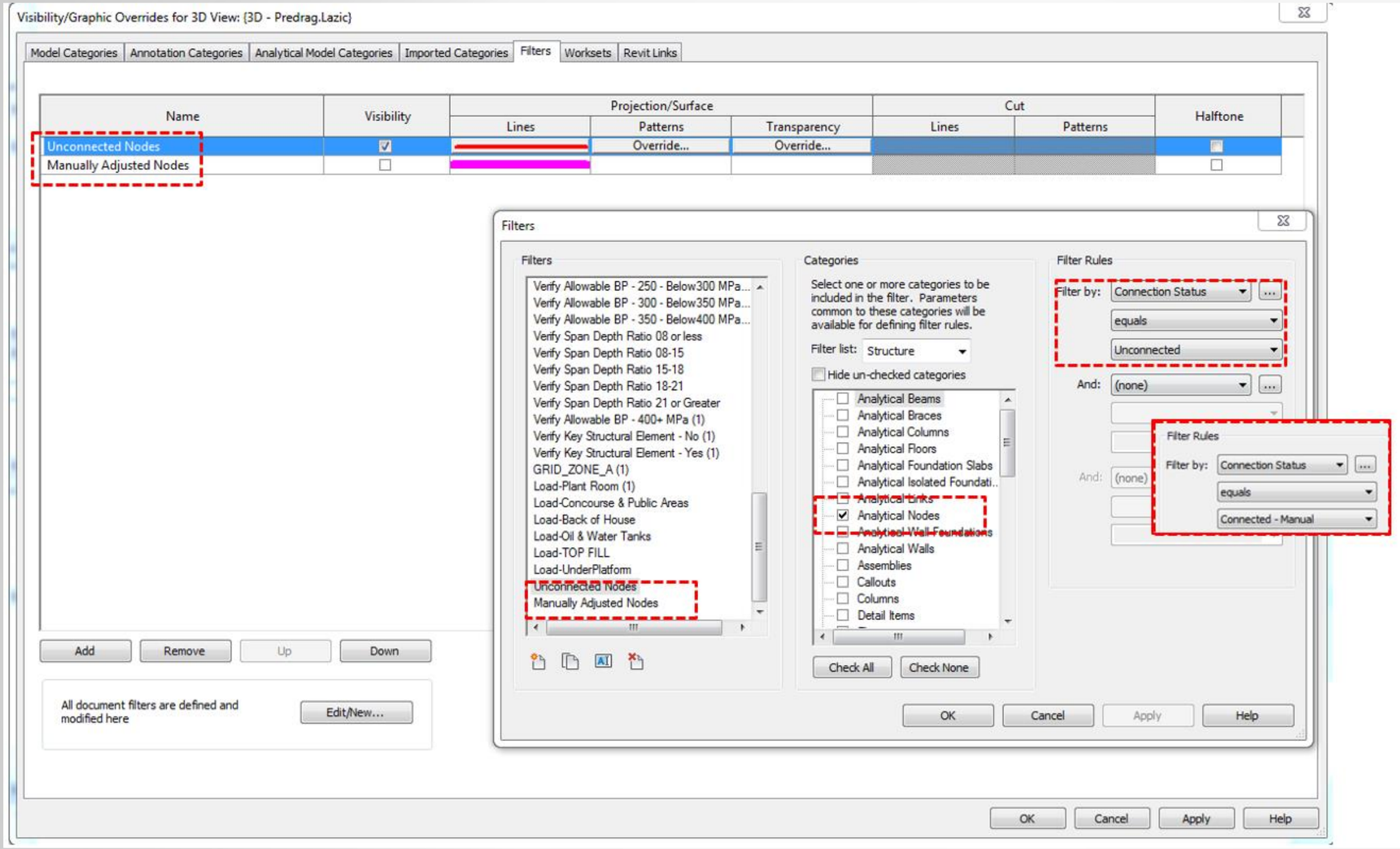


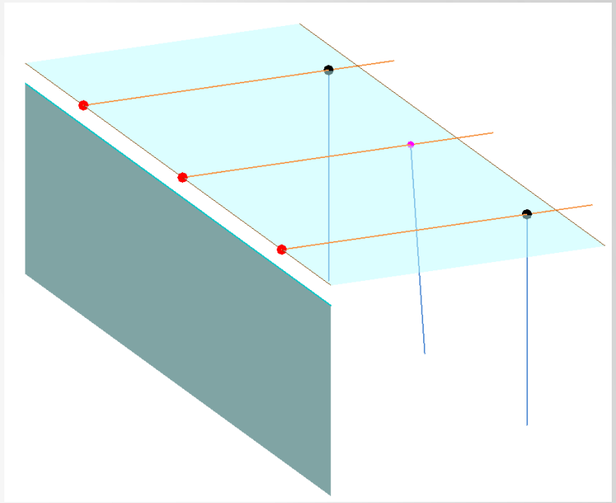
QA/QC – Reinforcement Checking

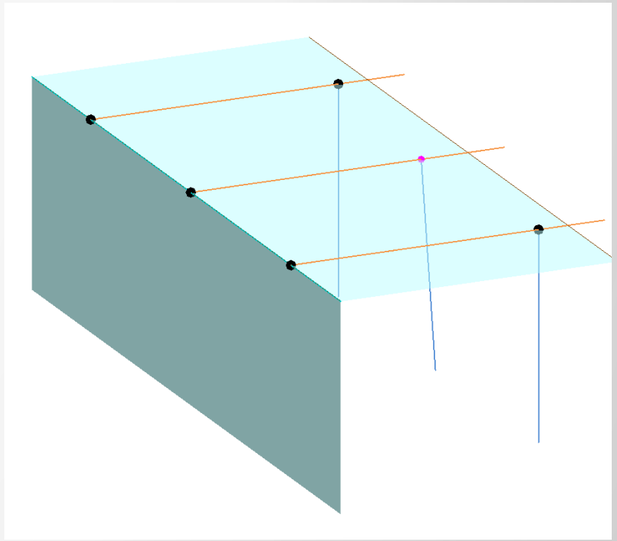
- Shape code compliance



QA/QC – Analysis Connectivity



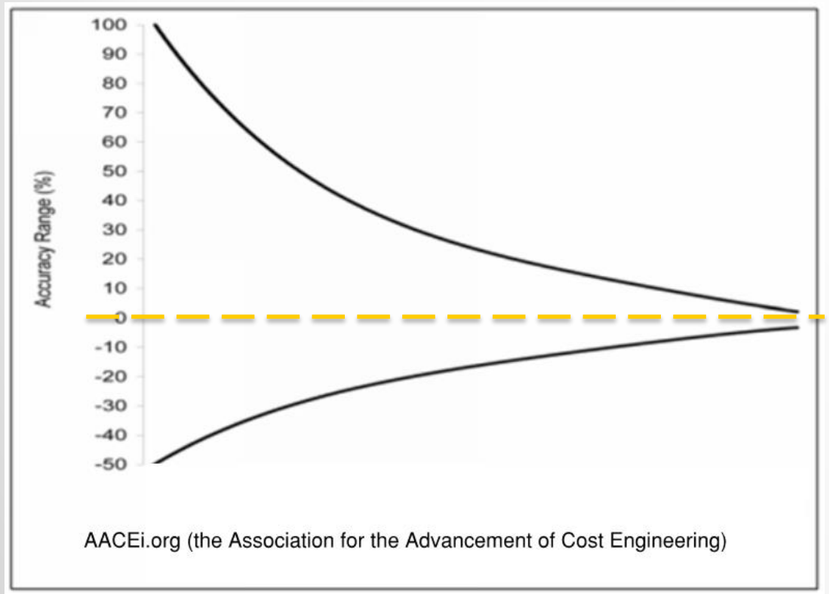




Quantities – Get more out of our models

- Filter your schedules
- Be open about contingencies

Concrete Wall Volumes			
Wall Type	No.	Concrete Type	Volume
150mm Thick R.C. wall	15	C50/60	118 m³
250mm Thick R.C. wall	1	C50/60	2 m³
300mm Thick R.C. wall	568	C50/60	2441 m³
350mm Thick R.C. wall	2	C50/60	2 m³
