



University of
Salford
MANCHESTER

BIM Theory and Practice

By: Solomon Tesfaye

Project Description

Project Title:

Surf Central
Headquarters for surf life saving South Australia

Design:

HAMES SHARLEY

Consultants:

Project manager	ECPM
Civil engineer	CPR engineers
Structural engineer	CPR engineers
Building services	BCA engineers
Cost consultant	Rider Levett Bucknall
Acoustic engineer	VIPAC
Certification	Katnich Dodd
Surveyor	Lock surveys

Year:

2011



Fig.1. Project Location



(a)



(b)

Fig.2. (a) & (b) Life Surf Building after construction Source: Google Earth Pro 



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- BIM Dimensions
- BIM Uses
- ISO 19650 and RIBA plan of work
- 3D Model check & information analysis
- Model Check using Solibri
- Clash detection using Navisworks
- 3D Model health check
- 4D Scheduling using Synchro
- 5D Cost Estimating using Navisworks
- 6D COBie - Facility Management
- 7D Sustainability
- 8D Health and Safety and Accessibility
- Findings
- Effects of Findings on the Project Development
- Recommendations
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50



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55

BIM DIMENSIONS



3D BIM is a digital geometric model that constitutes an X, Y and Z axis associated with further information.



4D BIM is adding scheduling information to model construction sequences.



5D BIM is generally considered to be adding cost information to a model.



6D BIM is considered by some to be adding facility management to the information set.



7D BIM is considered by some to be adding sustainability information to the information set.



8D BIM is considered by some to be adding health and safety information to the information set.

BIM

DIMENSIONS

USES



A BIM Use can be defined as "a method of applying Building Information Modeling during a facility's lifecycle to achieve one or more specific objectives." BIM uses can be categorized mainly according to the objectives of utilizing BIM during the entire lifespan of a facility. Besides the purpose itself, multiple other traits can be outlined to effectively pinpoint and convey a BIM Use (Kreider & Messner, 2013).

Therefore, the project Surf Life will be explored according to the BIM uses.

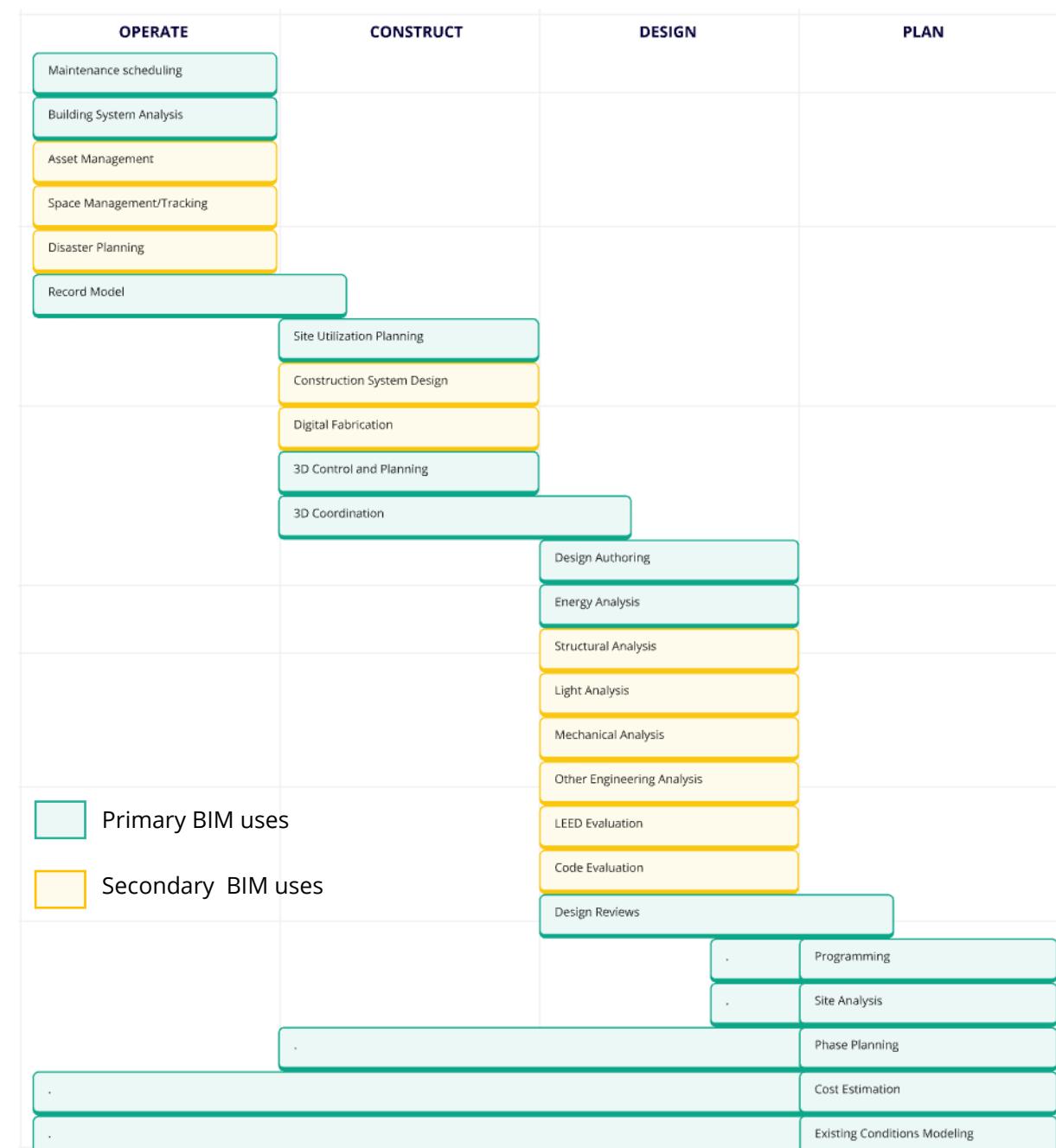
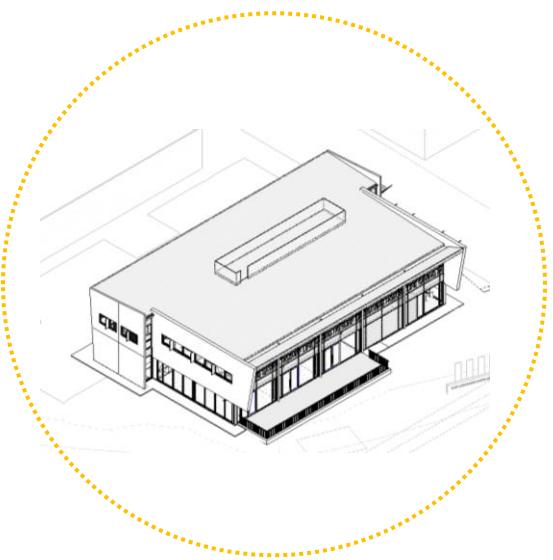


Fig. 3. BIM Uses throughout a Building Lifecycle (organized in reverse chronological order from project implementation). Source: Computer Integrated Construction Research Program, 2010.





ISO 19650 is an international standard for managing information during the lifecycle of a building or infrastructure asset using Building Information Modelling (BIM). ISO 19650 complements the RIBA Plan of Work by providing a structured framework for information management that aligns with each stage of the RIBA process.



Based on the provided information, Surf Life model is at **Stage 5 (Construction)**.

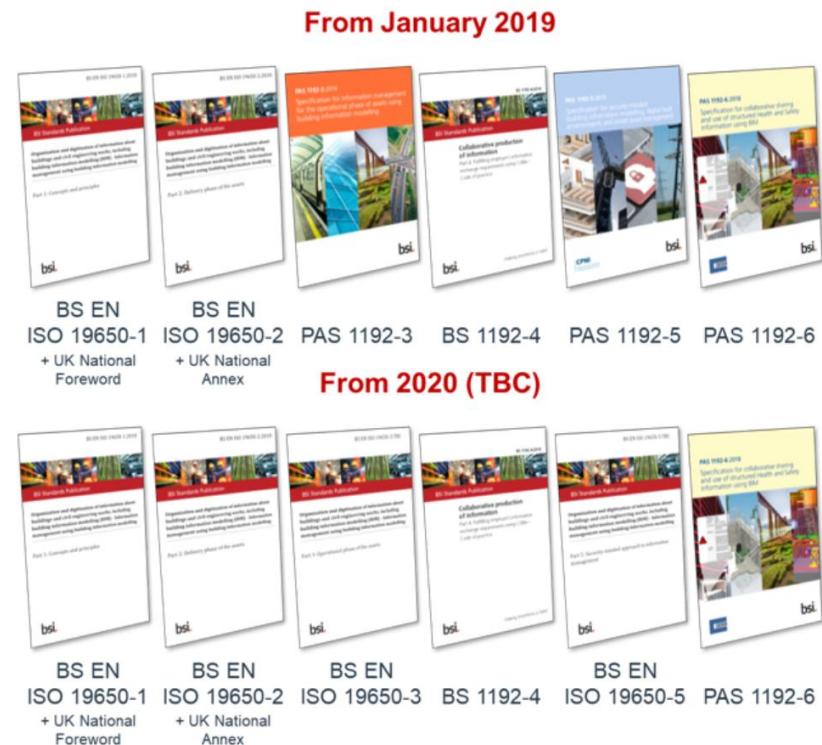


Fig. 4. UK transition of ISO standards. source: RickieJ, 2019.

The RIBA Plan of Work is a structured format that outlines the stages involved in construction projects, mainly in the UK. Developed by the Royal Institute of British Architects, it provides a clear roadmap from project conception to completion and beyond.



Fig. 5. RIBA Plan of Work. source: Royal Institute of British Architects, 2020.



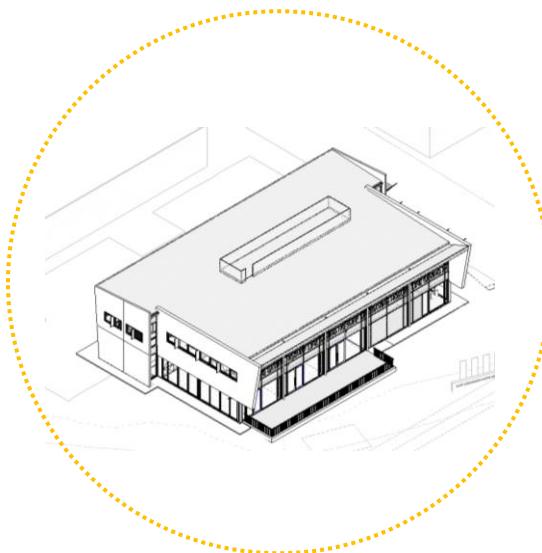
Stage 5 (Construction).

At this stage:

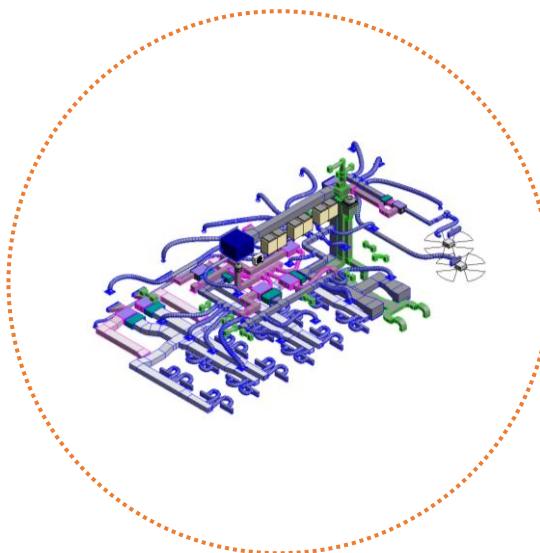
- Validate Project Information Requirement (PIR) against the Exchange Information Requirement (EIR).
- Use a Common Data Environment (CDE) to centralize and manage construction data.
- Update the Project Information Model (PIM) to reflect as-built conditions.
- Maintain real-time coordination and communication among all parties.
- Safeguard sensitive information through security protocols (ISO 19650-5) if any.
- Prepare asset information (AIR) for handover, enabling efficient transition to operations and maintenance.

Clauses	Title	Description
5.1	Assessment and Need	Details the initial assessment of information requirements and the establishment of the project's information management framework.
5.2	Invitation to Tender	Covers the requirements for inviting tenders, including the information to be provided and the criteria for selection.
5.3	Tender Response	Describes the process of responding to tenders, including the preparation and submission of tender responses.
5.4	Appointment	Describes the process of appointing parties and defining their information management responsibilities.
5.5	Mobilization	Focuses on the preparation and mobilization of resources to meet the information requirements.
5.6	Collaborative Production of Information	Details the collaborative processes for producing information, including the use of a CDE.
5.7	Information Model Delivery	Outlines the delivery of information models at key stages of the project.
5.8	Project Close-Out	Describes the activities required to close out the project, including the final delivery of information.

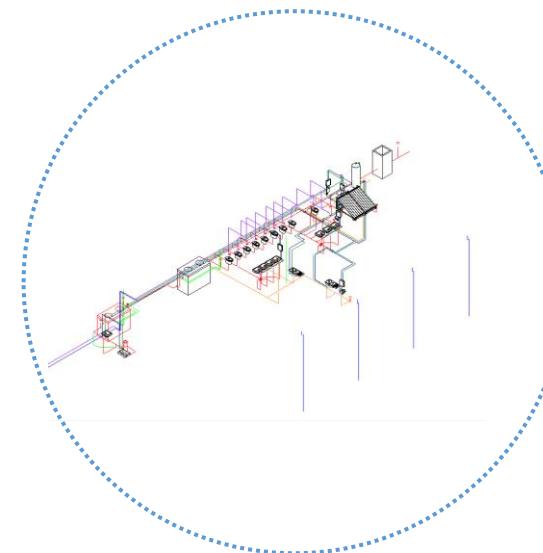
Table 1: ISO 19650-2:2018 Clauses. Source: BSI Standards Publication, 2018.



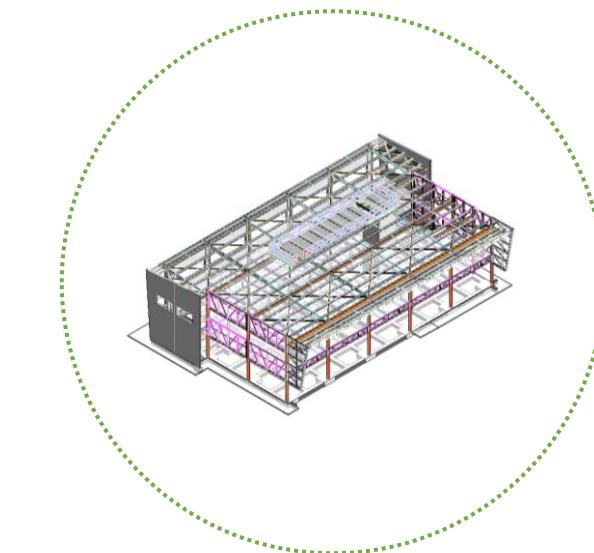
Architectural
3D model check
+ clash detection



HVAC
Clash Detection



Plumbing
Clash Detection



Structural
Clash Detection

**A**

3D Model
Information/Coordin
ation Analysis

**B**

3D Model Health
Check

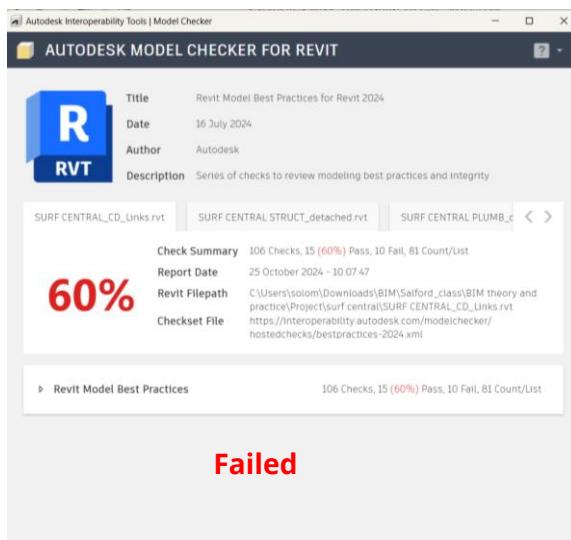




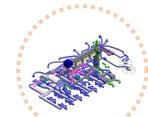
A



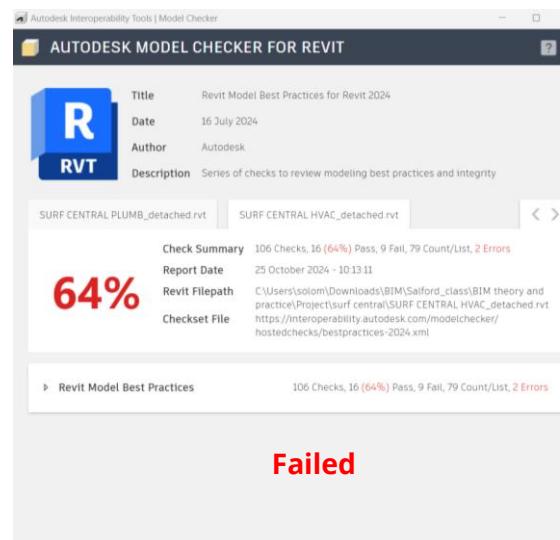
Architectural



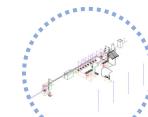
(a)



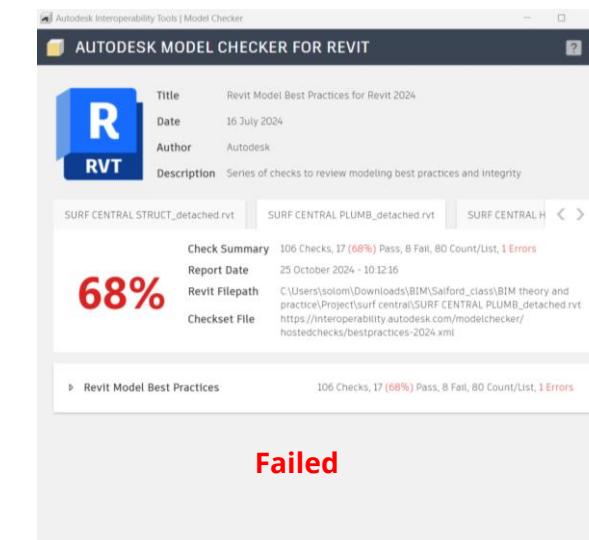
HVAC



(b)



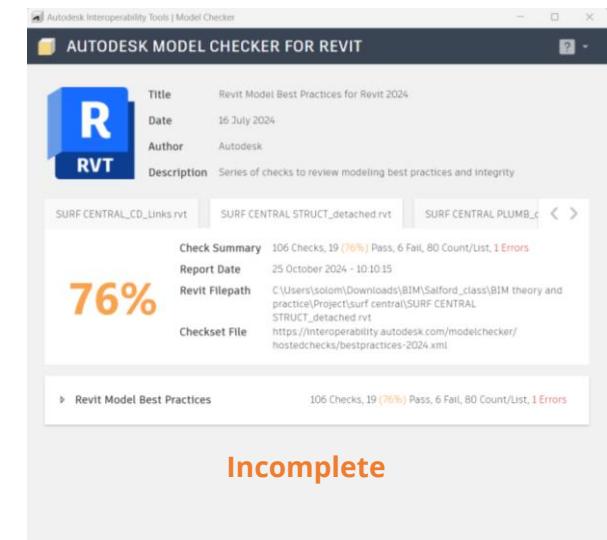
Plumbing



(c)



Structural

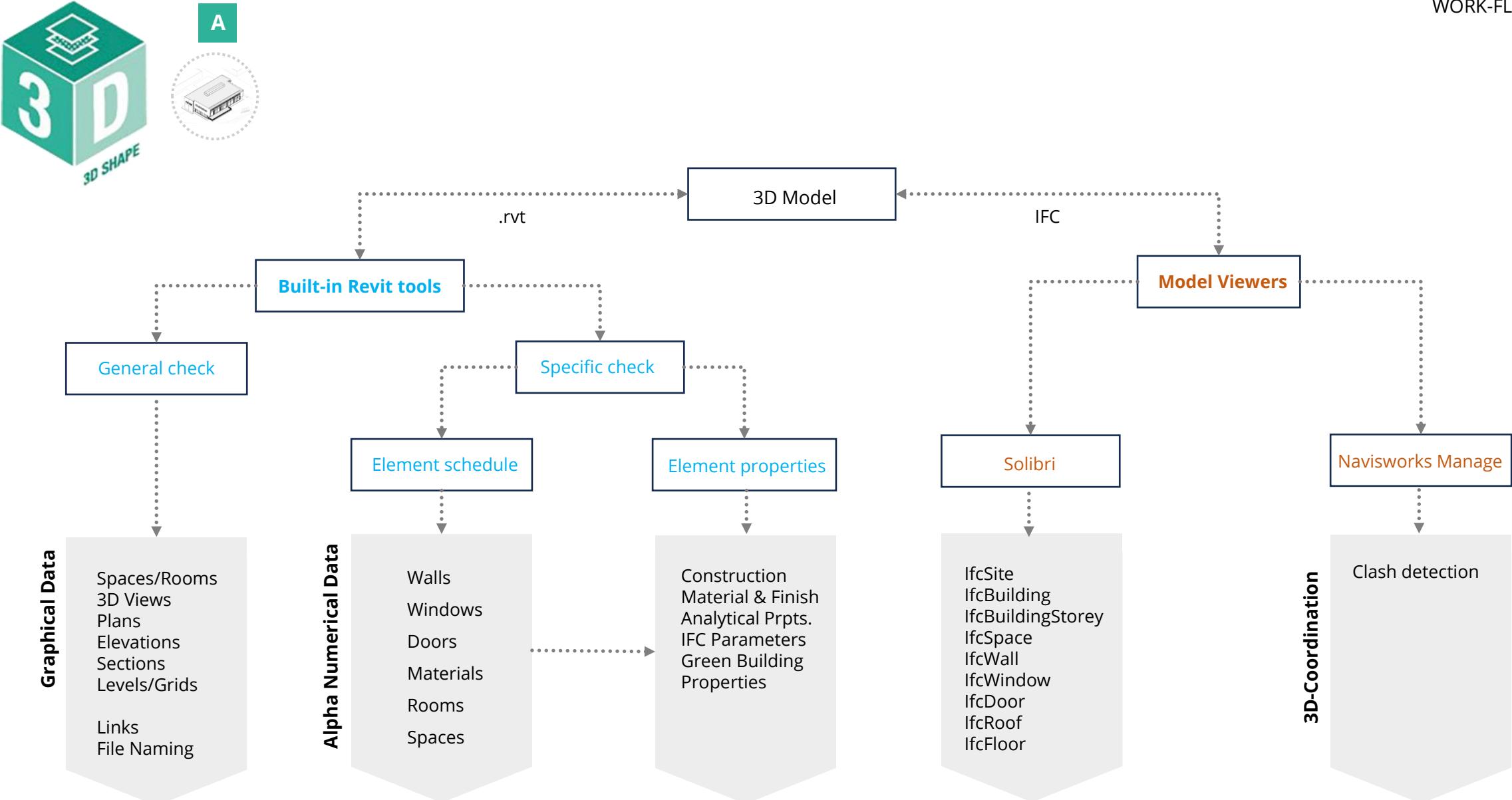


(d)

Revit model checker is used to analyse the information correctness of the federated model by comparing it to **"Revit Model Best Practices for Revit 2024"**.

According to the analysis result, the models didn't satisfy some/most of the ISO 19650 standards that will be investigated in the next slides. **Therefore, for this presentation the Architectural Model is used for further analysis.**

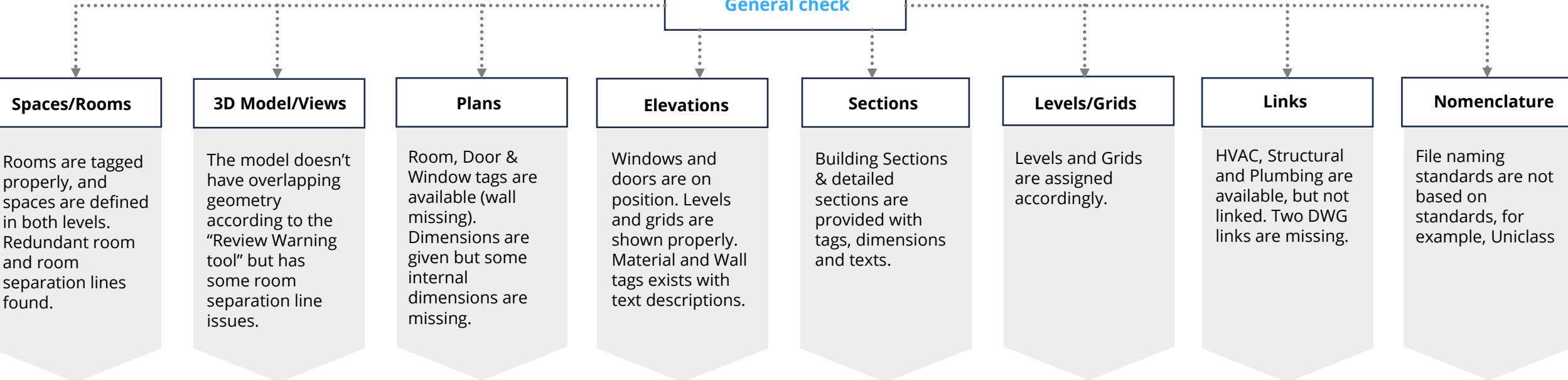
Fig. 6. Percentage result of the compared models. (a) Architectural, (b) HVAC, (c) Plumbing, (d) Structural



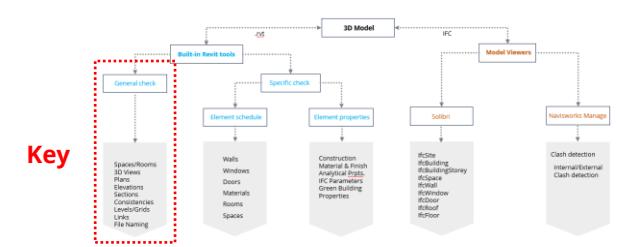
Since the way we produce information in the authoring software affects the rest of the deliverables, it is crucial to check the Revit model thoroughly before exporting it to model viewers to minimize the back-and-forth process. In this sense, I used Revit's built in tools to check the geometry and the metadata.



