LEAPTHOUGHT

FULCRUMHQ

CORENETX AUTOMATED MODEL CHECKER FUNCTIONALITIES

04 SEPT 2024

Introduction to CORENETX

One-Stop Portal for All Co-ordinated BIM Submissions and Regulatory Processing Across All Agencies - powered by FulcrumHQ

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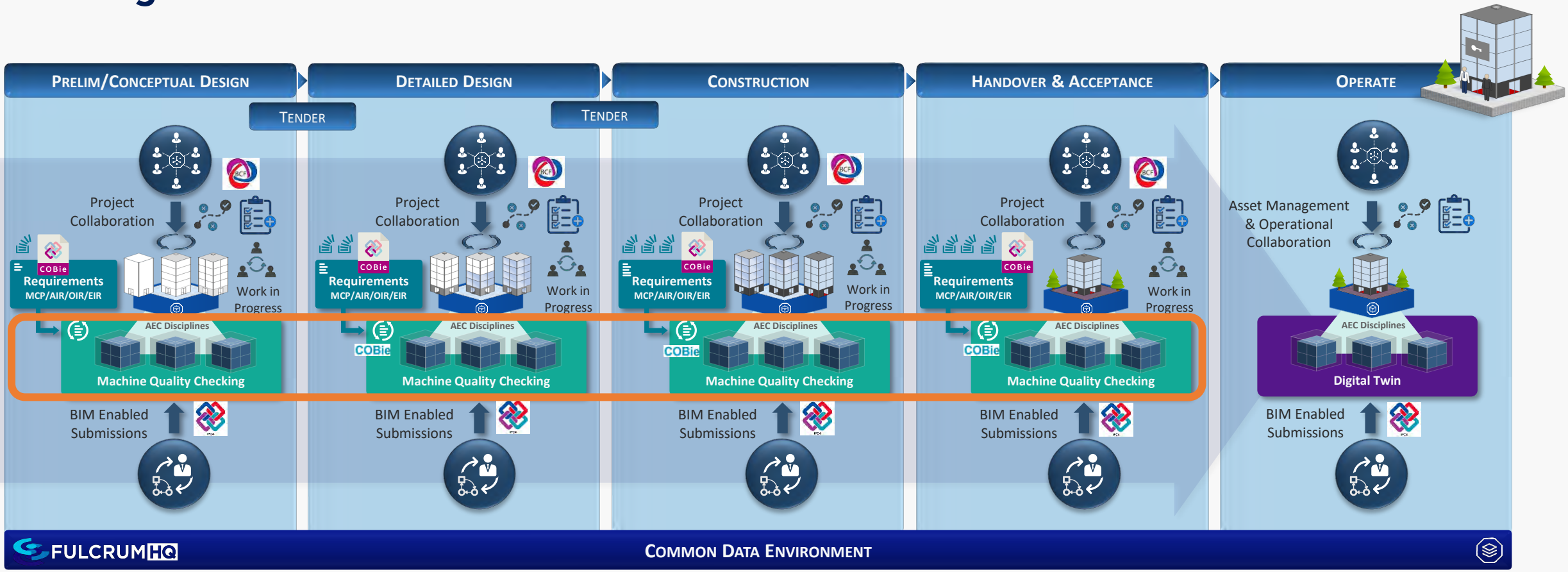
Trusted Source of Truth

Safe-guarding and future-proofing Asset Owners and Operators by ensuring BIM Models are trusted and reliable sources of truth.



Fulcrum offers full conformance to the following open standards:

buildingSMART openBIM IFC BCF COBie **ISO19650-1 & 2**

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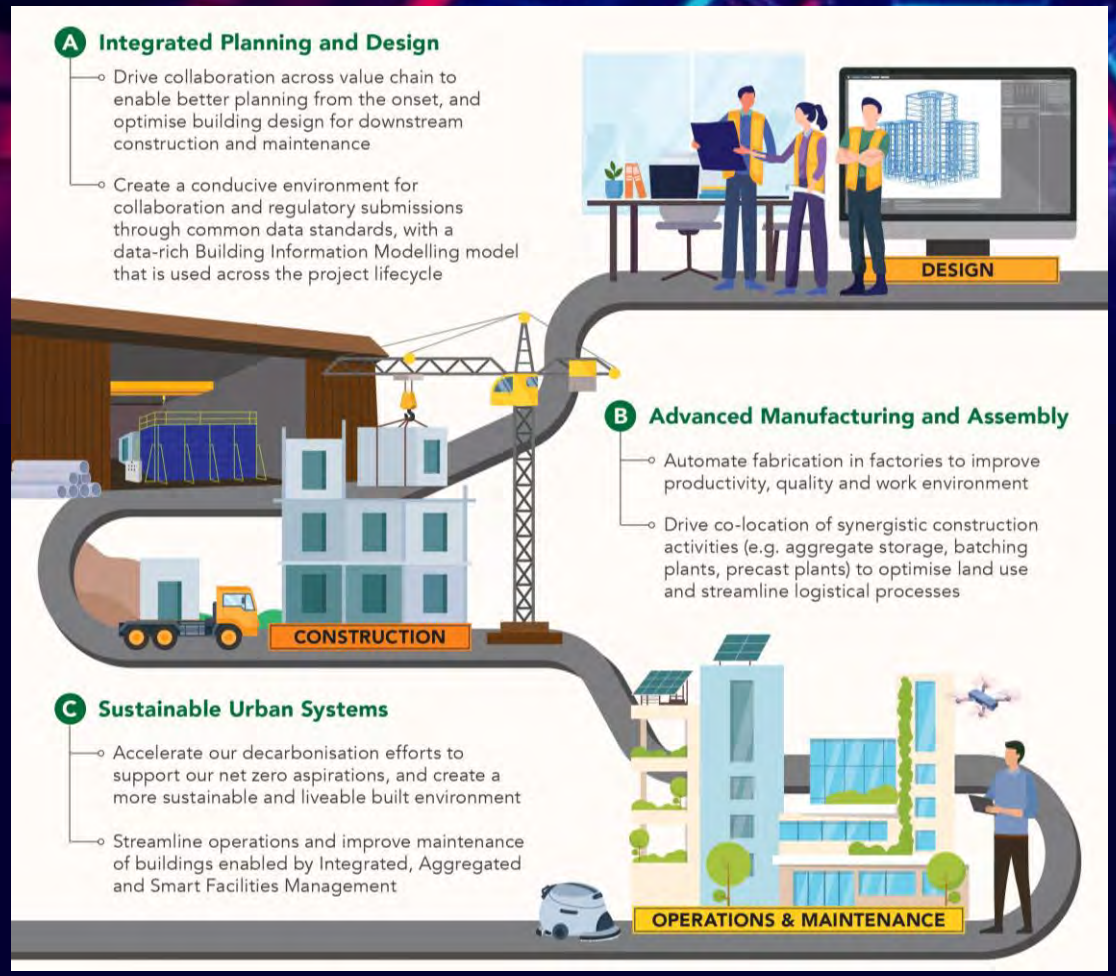
Industry Transformation Map



Integrated Planning and Design

Streamlining project approval processes by centralizing submissions, facilitating collaboration among government agencies, and ensuring consistent decision-making.

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Key Transformation #1
Redesigned Process

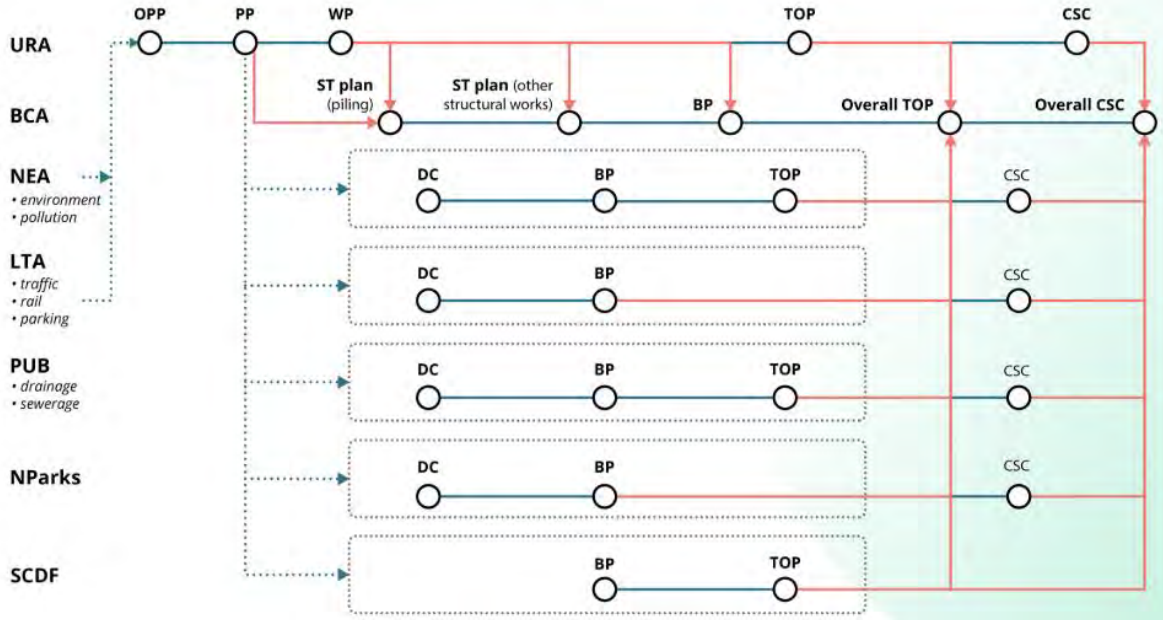
Current regulatory approval process

All building developments in Singapore are regulated by **8 key regulatory agencies**

Currently, building professionals *(e.g. architects, civil and structural engineers, mechanical and electrical engineers)* can make **separate submissions** to individual agencies based on project progress.

Projects are required to obtain **regulatory approvals** from the relevant agencies at various milestones of the project.

Under the current approval process, a typical building project will need to undergo **over 20 approval gates** across **8 agencies**.