500mm Thick R.C. wall	112	C50/60	1971 m³
600mm Thick R.C. wall	128	C50/60	2696 m³
P1 Upstand	1	C32/40	53 m³
Wing1 Parapet	1	C32/40	20 m³
Wing2 Parapet	1	C32/40	22 m³
			7325 m³



AACEi.org (the Association for the Advancement of Cost Engineering)

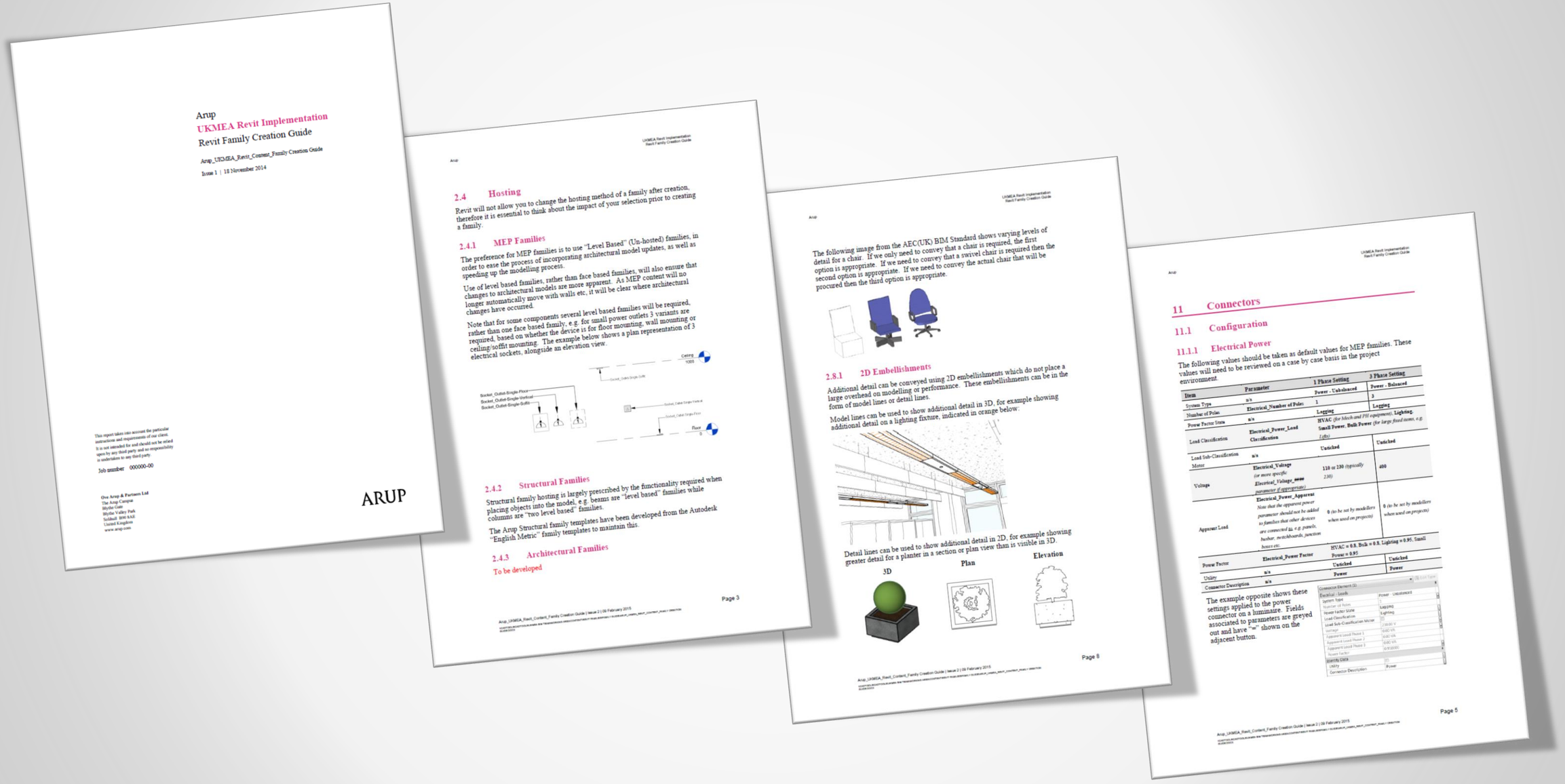
FLOOR SYSTEM	APPROX TONS	CONNECTIONS	TOTAL	DESIGN CONTINGENCY	**TOTAL**
RESIDENTIAL	775	10%	853	10%	938
OFFICE	2,075	10%	2,283	10%	2,511
OTHER	625	10%	688	30%	894
OUTRIGGER TRUSSES	125	20%	150	20%	180
COLUMNS	1,550	5%	1,628	10%	1,790
TOTAL:	**5,150**	450	**5,600**	713	**6,313**
			8.7%		22.6%