A

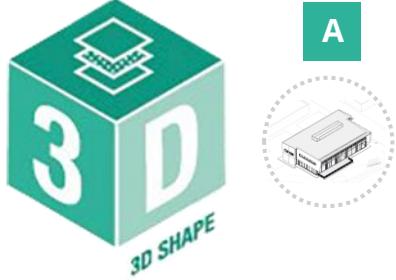


GENERAL CHECK



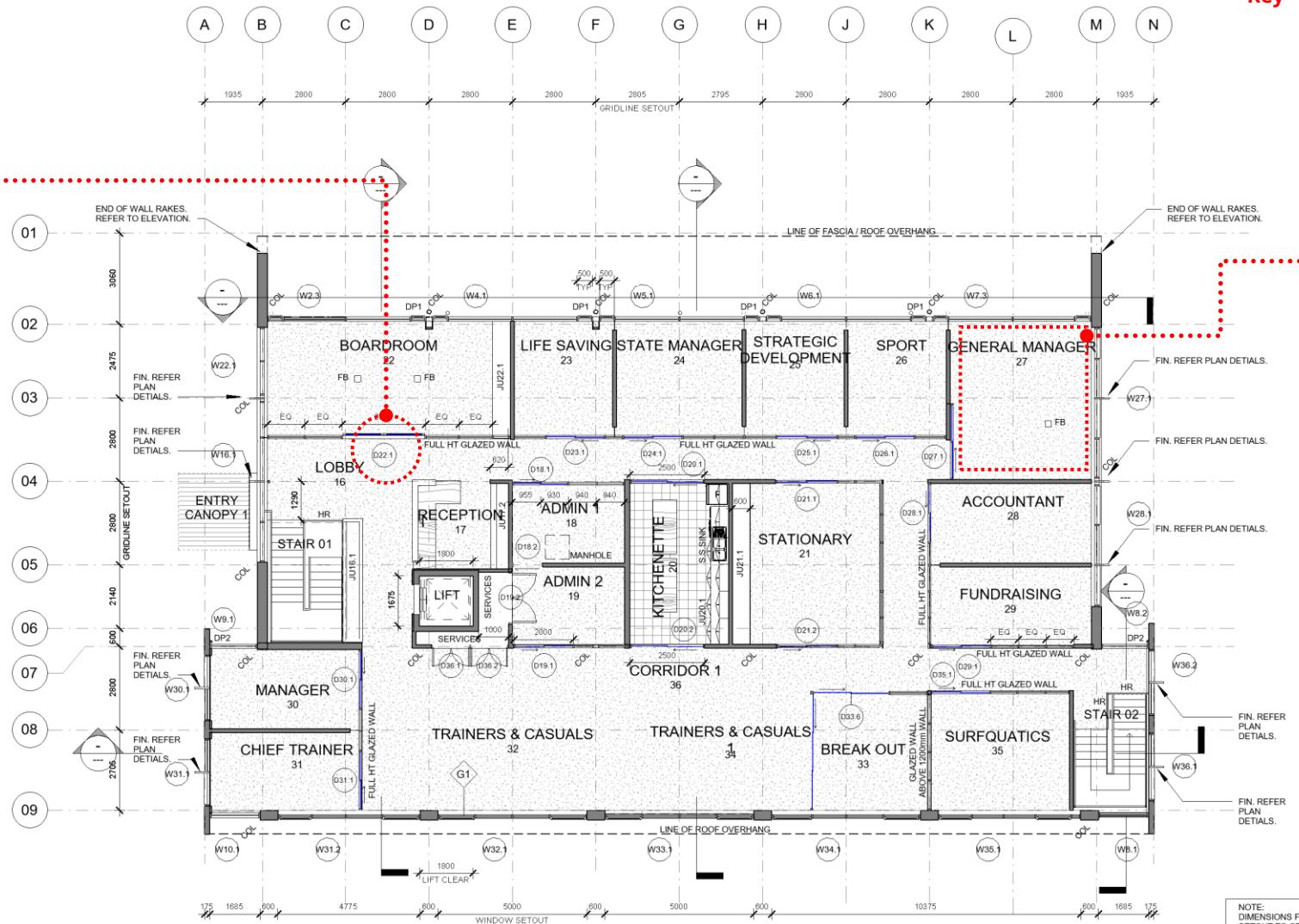
Check Type	Existing	Missing
3D Model/Views	✓	
Elevations	✓	
Sections	✓	
Rooms/Spaces	✓	
Levels/Grids	✓	
Other Models (HVAC, Structure, Plumbing) Nomenclature as per standards	✓	✗

The existing or the missing information during the general check of the 3D model has an impact on the relevant information layers/ BIM dimensions (4D, 5D, 6D, 7D, 8D). The general check also helped to know if the model is ready for coordination as per the ISO 19650.

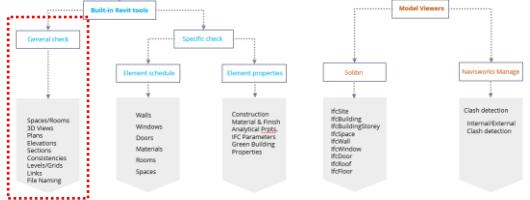


A

Tags windows, doors, and walls enhance **coordination** and ensure **compliance** with ISO 19650 by supporting proper **naming conventions** and efficient **information management** within the **Common Data Environment (CDE)**. They facilitate **scheduling**, **clash detection**, and **data validation**, which align with ISO 19650 requirements for clear **information exchanges** and **quality control** throughout the asset lifecycle.



Key

**Spaces**

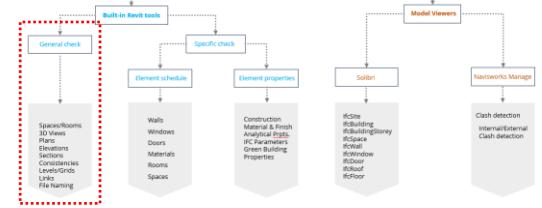
Properly defined spaces support **clash detection**, **coordination**, and **compliance** with **Level of Information Need**. In the operational phase (ISO 19650 Part 3), they provide critical data for **Facilities Management** and align with COBie requirements, ensuring smooth project handovers and long-term asset management.

Fig. 7. First Floor Plan. Source: Surf Life Revit Model.



A

GRAPHICAL DATA - NORTH ELEVATION



Tags and Material description

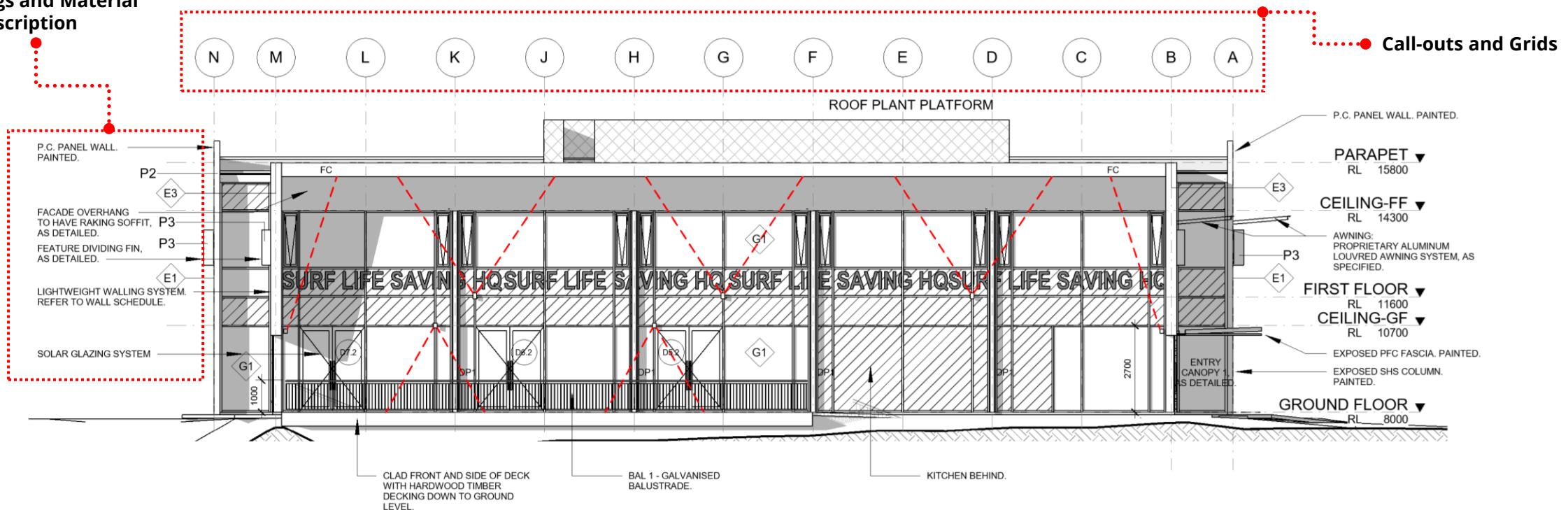


Fig. 8. North Elevation. Source: Surf Life Revit Model.



A

Spaces Properly defined spaces support **clash detection, coordination, and compliance with Level of Information Need**. In the operational phase (ISO 19650 Part 3), they provide critical data for **Facilities Management** and align with COBie requirements, ensuring smooth project handovers and long-term asset management.

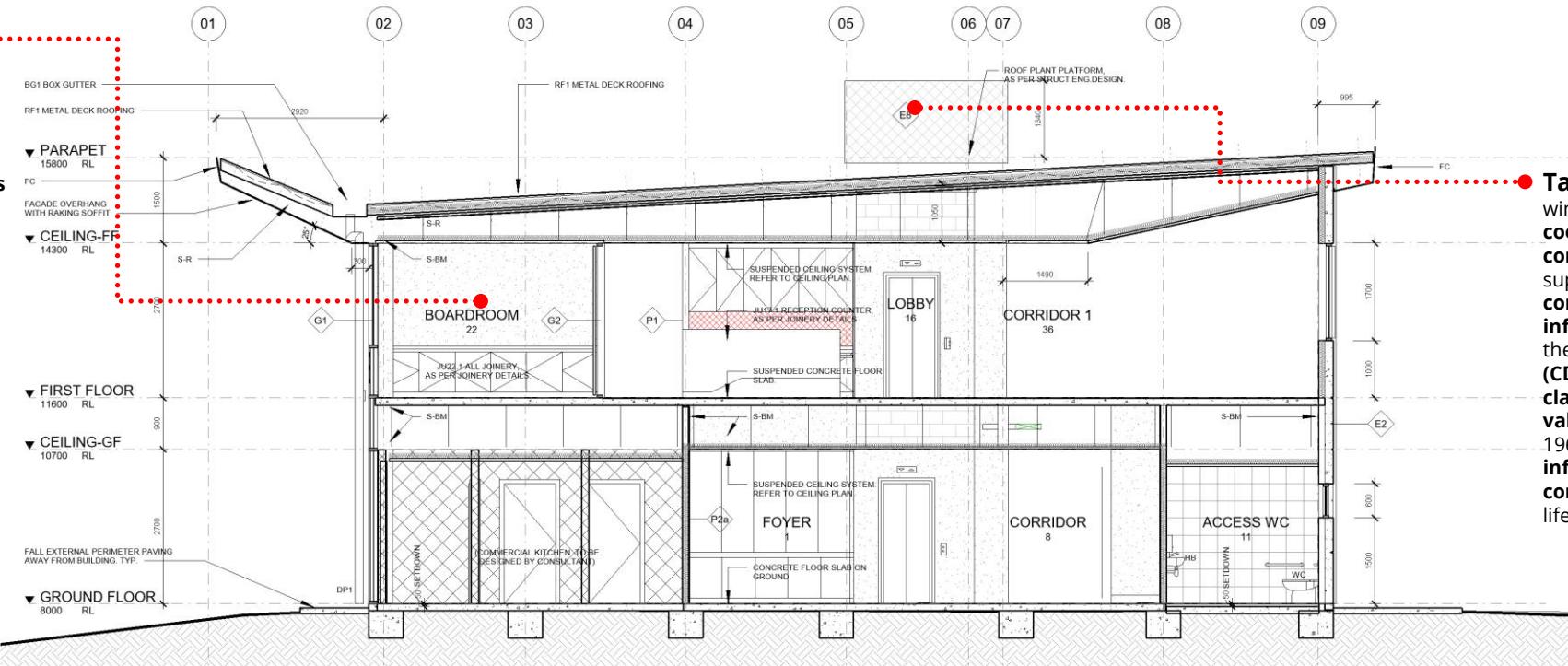
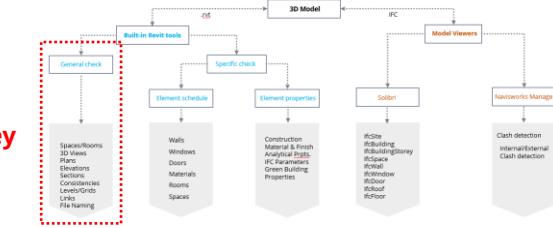


Fig. 9. Section view. Source: Surf Life Revit Model.

GRAPHICAL DATA - SECTION



Tags

windows, doors, and walls enhance **coordination** and ensure **compliance** with ISO 19650 by supporting proper **naming conventions** and efficient **information management** within the **Common Data Environment (CDE)**. They facilitate **scheduling**, **clash detection**, and **data validation**, which align with ISO 19650 requirements for clear **information exchanges** and **quality control** throughout the asset lifecycle.



A



Uniclass

Type Properties

Family: System Family: Basic Wall

Type: E1 -175 mm PC Panel. Painted.

Type Parameters

Parameter	Value
Assembly Description	
Assembly Code	
Type Mark	E1
Fire Rating	
Cost	
IFC Parameters	
Export Type to IFC	Default
Export Type to IFC As	
Type IFC Predefined Type	
Type IfcGUID	0rd9QX3hzD9B\$KWD4_1rSK
Data	
Classification.Uniclass.EF.Description	
Classification.Uniclass.EF.Number	
Classification.Uniclass.Pr.Description	
Classification.Uniclass.Pr.Number	
Classification.Uniclass.Ss.Description	
Classification.Uniclass.Ss.Number	

What do these properties do?

OK Cancel Apply

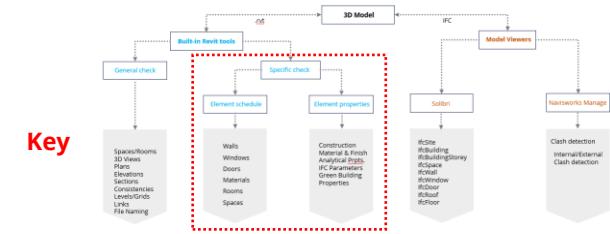
The Surf Life Building did not follow Uniclass standard, however, **ISO 19650-2:2018** mentions the need for classification in managing **information containers (Clause 5.1.7)**, in accordance with **ISO 12006-2**. Uniclass 2015 is compliant with ISO 12006-2 and is the preferred classification system in the UK.

The project did not follow a standard information container format. **ISO 19650-2 (National Annex 2.2)** outlines a standard format for naming and structuring information containers to ensure **consistency, traceability, and accessibility** within the Common Data Environment (**CDE**).

31131-ARC-A-01-DR-A-0001_C01

Project: 31131 Originator: Architecture firm Volume/System: Architectural information Level/Location: Level 1 Type: Drawing Role: Architect Number: 0001 Status: Construction, Revision 1

CLASSIFICATION AND INFORMATION CONTAINERS



Information Containers

STAGE 2
SURF CENTRAL.
Headquarters for Surf Life
Saving SA
Barcoo Rd, West

SHEET

Cover Sheet

DRAWN	TJB	DATE
CHECKED	TPB	SCALE
CAD (Lot 100) Barcoo Road, West Beach. S.A.		
PROJECT No.	DRAWING No.	REVISION
31131	A0.1	G

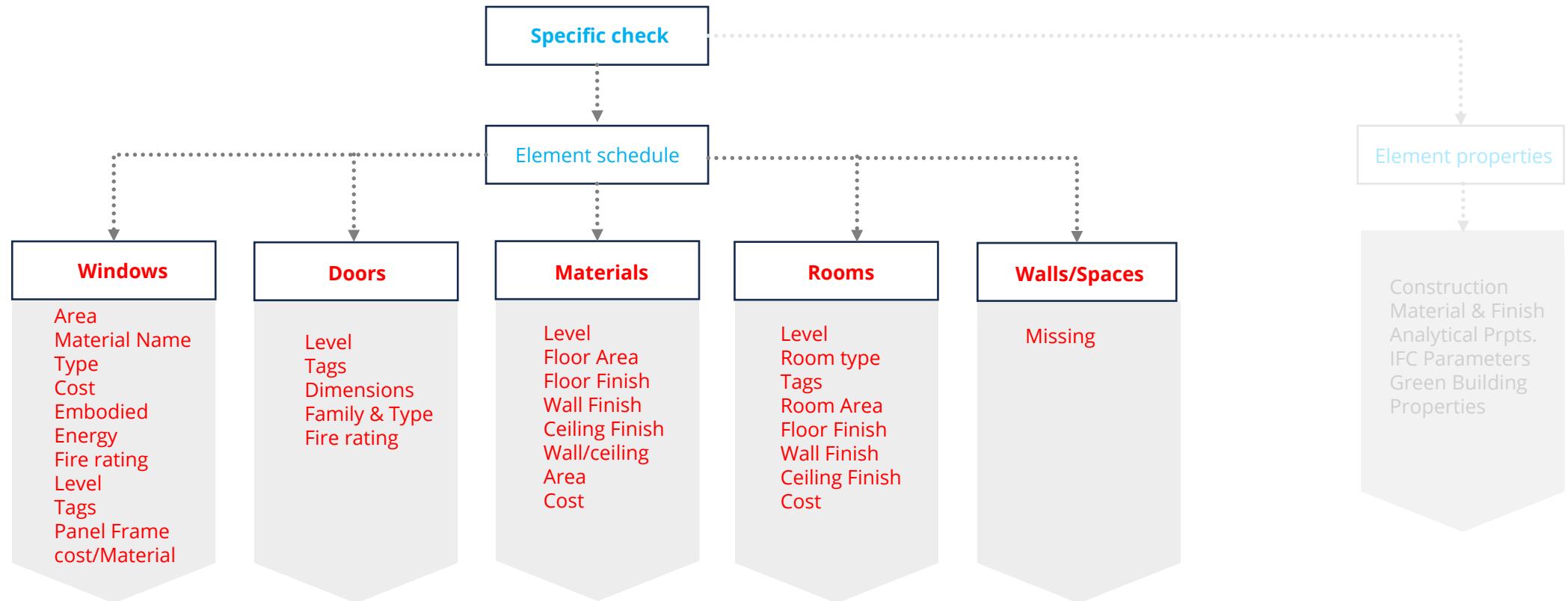
© Copyright.
 Use figured dimensions in preference to scaled.
 All dimensions to be verified and checked on the job.



A



ELEMENT SCHEDULES



ISO 19650 provides standards for managing information throughout a built asset's lifecycle using BIM, focusing on standardized naming, structured data management, and seamless data exchange. **Revit schedules align with ISO 19650** by ensuring **consistent naming conventions, managing data to be current and accessible, and facilitating collaboration** among project stakeholders, enhancing clarity and coordination.



Available information



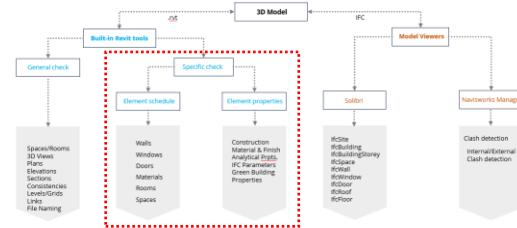
Missing information



A



Key



<Window Schedule>

A	B	C	D	E	F	G	H	I	J	K
Family and Type	Height	Width	Level	Count	Material	Manufacturer	Assembly Code	Thermal Resistance	Heat Transfer Coeffi	Cost
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						
Standard Window (0	0	0	GROUND FLOOR	1						

(a)

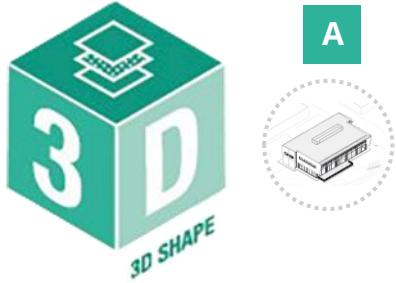
<Door Schedule>

A	B	C	D	E	F	G	H	I	J	K	L
Family and Type	Width	Height	Level	Count	Assembly Code	Fire Rating	Frame Material	Heat Transfer Coeffi	Thermal Resistance	Manufacturer	Cost
0453_Standard Dou	0	0	GROUND FLOOR	1							
0453_Standard Sin	0	0	GROUND FLOOR	1							
0453_Standard Dou	0	0	GROUND FLOOR	1							
Awning_Window-to	0	0	FIRST FLOOR	1							
Awning_Window-to	0	0	FIRST FLOOR	1							
Awning_Window-to	0	0	FIRST FLOOR	1							
Awning_Window-to	0	0	FIRST FLOOR	1							
Awning_Window-to	0	0	GROUND FLOOR	1							
Awning_Window-to	0	0	GROUND FLOOR	1							

(b)

Fig. 10. (a) Window schedule, (b) Door schedule.

The Surf Life project misses important metadata information as shown in Fig 10. This is an indication of **unstructured, inconsistent information** that hinders project organization and communication. It also affects the **PIM** and **AIM** in terms of handover. Moreover, the lack of these metadata **affects facility managers** post-construction maintenance tasks that contradicts with operational standards, ultimately **impacts quality control and project efficiency** in alignment with ISO 19650.



A

<Furniture Schedule>						
A	B	C	D	E	F	G
Family and Type	Level	Assembly Code	Manufacturer	Count	Cost	Description
1800x750_1200x75	FIRST FLOOR			1		
computer: compute	FIRST FLOOR		Tok&Stok	1	685.00	
Office_Chair_withou	FIRST FLOOR	E2020200		1		
1800x750_1200x75	FIRST FLOOR			1		
computer: compute	FIRST FLOOR		Tok&Stok	1	685.00	
Office_Chair_withou	FIRST FLOOR	E2020200		1		
1800x750_1200x75	FIRST FLOOR			1		
computer: compute	FIRST FLOOR		Tok&Stok	1	685.00	
Office_Chair_withou	FIRST FLOOR	E2020200		1		
1800x750_1200x75	FIRST FLOOR			1		
computer: compute	FIRST FLOOR		Tok&Stok	1	685.00	
Office_Chair_withou	FIRST FLOOR	E2020200		1		

(a)

<Wall Schedule>										
A	B	C	D	E	F	G	H	I	J	K
Family and Type	Width	Length	Area	Assembly Code	Manufacturer	Count	Thermal Resistance	Fire Rating	Heat Transfer Coeffi	Cost
Basic Wall: E3 - 9	0	15	62.0			1				
Curtain Wall: G1 -		30	174.5			1				
Basic Wall: P6 - 15	0	10	25.5			1				
Basic Wall: P1 - 92	0	0	3.5			1				
Basic Wall: P2 - 13	0	15	40.0			1				
Basic Wall: E3 - 9	0	15	63.5			1				
Basic Wall: P3 - 92	0	5	12.0			1				
Basic Wall: P3 - 92	0	0	3.0			1				

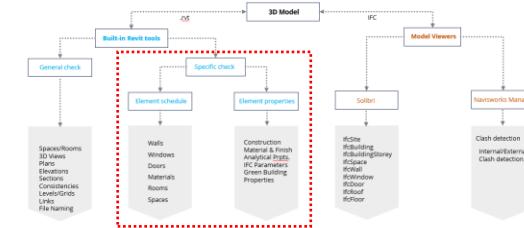
(b)

Data Inconsistency

The figure (Fig 11 (a)) shows **inconsistent data input** for the furniture schedule. Moreover, some of the capture data in this schedule is not available for the other element schedules which compromises **ISO 19650**.

The project misses Wall schedule metadata that can hinder **collaboration** and **consistency** across different teams, leading to **delays, cost overruns**, and potential **misinterpretations**. In addition to that, without wall schedules, **FM** teams may struggle with **maintenance, asset tracking, and compliance tasks**, which affects the project's alignment with **ISO 19650** standards for structured and accessible information.

Fig. 11. (a) Furniture schedule, (b) Wall schedule.





A



Specific check

Element schedule

Windows

- Area
- Material Name
- Type
- Cost
- Embodied Energy
- Fire rating
- Level
- Tags
- Panel Frame cost/Material

Doors

- Level
- Tags
- Dimensions
- Family & Type
- Fire rating

Materials

- Level
- Floor Area
- Floor Finish
- Wall Finish
- Ceiling Finish
- Wall/ceiling Area
- Cost

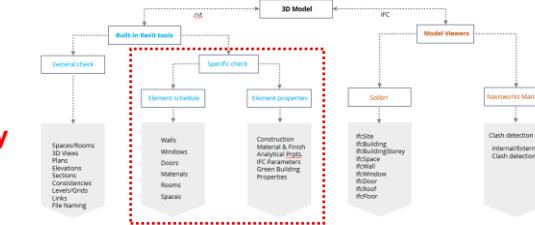
Rooms

- Level
- Room type
- Floor Finish
- Tags
- Room Area
- Floor Finish
- Wall Finish
- Ceiling Finish
- Cost

Walls/Spaces

Missing

Key



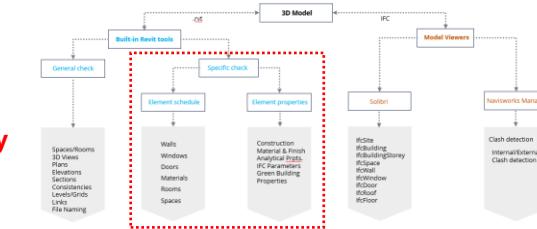
Element properties

Construction
Material & Finish
Analytical Prpts.
IFC Parameters
Green Building
Properties

Walls
Doors
Windows
Floors
Roof



A



Walls

Category	Revit Element Property	Existing	Missing	Affected BIM Dimension
Construction	Structure	✓		4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts	✓		5D (Cost)
Construction	Wrapping at Ends	✓		5D (Cost)
Construction	Width	✓		4D (Scheduling), 5D (Cost)
Construction	Function	✓		4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material	✓		4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)		✗	7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)		✗	7D (Sustainability)
Analytical Properties	Thermal Mass		✗	7D (Sustainability)
Analytical Properties	Absorptance	✓		7D (Sustainability)
Analytical Properties	Roughness	✓		7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image		✗	6D (Facility Management)
Identity Data	Keynote		✗	6D (Facility Management)
Identity Data	Model		✗	5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer		✗	6D (Facility Management)
Identity Data	Type Comments		✗	6D (Facility Management)
Identity Data	URL		✗	6D (Facility Management)
Identity Data	Description		✗	5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description		✗	5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code		✗	4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark		✗	6D (Facility Management)
Identity Data	Fire Rating		✗	8D (Safety), 6D (Facility Management)
Identity Data	Cost		✗	5D (Cost)
IFC Parameters	Export Type to IFC As		✗	6D (Facility Management)
IFC Parameters	Type IFC Predefined Type		✗	6D (Facility Management)
IFC Parameters	Type IFC GUID		✗	6D (Facility Management)
Green Building Properties	Embodied Energy		✗	7D (Sustainability)

Walls

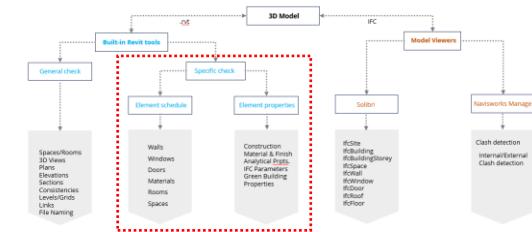
Category	Revit Element Property	Existing	Missing	BIM Dimension
Construction	Structure			4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts			5D (Cost)
Construction	Wrapping at Ends			5D (Cost)
Construction	Width			4D (Scheduling), 5D (Cost)
Construction	Function			4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material			4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)			7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)			7D (Sustainability)
Analytical Properties	Thermal Mass			7D (Sustainability)
Analytical Properties	Absorptance			7D (Sustainability)
Analytical Properties	Roughness			7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image			6D (Facility Management)
Identity Data	Keynote			6D (Facility Management)
Identity Data	Model			5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer			6D (Facility Management)
Identity Data	Type Comments			6D (Facility Management)
Identity Data	URL			6D (Facility Management)
Identity Data	Description			5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description			5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code			4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark			6D (Facility Management)
Identity Data	Fire Rating			8D (Safety), 6D (Facility Management)
Identity Data	Cost			5D (Cost)
IFC Parameters	Export Type to IFC As			6D (Facility Management)
IFC Parameters	Type IFC Predefined Type			6D (Facility Management)
IFC Parameters	Type IFC GUID			6D (Facility Management)
Green Building Properties	Embodied Energy			7D (Sustainability)