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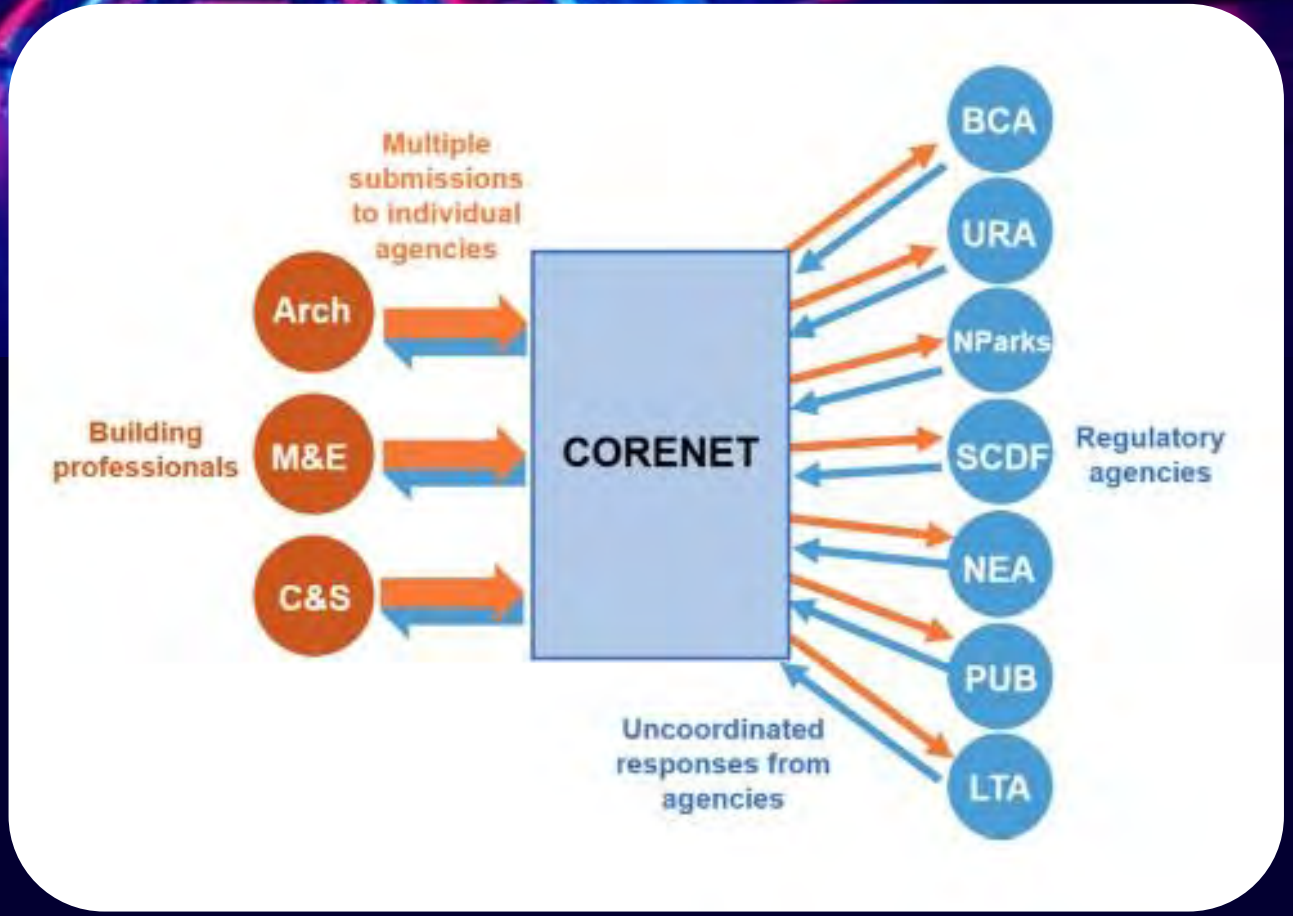
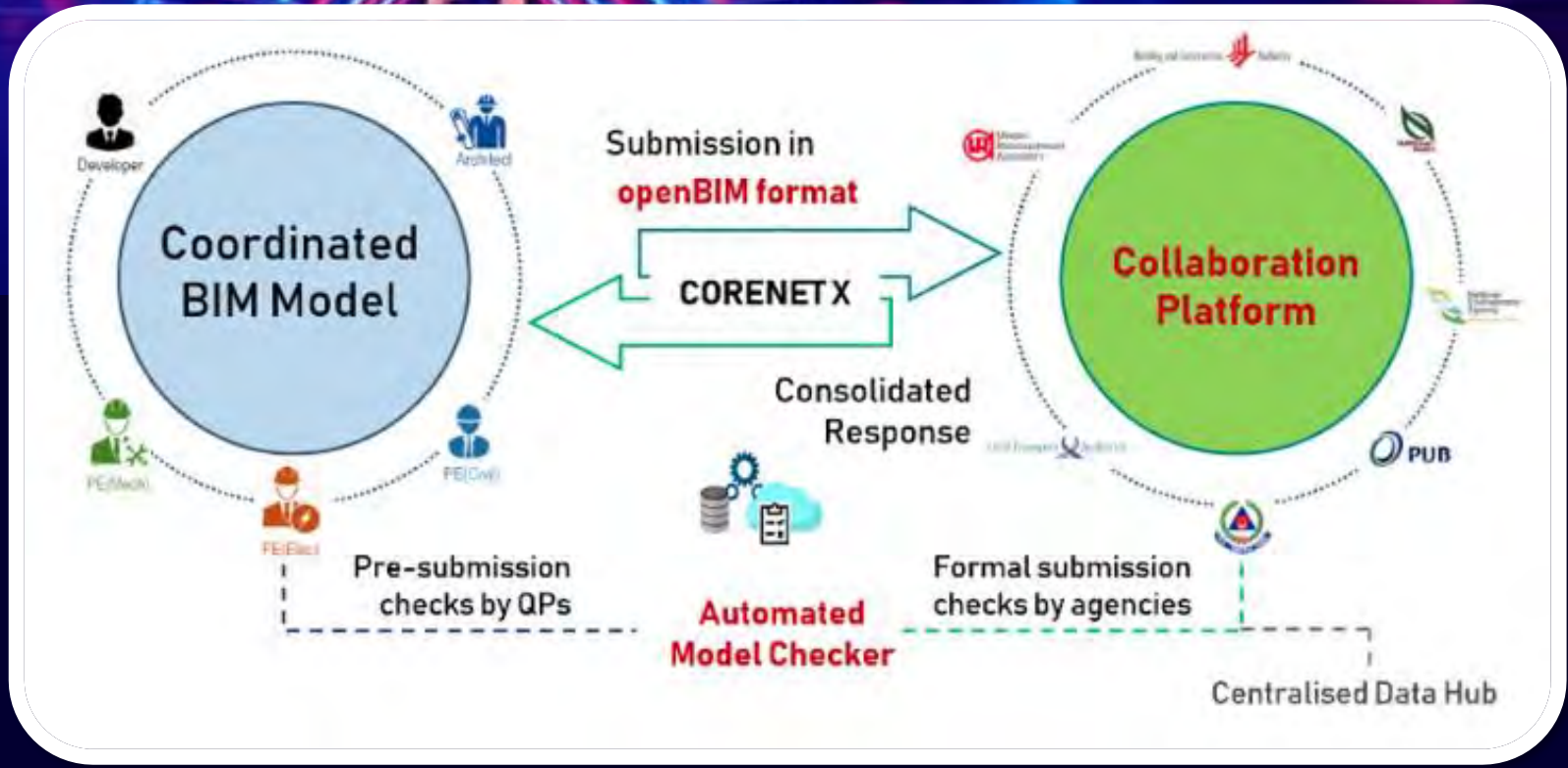
- The current regulatory process allows concurrent submissions, where industry consultants submit plans to various agencies separately.
- This approach does not incentivise consultants to conduct proper design coordination, which is important for productive construction practices.
- The plans approval process and response time of the regulatory agencies are also largely dependent on the project teams' own coordination as each individual agency assesses the submissions independently.