Best Practice Guidelines

Best Practice Guidelines

- BIM Execution Plan Template
- Virtual Design Review Procedures
- 5 minute guide on clash detection
- BIM Guidance for LOD
- Template LOD Matrices
- Incoming Model Review
- Revit Family Creation Guide
- Revit Model Issue Guide

Family Creation Guide



Arup
UKMEA Revit Implementation
Revit Family Creation Guide

Arup_UKMEA_Revit_Content_Family Creation Guide

Issue 1 | 18 November 2014

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 000000-00

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ARUP

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2.4 Hosting

Revit will not allow you to change the hosting method of a family after creation, therefore it is essential to think about the impact of your selection prior to creating a family.

2.4.1 MEP Families

The preference for MEP families is to use "Level Based" (Un-hosted) families, in order to ease the process of incorporating architectural model updates, as well as speeding up the modelling process.

Use of level based families, rather than face based families, will also ensure that changes to architectural models are more apparent. As MEP content will no longer automatically move with walls etc, it will be clear where architectural changes have occurred.

Note that for some components several level based families will be required, rather than one face based family, e.g. for small power outlets 3 variants are required, based on whether the device is for floor mounting, wall mounting or ceiling/soffit mounting. The example below shows a plan representation of 3 electrical sockets, alongside an elevation view.

2.4.2 Structural Families

Structural family hosting is largely prescribed by the functionality required when placing objects into the model, e.g. beams are "level based" families while columns are "two level based" families.

The Arup Structural family templates have been developed from the Autodesk "English Metric" family templates to maintain this.

2.4.3 Architectural Families

To be developed

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The following image from the AEC(UK) BIM Standard shows varying levels of detail for a chair. If we only need to convey that a chair is required, the first option is appropriate. If we need to convey that a swivel chair is required then the second option is appropriate. If we need to convey the actual chair that will be procured then the third option is appropriate.

2.8.1 2D Embellishments

Additional detail can be conveyed using 2D embellishments which do not place a large overhead on modelling or performance. These embellishments can be in the form of model lines or detail lines.

Model lines can be used to show additional detail in 3D, for example showing additional detail on a lighting fixture, indicated in orange below:

Detail lines can be used to show additional detail in 2D, for example showing greater detail for a planter in a section or plan view than is visible in 3D.

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11 Connectors

11.1 Configuration

11.1.1 Electrical Power

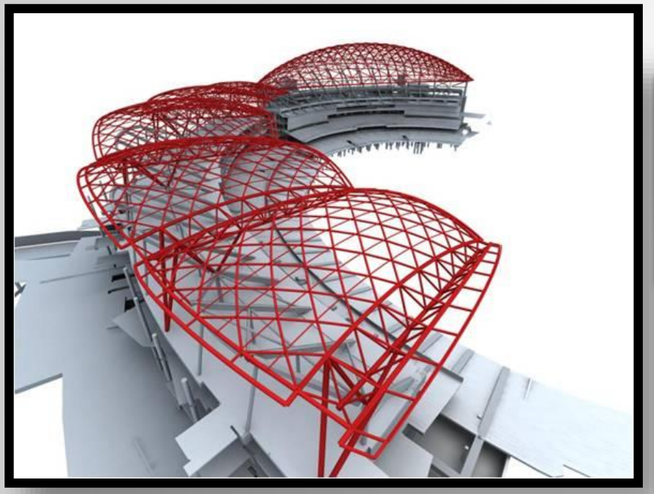
The following values should be taken as default values for MEP families. These values will need to be reviewed on a case by case basis in the project environment.