Table 2. Wall Property



Construction	Function			4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material	✓		4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)		✗	7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)		✗	7D (Sustainability)
Analytical Properties	Thermal Mass		✗	7D (Sustainability)
Analytical Properties	Absorptance	✓		7D (Sustainability)
Analytical Properties	Roughness	✓		7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image		✗	6D (Facility Management)
Identity Data	Keynote		✗	6D (Facility Management)
Identity Data	Model		✗	5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer		✗	6D (Facility Management)
Identity Data	Type Comments		✗	6D (Facility Management)
Identity Data	URL		✗	6D (Facility Management)
Identity Data	Description		✗	5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description		✗	5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code		✗	4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark	✓		6D (Facility Management)
Identity Data	Fire Rating		✗	8D (Safety), 6D (Facility Management)
Identity Data	Cost		✗	5D (Cost)
IFC Parameters	Export Type to IFC	✓		6D (Facility Management), 4D (Scheduling)
IFC Parameters	Export Type to IFC As		✗	6D (Facility Management)
IFC Parameters	Type IFC Predefined Type		✗	6D (Facility Management)
IFC Parameters	Type IfcGUID	✓		6D (Facility Management)
Green Building Properties	Embodied Energy		✗	7D (Sustainability)

ELEMENT PROPERTIES AND BIM USES



Walls

Category	Revit Element Property	Existing	Missing	BIM Dimension
Construction	Structure			4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts			5D (Cost)
Construction	Wrapping at Ends			5D (Cost)
Construction	Width			4D (Scheduling), 5D (Cost)
Construction	Function			4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material			4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)			7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)			7D (Sustainability)
Analytical Properties	Thermal Mass			7D (Sustainability)
Analytical Properties	Absorptance			7D (Sustainability)
Analytical Properties	Roughness			7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image			6D (Facility Management)
Identity Data	Keynote			6D (Facility Management)
Identity Data	Model			5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer			6D (Facility Management)
Identity Data	Type Comments			6D (Facility Management)
Identity Data	URL			6D (Facility Management)
Identity Data	Description			5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description			5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code			4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark			6D (Facility Management)
Identity Data	Fire Rating			8D (Safety), 6D (Facility Management)
Identity Data	Cost			5D (Cost)
IFC Parameters	Export Type to IFC			6D (Facility Management), 4D (Scheduling)
IFC Parameters	Export Type to IFC As			6D (Facility Management)
IFC Parameters	Type IFC Predefined Type			6D (Facility Management)
IFC Parameters	Type IfcGUID			6D (Facility Management)
Green Building Properties	Embodied Energy			7D (Sustainability)



A

**Doors**

Category	Revit Element Property	Existing	Missing	Affected BIM Dimension
Construction	Structure	✓		4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts	✓		5D (Cost)
Construction	Wrapping at Ends	✓		5D (Cost)
Construction	Width	✓		4D (Scheduling), 5D (Cost)
Construction	Function	✓		4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material	✓		4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)	✗		7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)	✗		7D (Sustainability)
Analytical Properties	Thermal Mass	✗		7D (Sustainability)
Analytical Properties	Absorptance	✓		7D (Sustainability)
Analytical Properties	Roughness	✓		7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image	✗		6D (Facility Management)
Identity Data	Keynote	✗		6D (Facility Management)
Identity Data	Model	✗		5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer	✗		6D (Facility Management)
Identity Data	Type Comments	✗		6D (Facility Management)
Identity Data	URL	✗		6D (Facility Management)
Identity Data	Description	✓		5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description	✗		5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code	✗		4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark	✓		6D (Facility Management)
Identity Data	Fire Rating	✗		8D (Safety), 6D (Facility Management)
Identity Data	Cost	✗		5D (Cost)
IFC Parameters	Export Type to IFC	✓		6D (Facility Management), 4D (Scheduling)
IFC Parameters	Export Type to IFC As	✓		6D (Facility Management)
IFC Parameters	Type IFC Predefined Type			6D (Facility Management)
IFC Parameters	Type IfcGUID	✗		6D (Facility Management)
Green Building Properties	Embodied Energy	✓		7D (Sustainability)

(a)

Windows

Category	Revit Element Property	Existing	Missing	Affected BIM Dimension
Construction	Structure	✓		4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts	✓		5D (Cost)
Construction	Wrapping at Ends	✓		5D (Cost)
Construction	Width	✓		4D (Scheduling), 5D (Cost)
Construction	Function	✓		4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material	✓		4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)	✗		7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)	✗		7D (Sustainability)
Analytical Properties	Thermal Mass	✗		7D (Sustainability)
Analytical Properties	Absorptance	✓		7D (Sustainability)
Analytical Properties	Roughness	✓		7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image	✗		6D (Facility Management)
Identity Data	Keynote	✗		6D (Facility Management)
Identity Data	Model	✗		5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer	✗		6D (Facility Management)
Identity Data	Type Comments	✗		6D (Facility Management)
Identity Data	URL	✗		6D (Facility Management)
Identity Data	Description	✓		5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description	✗		5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code	✗		4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark	✓		6D (Facility Management)
Identity Data	Fire Rating	✗		8D (Safety), 6D (Facility Management)
Identity Data	Cost	✗		5D (Cost)
IFC Parameters	Export Type to IFC	✓		6D (Facility Management), 4D (Scheduling)
IFC Parameters	Export Type to IFC As	✓		6D (Facility Management)
IFC Parameters	Type IFC Predefined Type			6D (Facility Management)
IFC Parameters	Type IfcGUID	✗		6D (Facility Management)
Green Building Properties	Embodied Energy	✓		7D (Sustainability)

(b)

Floors

Category	Revit Element Property	Existing	Missing	Affected BIM Dimension
Construction	Structure	✓		4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts	✓		5D (Cost)
Construction	Wrapping at Ends	✓		5D (Cost)
Construction	Width	✓		4D (Scheduling), 5D (Cost)
Construction	Function	✓		4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material	✓		4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)	✗		7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)	✗		7D (Sustainability)
Analytical Properties	Thermal Mass	✗		7D (Sustainability)
Analytical Properties	Absorptance	✓		7D (Sustainability)
Analytical Properties	Roughness	✓		7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image	✗		6D (Facility Management)
Identity Data	Keynote	✗		6D (Facility Management)
Identity Data	Model	✗		5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer	✗		6D (Facility Management)
Identity Data	Type Comments	✗		6D (Facility Management)
Identity Data	URL	✗		6D (Facility Management)
Identity Data	Description	✗		5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description	✗		5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code	✗		4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark	✓		6D (Facility Management)
Identity Data	Fire Rating	✗		8D (Safety), 6D (Facility Management)
Identity Data	Cost	✗		5D (Cost)
IFC Parameters	Export Type to IFC	✓		6D (Facility Management), 4D (Scheduling)
IFC Parameters	Export Type to IFC As	✓		6D (Facility Management)
IFC Parameters	Type IFC Predefined Type			6D (Facility Management)
IFC Parameters	Type IfcGUID	✗		6D (Facility Management)
Green Building Properties	Embodied Energy	✓		7D (Sustainability)

(c)

Roof

Category	Revit Element Property	Existing	Missing	Affected BIM Dimension
Construction	Structure	✓		4D (Scheduling), 5D (Cost)
Construction	Wrapping at Inserts	✓		5D (Cost)
Construction	Wrapping at Ends	✓		5D (Cost)
Construction	Width	✓		4D (Scheduling), 5D (Cost)
Construction	Function	✓		4D (Scheduling), 6D (Facility Management)
Materials and Finishes	Structural Material	✓		4D (Scheduling), 5D (Cost), 7D (Sustainability)
Analytical Properties	Heat Transfer Coefficient (U)	✗		7D (Sustainability), 6D (Facility Management)
Analytical Properties	Thermal Resistance (R)	✗		7D (Sustainability)
Analytical Properties	Thermal Mass	✗		7D (Sustainability)
Analytical Properties	Absorptance	✓		7D (Sustainability)
Analytical Properties	Roughness	✓		7D (Sustainability), 6D (Facility Management)
Identity Data	Type Image	✗		6D (Facility Management)
Identity Data	Keynote	✗		6D (Facility Management)
Identity Data	Model	✗		5D (Cost), 6D (Facility Management)
Identity Data	Manufacturer	✗		6D (Facility Management)
Identity Data	Type Comments	✗		6D (Facility Management)
Identity Data	URL	✗		6D (Facility Management)
Identity Data	Description	✗		5D (Cost), 6D (Facility Management)
Identity Data	Assembly Description	✗		5D (Cost), 4D (Scheduling)
Identity Data	Assembly Code	✗		4D (Scheduling), 6D (Facility Management)
Identity Data	Type Mark	✓		6D (Facility Management)
Identity Data	Fire Rating	✗		8D (Safety), 6D (Facility Management)
Identity Data	Cost	✗		5D (Cost)
IFC Parameters	Export Type to IFC	✓		6D (Facility Management), 4D (Scheduling)
IFC Parameters	Export Type to IFC As	✓		6D (Facility Management)
IFC Parameters	Type IFC Predefined Type			6D (Facility Management)
IFC Parameters	Type IfcGUID	✗		6D (Facility Management)
Green Building Properties	Embodied Energy	✓		7D (Sustainability)

(d)

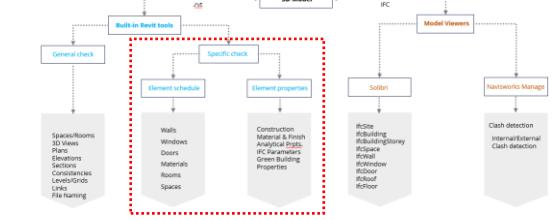
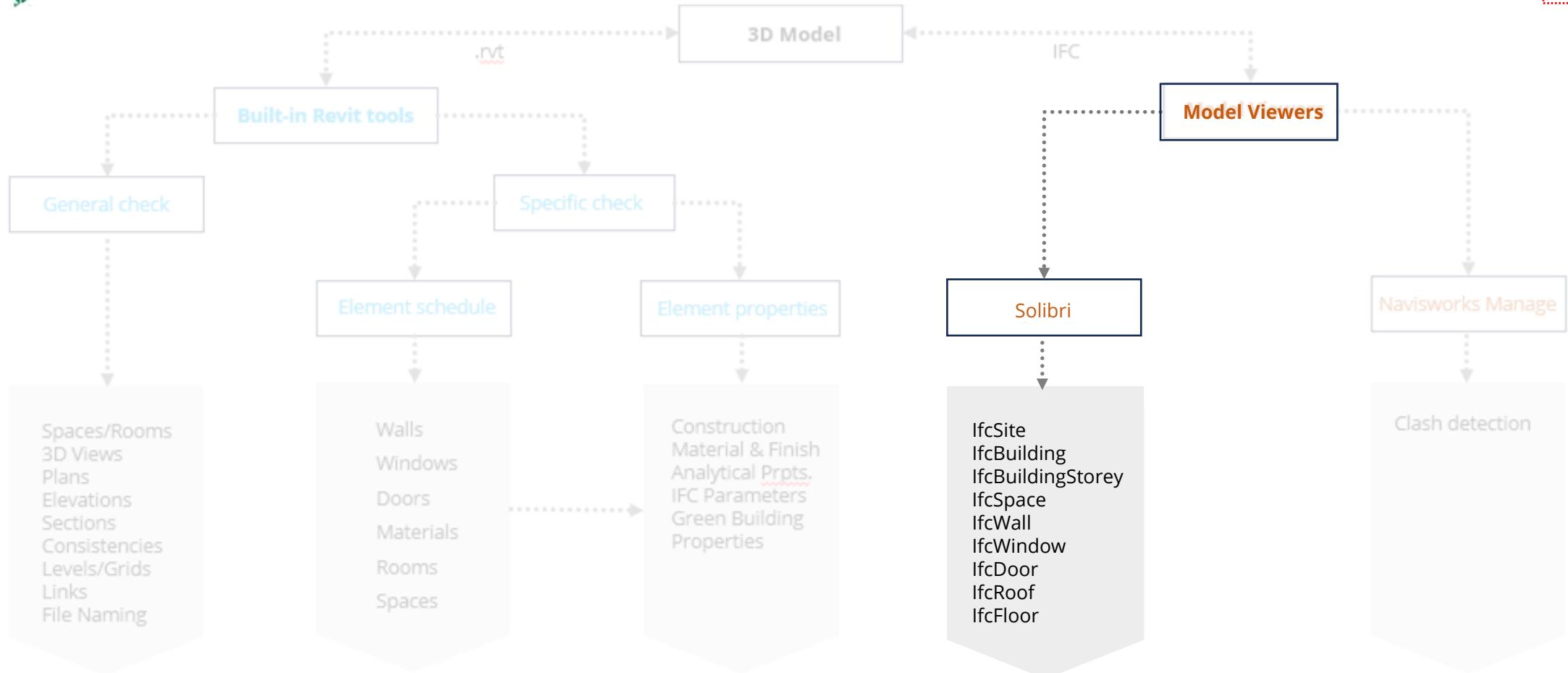


Table 3. (a) Doors Property, (b) Windows Property, (c) Floors Property, (d) Roofs Property.

**A**



A



Conducting a model check in Solibri helps to set up and **run rule sets** to validate the BIM model for various parameters, such as geometry, compliance, data accuracy, BIM Validation, and Fire Safety.

IFC Element	IFC Type Properties	BIM Dimension
IfcSite	Geographic Location, Site Area, Land Use, Topography	4D (Scheduling), 5D (Cost), 7D (Sustainability)
IfcBuilding	Building Name, Function, Building Gross Floor Area	4D (Scheduling), 5D (Cost), 6D (Facility Management)
IfcBuildingStorey	Storey Name, Elevation, Net Floor Area	4D (Scheduling), 5D (Cost)
IfcSpace	Space Name, Space Type (e.g., Room, Hall), Area, Volume	4D (Scheduling), 5D (Cost), 6D (Facility Management)
IfcWall	Wall Type, Material, Fire Rating, Load-Bearing	4D (Scheduling), 5D (Cost), 7D (Sustainability), 8D (Safety)
IfcWindow	Window Type, Width, Height, U-Value, Shading Coefficient	4D (Scheduling), 5D (Cost), 7D (Sustainability), 8D (Safety)
IfcDoor	Door Type, Width, Height, Operation Type, Fire Rating	4D (Scheduling), 5D (Cost), 7D (Sustainability), 8D (Safety)
IfcRoof	Roof Type, Slope, Material, Thermal Resistance (R-Value), Fire Rating	4D (Scheduling), 5D (Cost), 7D (Sustainability), 8D (Safety)
IfcFloor	Floor Type, Thickness, Material, Load-bearing Capacity	4D (Scheduling), 5D (Cost), 7D (Sustainability), 8D (Safety)

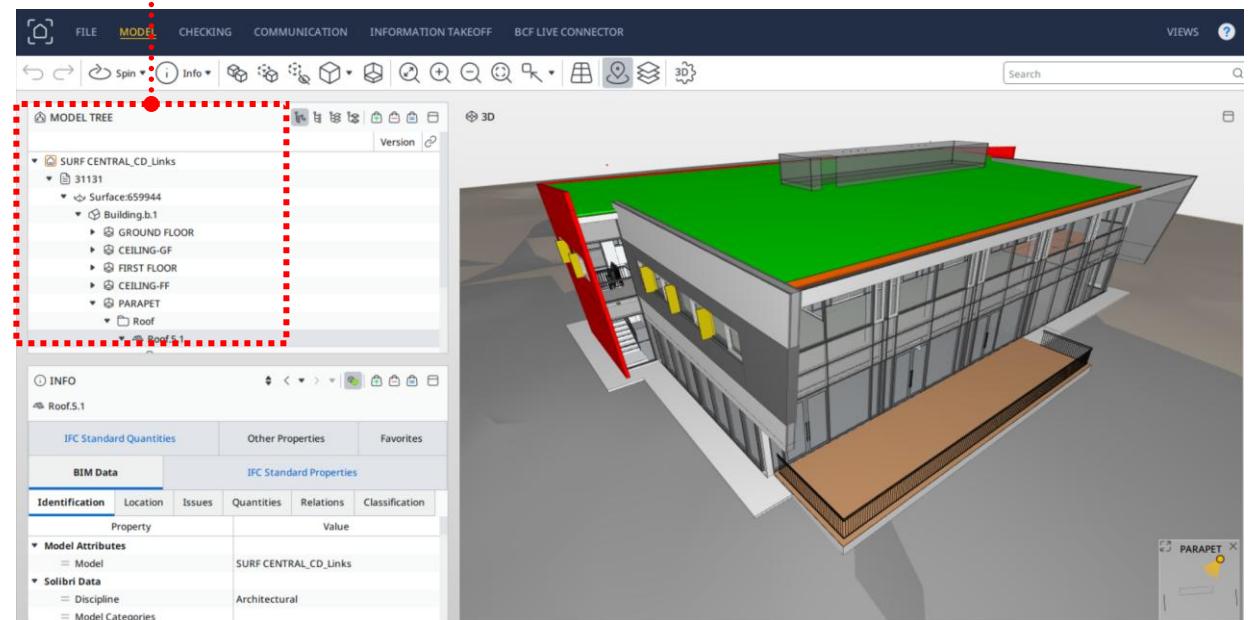


Fig. 14. Model check using Solibri.



A



The Surf Life Building has different levels of issues (missing information) for different Rule-based checks in Solibri. For example, the model has **insufficient metadata for fire safety** or **Escape route analysis**.

(a)

RESULTS

- No Filtering ▾ Automatic ▾
- Check Model Report

Ruleset - Checked Model

- BIM Validation - Architectural
 - Model Structure Check
 - Wall too close to Window component [0/2]
 - P8 - 1800mm High Proprietary toilet partitioning system, as Wall.1.2, Wall.1.17 too close to Window.1.4 component
 - Wall.1.17
 - Wall.1.22
 - Window.1.4
 - P8 - 1800mm High Proprietary toilet partitioning system, as Wall.1.6 too close to Window.1.6 component
 - Wall.1.16
 - Window.1.6

RESULT SUMMARY

Issue Count	△	○	△	×	✓
Issue Count	2	0	0	0	0
Issue Density	0.44	0	0	0	0

INFO

- Clearance in Front of Windows
- Description
- This rule checks there is enough clearance on both sides of windows.
- (Solibri, Inc. - 2021-11-25)
- Support Tag: SOL/226/3.1
- Rule Help

Welcome to Solibri Office

(b)

RESULTS

- No Filtering ▾ Automatic ▾
- Check Model Report

Ruleset - Checked Model

- Inadequate Information [0/1]
 - No Fire Compartments [0/1]
 - Building.b.1
- BIM Validation - Architectural
 - #172 Fire Walls Must Have Correct Wall, Door, and Window Types
 - #179 Escape Route Analysis
 - #238 Accessible Route
 - #236 Horizontal Structures must be Guarded against Falling

RESULT SUMMARY

Issue Count	△	○	△	×	✓
Issue Count	0	1	0	0	0
Issue Density	0	0.22	0	0	0

INFO

- Building.b.1
- BIM Data IFC Standard Properties Other Properties Favorites
- Pset_BuildingStoreyCommon Pset_BuildingSystemCommon Pset_BuildingElementProxyCommon
- Property Value
- IsLandmarked UNKNOWN
- NumberofStores 5
- Reference Project Information

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(c)

RESULTS

- No Filtering ▾ Automatic ▾
- Check Model Report

Ruleset - Checked Model

- Insufficient vertical barriers [0/3]
 - Slab.1.10
 - Slab.3.2
 - Slab.5.1
- Landing components too far [0/2]
 - Slab.1.10
 - Slab.3.4
- Missing barriers [0/6]
 - Slab.1.1
 - Slab.1.10
 - Slab.1.8
 - Slab.3.1

RESULT SUMMARY

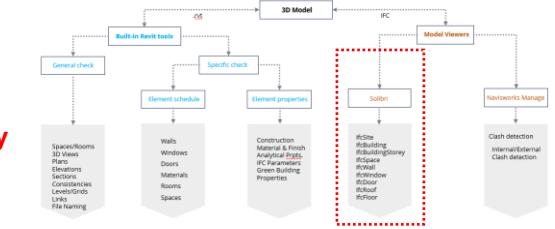
Issue Count	△	○	△	×	✓
Issue Count	0	11	0	0	0
Issue Density	0	2.4	0	0	0

INFO

- Falling from slabs 1 - small drop
- Description
- This rule checks that it is not possible to fall from horizontal components, such as slabs.
- This rule checks that horizontal components are surrounded by vertical components, such as walls, or railings.
- If no vertical component exists on the edge of a horizontal component, another horizontal component needs to continue and drop to the other horizontal component must not be more than specified.
- (Solibri, Inc. - 2018-06-14)
- Support Tag: SOL/236/1.2
- Rule Help

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Key



Rule Check = BIM Validation Architectural

This Ruleset includes rules to validate BIM models in general. This Ruleset does not check intersections between components nor spaces (there are other Rulesets for them).

Rule Check = Fire Walls, Door, and Window

This rule checks that all wall components between different fire zones have correct fire-resistant construction types and that doors and windows in these walls are fire-resistant. It also checks that fire-resistant wall, door, and window types are not used elsewhere.

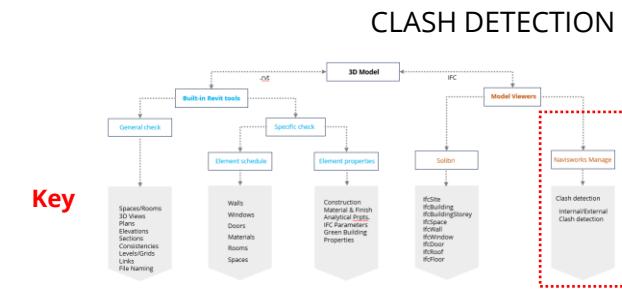
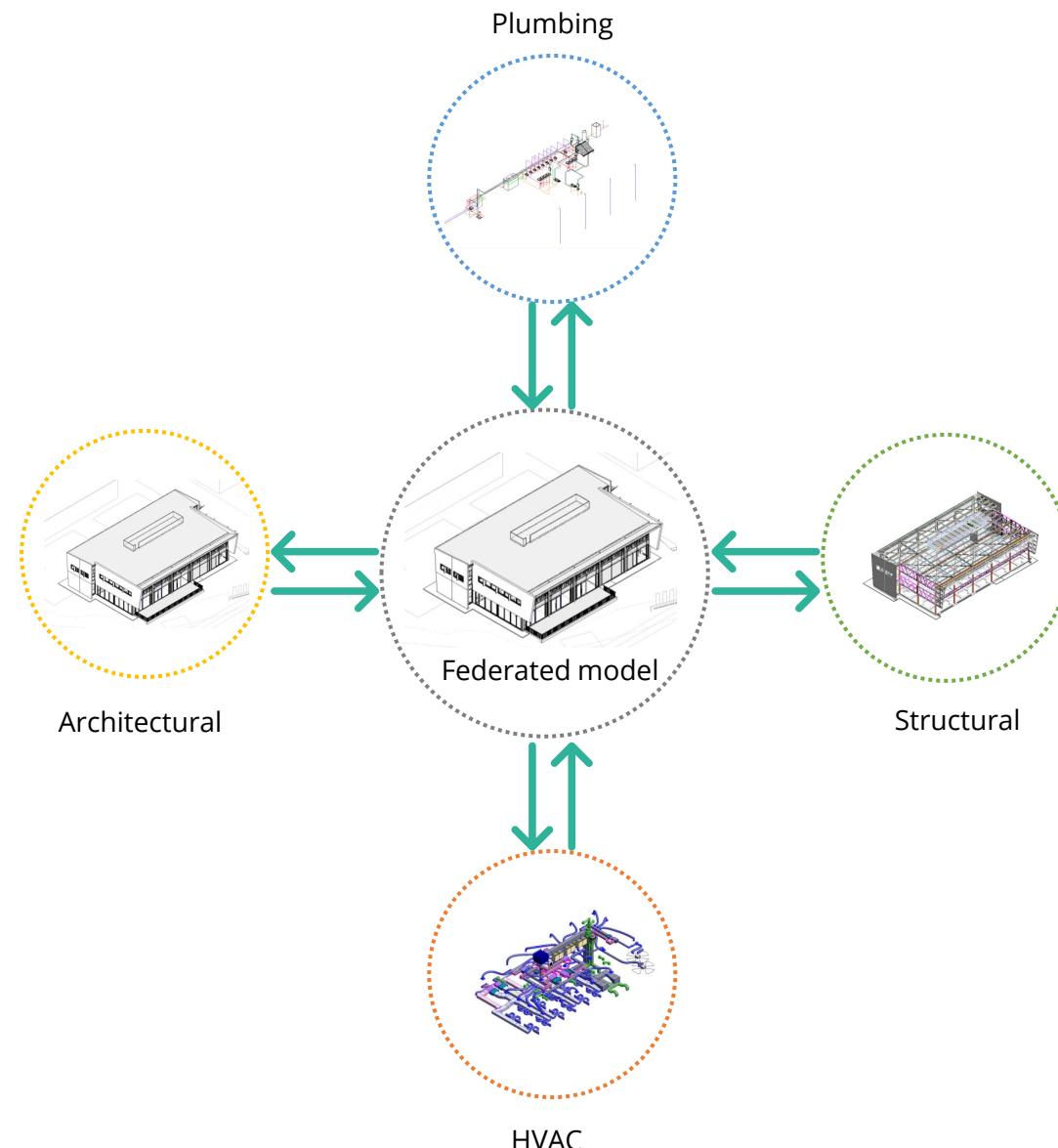
Rule Check = Guarded Against Falling

This rule checks that it is not possible to fall from horizontal components, such as slabs. This rule checks that horizontal components are surrounded by vertical components, such as walls, or railings

Fig. 15. (a) BIM Validation Architectural, (b) Fire Safety check, (c) Guarded Against Falling check.



A



Clash detection at the construction document phase puts an emphasis on improving the completeness of the document to be delivered, while clash detection at the construction phase places an emphasis on the completeness of the structure itself by utilizing the actual results of the constructability review (Seo, Lee, Kim, & Kim, 2012).

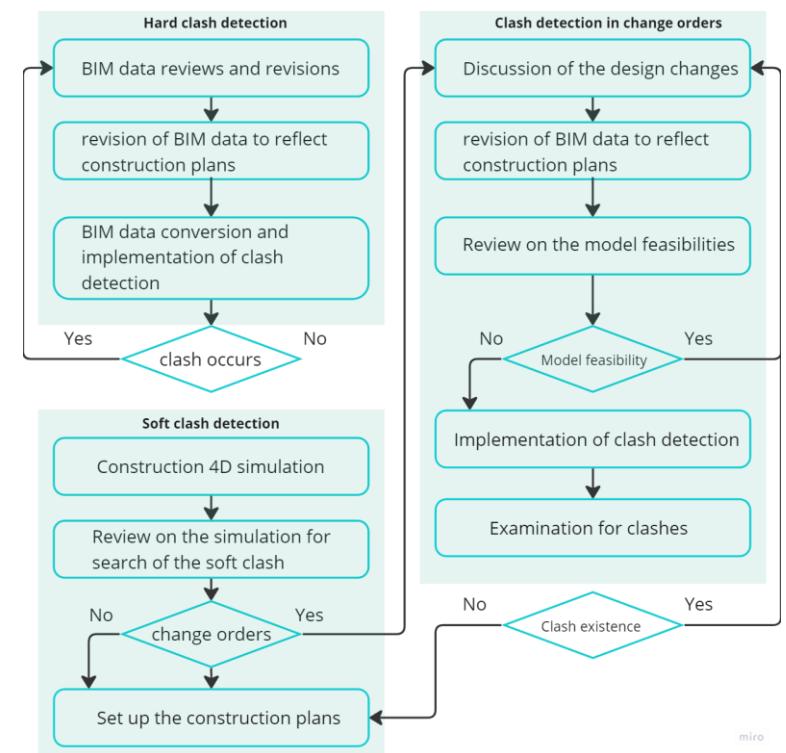
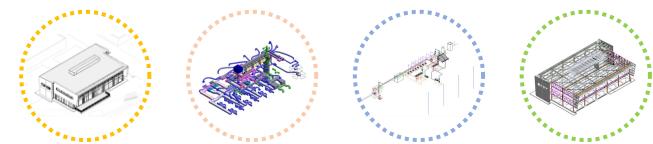


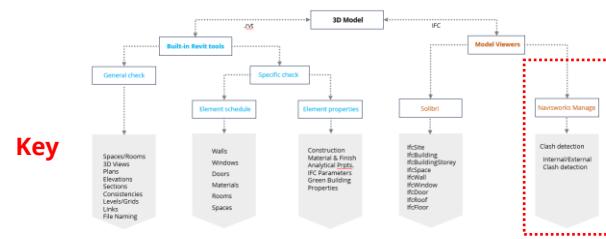
Fig 16. Clash detection workflow at construction phase. Source: Seo et al., 2012.