CORENETX

- CORENET X requires the consultants to collaborate upfront to de-conflict their designs
- Submit a coordinated BIM model to the authorities
- Agencies will collectively review the submission and provide a consolidated response to the consultants.
- This integrated submission process provides a one-stop shopfront experience and improves regulatory governance and synergy among agencies.



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Harnessing the power of digitalisation and technology, CORENET X will allow Qualified Persons (QPs, i.e. professional engineers and registered architects) to submit a three-dimensional model of a development or building - created and developed digitally through Building Information Modelling (BIM) - to the regulatory agencies.

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1

Receiving Submissions and Project Information

Incoming submissions are available on the Submissions Dashboard, with specific project and submissions details

2

Processing Submissions with Model Analytics

Processing Officers can process submission BIM models and documents, create Issues for further collaboration and as part of responses to QP

3

Coordinated Response and Packaging

Processing Officers can promote Issues along collaboration workflow stages, create Response Letters and upload documents for Response Packaging

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AUTOMATED MODEL CHECKER

Through an industry-facing portal, CORENET X will utilize technological enablers to bring about collaboration, automation and interoperability.

Project Team creates coordinated BIM

Project Team conducts pre-submission checks

openBIM Format

OPEN FORMAT FOR INTEROPERABILITY
The openBIM format is a platform-neutral and vendor-neutral solution. It will enable the industry to continue using the software of their choice to design and coordinate.