Item	Parameter	1 Phase Setting	3 Phase Setting
System Type	n/a	Power - Unbalanced	Power - Balanced
Number of Poles	Electrical_Number of Poles	1	3
Power Factor State	n/a	Lagging	Lagging
Load Classification	Electrical_Power_Load Classification	HVAC (*for Mech and FH equipment*), Lighting, Small Power, Bulk Power (*for large fixed items, e.g. [dbs]*)	
Load Sub-Classification	n/a	Unticked	Unticked
Motor			
Voltage	Electrical_Voltage (*or more specific: Electrical_Voltage_xxxx parameter if appropriate*)	110 or 230 (*typically 230*)	400
Apparent Load	Electrical_Power_Apparent *Note that the apparent power parameter should not be added to families that other devices are connected to, e.g. panels, busbar, metalwork, junction boxes etc.*	0 (*to be set by modellers when used on projects*)	0 (*to be set by modellers when used on projects*)
Power Factor	Electrical_Power Factor	HVAC = 0.8, Bulk = 0.8, Lighting = 0.95, Small Power = 0.95	
Unity	n/a	Unticked	Unticked
Connector Description	n/a	Power	Power

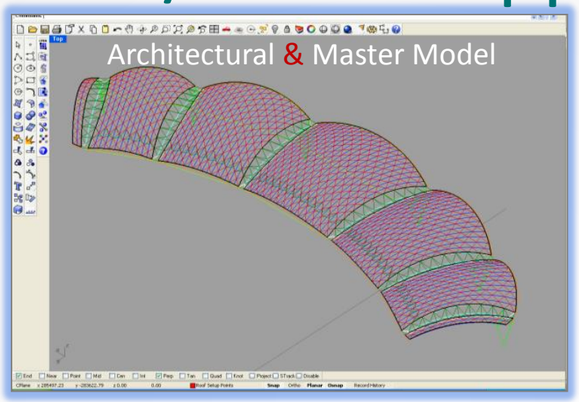
The example opposite shows these settings applied to the power connector on a luminaire. Fields associated to parameters are greyed out and have "=" shown on the adjacent button.