A



CLASH MATRIX SETUP



Key

		Architecture										HVAC					Plumbing				Structure		
		Arc_Ceilings	Arc_Curtain Panels	Arc_Curtain Wall Mullions	Arc_Doors	Arc_Floors	Arc_Railings	Arc_Roofs	Arc_Stairs	Arc_Walls	Arc_Windows	HVAC_Air Terminals	HVAC_Duct Accessories	HVAC_Duct Fittings	HVAC_Duct Insulations	HVAC_Flex Ducts	Plum_Pipe Accessories	Plum_Pipe Fittings	Plum_Pipes	Plum_Plumbing Fixtures	Str_Structural Columns	Str_Structural Foundations	Str_Structural Framing
Architecture	Arc_Ceilings	-	H	H	O	H	-	H	H	O	O	O	C-50	C-50	C-50	C-50	O	C-50	C-50	O	H	O	H
	Arc_Curtain Panels	-	-	H	H	H	-	-	0	0	-	0	0	0	0	0	O	O	O	O	H	0	H
	Arc_Curtain Wall Mullions	-	-	-	-	-	-	H	0	-	-	-	-	-	-	-	-	-	-	-	H	0	H
	Arc_Doors	-	-	H	-	H	-	0	0	-	-	-	-	0	0	0	O	O	O	O	H	0	O
	Arc_Floors	-	-	-	-	-	-	H	-	-	-	0	0	H	0	H	O	H	H	C-50	O	H	O
	Arc_Railings	-	-	-	-	H	-	-	0	-	-	0	0	0	0	0	O	O	O	O	O	O	O
	Arc_Roofs	-	-	-	-	-	-	-	-	-	H	0	H	0	H	H	O	O	O	C-50	O	H	O
	Arc_Stairs	-	-	-	-	H	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	H
	Arc_Walls	-	H	H	-	H	H	H	-	0	H	O	C-50	C-50	C-50	C-50	H	H	H	H	H	H	H
	Arc_Windows	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	O	O	O	O	O	O	O
HVAC	HVAC_Air Terminals	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	O	O	O	O	-	-	-
	HVAC_Duct Accessories	-	-	-	-	-	-	-	-	-	-	-	0	0	H	H	O	O	O	O	-	-	-
	HVAC_Duct Fittings	-	-	-	-	-	-	-	-	-	-	-	-	0	0	H	H	O	O	O	-	-	-
	HVAC_Duct Insulations	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	H	H	O	O	-	-	-
	HVAC_Ducts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	H	C-50	O	-	-	-
	HVAC_Flex Ducts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plumbing	Plum_Pipe Accessories	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Plum_Pipe Fittings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Plum_Pipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	-	-
	Plum_Plumbing Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Str_Structural Columns	-	-	-	-	-	-	-	-	-	-	H	0	C-50	0	0	O	O	O	O	-	-	H
Structure	Str_Structural Foundations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H	H	0	-	-	-	H
	Str_Structural Framing	-	-	-	-	-	-	-	-	-	-	H	H	H	H	0	H	H	0	-	-	-	-

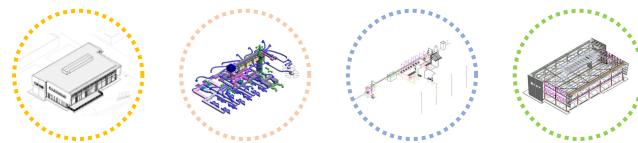
Fig 17. Clash matrix-setup table for Surf Life Building.

Hard clash: A hard clash happens when two systems or components occupy the same space or overlap (Ellis, 2023).

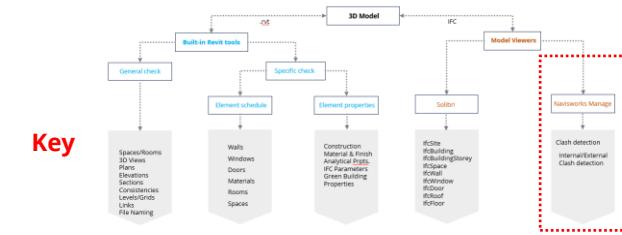
Soft clash: A soft clash (often referred to as a clearance clash) happens when a building element or component lacks sufficient space or buffer to function effectively and safely (Ellis, 2023).



A



CLASH RESULT MATRIX

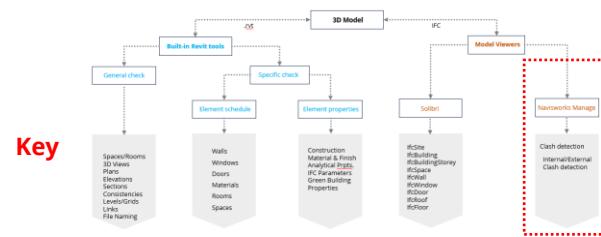
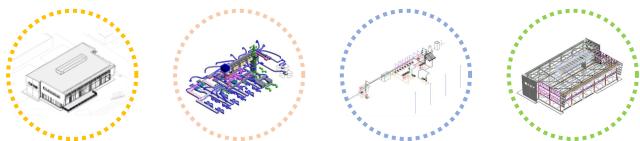


		Architecture												HVAC												Plumbing						
		Arc_Ceilings	Arc_Curtain Panels	Arc_Curtain Wall Mullions	Arc_Doors	Arc_Floors	Arc_Railings	Arc_Roofs	Arc_Stairs	Arc_Walls	Arc_Windows	HVAC_Air Terminals	HVAC_Duct Accessories	HVAC_Duct Fittings	HVAC_Duct Insulations	HVAC_Ducts	HVAC_Flex Ducts	Plum_Pipe Accessories	Plum_Pipe Fittings	Plum_Pipes	Str_Structural Columns	Str_Structural Foundations	Str_Structural Framing									
Architecture	Arc_Ceilings	-	7	26	0	3	-	1	1	74	0	83	0	141	68	94	69	68	0	3	49	0	18	0	20							
	Arc_Curtain Panels	-	15	2	12	-	0	0	-	-	0	0	0	0	0	0	0	0	-	-	-	11	0	6								
	Arc_Curtain Wall Mullions	-	-	-	-	-	5	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	19						
	Arc_Doors	-	-	1	-	16	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0						
	Arc_Floors	-	-	-	-	-	-	1	-	-	-	0	0	0	0	7	0	10	0	12	15	109	4	30	49	44						
	Arc_Railings	-	-	-	-	-	1	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1				
	Arc_Roofs	-	-	-	-	-	-	-	-	-	-	5	0	8	0	27	20	4	0	28	0	15	0	186								
	Arc_Stairs	-	-	-	-	-	4	5	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0			
	Arc_Walls	-	4	34	-	145	3	18	1	-	0	1	0	69	41	60	20	1	4	78	27	34	4	263								
	Arc_Windows	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
HVAC	HVAC_Air Terminals	-	-	-	-	-	-	-	-	-	-	-	0	7	0	15	13	0	0	0	0	0	0	0	-	-	-	-	-	-		
	HVAC_Duct Accessories	-	-	-	-	-	-	-	-	-	-	-	-	0	24	10	0	0	0	0	0	0	0	0	-	-	-	-	-	-		
	HVAC_Duct Fittings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	15	12	0	2	34	0	-	-	-	-	-	-	-	-		
	HVAC_Duct Insulations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	9	29	0	-	-	-	-	-	-	-	-		
	HVAC_Ducts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	3	86	0	-	-	-	-	-	-	-	-		
	HVAC_Flex Ducts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2	37	0	-	-	-	-	-	-	-	-	-		
Plumbing	Plum_Pipe Accessories	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	
	Plum_Pipe Fittings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	0	-	-	-	-	-	-	-	-	-	-	-	
	Plum_Pipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-		
	Plum_Plumbing Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Structure	Str_Structural Columns	-	-	-	-	-	-	-	-	-	-	-	-	1	0	2	0	0	0	0	0	0	0	0	0	18						
	Str_Structural Foundations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	8	0	-	-	-	7								
	Str_Structural Framing	-	-	-	-	-	-	-	-	-	-	-	-	11	1	25	14	0	1	48	0	-	-	-	-	-	-	-	-	-		

Fig 18. Clash result matrix table for Surf Life Building.

Issues:

The Surf Life models (Architecture & Plumbing) contain redundant spaces that might cause a misleading calculation results for BIM 5D and BIM 7D that also affects the budget and the time.

**A**

Clash Detective

Arc_Curtain Panels-vs-Str_Structural Framing

Last Run: 20 October 2024 20:02:30

Clashes - Total: 6 (Open: 6 Closed: 0)

Name	Status	Clashes	New	Active	Reviewed	Approved	Resolved
Arc_Curtain Panels-vs-Str_Structural Found	Done	0	0	0	0	0	0
Arc_Curtain Panels-vs-Str_Structural Framin	Done	6	6	0	0	0	0
Arc_Curtain Wall Mullions-vs-Arc_Floors	Done	0	0	0	0	0	0

Add Test **Reset All** **Compact All** **Delete All** **Update All**

Rules **Select** **Results** **Report**

New Group **Assign** **Items** **None** **Re-run Test**

Name	Approved	Description...	Assigned...	Distance	Start
Clash1	Hard			-0.090 m	
Clash2	Hard			-0.090 m	
Clash3	Hard			-0.039 m	
Clash4	Hard			-0.039 m	
Clash5	Hard			0.014 m	

Highlighting
Item 1 (Red) Item 2 (Green)
Use item colors
Highlight all clashes

Isolation
Dim Other Hide Other

Items

Item 1 (Red): System Panel, Item Name: System Panel, Item Name: System Panel, Item Unit: Feet, Glazed, System Panel.

Item 2 (Green): PFC-Parallel Flange Channels (AS 3679_1), Item Name: PFC-Parallel Flange Channels (AS 3679_1), Item Name: PFC-Parallel Flange Channels (AS 3679_1), Item Unit: Feet.

Quantification Workbook Item Catalog Resource Catalog Find Items Comments TimeLiner Animator Scripter

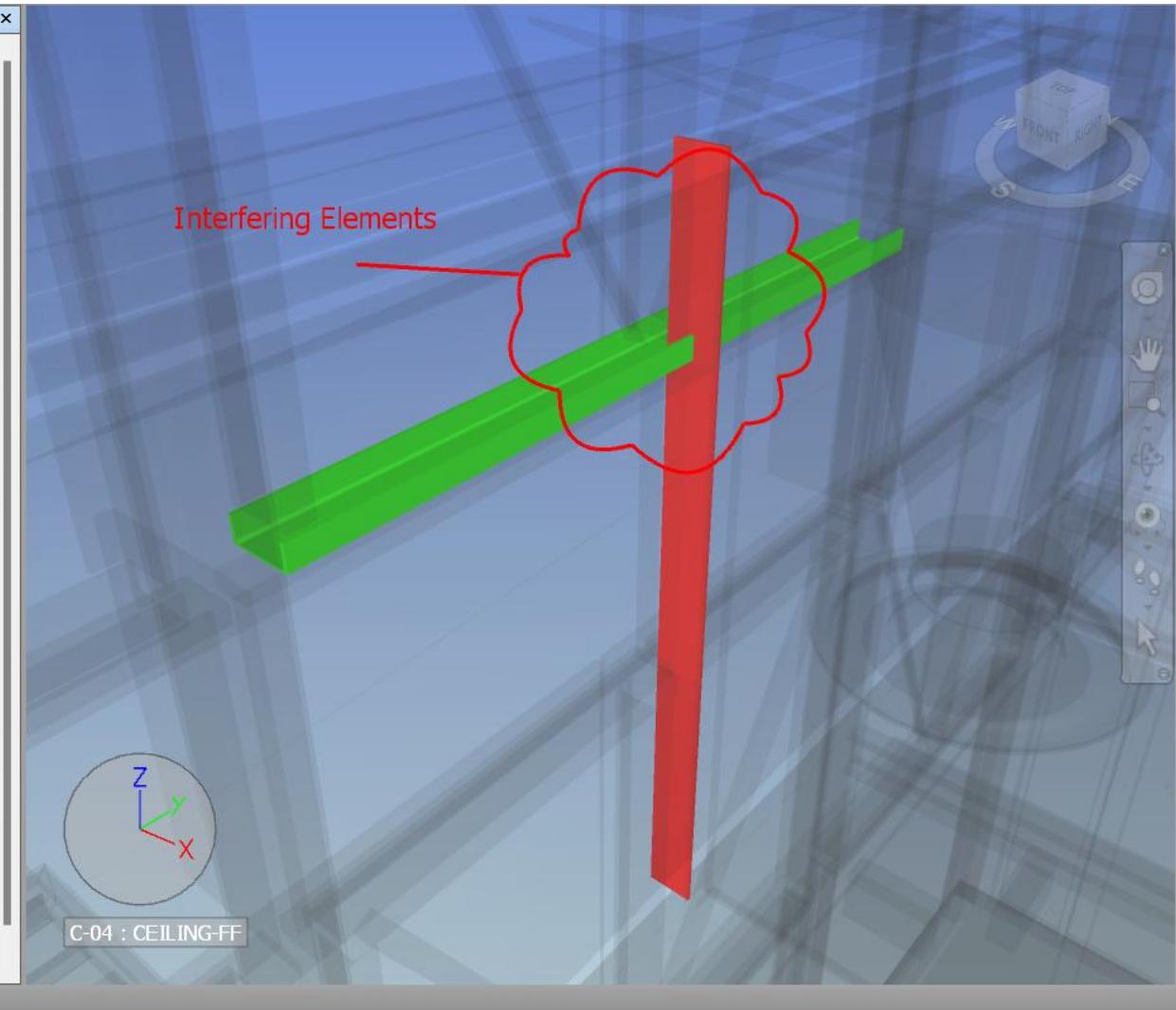
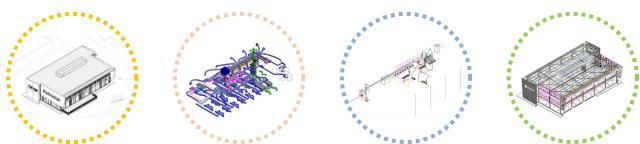


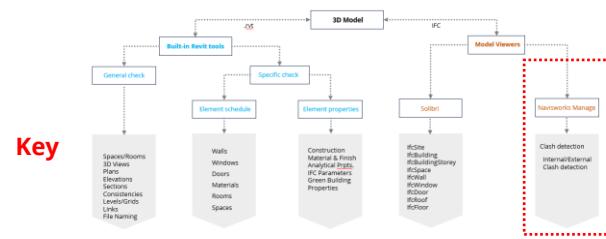
Fig 19. Hard clash, Arc_Curtain Panels-Vs-Str_Structural Framing.



A



CLEARANCE CLASH



Clash Detective

HVAC_Ducts-vs-Plum_Pipes Last Run: 20 October 2024 22:40:57

Clashes - Total: 86 (Open: 86 Closed: 0)

Name	Status	Clashes	New	Active	Reviewed	Approved	Resolved
HVAC_Ducts-vs-Plum_Pipe Fittings	Done	3	3	0	0	0	0
HVAC_Ducts-vs-Plum_Pipes	Done	86	86	0	0	0	0
HVAC_Ducts-vs-Plum_Plumbing Fixtures	Done	0	0	0	0	0	0

Add Test Reset All Compact All Delete All Update All

Rules Select Results Report

New Group Assign

None Re-run Test

Name	Type	Description	Assigned To	Distance	Start
Clash48	Clearance	Solomon	-0.072 m		
Clash49	Clearance	Solomon	-0.053 m		
Clash50	Clearance	Solomon	-0.038 m		
Clash51	Clearance	Solomon	-0.027 m		
Clash52	Clearance	Solomon	-0.025 m		

Items

Item 1 Item 2

Item Name: Rectangular Duct Item Name: Pipe Types
Item Name: Rectangular Duct Item Name: Pipe Types
Item Unit: Feet Item Unit: Feet

Flanged Radius Bend / Shoe Branch HYD-Cold Water
Rectangular Duct Pipe Types

Quantification Workbook Item Catalog Resource Catalog Find Items Comments TimeLiner Animator Scripter

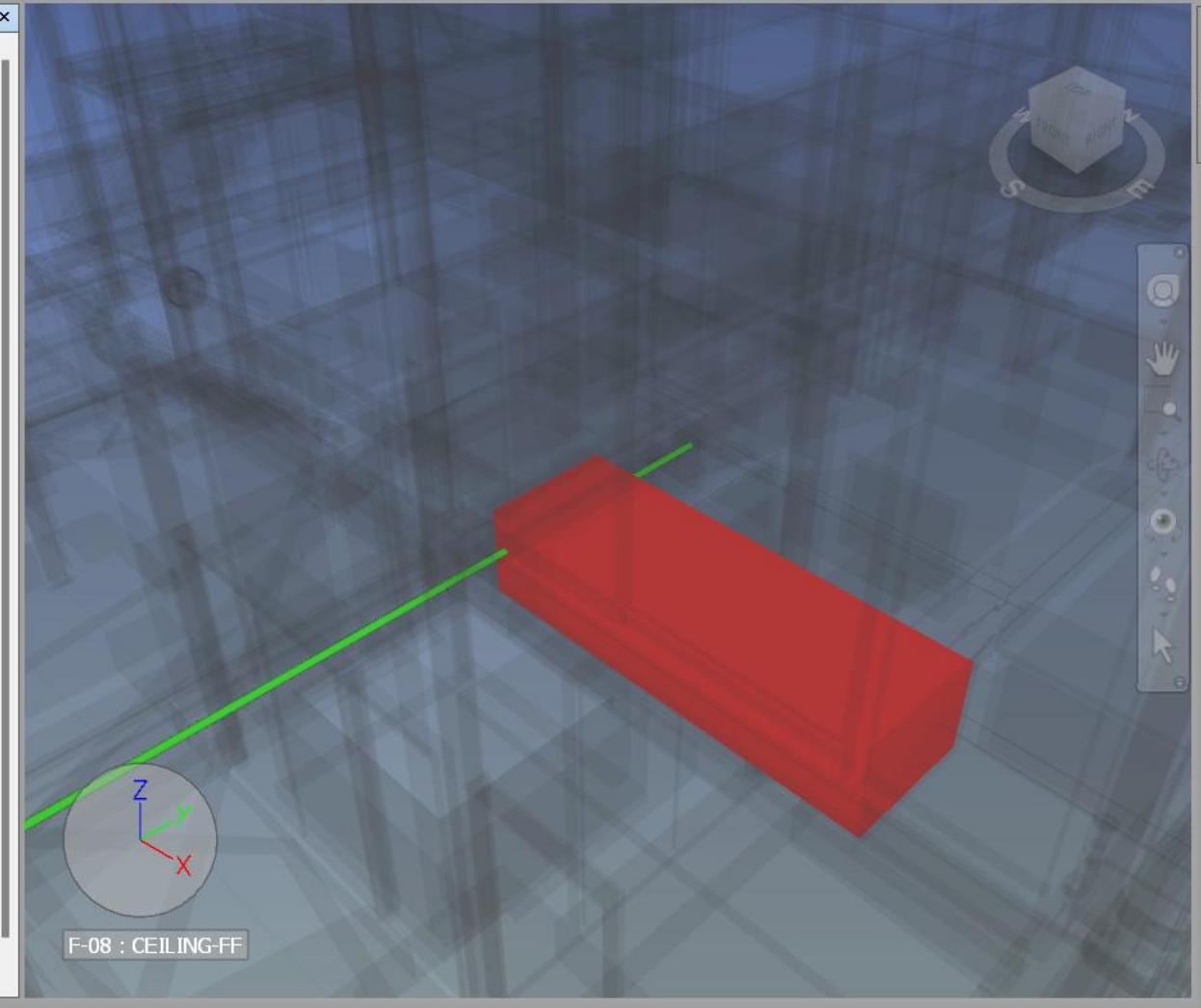
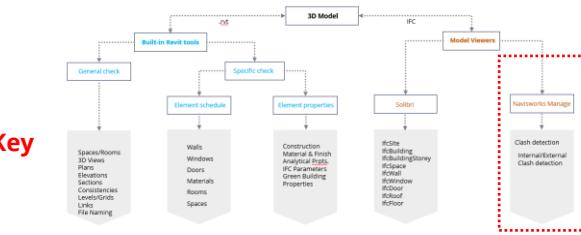
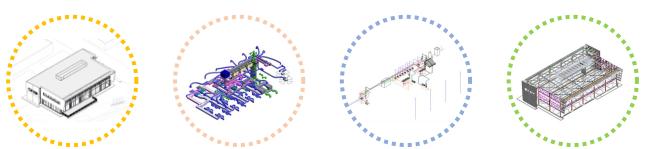


Fig 20. Soft clash, HVAC_Ducts-Vs-Plum_Pipes.



A



AUTODESK® NAVISWORKS® Clash Report

Arc_Ceilings-vs-Arc_Curtain Panels	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.001m	7	7	0	0	0	0	Hard	OK

Image	Clash Name	Status	Distance	Grid Location	Description	Date Found	Assigned To	Item 1				Item 2				Comments			
								Item ID	Layer	Item Name	Item Name	Item Unit	Item ID	Layer	Item Name	Item Name			
	Clash1	New	-0.050	J-06 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:12.236, y:-13.265, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1963597	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.
	Clash2	New	-0.050	J-05 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:12.236, y:-12.387, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1963530	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.
	Clash3	New	-0.050	J-05 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:12.236, y:-10.791, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1963644	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.
	Clash4	New	-0.050	J-04 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:12.236, y:-9.801, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1963919	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.
	Clash5	New	-0.050	J-04 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:12.236, y:-8.628, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1949582	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.
	Clash6	New	-0.016	J-07 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:10.151, y:-14.155, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1950162	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.
	Clash7	New	-0.016	J-07 : FIRST FLOOR	Hard	2024/10/20 19:02	Solomon	x:12.256, y:-14.155, z:14.100	Element ID: 1525401	FIRST FLOOR	Finishes - Interior - Plasterboard (HS)	Finishes - Interior - Plasterboard (HS)	Feet	Element ID: 1949652	FIRST FLOOR	Glass	Glass	Feet	#0 - solom - 2024/10/20 21:44 Assigned to Solomon _____ Please fix these clashes.

Fig 21. Clash Report.



A

TASK PRIORITY – ALL CLASHES

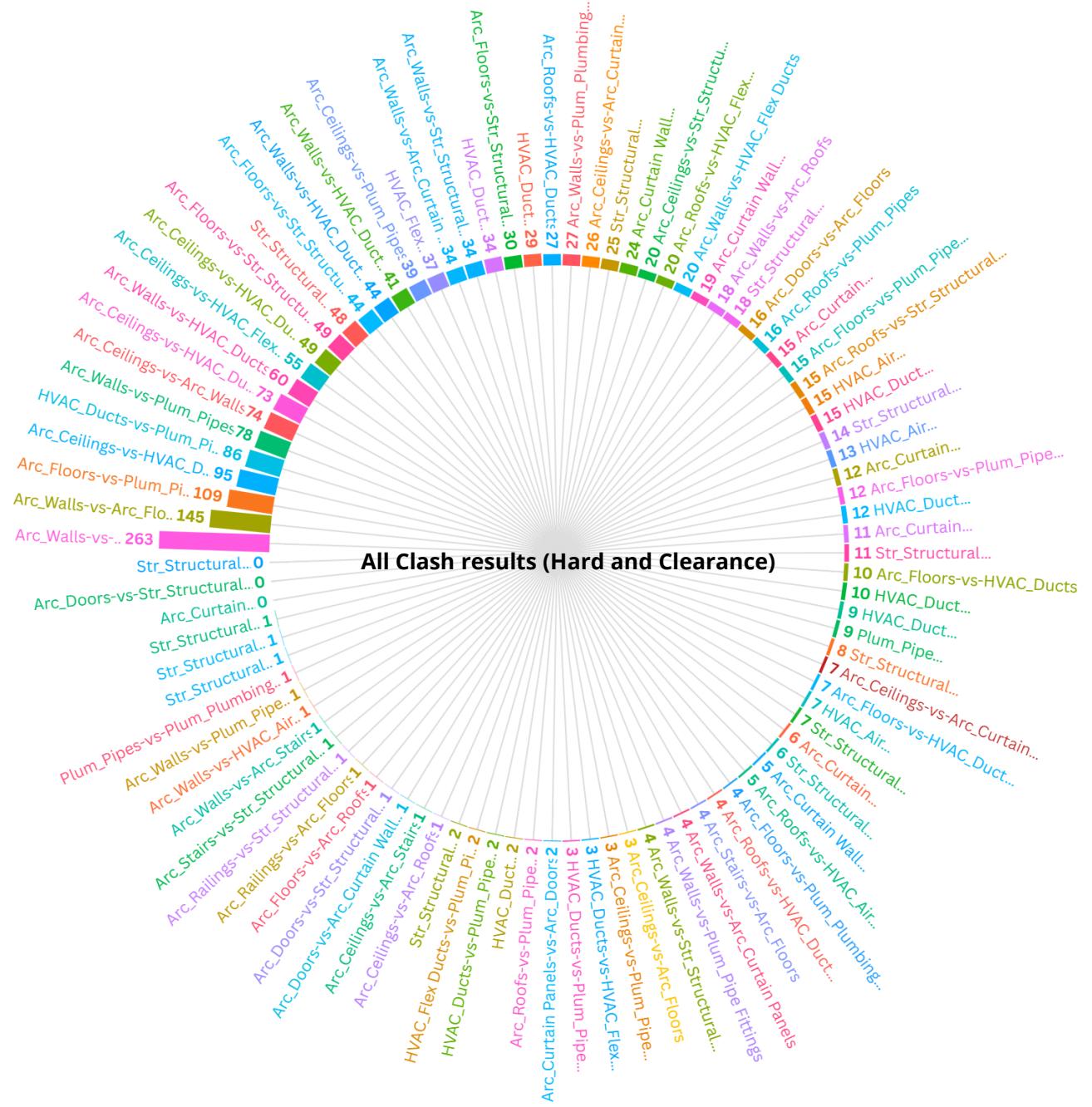
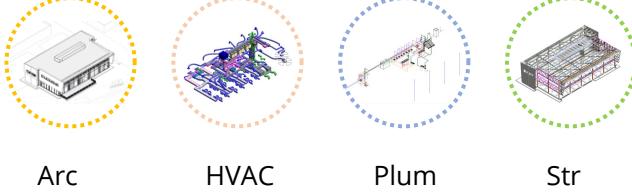


Fig 22. Task Priority graph for all clash results.