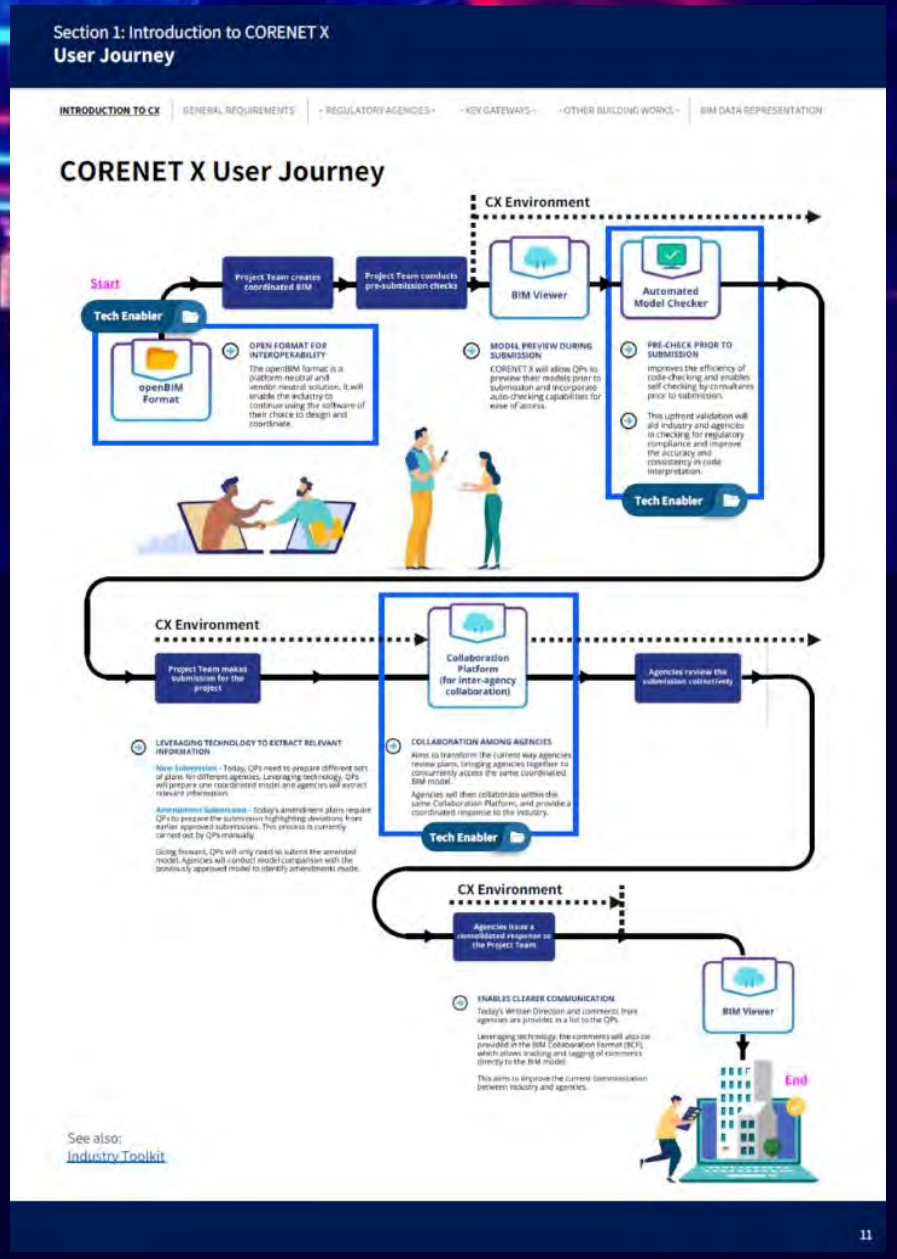
MODEL PREVIEW DURING SUBMISSION
CORENET X will allow QPs to to preview their models prior to submission and incorporate auto-checking capabilities for ease of access.

BIM Viewer

PRE-CHECK PRIOR TO SUBMISSION
Improves the efficiency of code checking and enables self-checking by consultants prior to submission.

Automated Model Checker

This upfront validation will aid industry and agencies in checking for regulatory compliance and improve the accuracy and consistency in code interpretation