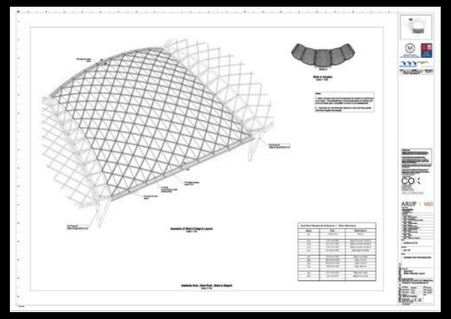
Interoperability

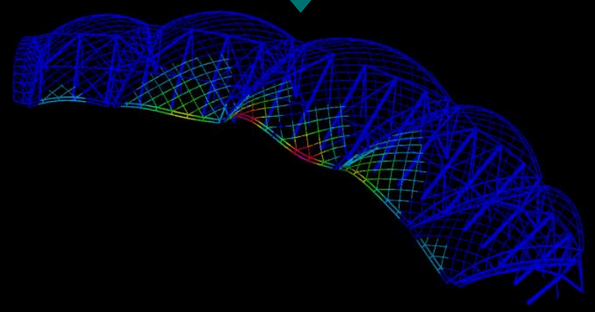
Interoperability | Data exchange

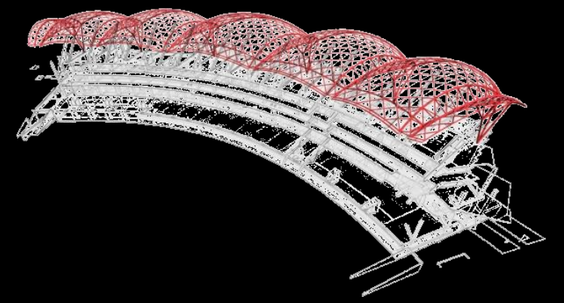


Rhino / Grasshopper





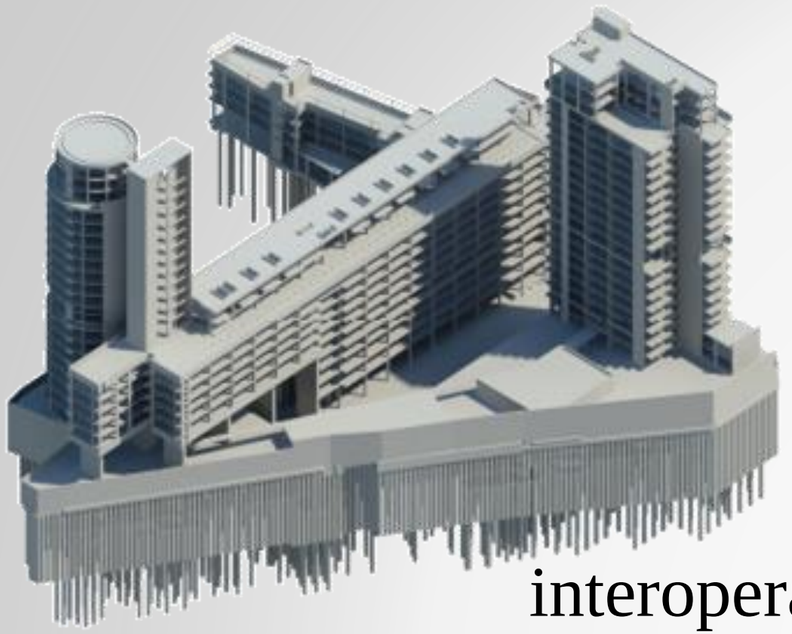




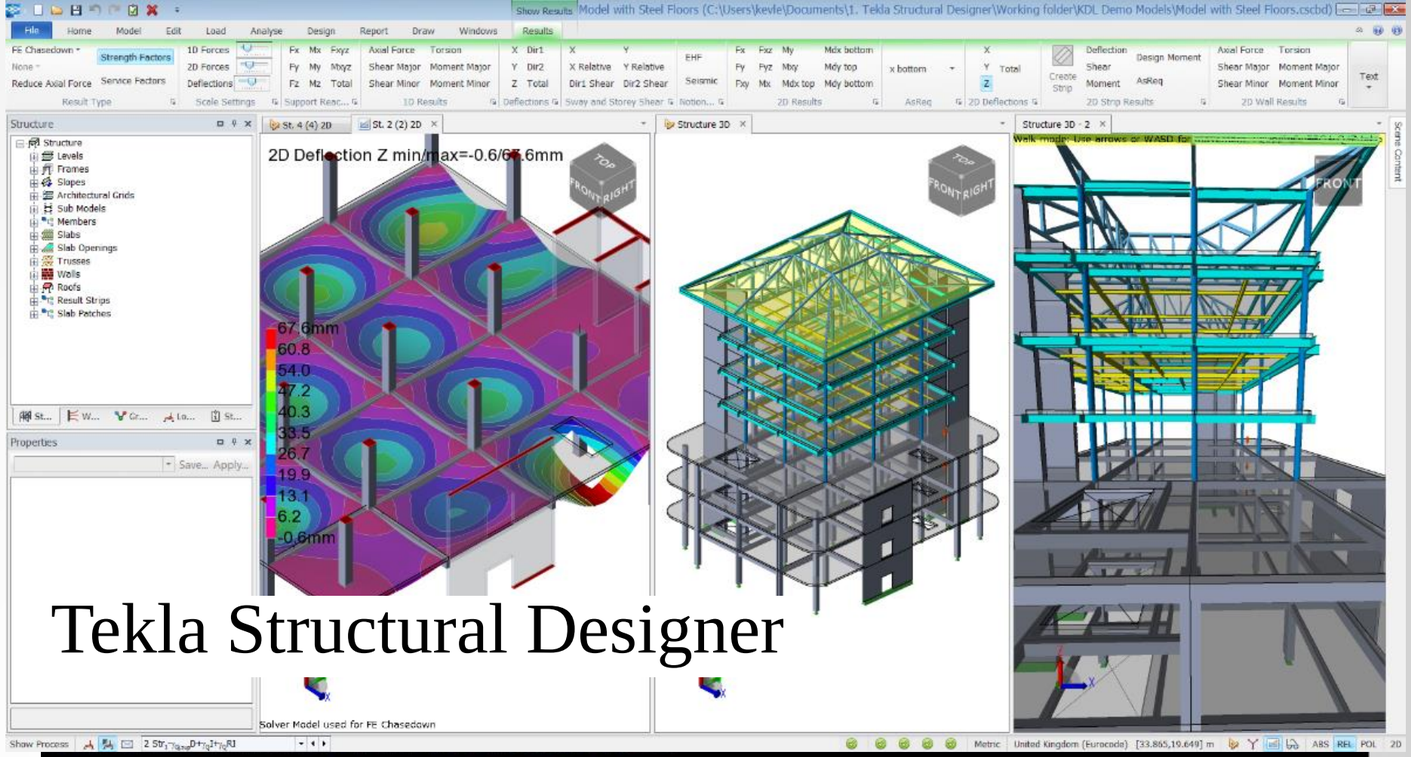
Bentley / Revit ⟷ GSA ⟷ Fabrication Model