A

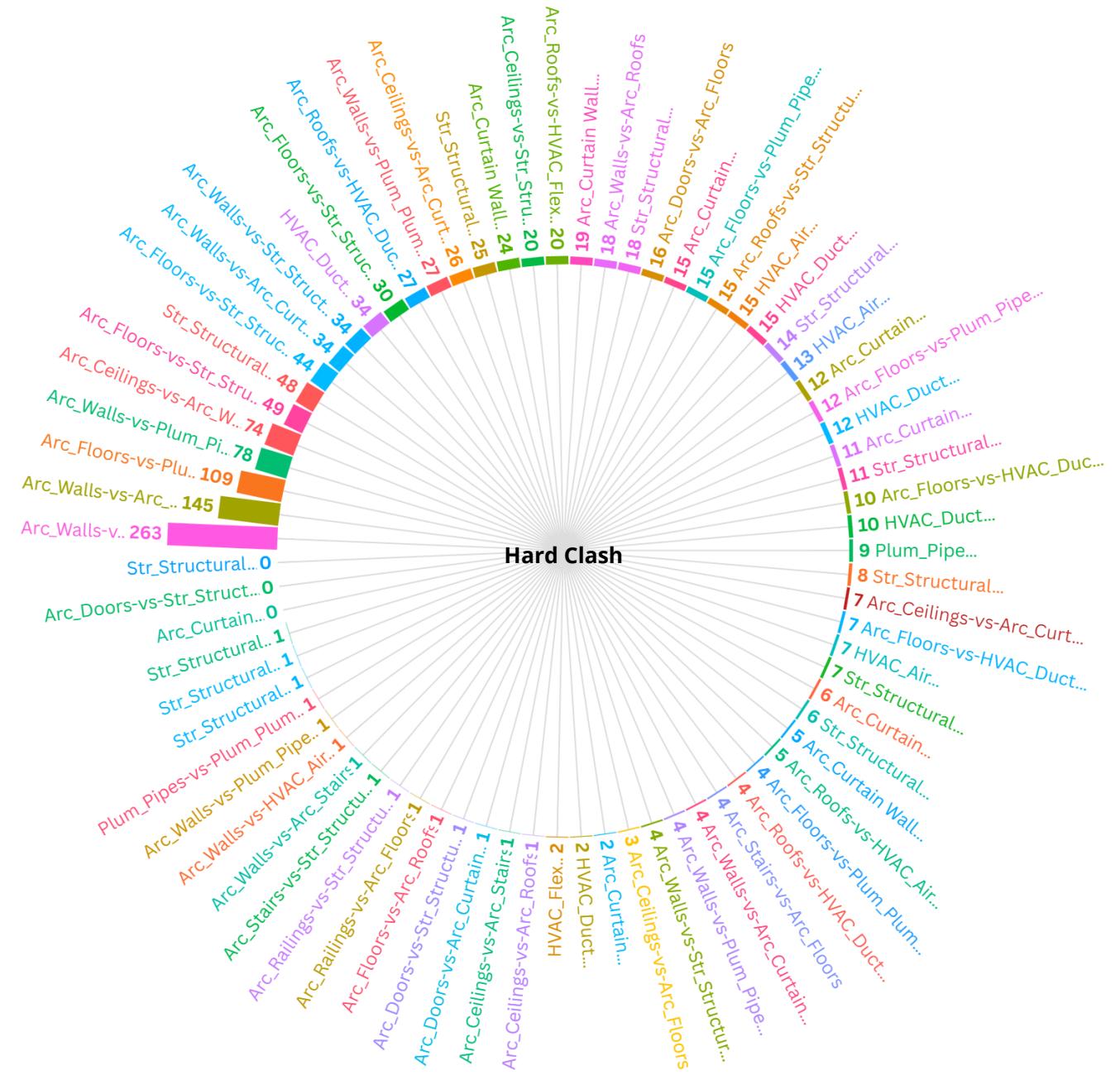
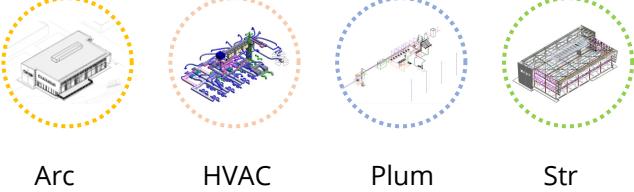
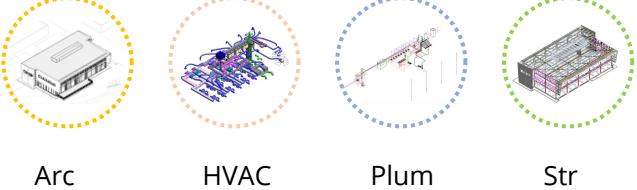


Fig 23. Task Priority graph for Hard clashes.



A



Arc

HVAC

Plum

Str

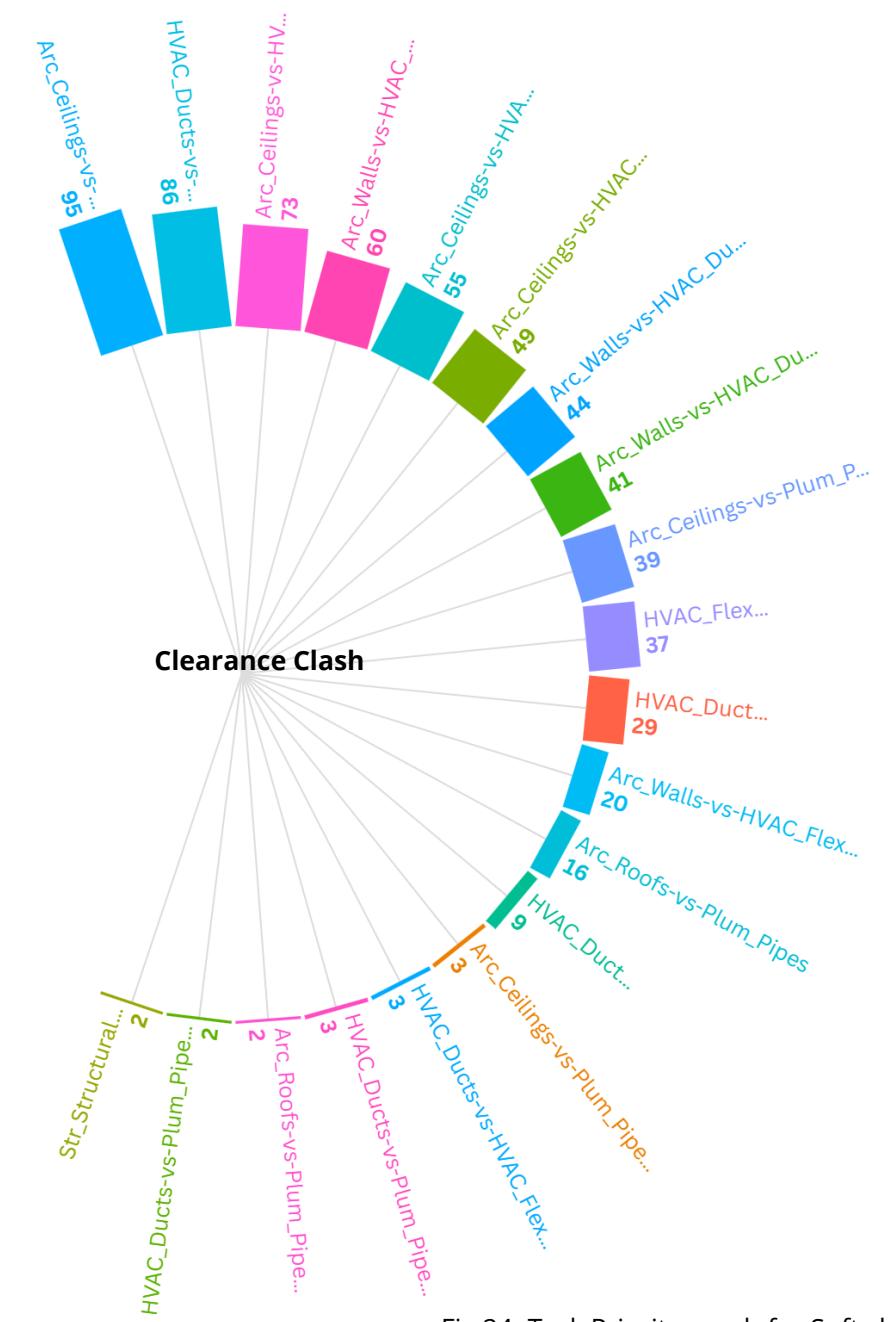


Fig 24. Task Priority graph for Soft clashes.



A

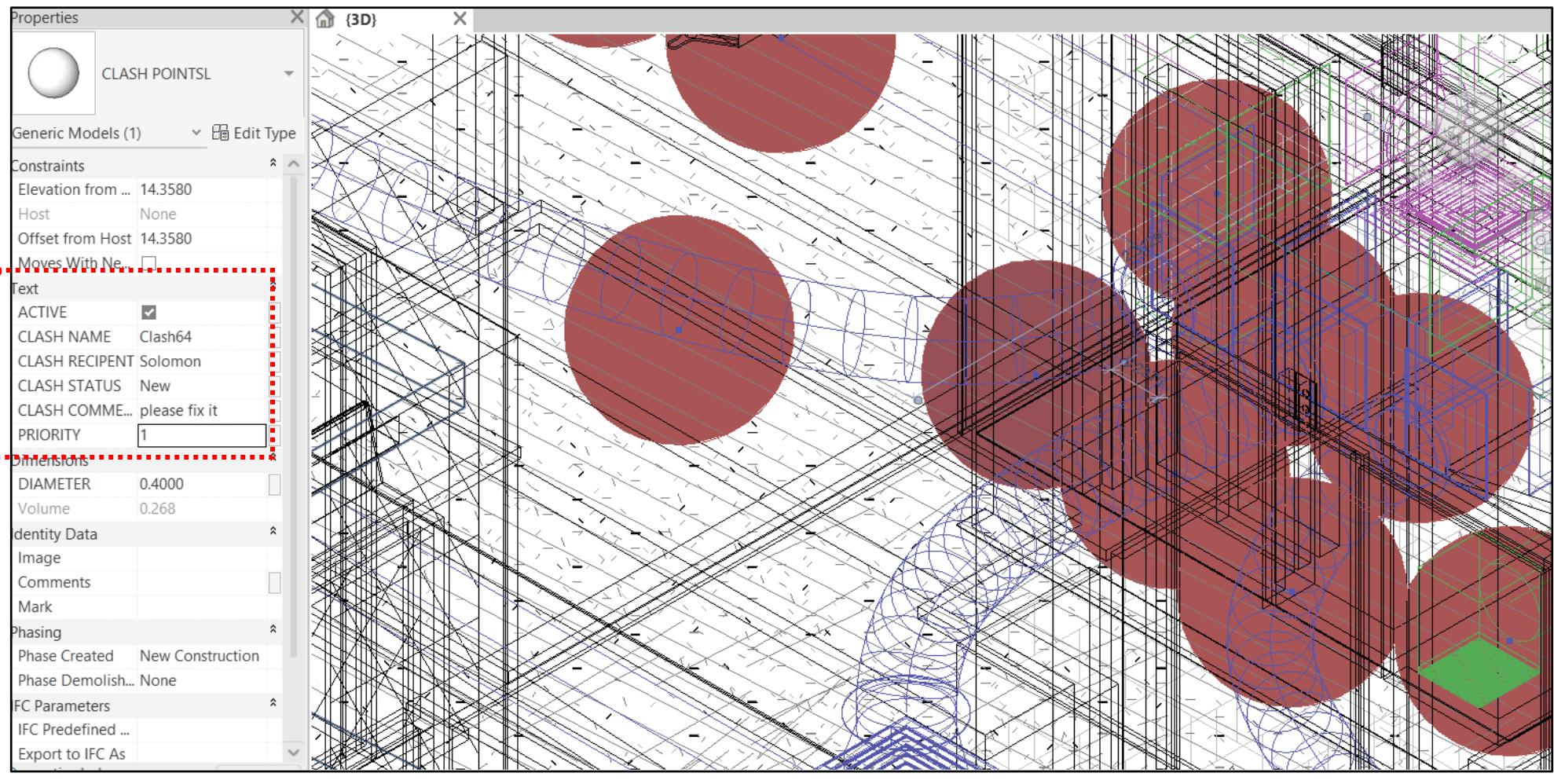
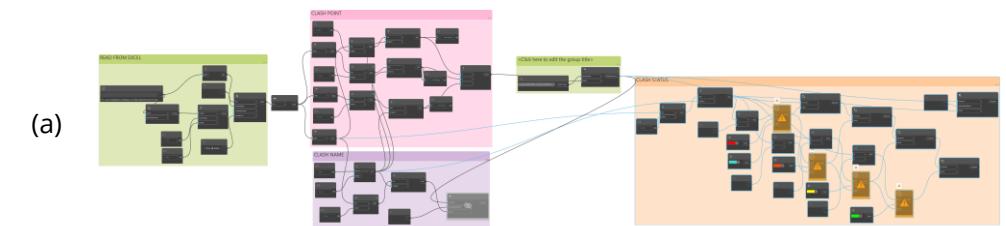
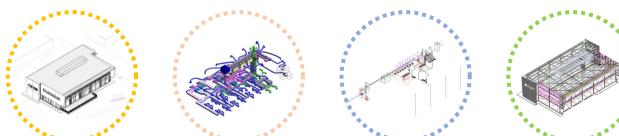


Fig 25. (a) Dynamo script to import clash points to Revit (b) Highlighted clash points in the federated model.



A

3D Models

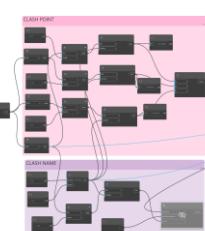
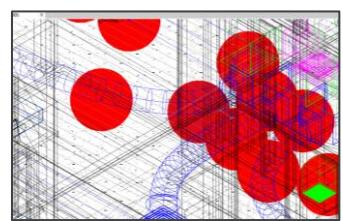
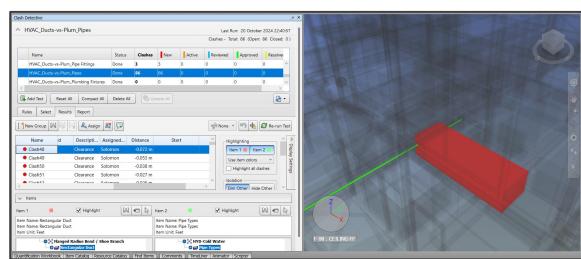


Clash Matrix Setup

		Architecture	HVAC	Plumbing	Structures
	H-Hard Clash_C-50 - Clearance_Screws				
Architecture	Arc_Ceilings	- x -	x -	x -	x -
	Arc_Curtain Panels	- x -	x -	x -	x -
	Arc_Ductwork Wall Mounts	- x -	x -	x -	x -
	Arc_Ductwork	- x -	x -	x -	x -
	Arc_Furniture	- x -	x -	x -	x -
	Arc_Railings	- x -	x -	x -	x -
	Arc_Stairs	- x -	x -	x -	x -
	Arc_Windows	- x -	x -	x -	x -
	Arc_Walls	- x -	x -	x -	x -
	Arc_Windows	- x -	x -	x -	x -
HVAC	HVAC_Duct Panels	-	-	-	-
	HVAC_Duct Accessories	-	-	-	-
	HVAC_Duct Insulation	-	-	-	-
	HVAC_Flex Ducts	-	-	-	-
	HVAC_Piping	-	-	-	-
	HVAC_Piping Fittings	-	-	-	-
Plumbing	Pipe_Plumbing Fixtures	-	-	-	-
	Pipe_Structural Foundations	-	-	-	-
Structures	St_Structural Foundations	-	-	-	-
	St_Structural Columns	-	-	-	-



Clash Detection



Fixing the Clash

Dynamo to Revit

Clash Priority



Clash Report



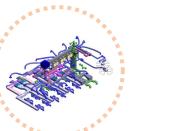
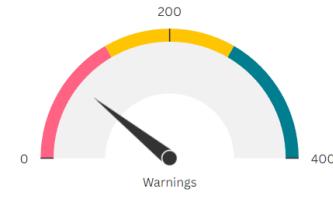
Fig 26. 3D Coordination workflow.

**B**

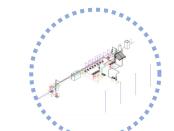
Warnings
Goal: <500



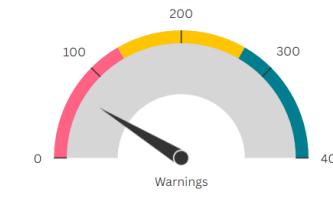
Architectural



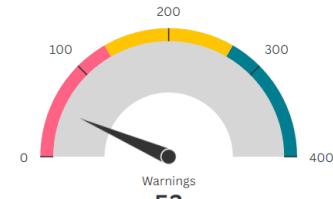
HVAC



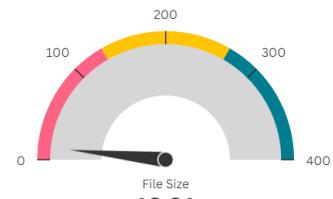
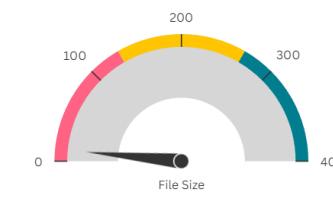
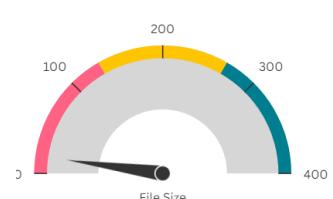
Plumbing



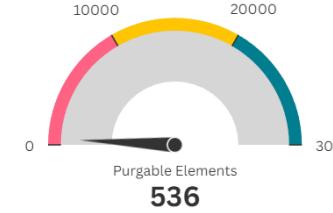
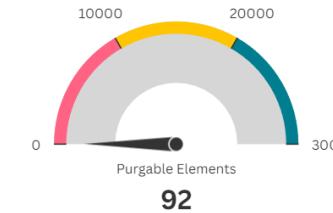
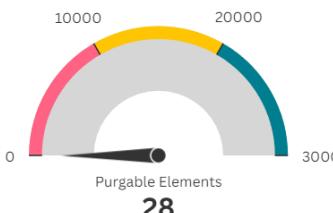
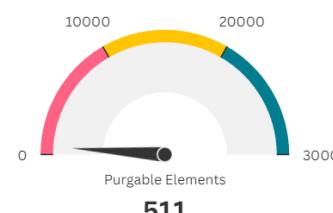
Structural



File Size
Goal: <200MB



Purgeable Elements
Goal: purge unused



Total Model Elements
Goal: < 1,000,000

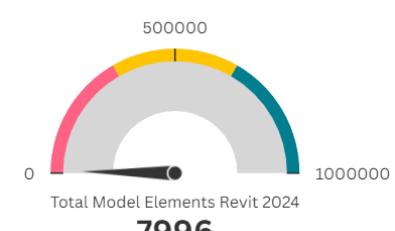
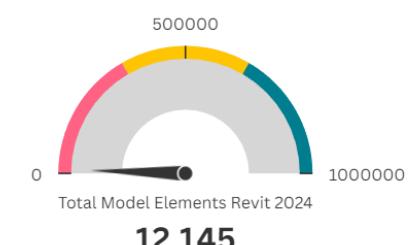
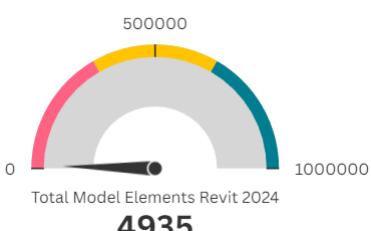
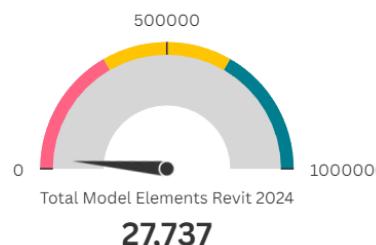
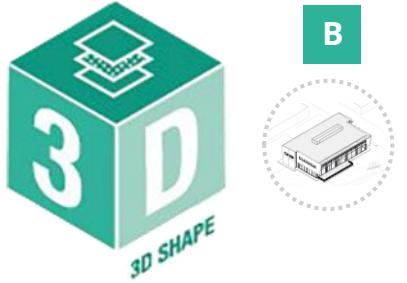


Fig 27. 3D Model Health check using Revit.



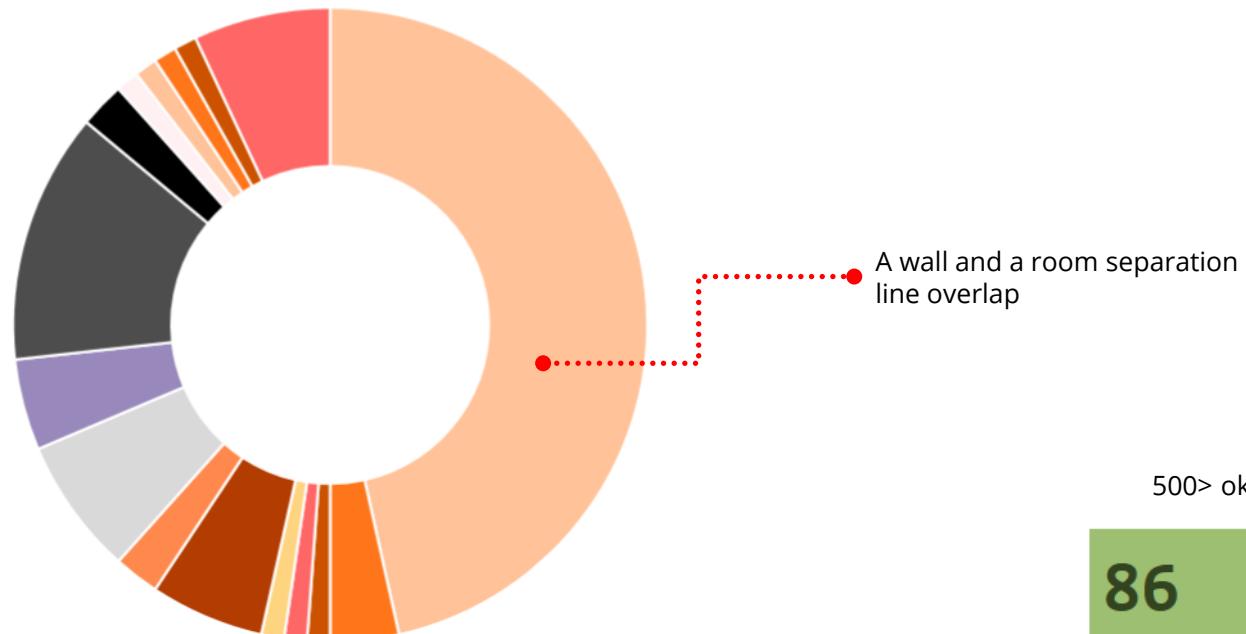
Warnings for Architecture Model

- A wall and a room separation line overlap. One of them may be ignored when Revit finds room boundaries. Shorten or delete the room separation line to remove the overlap.
 - Area is not in a properly enclosed region
 - Conditions for wall embedding are no longer satisfied.
 - Elements have duplicate "Mark" values.
 - Elements have duplicate "Number" values.
 - Elements have duplicate "Type Mark" values.
 - Highlighted lines overlap. Lines may not form closed loops.
 - Highlighted room separation lines overlap. One of them may be ignored when Revit finds room boundaries. Delete one of the lines.
 - Highlighted walls are attached to, but miss, the highlighted targets.
 - Highlighted walls overlap. One of them may be ignored when Revit finds room boundaries. Use Cut Geometry to embed one wall within the other.
 - Insert conflicts with joined Wall.

Multiple Areas are in the same enclosed region. The correct area and perimeter will be assigned to one Area and the others will display "Redundant Area." You should separate the regions, delete the extra Areas, or move them into different regions.

Multiple Rooms are in the same enclosed region. The correct area and perimeter will be assigned to one Room and the others will display "Redundant Room." You should separate the regions, delete the extra Rooms, or move them into different rooms.

 - Room is not in a properly enclosed region
 - Room is very short. If this is not intended, change its Upper Limit and Offset.
 - There are identical instances in the same place. This will result in double counting in schedules. You can tab-select one of the overlapping elements to exclude it from the group instance.



500> ok

Goal=0

86
WARNINGS

19
CRITICAL
WARNINGS

Fig. 28. Warnings detail for the Architectural model.



4D BIM combines **scheduling** with **modeling**, offering a simulation of the construction timeline that enables stakeholders to envision and enhance the order of events (Eastman et al., 2011).

Even though the Surf Life building doesn't have a schedule data it was possible to make one and link it with the model using Synchro. Moreover, It is possible to develop the simulation of the construction timeline and communicate with the project teams.

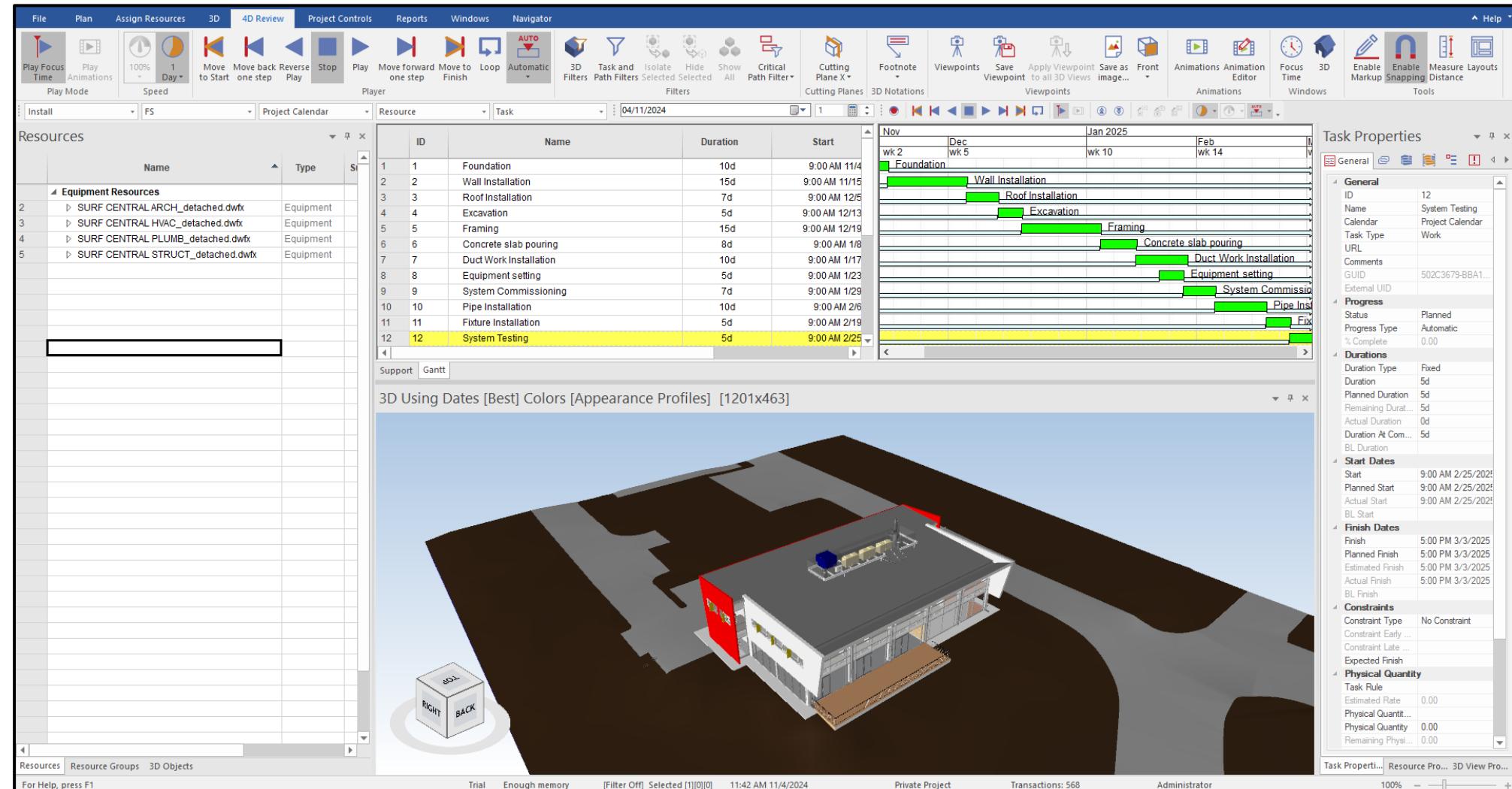


Fig. 29. Scheduling of Surf Life Building (all disciplines) using Synchro.