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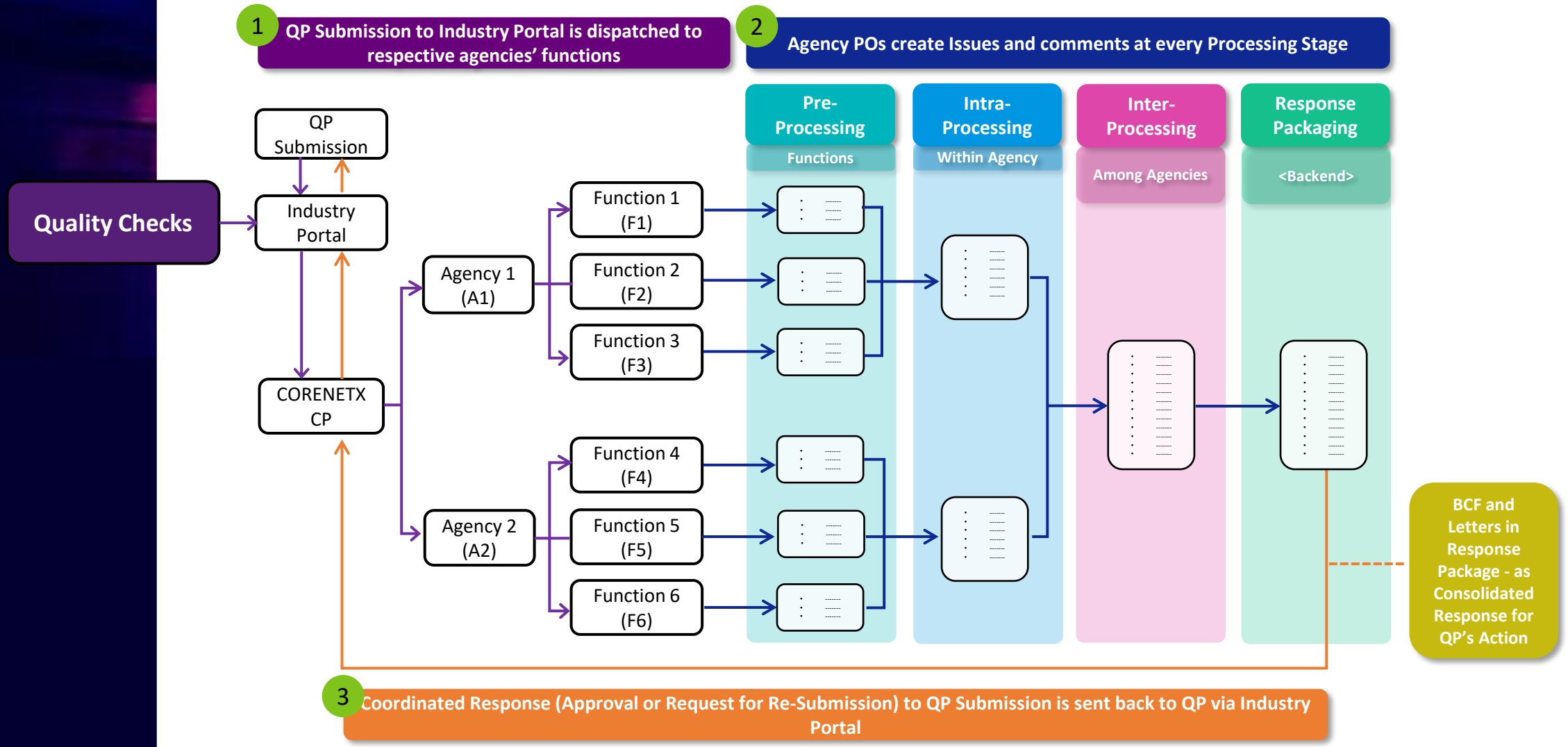
1
QP Submission to Industry Portal is dispatched to respective agencies' functions
2
Agency POs create Issues and comments at every Processing Stage
Quality Checks
QP Submission
Industry Portal
CORENETX CP
Agency 1 (A1)
Agency 2 (A2)
Function 1 (F1)
Function 2 (F2)
Function 3 (F3)
Function 4 (F4)
Function 5 (F5)
Function 6 (F6)
Pre-Processing
Functions
Intra-Processing
Within Agency
Inter-Processing
Among Agencies
Response Packaging
<Backend>
BCF and Letters in Response Package - as Consolidated Response for QP's Action
3
Coordinated Response (Approval or Request for Re-Submission) to QP Submission is sent back to QP via Industry Portal

Quality Checker (QC)

Automated Quality Checks ensuring Model Hygiene and Optimized Processing for BIM Submissions to CORENETX

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AUTOMATED MODEL CHECKER

Computational BIM enabled Quality Control

Computational automated checks driving conformity against modelling guidelines, AIR, EIR on Project Information and Asset Information models.

Computational BIM enabled Compliance Checks

Computational automated checks driving conformity against regulatory and design requirements.

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Introduction to FulcrumHQ's Quality Checks

5 Types of Quality Checks

QC 1 – Building Level Naming Convention

QC 1 analyses if building levels follow established naming conventions.

QC 2 – Clash Detection

QC 2 checks for meaningful clashes between select IFC4 Entities

QC 3 – Parameter Value Analysis

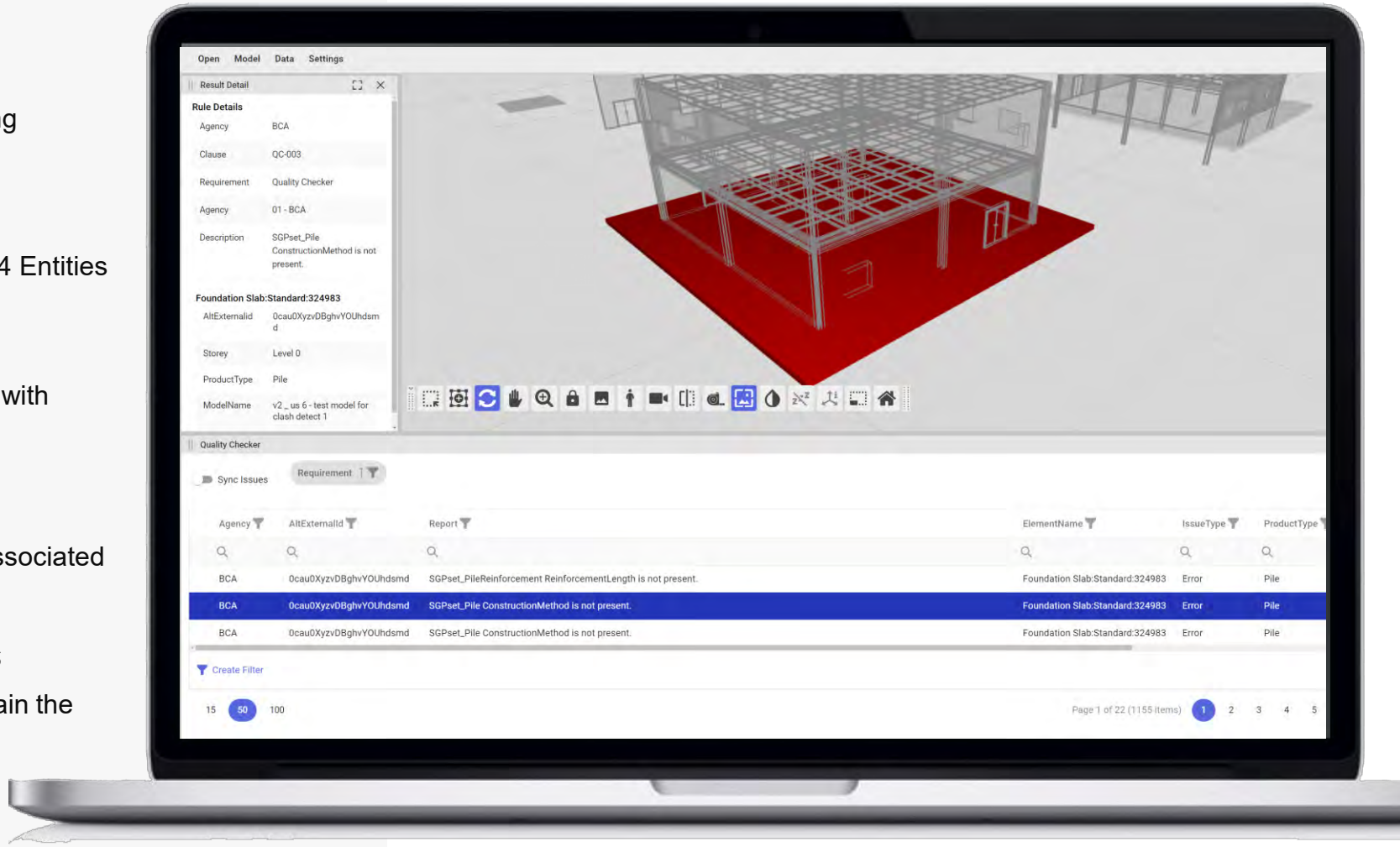
QC 3 checks for the presence of parameters associated with specific IFC4 Entities