Documentation

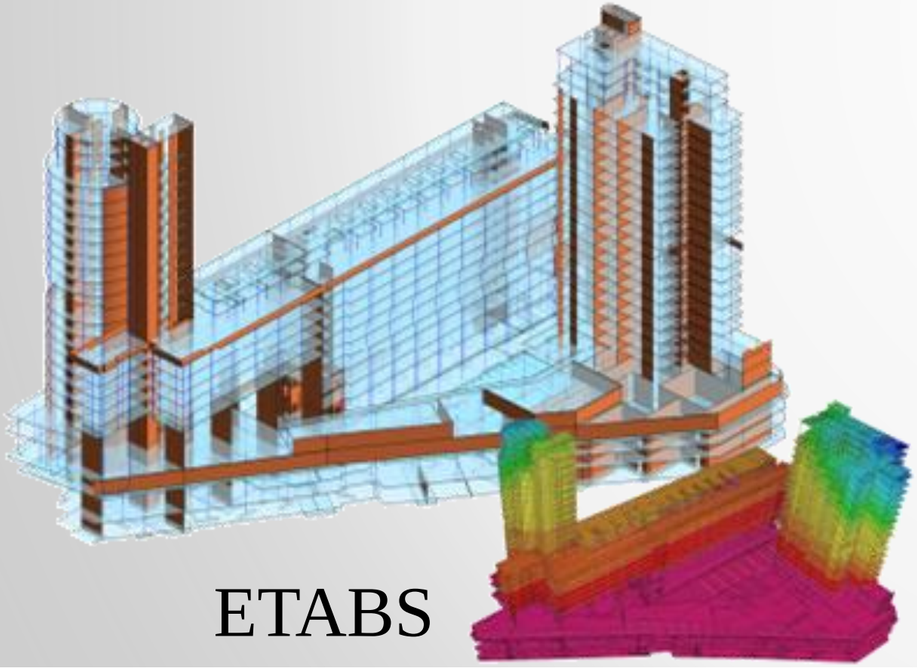
Analysis



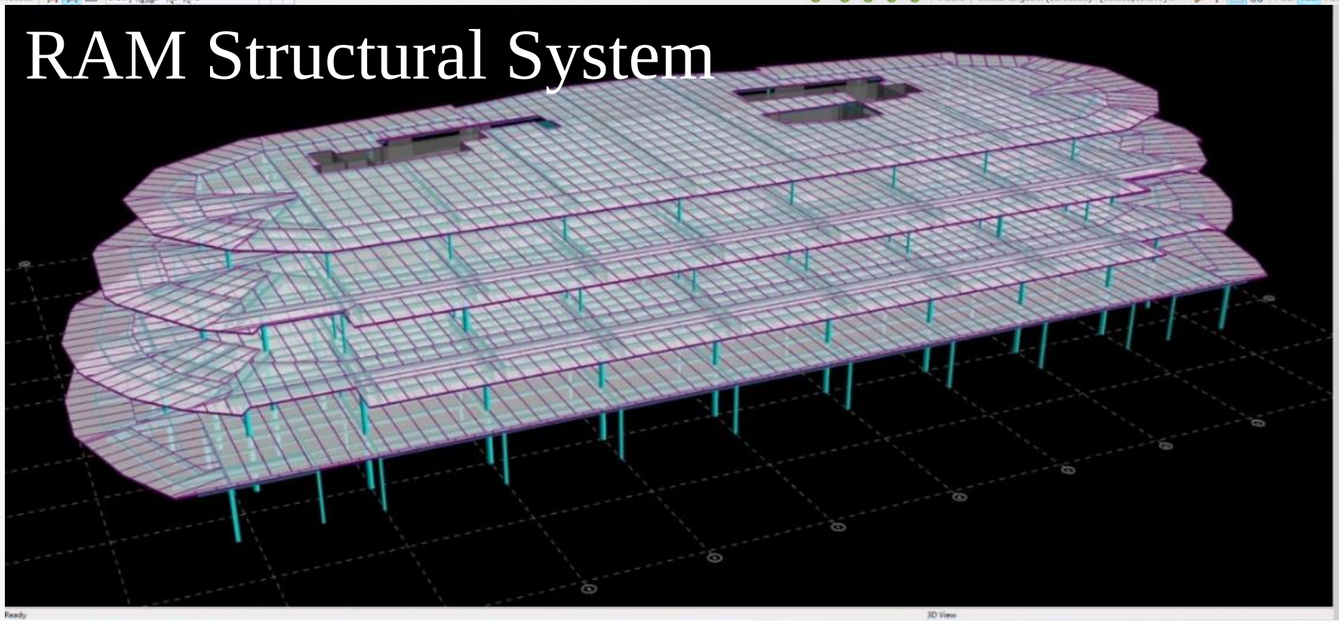
Revit interoperability with Robot and….