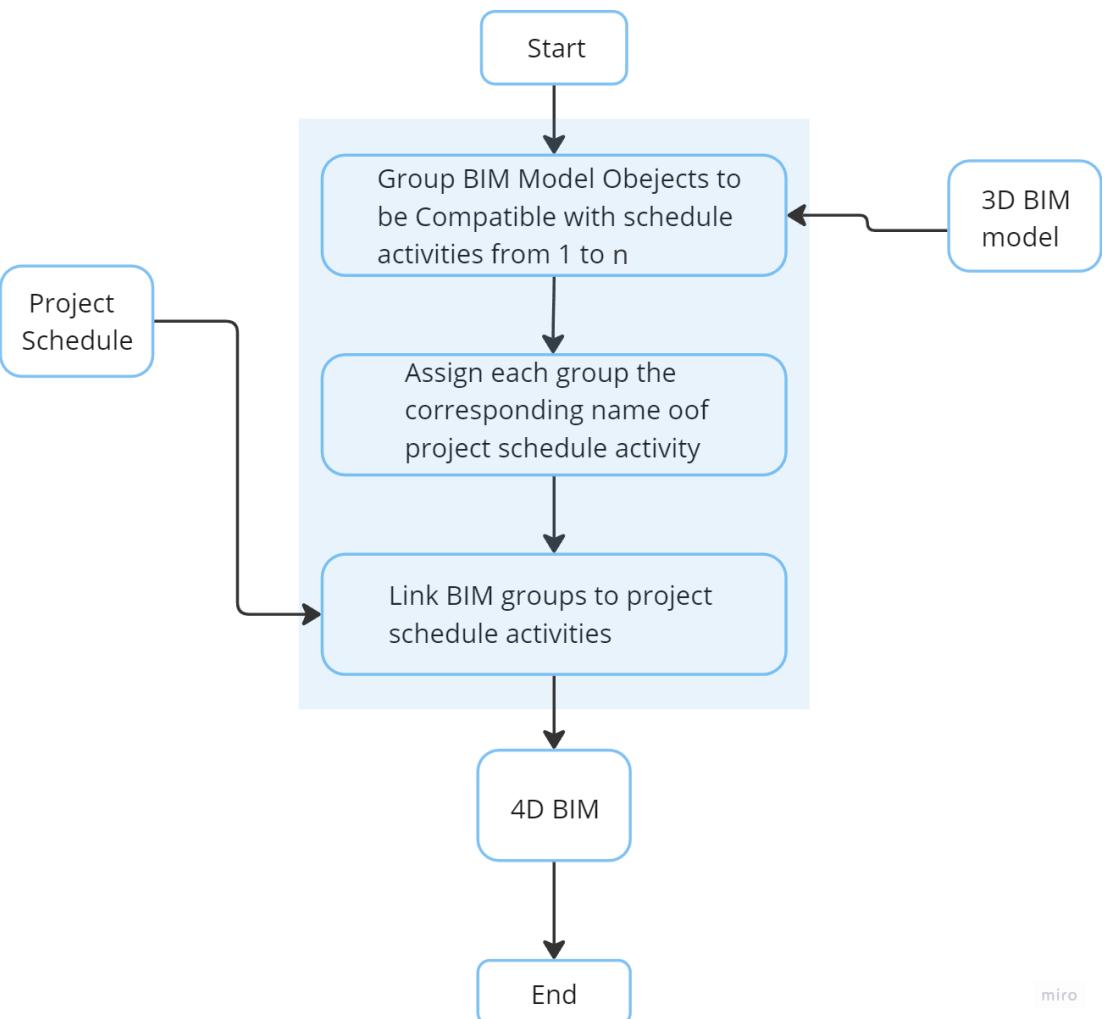
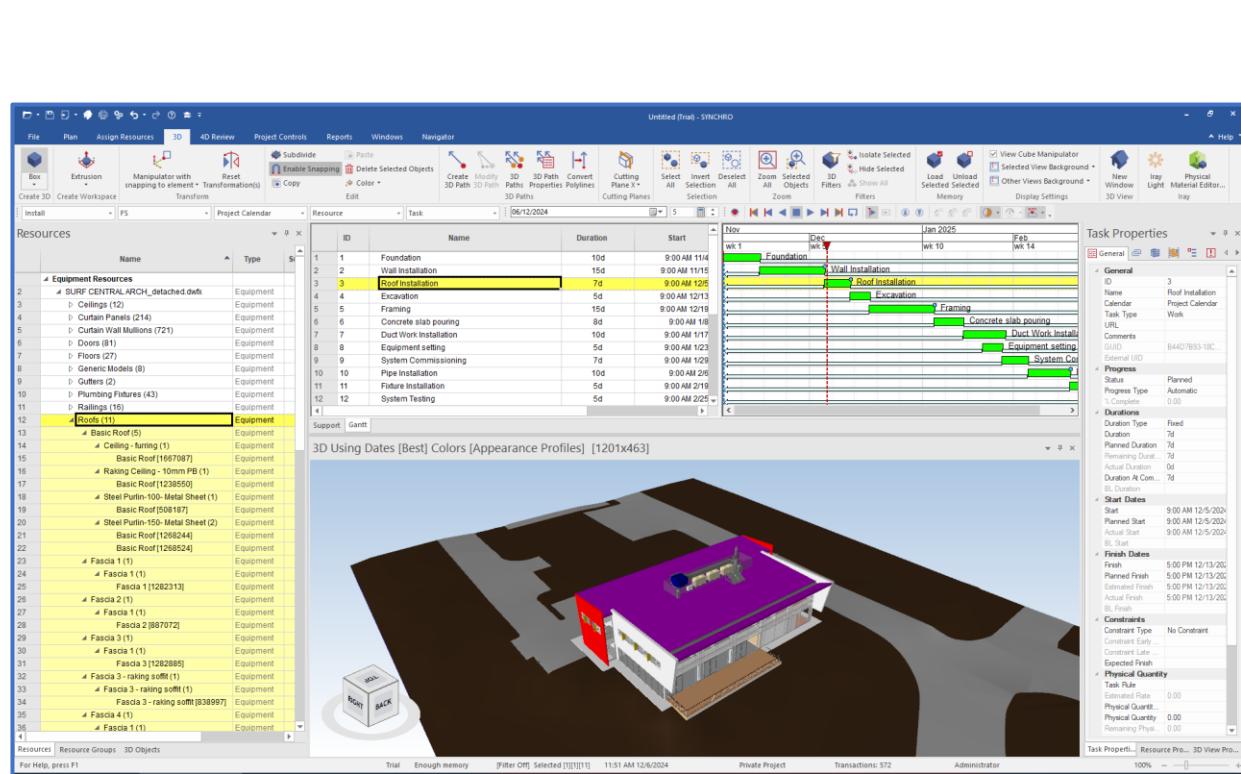


Fig. 30. Linking the 3D BIM model to project schedule. source: Montaser & Moselhi, 2015.



Linking financial data directly to the 3D model enhances cost data integration into Building Information Modelling (BIM) to create a 5D model, which improves project cost management by facilitating accurate cost estimation, real-time budget monitoring, and efficient resource allocation throughout the project (Vigneault, Boton, & Chong, 2020).

The **Surf Life building** doesn't have a cost data that can expose it to budget overruns since element schedules, such as those for walls, windows, and furnishings, do not provide comprehensive cost information.

Elements are assigned based on Uniclass Catalogue.

Quantification Workbook

Items	WBS	Status	WBS/RBS	Name	Description	Comments	Length	Width	Thickness
Substructure	A	B.10.12.1.1	250UB37.3				35.266 m	0.000 m	0.000 m
Special Construction & Demolition	F								
Shell	B								
Services	D								
Interiors	C								
Equipment & Furnishings	E								
Building Sitework	G								

Status	WBS	Object	Viewpoint	Comments	ModelLength	ModelWidth	ModelThickness	ModelHeight
B.10.12.1.1.1	UB-Universal Beams (AS 36...				14.454 m			
B.10.12.1.1.2	UB-Universal Beams (AS 36...				14.454 m			
B.10.12.1.1.3	UB-Universal Beams (AS 36...				3.179 m			
B.10.12.1.1.4	UB-Universal Beams (AS 36...				3.179 m			

AutoSaved: C:\Users\solom\AppData\Roaming\Autodesk\Navisworks Manage 2024\AutoSave\Untitled.Autosave67.nwf

Fig. 31. Surf Life Building (all disciplines) Cost Estimation using Navisworks Manage.

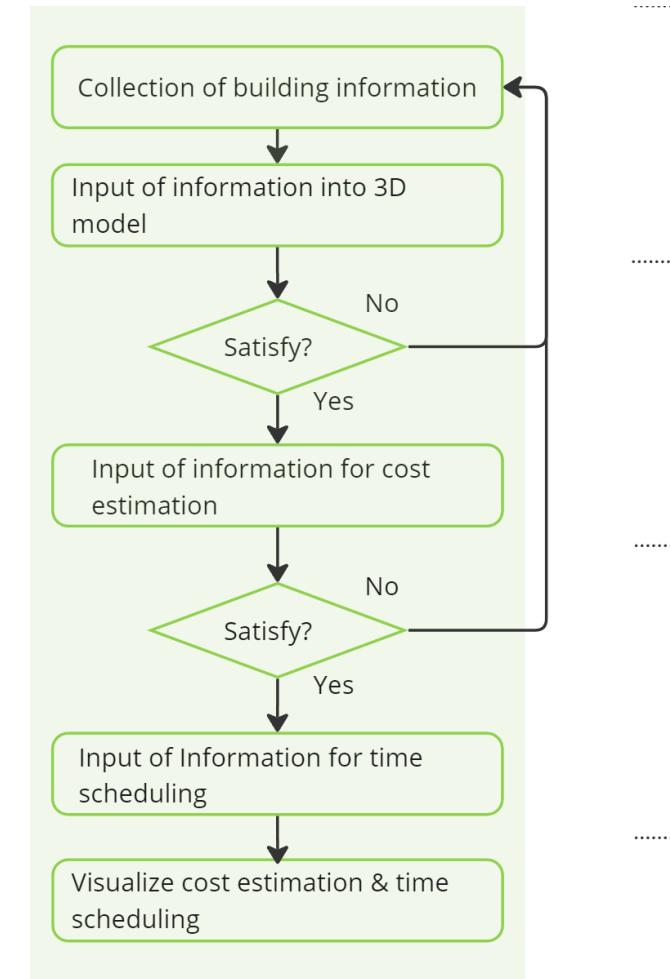
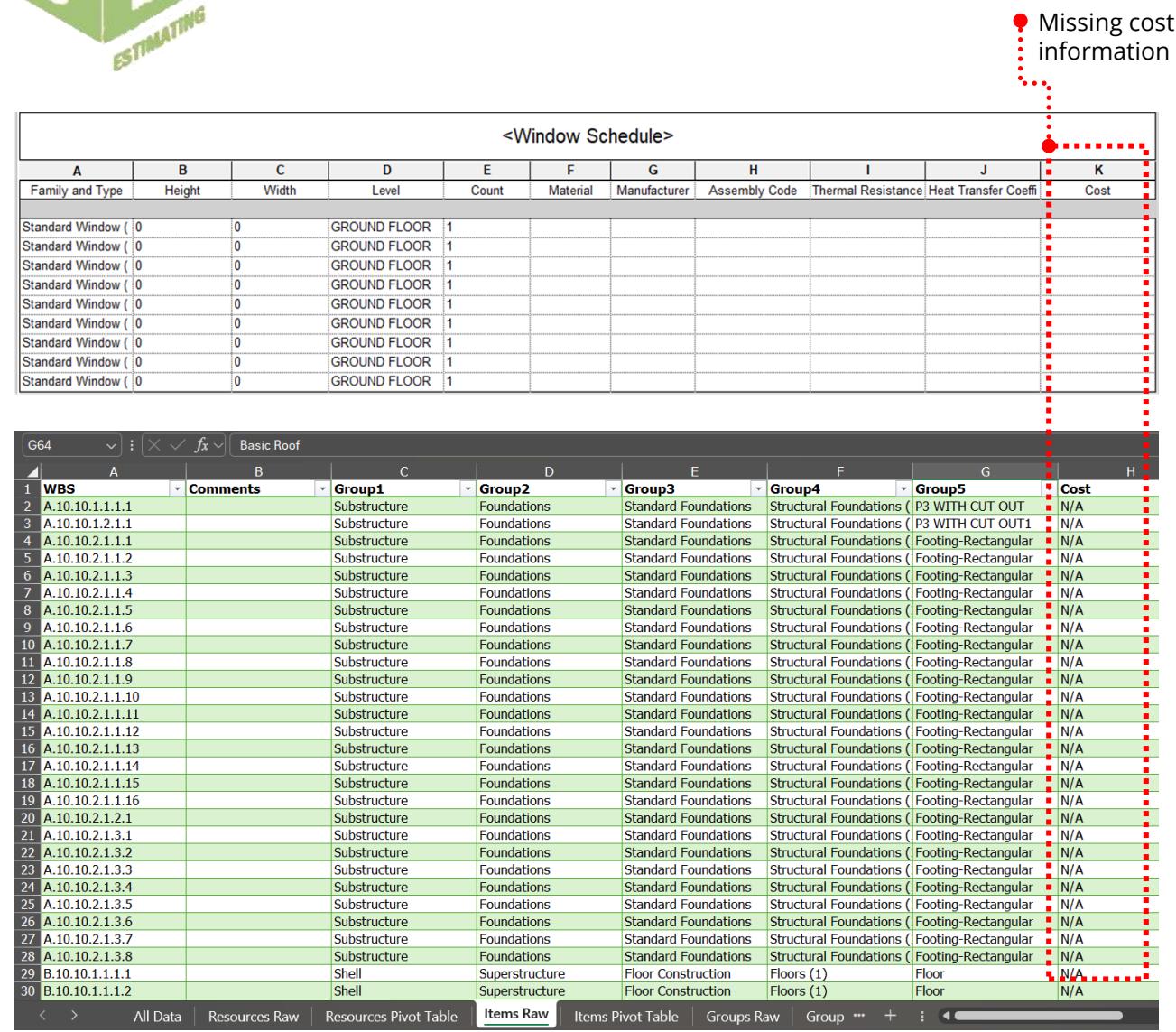


Fig. 32. 5D BIM Process Flowchart. Source: Lee, Cheah, & Khamidi, 2016.



COBie defines what information is needed at each phase of a project and emphasizes non-graphical information such as equipment, spaces, and maintenance schedules. It is important in BIM, as there is no barrier to data transfer from construction to operations. **ISO 19650:2-2018, ISO 55000 (asset management), and BS 8536 (FM)** collectively support COBie by establishing a structured approach to managing asset information throughout the lifecycle of a built asset. Moreover, a detailed guideline about COBie is outlined in **Chapter 4.2 of the NBIMS-US standard**.

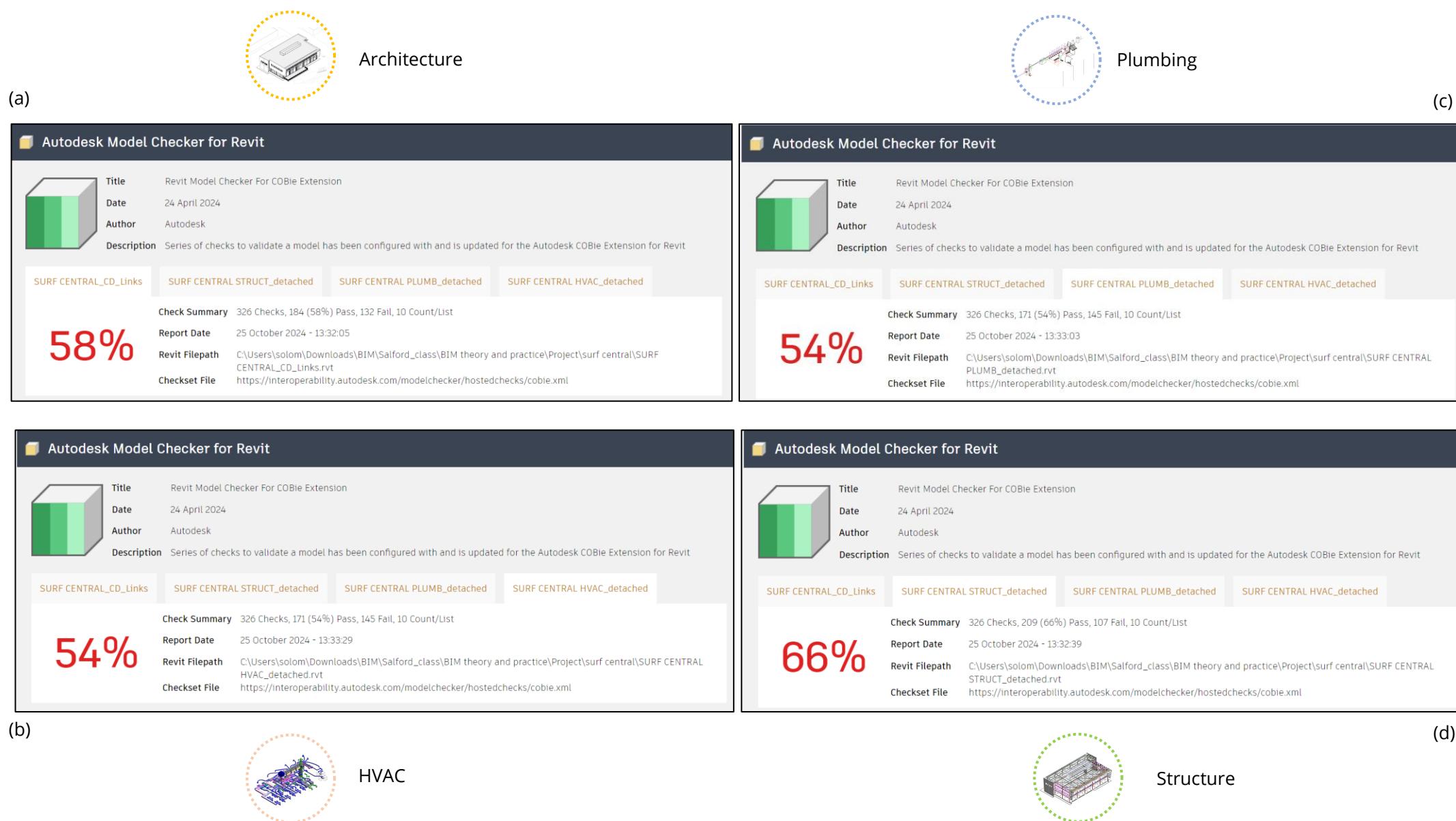


Fig. 33. Revit Model Checker for COBie Extension results, (a) Architecture, (b) HVAC, (c) Plumbing, (d) Structure



Type Properties	
Family:	M_Single-Flush Glass Panel with push plate
Type:	6920 x 2300MM
Type Parameters	
Parameter	Value

Data

COBie:Type	
COBie:AccessibilityPerformance	
COBie:TypeArea	
COBie:TypeAssetType	
COBie:TypeCategory	
COBie:TypeCodePerformance	
COBie:TypeColor	
COBie:TypeConstituents	
COBie:TypeCreatedBy	
COBie:TypeCreatedOn	
COBie:TypeDescription	
COBie:TypeHeight	
COBie:TypeLength	
COBie:TypeManufacturer	
COBie:TypeMaterial	
COBie:TypeModelNumber	
COBie:TypeModelReference	
COBie:TypeName	
COBie:TypeNominalHeight	
COBie:TypeNominalLength	
COBie:TypeNominalWidth	
COBie:TypeReplacementCost	
COBie:TypeShape	

Missing Parameter values

Results

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
	Name	CreatedBy	CreatedOn	TypeName	Space	Description	ExtSystem	ExtObject	ExtIdentifier	SerialNumber	InstallationDate	WarrantyStartDate	TagNumber	Barcode	AssetIdentifier	Area	Length
1	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	7ccc8c9a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	82295873	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	fd09f87c-1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	fd09f87c-1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	e79f3791	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
21	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	ba93426c	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
22	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	9b7590d1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	9b7590d1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
24	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	56f0016b-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
25	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	cfc7faf8-4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
26	n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IfcFurniture	cfc7faf8-4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Legend

Text	Required
Text	Reference to other sheet or pick list
Text	External reference
Text	If specified as required
Text	Secondary information when preparing product data
Text	Regional, owner, or product-specific data
Text	Not used

Fig. 34. COBie spreadsheet for Surf life Building (Architecture) with unavailable information.



The current gaps in the Surf Life model's **COBie** data may be critical in satisfying standard information requirements, hence showing potential problems in smooth transition from the Project Information Model (**PIM**) to the Asset Information Model (**AIM**) at handover. These gaps can **disrupt facility management** during operations, which will definitely reflect on efficiency and effectiveness. Therefore, it is strongly recommended to **adopt ISO 19650** standards for total data capture through design, construction, and handover.

Contact

Email		CreatedBy		CreatedOn		Category		Company		Phone		ExtSystem		ExtObject		ExtIdentifier		Department		OrganizationCode		GivenName		FamilyName		Street		PostalBox		Town		StateRegion		PostalCode		Country	
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a					

Facility

Name	CreatedBy	CreatedOn	Category	ProjectName	SiteName	LinearUnits	AreaUnits	VolumeUnits	CurrencyUnit	Revit defa	Autodesk	IfcProject	2GUtUyNl	IfcSite	2GUtUyNl	IfcBuilding	2GUtUyNl	n/a											
n/a	n/a	n/a	n/a	n/a	n/a	Millimeters	Square m	Cubic met	£	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Floor

Name	CreatedBy	CreatedOn	Category	FloorName	Description	ExtSystem	ExtObject	ExternalProjectObject	ExternalSiteObject	ExternalProjectIdentifier	ExternalIdentifier																					
n/a	n/a	n/a	Floor	Autodesk Revit 2024, Build: 24.1.11.26	IfcBuildingStorey	e3e052f9-0156-11d5-9301-0000863f27ad-00000137	n/a	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
n/a	n/a	n/a	Floor	Autodesk Revit 2024, Build: 24.1.11.26	IfcBuildingStorey	458c0e49-01bb-11d5-9302-0000863f27ad-000002b6	n/a	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
n/a	n/a	n/a	Floor	Autodesk Revit 2024, Build: 24.1.11.26	IfcBuildingStorey	bfe0f1c6-6caa-4841-920e-ae0b9e8b18fc-0006f2cf	n/a	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
n/a	n/a	n/a	Floor	Autodesk Revit 2024, Build: 24.1.11.26	IfcBuildingStorey	7b9d3fd-4253-4112-9754cc7762e-000acd5b	n/a	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		

Space

Name	CreatedBy	CreatedOn	Category	Description	AssetType	Manufacturer	ModelNumber	ExtSystem	ExtObject	ExternalIdentifier																				
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk Revit 2024, Build: 24.1.11.26	IfcSpace	5669ce45-8e50-4032-8c83-fa720f717d0c-00005f62f	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk Revit 2024, Build: 24.1.11.26	IfcSpace	5669ce45-8e50-4032-8c83-fa720f717d0c-00005f632	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk Revit 2024, Build: 24.1.11.26	IfcSpace	5669ce45-8e50-4032-8c83-fa720f717d0c-00005f634	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk Revit 2024, Build: 24.1.11.26	IfcSpace	1fcf7ffd-7c2d-490a-ad0b-270f8560d646-0005f8af	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Type

Name	CreatedBy	CreatedOn	Category	Description	ExtSystem	ExtObject	ExternalIdentifier			
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n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCFurniture	7cc8ce98	n/a	

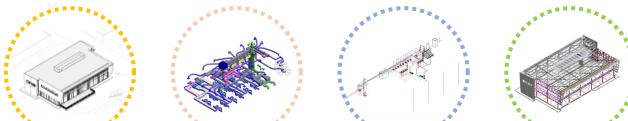
Component

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n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	
n/a	n/a	n/a	n/a	n/a	n/a	Autodesk	IFCCable	d938ce06	n/a	n/a

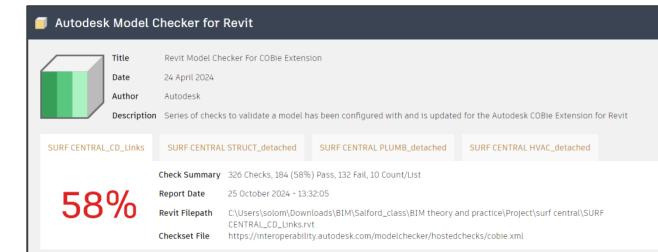
Fig. 35. COBie spreadsheet result for the "Required" workbooks.



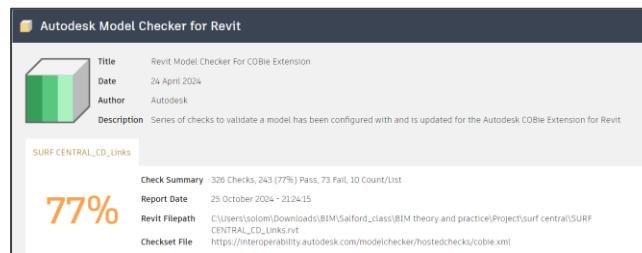
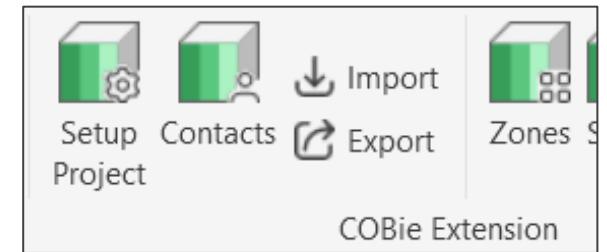
3D Models



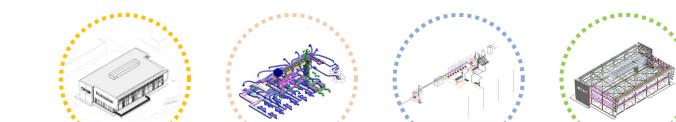
Checking



Data entry and mapping



Validate Compliance



Adjust Revit Model

Instruction	Contact	Facility	Space	Zone	Type	Component	System	Assembly	Connection	Open	Review
1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10	10	10	10	10
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21	21	21	21	21	21	21	21	21	21	21	21
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42	42	42	42	42	42	42	42	42	42	42	42
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64	64	64	64	64	64	64	64	64	64	64	64
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66	66	66	66	66	66	66	66	66	66	66	66
67	67	67	67	67	67	67	67	67	67	67	67
68	68	68	68	68	68	68	68	68	68	68	68
69	69	69	69	69	69	69	69	69	69	69	69
70	70	70	70	70	70	70	70	70	70	70	70
71	71	71	71	71	71	71	71	71	71	71	71
72	72	72	72	72	72	72	72	72	72	72	72
73	73	73	73	73	73	73	73	73	73	73	73
74	74	74	74	74	74	74	74	74	74	74	74
75	75	75	75	75	75	75	75	75	75	75	75
76	76	76	76	76	76	76	76	76	76	76	76
77	77	77	77	77	77	77	77	77	77	77	77
78	78	78	78	78	78	78	78	78	78	78	78
79	79	79	79	79	79	79	79	79	79	79	79
80	80	80	80	80	80	80	80	80	80	80	80
81	81	81	81	81	81	81	81	81	81	81	81
82	82	82	82	82	82	82	82	82	82	82	82
83	83	83	83	83	83	83	83	83	83	83	83
84	84	84	84	84	84	84	84	84	84	84	84
85	85	85	85	85	85	85	85	85	85	85	85
86	86	86	86	86	86	86	86	86	86	86	86
87	87	87	87	87	87	87	87	87	87	87	87
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90	90	90	90	90	90	90	90	90	90	90	90
91	91	91	91	91	91	91	91	91	91	91	91
92	92	92	92	92	92	92	92	92	92	92	92
93	93	93	93	93	93	93	93	93	93	93	93
94	94	94	94	94	94	94	94	94	94	94	94
95	95	95	95	95	95	95	95	95	95	95	95
96	96	96	96	96	96	96	96	96	96	96	96
97	97	97	97	97	97	97	97	97	97	97	97
98	98	98	98	98	98	98	98	98	98	98	98
99	99	99	99	99	99	99	99	99	99	99	99
100	100	100	100	100	100	100	100	100	100	100	100

COBie output

Fig. 36. Workflow to check the compliance.



Conducting sustainability analysis without enhancing and validating relevant data early in the design stage can lead to inaccurate results, potentially causing budget overruns. Early integration of reliable data ensures that sustainability goals are met efficiently, reducing the risk of costly adjustments later.

Autodesk Interoperability Tools | Model Checker

AUTODESK MODEL CHECKER FOR REVIT

Description Series of checks to review modeling best practices for sustainable analysis

SURF CENTRAL ARCH_detached.rvt

Check Summary 25 Checks, 3 (43%) Pass, 4 Fail, 18 Count/List

Report Date 29 October 2024 - 21:25:23

Revit Filepath C:\Users\solom\Downloads\BIM\Salford_class\BIM theory and practice\Project\surf central\SURF CENTRAL ARCH_detached.rvt

Checkset File https://interoperability.autodesk.com/modelchecker/hostedchecks/sustainableanalysisreadiness.xml

43%

Sustainability Best Practices for Revit 25 Checks, 3 (43%) Pass, 4 Fail, 18 Count/List

This checkset checks model viability for sustainability analysis

- Model Statistics & General Analysis** 13 Checks, 0 (0%) Pass, 2 Fail, 11 Count/List
 - Checks in this section help ensure the model is free of extraneous content that could interfere with sustainable analysis calculations. Failed checks in this category can impact all the analysis types. Please review and ensure compliance with checks in this section before proceeding.
- Geolocation** 3 Checks, 2 (100%) Pass, 0 Fail, 1 Count/List
 - Checks in this section will verify the model is ready for performing Shadow Studies in Revit
- Rooms and Volumes** 5 Checks, 1 (50%) Pass, 1 Fail, 3 Count/List
 - Checks the model to ensure it is ready for Solar Analysis. Note the Shadow Study Checks are also required to complete solar analysis.
- Elements and Materials** 4 Checks, 0 (0%) Pass, 1 Fail, 3 Count/List

According to the European Committee for Standardization (2011), **EN 15978** provides a framework for **assessing a building's environmental performance across its lifecycle**. This standard is critical in 7D BIM, as it enables sustainability evaluations that cover resource efficiency, emissions, and energy use, aligning with BIM's goal of integrating sustainability into building design and operations.

Redundant and Unenclosed Rooms
PASS/FAIL check to determine if any rooms are in the same location as another room or if rooms are not enclosed. These rooms are redundant or not enclosed within the model
Count: 2

Category	Name	ID
Rooms	Rooms : BALCONY 41	430448
Rooms	Rooms : TRAINERS & CASUALS 2 32	728725

Element has a material with a value
This check looks for Thermal Resistance values in curtain wall panels, doors, floors, roofs, stairs, walls, windows, and generic model elements.
Not all the required elements have a material with a Thermal Resistance. Please review the curtain panels, doors, floors, roofs, stairs, walls, windows and/or generic model element properties.
Count: 739

Light Transmittance
LISTS objects where Light Transmittance is Blank
Count: 2

Category	Family	Type	Name
Windows	Standard Window (parametric)	Parametric	Windows : Type : Standard Window (parametric) : Parametric
Windows	Standard Window (type)	1500w x 900h	Windows : Type : Standard Window (type) : 1500w x 900h

Thermal Resistance
LISTS objects where Thermal Resistance is Blank
Count: 700

Heat Transfer Coefficient
LISTS objects where Heat Transfer Coefficient is Blank
Count: 2

Category	Family	Type	Name
Windows	Standard Window (parametric)	Parametric	Windows : Type : Standard Window (parametric) : Parametric
Windows	Standard Window (type)	1500w x 900h	Windows : Type : Standard Window (type) : 1500w x 900h

Fig. 37. Model readiness result for sustainability analysis.



The benchmark comparison of Surf Life Building shown, with an energy intensity of **449 kWh/m²/year**, reflects the building's current energy efficiency relative to recognized standards like **ASHRAE 90.1** and **Architecture 2030**. Moreover, following the guidelines of **ISO 50001** could drive energy efficiency improvements, leading to operational cost savings and reduced environmental impact.

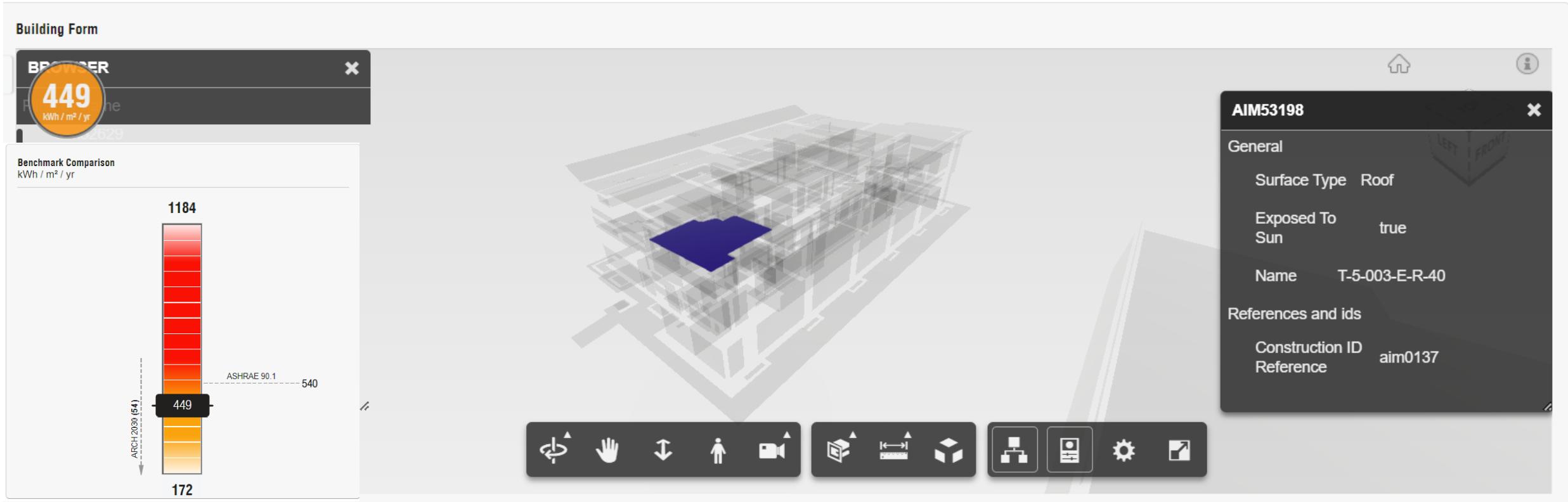


Fig. 38. Energy Analytical Model of Surf Life Building inside Autodesk Insight.



Heating Loads

Conditions at Time of Peak					
	Instant Sensible [W]	Delayed Sensible [W]	Latent [W]	Total [W]	Percent of Total [%]
Time at Peak: 7/21 24:00:00					
Outside	-	0	-	0	0.0
DB: 0.0 C					
HR: 3.9000 kg/kg					
WB: 3.9 C					
Zone					
DB: 21.1 C					
HR: 0.0050 kg/kg					
RH: 32.3 %					
Engineering Checks					
Capacity per Floor Area					
-27.23 W/m ²					
Outdoor Air Percentage					
7.76 %					
Airflow per Floor Area					
1.275510 l/s-m ²					
Number of People					
1.0					
Heating Load Components [W]					
	441	0	0	53	0
Conduction	441	0	0	53	0
Solar	0	0	0	0	0.0
Equipment	0	0	0	0	0.0
Lights	0	0	0	0	0.0
People	0	0	0	0	0.0
Outdoor Air	0	0	0	53	0.0
Other	0	0	0	0	0.0
Systems					
Zone Ventilation	-53	-	0	-53	12.4
Transfer Air	0	-	0	0	0.0
DOAS Direct to Zone	0	-	0	0	0.0
Return Air - Other	0	-	-	0	0.0
Power Generation Equipment	0	0	-	0	0.0
Refrigeration	0	-	0	0	0.0
Water Use Equipment	0	-	0	0	0.0
HVAC Equipment Loss	0	0	-	0	0.0
Subtotal	-53	0	0	-53	12.4
Total					
Sizing Factor Adjustment	0	-	-	0	0.0
Time Delay Correction	-	0	-	0	0.0
Grand Total	-306	-121	0	-427	100.0

(a)

Cooling Loads

Conditions at Time of Peak					
	Instant Sensible [W]	Delayed Sensible [W]	Latent [W]	Total [W]	Percent of Total [%]
Time at Peak: 1/21 15:45:00					
Outside	-	0	-	0	0.0
DB: 0.0 C					
HR: 19.3200 kg/kg					
WB: 39.6 C					
Zone					
DB: 23.9 C					
HR: 0.0086 kg/kg					
RH: 46.3 %					
Engineering Checks					
Capacity per Floor Area					
47.96 W/m ²					
Floor Area per Capacity					
20.8500 m ² /kW					
Outdoor Air Percentage					
7.76 %					
Airflow per Floor Area					
3.826531 l/s-m ²					
Airflow per Capacity					
79.782990 l/s-kW					
Number of People					
1.0					
Internal Gains					
People	51	22	59	132	17.6
Lights	84	0	-	84	11.2
Return Air - Lights	0	-	-	0	0.0
Equipment	110	0	0	110	14.6
Subtotal	245	22	59	326	43.4
Systems					
Zone Ventilation	86	-	-39	47	6.2
Transfer Air	0	-	0	0	0.0
DOAS Direct to Zone	0	-	0	0	0.0
Return Air - Other	0	-	-	0	0.0
Power Generation Equipment	0	0	-	0	0.0
Refrigeration	0	-	0	0	0.0
Water Use Equipment	0	-	0	0	0.0
HVAC Equipment Loss	0	0	-	0	0.0
Subtotal	86	0	-39	47	6.2
Total					
Sizing Factor Adjustment	0	-	-	0	0.0
Time Delay Correction	-	0	-4	-4	-0.5
Grand Total	674	69	9	752	100.0

(b)

Fig. 39. (a) Heating Loads calculations, (b) Cooling Load calculations.

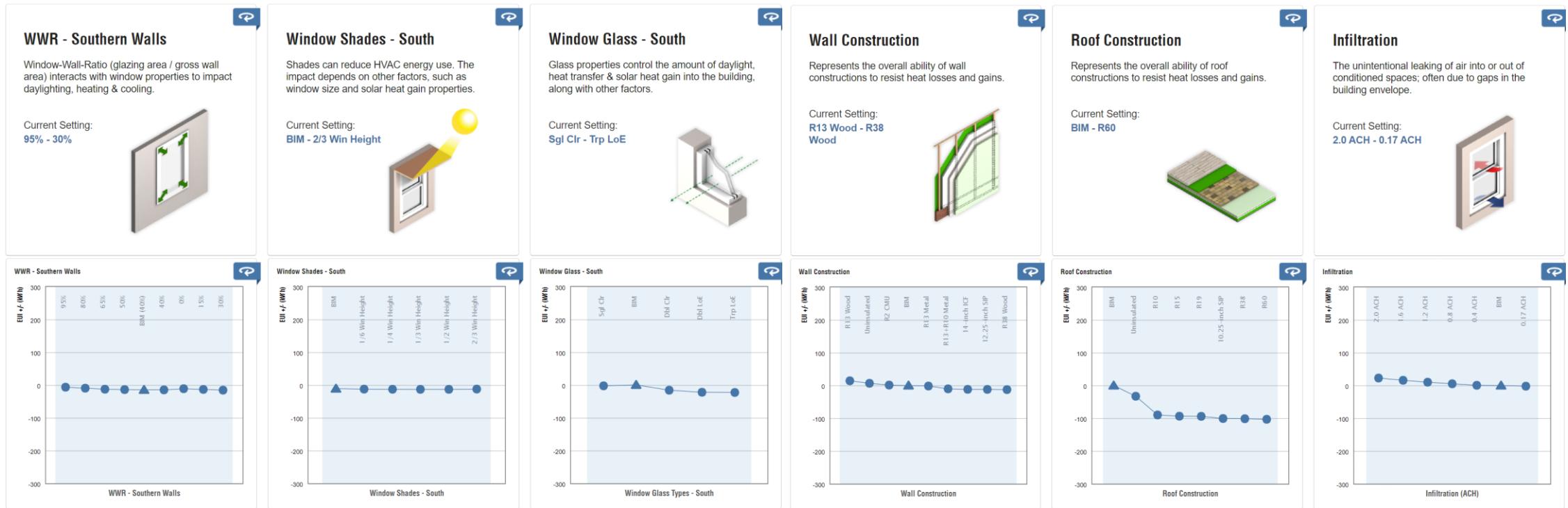


Fig. 40. Sample options to optimize the energy loads of Surf Life Building, suggested by Autodesk Insight.

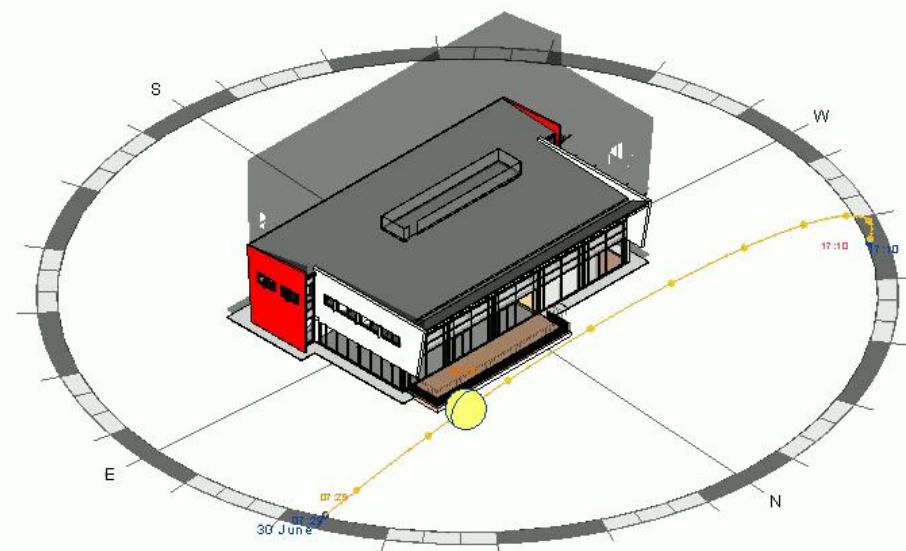


Fig. 41. Summer solar study.

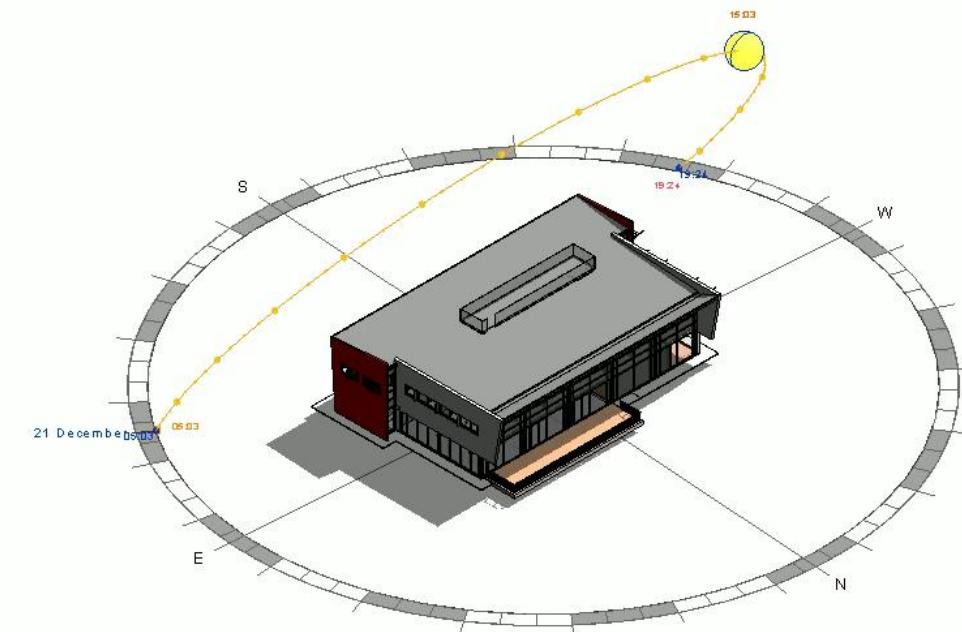
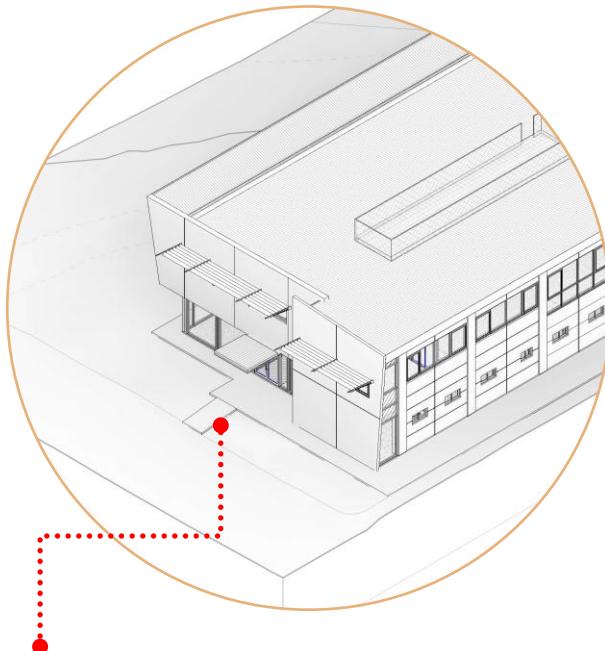


Fig. 42. Winter solar study.



Disable access

The Surf Life Building model includes ramp paving, meeting **AS1428.1:2021 standards for disabled accessibility**. However, it lacks sufficient **health and safety information** per **PAS 1192-6:2018**, limiting collaborative sharing of H&S information throughout the asset lifecycle.

Inadequate metadata on **fire safety components**, **escape routes**, and other safety-critical elements compromises emergency preparedness and occupant protection. The data that the Surf Life project lacks through different Solibri safety checks increases risks in meeting standards for safety compliance, while hard and soft clashes indicate potential dangers during the construction and operational phases of the projects. These 8D safety gaps need to be addressed in order to ensure regulatory compliance, effective emergency planning, and protection of the occupants of the building.

A screenshot of the Solibri Checking software interface. The top navigation bar includes FILE, GET STARTED, MODEL, CHECKING, COMMUNICATION, INFORMATION TAKEOFF, BCF LIVE CONNECTOR, SCORE, and a plus sign. The 'CHECKING' tab is selected. The left sidebar shows a tree view of 'RESULTS', 'CHECKING', and 'INFO'. The main area displays a table of issues under 'CHECKING - Checked Model'. One row is highlighted in blue: '#172 Fire Walls Must Have Correct Wall, Door, and Window Types'. The bottom section shows 'RESULT SUMMARY' and 'INFO' tabs.

Fig. 43. Fire Safety check.

Rule Check = Fire Walls, Door, and Window

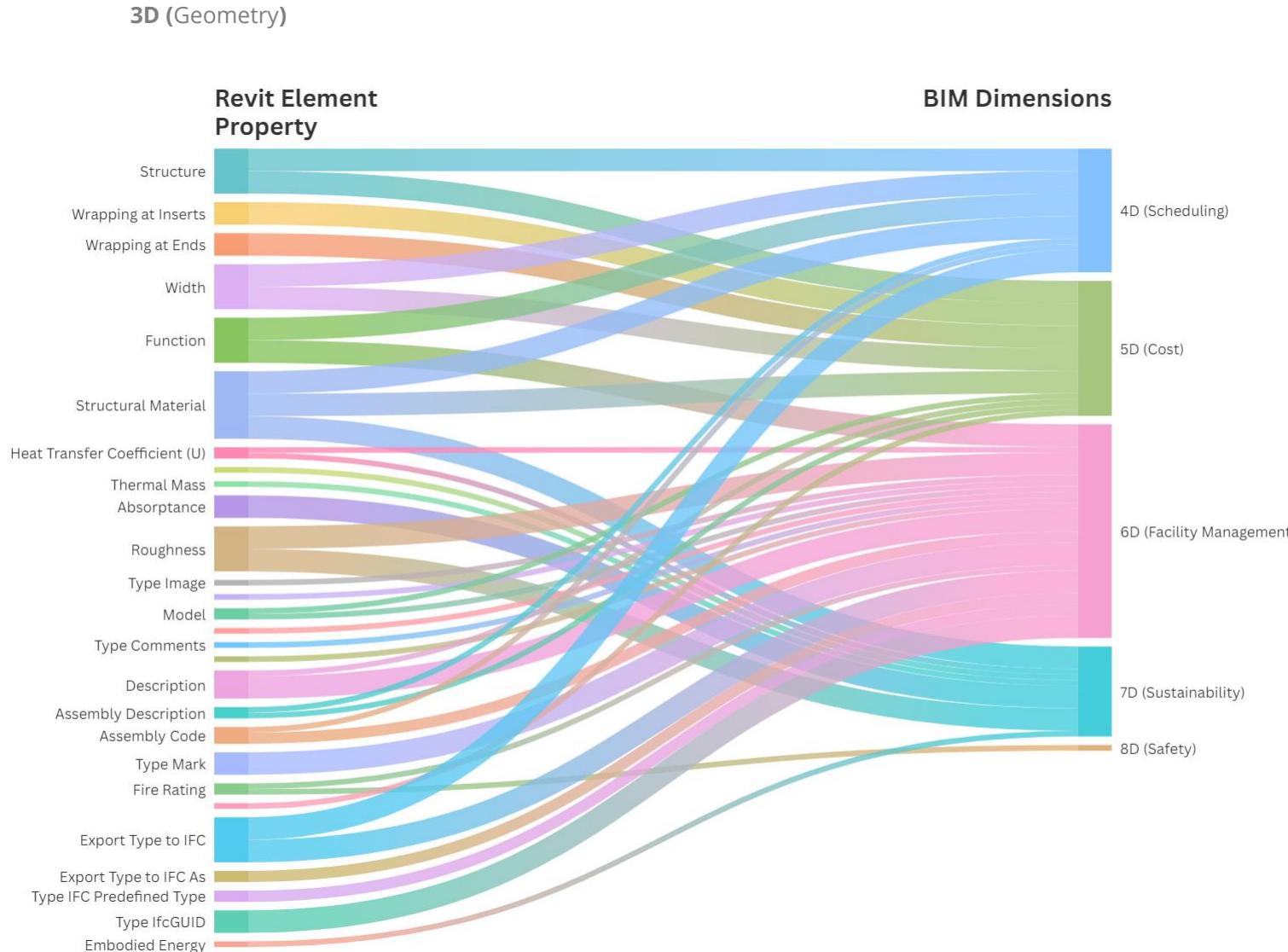
This rule checks that all wall components between different fire zones have correct fire-resistant construction types and that doors and windows in these walls are fire-resistant. It also checks that fire-resistant wall, door, and window types are not used elsewhere.

A screenshot of the Solibri Checking software interface, similar to Fig. 43. The 'CHECKING' tab is selected. The main area displays a table of issues under 'CHECKING - Checked Model'. One row is highlighted in blue: '#236 Horizontal Structures must be Guarded against Falling'. The bottom section shows 'RESULT SUMMARY' and 'INFO' tabs. The 'INFO' tab contains detailed rule help text.

Fig. 44. Guarded Against Falling check.

Rule Check = Guarded Against Falling

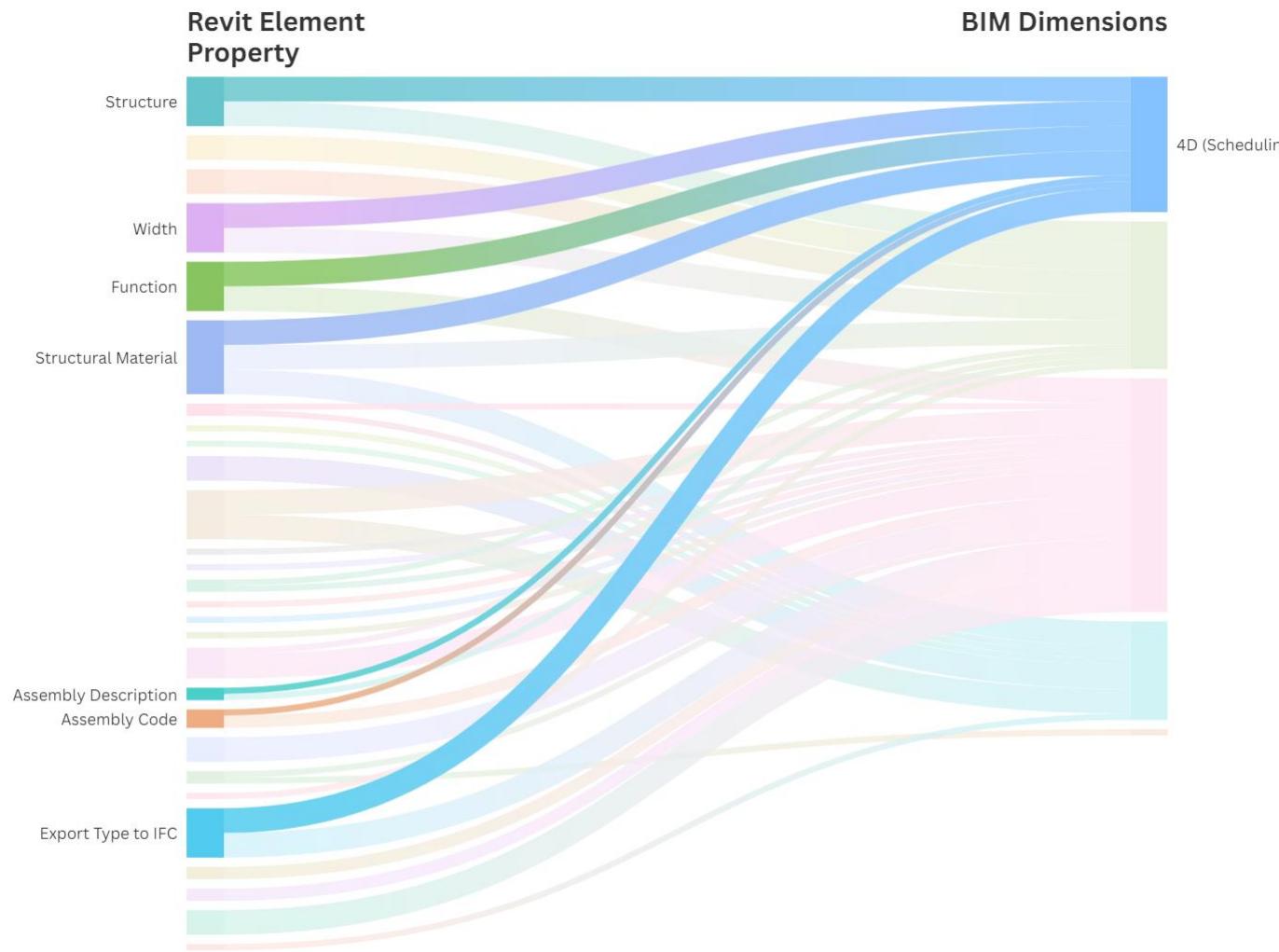
This rule checks that it is not possible to fall from horizontal components, such as slabs. This rule checks that horizontal components are surrounded by vertical components, such as walls, or railings.