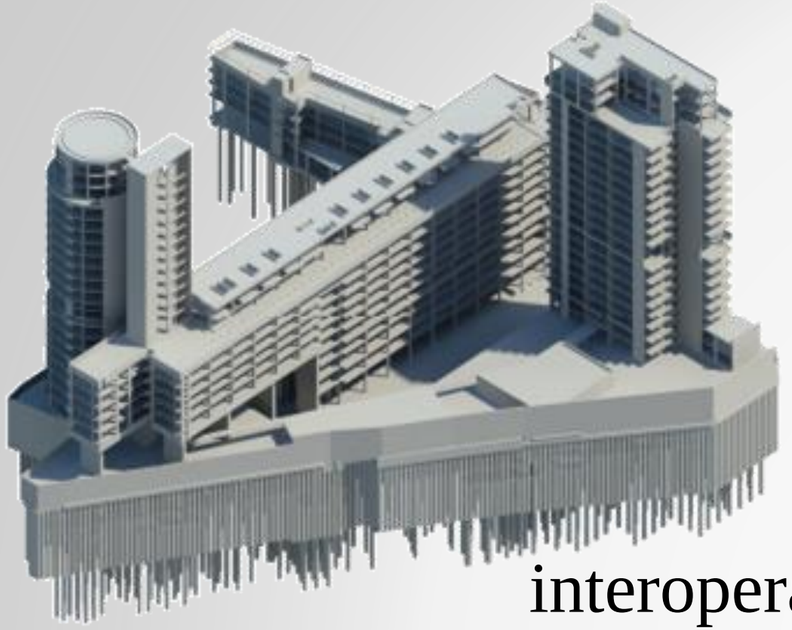
Tekla Structural Designer



ETABS



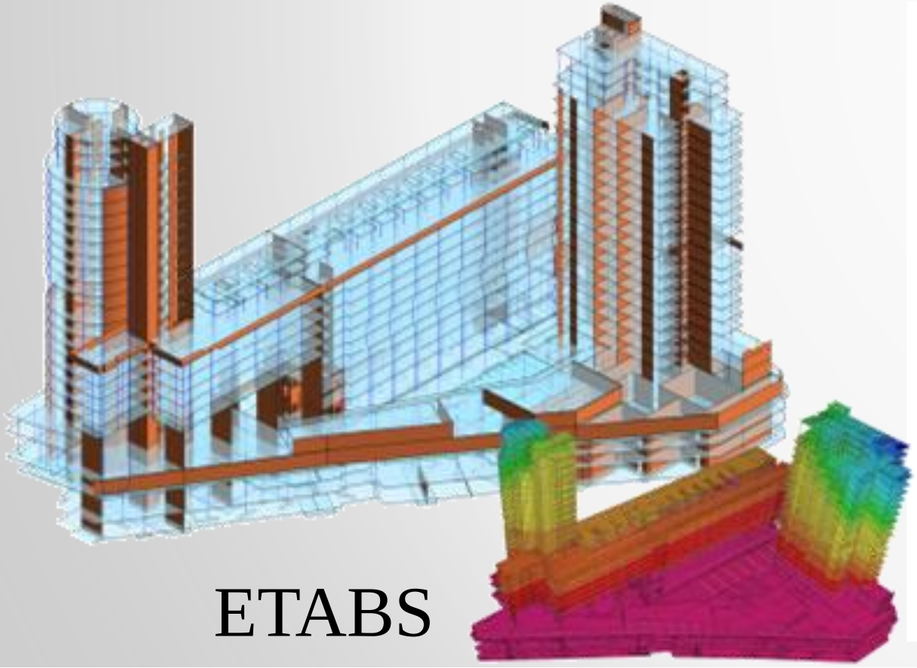
RAM Structural System



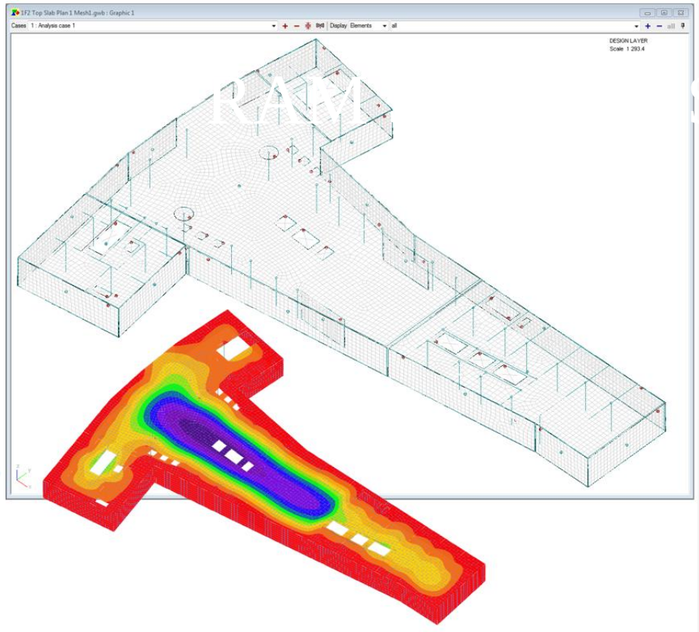
Revit & Structural Analysis Software Interoperability