General Findings

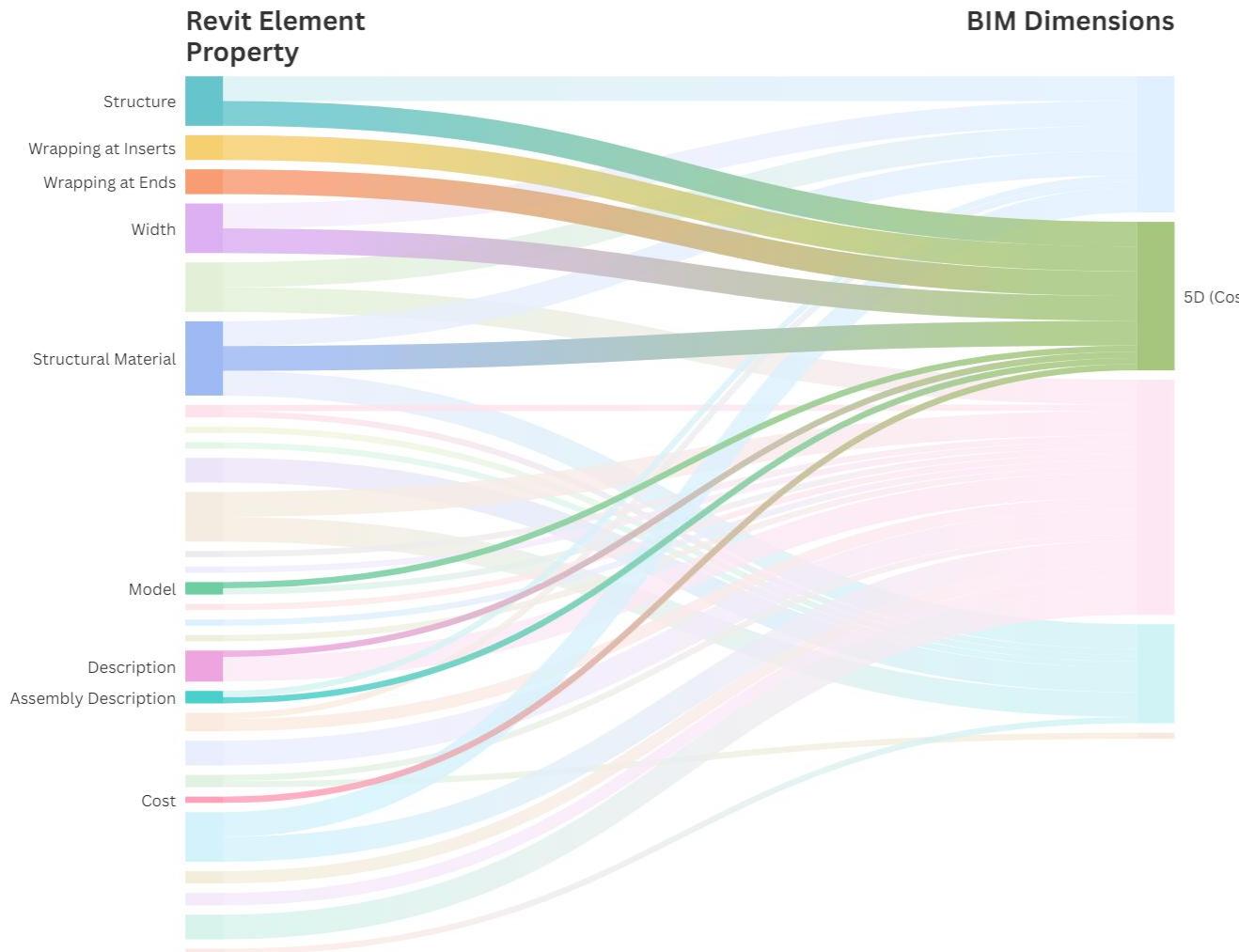
- **ISO 19650 Compliance:** The Surf Life Building model's lack of organized information and inconsistent metadata have an effect on collaboration, project coordination, and compliance throughout several stages.
- **COBie and Handover Gaps:** This complexity in data transition from PIM to AIM can be made even more onerous by large information gaps in the COBie data that could interfere with facility management and operational effectiveness.
- **Solibri Rule-Based Checks:** The model had failed some of the Solibri checks, showing hard and soft conflicts impacting safety compliance and project coordination, and data was missing for fire safety and escape routes.
- The model **does not have full scheduling (4D)** data, nor cost data (5D), both of which may affect project planning and cost control in terms of making it very hard to manage project timelines and create a realistic budget.
- **Energy Benchmarking:** The energy intensity of the building was 449 kWh/m²/year, which did not meet the ASHRAE 90.1 target but fell short of the Architecture 2030 goal. This could attain ISO 50001 standards in order to achieve sustainability goals, reduce operating costs, and increase energy efficiency.
- **Closed BIM Model:** The Surf Life Building has a closed BIM approach, with proprietary formats that inhibit smooth information sharing and platform coordination while limiting interoperability and impeding collaboration.

Fig. 45. The impact & relationship between Revit Element Properties (walls, windows, doors, floors, roof)) and BIM dimensions.

3D (Geometry)**Findings in 4D**

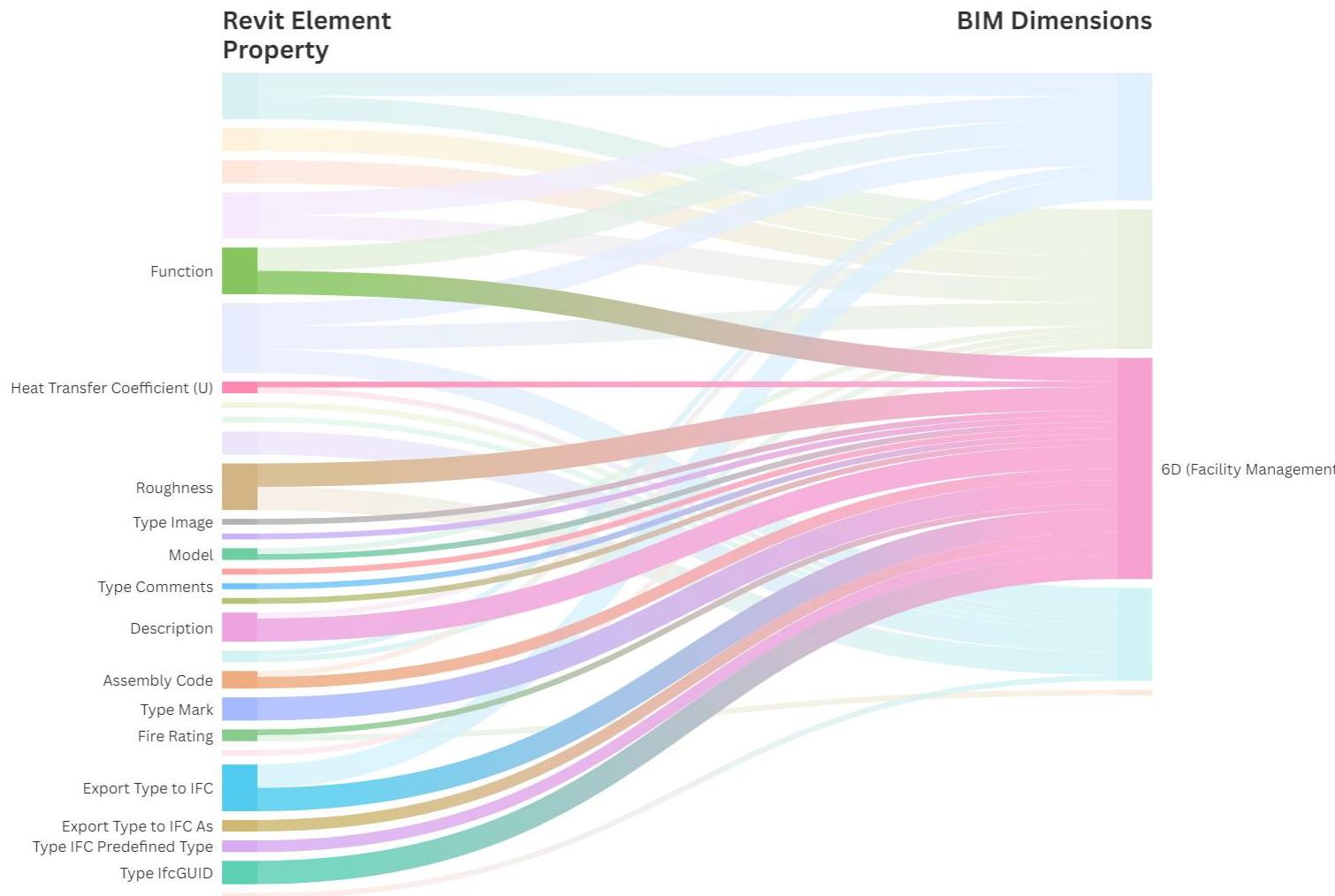
- **Project Delays:** Without complete scheduling information, it's very hard to plan and monitor the different stages for each project, so delays in meeting deadlines and milestones are highly probable.
- Without detailed scheduling information, it's difficult to manage the workers, tools, and supplies effectively, which might lead to bottlenecks and inefficient use of available resources.
- **Delay-Related Cost Increases:** Scheduling gaps, affecting the budget and viability of a project, usually bring about unanticipated extensions and related costs.
- **Reduced team coordination:** The incompleteness in 4D data will make it harder for disciplines like architecture, engineering, and construction to coordinate with each other, increasing the chances of workflow disputes and problems on the job site.
- **Impact on Project Planning and Control:** The lack of structured scheduling information, to begin with, is equivalent to blocking the use of good project control methods; therefore, tracking developments and plan adaptation changes will become even harder to do.

Fig. 46. The impact & relationship between Revit Element Properties (walls, windows, doors, floors, roof)) and BIM 4D.

3D (Geometry)**Findings in 5D**

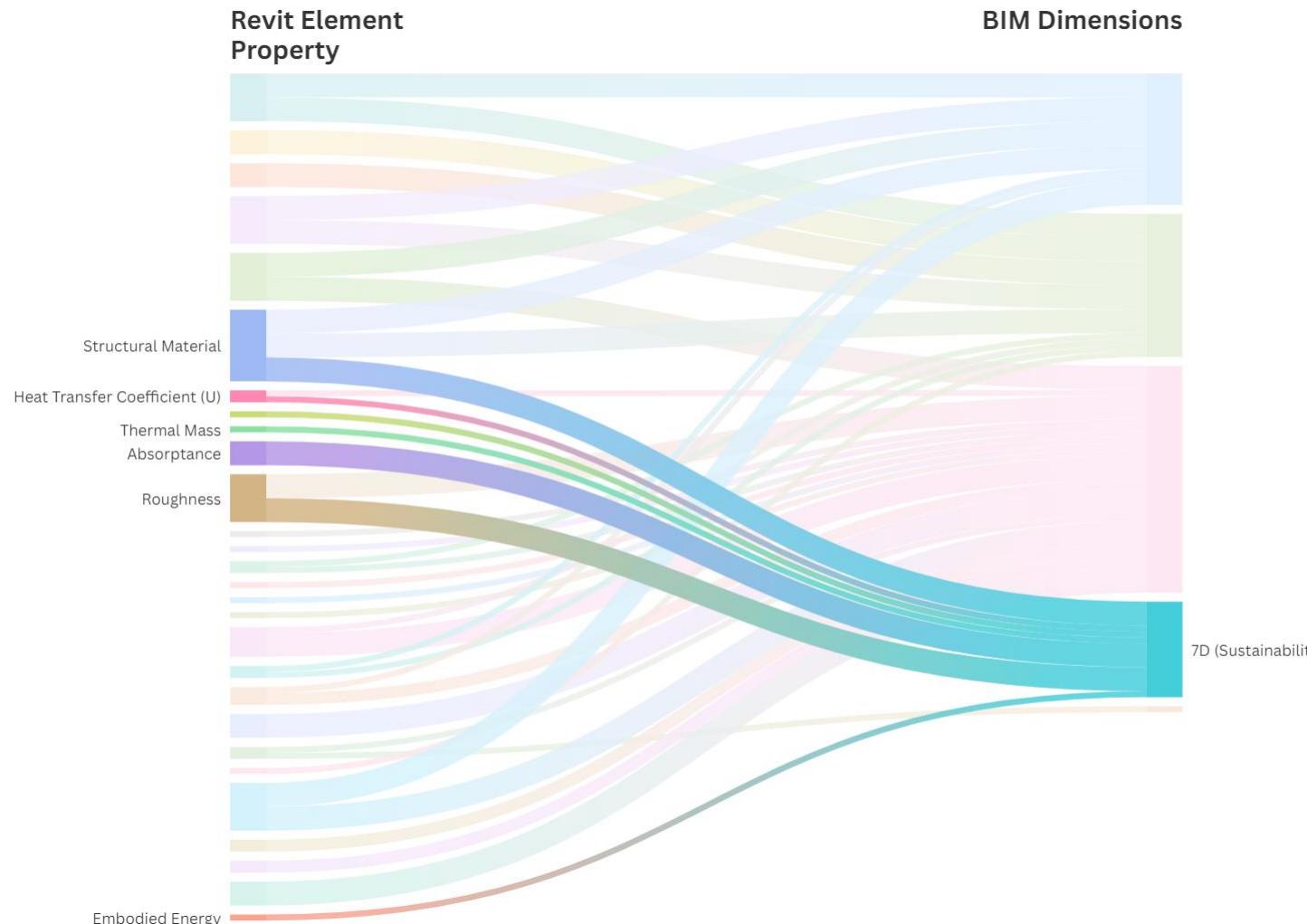
- The Surf Life Building has more risk to **budget overrun** because element schedules—walls, windows, and furnishings, for example—do not show complete cost information. Unpredicted expenses could create financial strain if they arise without accurate tracking.
- **Without any cost information on the element schedules**, it becomes rather difficult to have an accurate budget for materials, labor, and installation costs, which leaves one guessing at best when estimating the costs of major components. This may either result in hidden costs or unproductive money allocation.
- **Approval Delays Because of Incomplete Financial Data:** If element schedules contain incomplete cost data, funding approvals and financial decision-making may be delayed.
- **Little cost tracking and control over individual elements:** Without cost information in the element schedules, it is difficult to track and control costs of particular components. It then becomes so much harder to compare actual versus budgeted costs of a particular component, making any adjustments in spending so much more difficult.
- **Effects on Project Feasibility and Quality:** The overall feasibility of the Surf Life Building project may be affected where there are misaligned financial expectations due to a lack of element-level cost data that may involve compromise in quality or scope of work to fit within the budget.

Fig. 47. The impact & relationship between Revit Element Properties (walls, windows, doors, floors, roof)) and BIM 5D.

3D (Geometry)**Findings in 6D**

- **Ineffective Maintenance Scheduling:** Without COBie data for walls, doors, and furniture, repairs and upkeep become exponentially more difficult.
- The top challenges in asset tracking include incomplete data of assets that disturb lifecycle management, **making monitoring, replacement, and upgrading of components difficult.**
- **Increased Operational Costs:** Unstructured data increases costs since it makes routine maintenance, material requirements, and warranties less effective.
- **Compliance Risks:** Missing data on critical elements compromises regulatory compliance, risking safety standards.
- **Handover Challenges:** The handover process will be more complicated and delay facility performance and operational readiness because the COBie data are not accurate.

Fig. 48. The impact & relationship between Revit Element Properties (walls, windows, doors, floors, roof)) and BIM 6D.

3D (Geometry)**Findings in 7D**

- **Energy Performance Gaps:** The energy intensity of the Surf Life Building is 449 kWh/m²/year, which is below the Architecture 2030 objective, indicating that improvement in sustainability is needed.
- **Increased Operational Costs and Environmental Impact:** Organized energy management data is a must for the exploitation of opportunities in order to lower environmental impact and save operational costs.
- **ISO 50001 Alignment:** ISO 50001 guidelines help in enhancing energy efficiency, enabling the establishment of sustainability goals, and therefore reducing the carbon footprint of the building over its lifecycle.
- **Limited Lifecycle Sustainability Data:** Inadequate sustainability data impinge on long-term decisions, hence managing the total environmental performance of the building and implementing effective energy-saving strategies becomes more difficult.

Fig. 49. The impact & relationship between Revit Element Properties (walls, windows, doors, floors, roof)) and BIM 7D.

3D (Geometry)

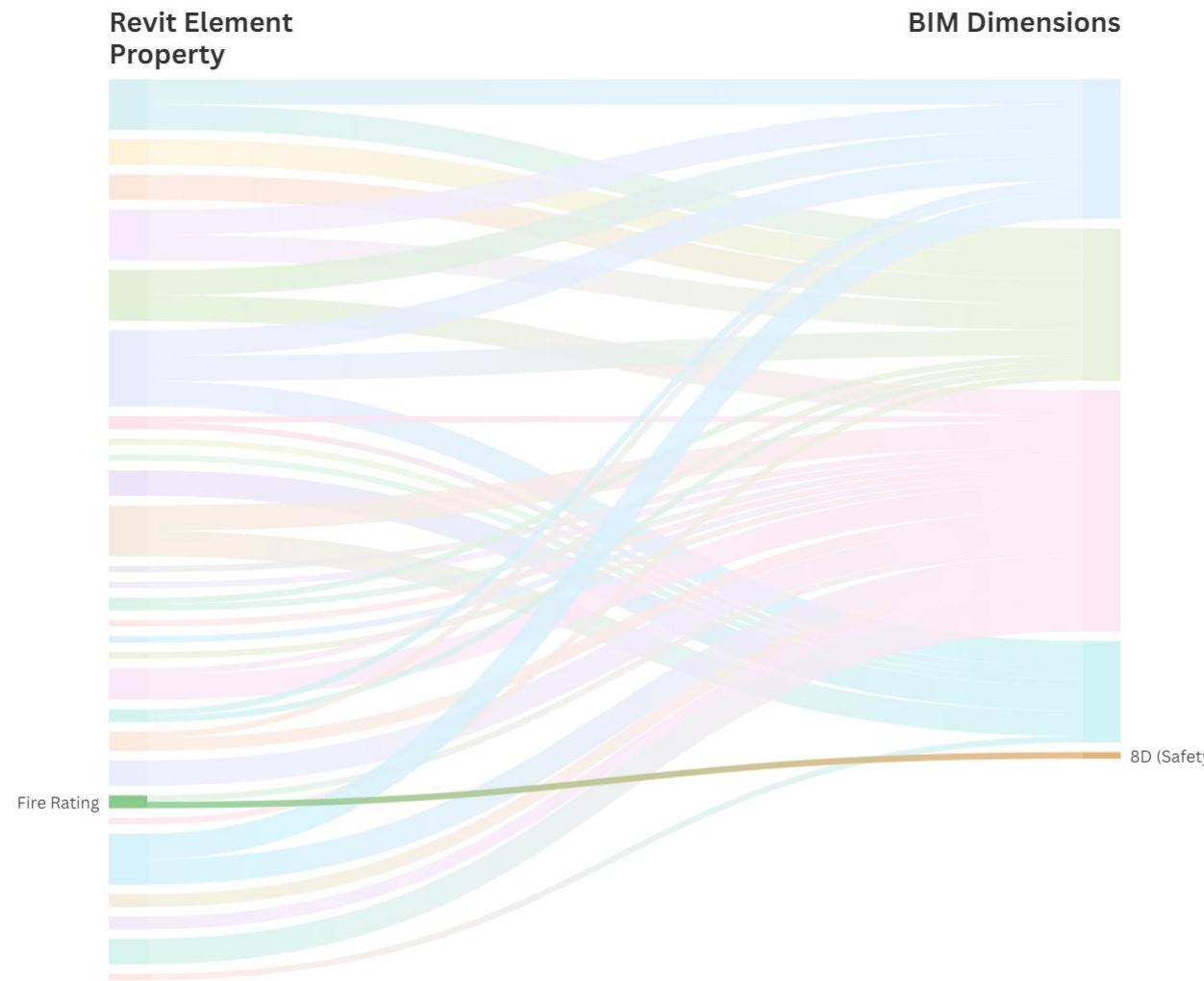


Fig. 50. The impact & relationship between Revit Element Properties (walls, windows, doors, floors, roof)) and BIM 8D.

Findings in 8D

- **Incomplete fire safety and escape route metadata:** Some important information in the Surf Life Building model, which can be used for escape route and fire safety planning, is missing and therefore may have implications for occupant safety and emergency preparedness.
- **Incomplete Data for Rule-Based Safety Checks:** Missing information in many of the Solibri rule-based safety checks makes compliance with safety standards difficult and project risk very high.
- **Risks to Handover and Operational Safety:** The knowledge gaps make it difficult to provide the facility managers with the information they need for a safe and compliant building environment throughout the operations phase.
- **Identification of Increased Risks to Safety Due to Conflicts:** Hard and soft clash detection by the model identifies spatial conflicts, which may expose a physical risk while under construction and during operation.

	Design Phase	Construction Phase	Handover Phase	Operations Phase
Affects: Architects & Engineers Facility Managers Sustainability Consultants	<p>They are more likely to involve delays and cost overruns when 4D and 5D data are missing since they get in the way of effective resource allocation and cost control. Moreover, without clear guidelines concerning materials and techniques, it will become more and more difficult to meet sustainability goals; insufficient 6D and 7D data means more changes have to be made during construction to fit maintenance demands.</p>	Affects: Project Managers Facility Managers Operations Teams	Increased Maintenance Costs and Inefficiencies: Without organized 4D and 6D information, facility managers cannot easily schedule maintenance, which means there is a lot of reactive repairs and increased operating expenses. Limited Energy Efficiency: This undermines the long-term sustainability and appeal of the building, as limited 7D information constrains energy management strategies and results in additional costs and environmental impact.	
Schedule and budgeting problems: 4D (schedule) and 5D (cost estimation) data are required to make project planning complex, which may lead to delay and miss budgeting. Ignoring sustainability and facility management: Without 6D (facility management) and 7D (sustainability) data, the maintenance requirements and energy-efficient design cannot be incorporated fully, hence a design that will not quite live up to environmental and lifetime expectations.	Affects: Contractors & Project Managers Quantity Surveyors Site Supervisors Environmental Engineers	Missing scheduling data—4D—results in delay in the hand-over timeline and hence its impact on occupancy schedules. Further, the lack of 6D data makes it even harder for handover to the operational team, and the missing 7D data limits the setting up of energy management systems and hence impacts readiness for sustainable and efficient operations.	Affects: Facility Managers Technicians Sustainability Teams	

- Implement **ISO 19650** (Fig. 53) for Information Management by Setting up a Common Data Environment (**CDE**) and define clear information containers with metadata to streamline tracking and access.
- Implement **ISO 7817** for a comprehensive framework for managing information requirements and to ensure the right level of information.
- Support collaboration and improve interdisciplinary coordination as per ISO 19650 and **apply the MacLeamy Curve** (Fig. 51) and **Integrated Project Delivery (IPD)** to make key decisions early, reducing rework and costs.
- Transition from **closed to open BIM** (Fig. 52) for better interoperability, for example, IFC and use NBS **Uniclass** for classification, ISO 19650 for file naming, and **COBie** for structured information management.
- Ensure health and safety compliance (**PAS 1192-6**), manage security risks (**ISO 19650-5**), and use the **Government Soft Landings (GSL)** approach for a smoother transition to operations.
- Integrate comprehensive scheduling data to avoid delays and include detailed cost data for accurate budgeting and financial control.
- Use structured COBie data for effective facility management and apply **ISO 50001** for energy efficiency and to support sustainability goals and **EN 15978** for assessing a building's environmental performance across its lifecycle.

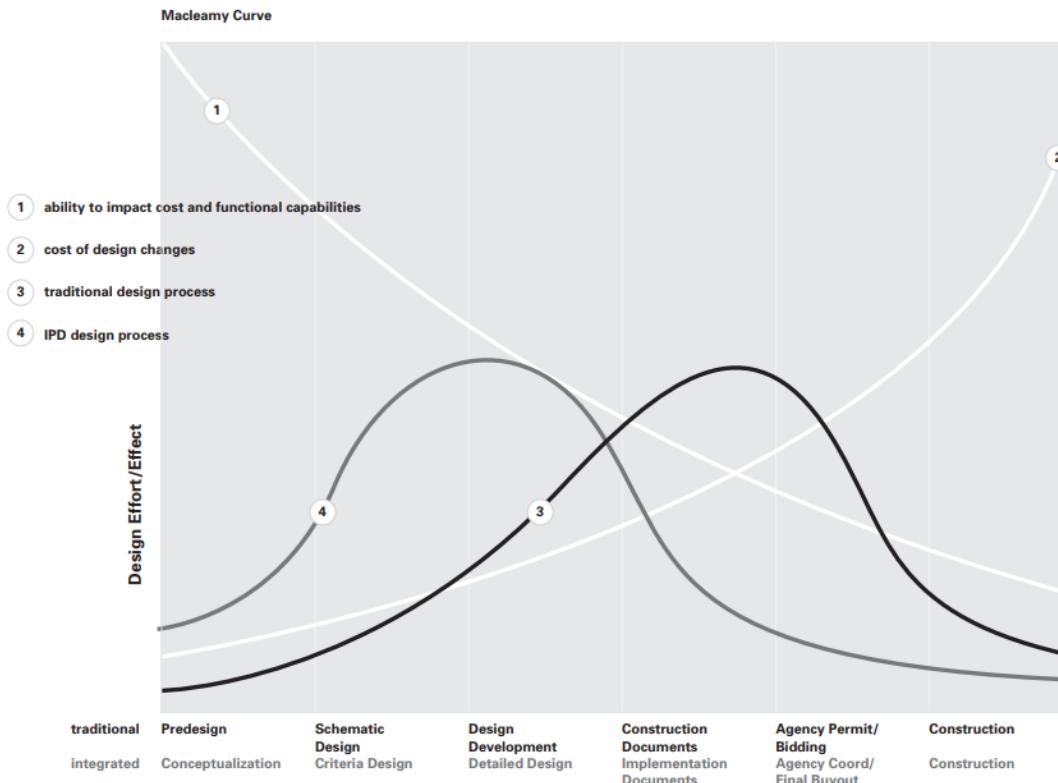


Fig. 51. MacLeamy Curve. Source: AIA, 2007.



Fig. 52. OpenBIM. Source: Eichler et al., 2023.



Fig. 53. NBS report & ISO 19650 standards.

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