Rev1 | 20 March 2015

Revit interoperability with Robot and…. OASYS GSA



ETABS



Contents

See Handouts

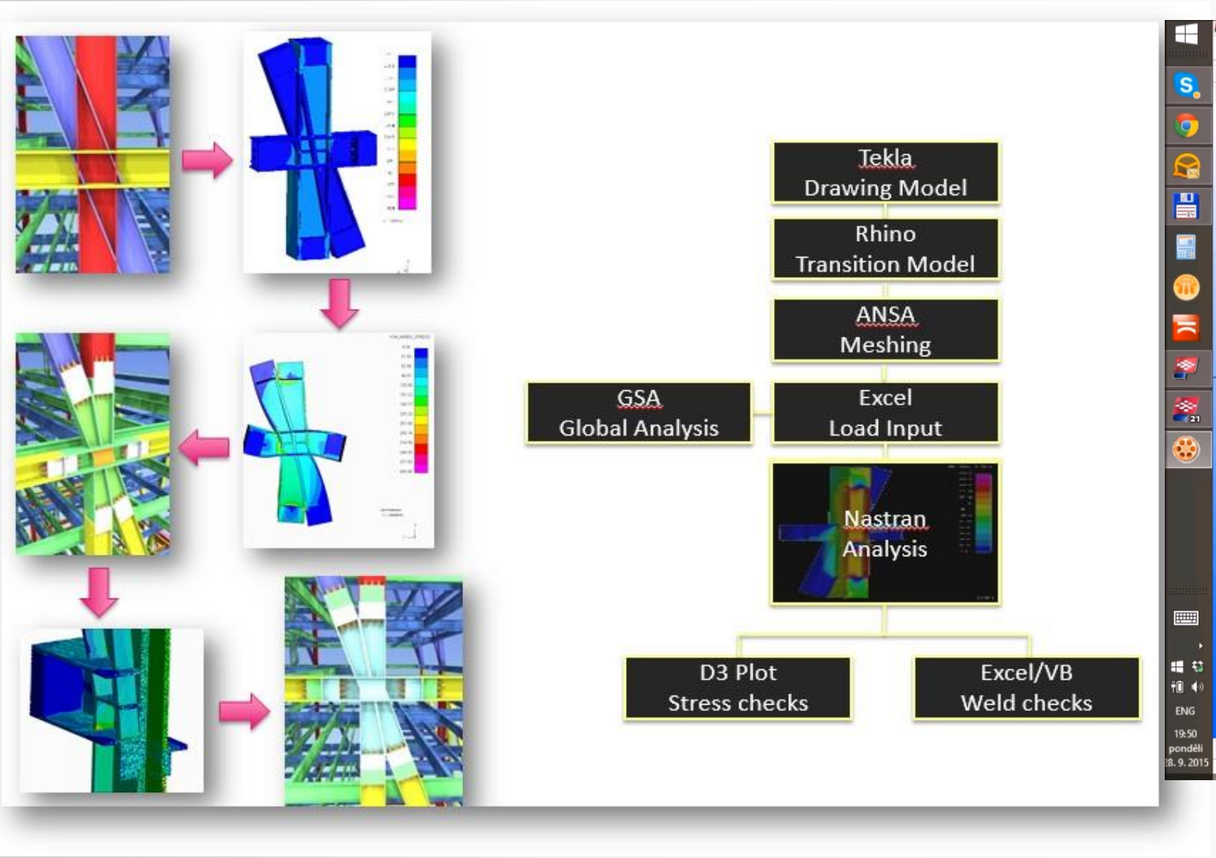
Interoperability Matrix

Matrix of Structural Design and Analysis Tools

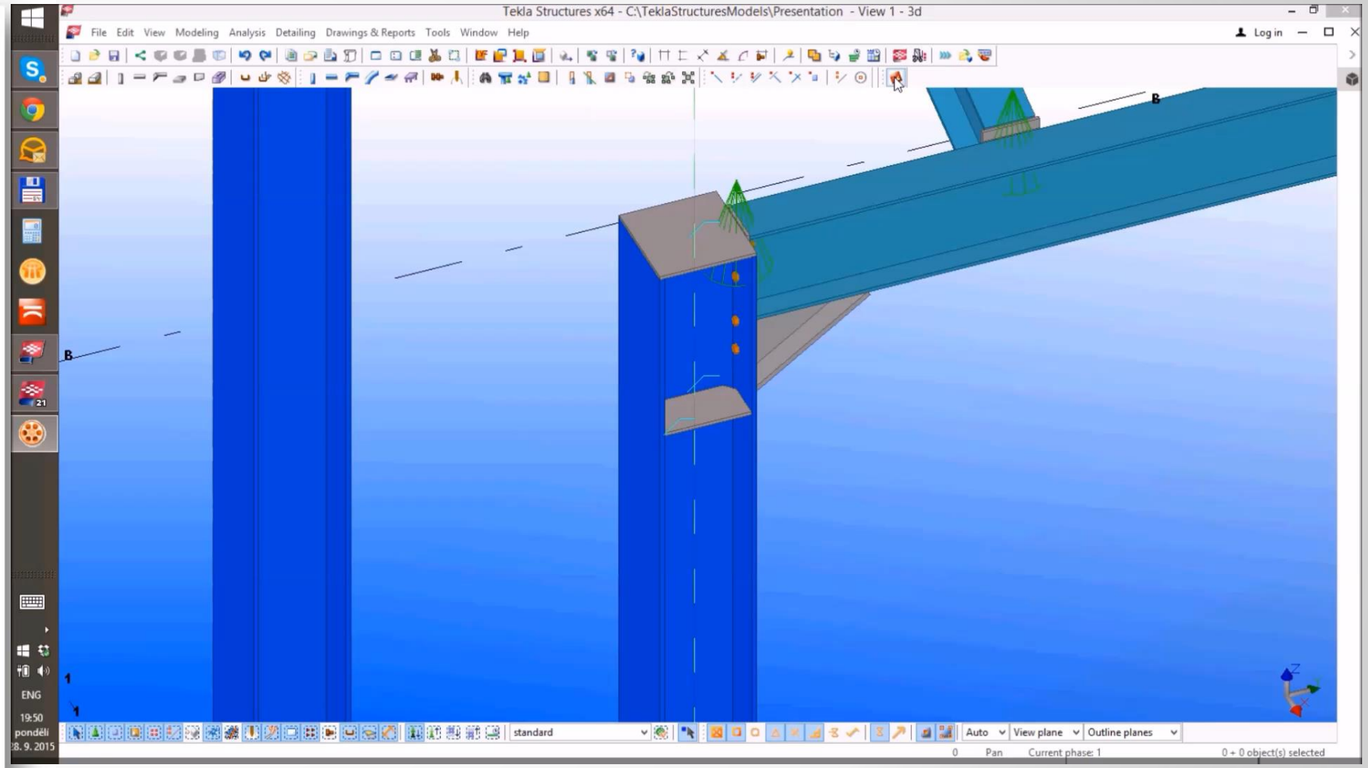
0 = Does not do this 1 = OK with effort or add-in 2 = Yes, standard part of package 3 = Would recommend for this task Software:	Rhino	Etabs	STAAD	SAP-2000	CSI Safe	Sofistik	RAPT	RAM Concept	RAM Structural Systems	GSA: Design	Robot	Midas	Tekla Structural Designer	RISA	Design Link	
Topic - Assume it's "Analysis AND Design" U.N.O.)																
Beams																
Cantilevers		2			3		3	2	2				2			
Curved		1			3		0	0	0				1			
Tension/Compression		2			2		0						2			
Columns																
Slanting/Raking		2			2		0	0	2				2			
Member Design							3	0	2				3			
Hangers		2			2		0	0	2				2			
Floors																
Post Tensioned		1			3		2	3	2				0			
Precast		1			3		0	0	2				1			
Composite							0	0	3				2			
Flat Slab		1			3		2	2	2	2			2			
Omnia Planks		1			3		0	2	0				1			
Cracked Sections for Deflections		1			3		3	2	2				1			
Slab edge overhangs		1			3		2	2	2				2			
Punching shear design		1			2			2	2				2			
Foundations																
Piles		1			2				1							
Settlement/Springs		2			2				1							
Soil-Structure interaction		2			3				0							
Cores																
Stick Elements		3			2				2				2			
2D FE		3			2				2				2			
Coupling Beams		2			2				2				2			

Steel Connection Design

Leadenhall back then…



… and what we could do now…



Interoperability | Tips

- Create physical model with analysis in mind
- Don’t expect to create a 100% analytical model in Revit
- Check both physical and analytical models, even when analytical model is not planned for analysis.
  - Eg overlapped walls, beams completely within the slabs etc
- Use Reference lines/planes to help aligning analytical elements
- Use Filters, Use Schedules
- Read the Handout!

Workflow Summary

Structural Delivery – Top 5 Tips

- Minimise double handling of information between Engineer/Draftsperson
- Make use of the data – Use excel or database as a repository
- Don’t over document – Detail only special and use typical details where possible
- Only produce drawings when you have to. Use the model as a communication tool
- Don’t double model – discuss with Architect how to share ownership of columns, walls, slabs

The Future is now

- Bi-directional interoperability between analysis and documentation

How accurate does your analysis model need to be?

- Roles and responsibilities will change

Upskilling of everyone involved in design, construction and operation

- Low hanging fruit

Quantities, Design Checks, Sustainability assessments – just do it!

- Digital Mark Ups

If using tools such as Bluebeam do we need to “cad up” details?

- Parametric Modelling

Is it becoming normal practice on all buildings?

- The 5D Quantity Surveyor

Will every QS price from the model instead of drawings? Why don’t we?

Interoperability and Workflow

Any questions?

Be heard! Provide AU session feedback.

- Via the Survey Stations, email or mobile device.
- AU 2016 passes awarded daily!
- Give your feedback after each session.
- Give instructors feedback in real-time.