QC 4 – Space Identification

QC 4 checks that every slab area in the model has an associated IfcSpace for identification

QC 5 – Alignment of BIM Model Coordinates

QC 5 ensures that the submitted trade BIM models contain the same coordinates



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QC 1 – Building Level Naming Convention

Objective

To ensure **building levels** follow established naming conventions.

Key Considerations

The check is also **designed to allow for some variation** in the way building levels may be named – for instance whether numerals or ordinal numerals should be indicated before or after fields such as 'Storey'

The current verification method is case-sensitive.

Verification Methodology

Step 1: Check for presence of IfcBuilding. This is a necessary condition.

Step 2: FHQ evaluates each IfcBuildingStorey present in the submitted model for its name

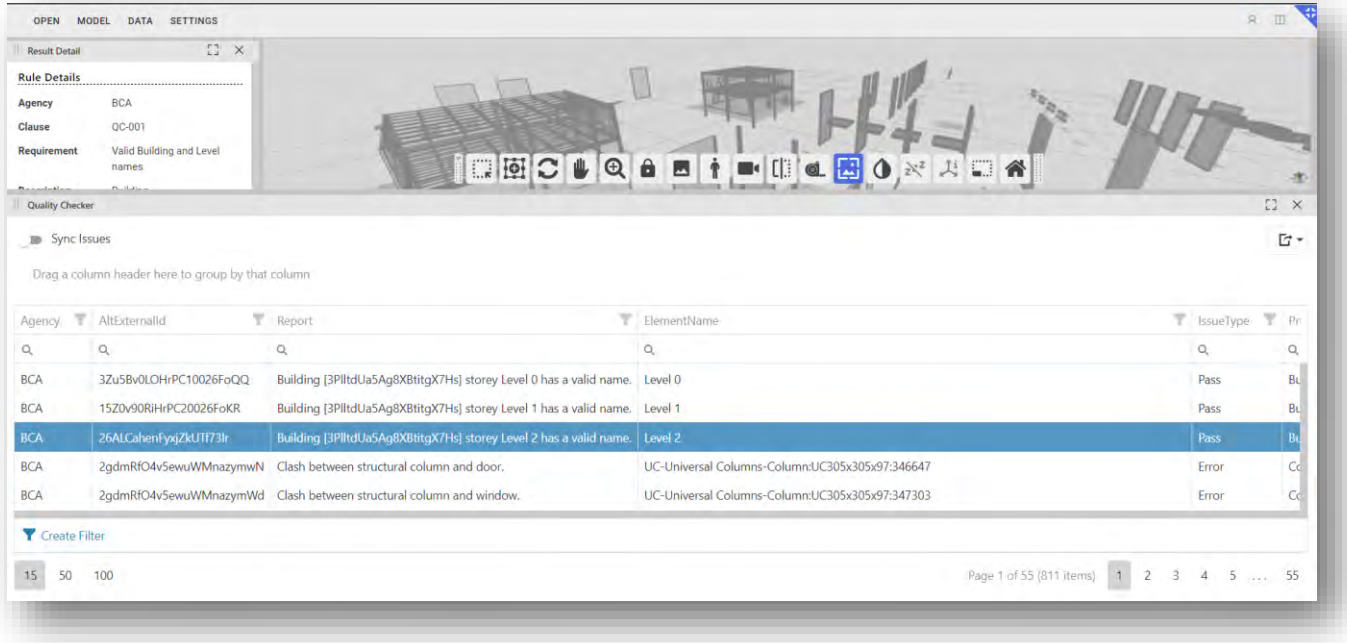
Step 3: IfcBuildingStorey name would be deemed acceptable if it adheres to any of the following conventions:

- 'Basement' followed by a numeral. E.g. Basement 1
- 'Level' followed by a numeral. E.g. Level 1
- 'Storey': Followed or preceded by a numeral. E.g. Storey 1, 1 Storey
- 'Storey': Followed or preceded by an ordinal numeral. E.g. Storey 1st, 1st Storey

Expected Outcomes

IssueTypes:

- **Pass Example:** for an IfcBuildingStorey named as 'Basement 1', QC 1 Report would state "Building storey has a valid name"
- **Warning Example:** for an IfcBuildingStorey named as 'Last Floor', QC 1 Report would state "Building storey Last Floor has an invalid name"



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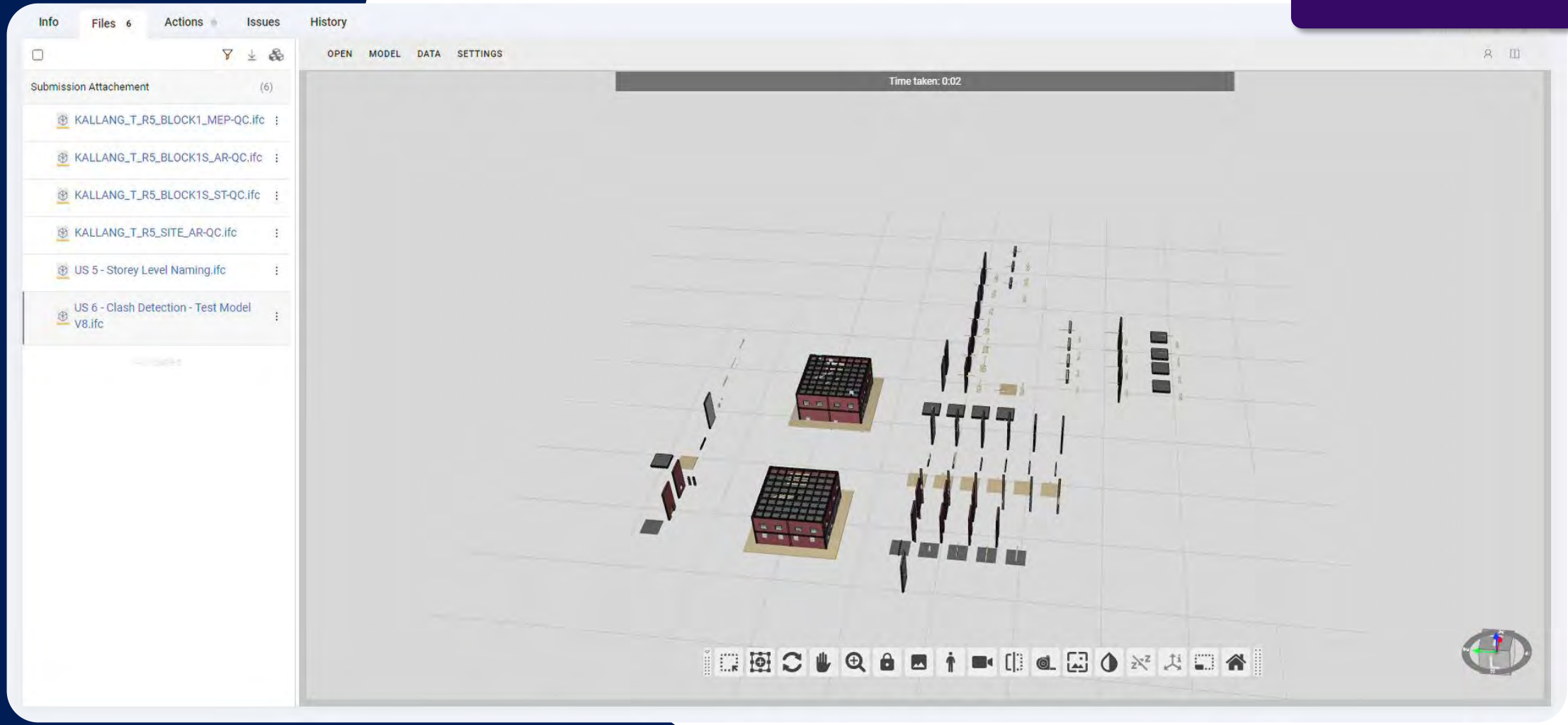
Quality Check 01 – Building Storey Convention



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QC 2 – Clash Detection

Objective

To check for **meaningful clashes** between select IFC4 Entities

Key Considerations

The check is based on an **established Clash Detection Matrix**, where geometrical overlaps between mapped IFC4 Entities generates various IssueTypes.

As this check evaluates many elements in a BIM model, it is designed to **show only IssueType: Fail or Warning results.**

Verification Methodology

Step 1: Check for presence of IFC4 Entities in the Clash Detection Matrix

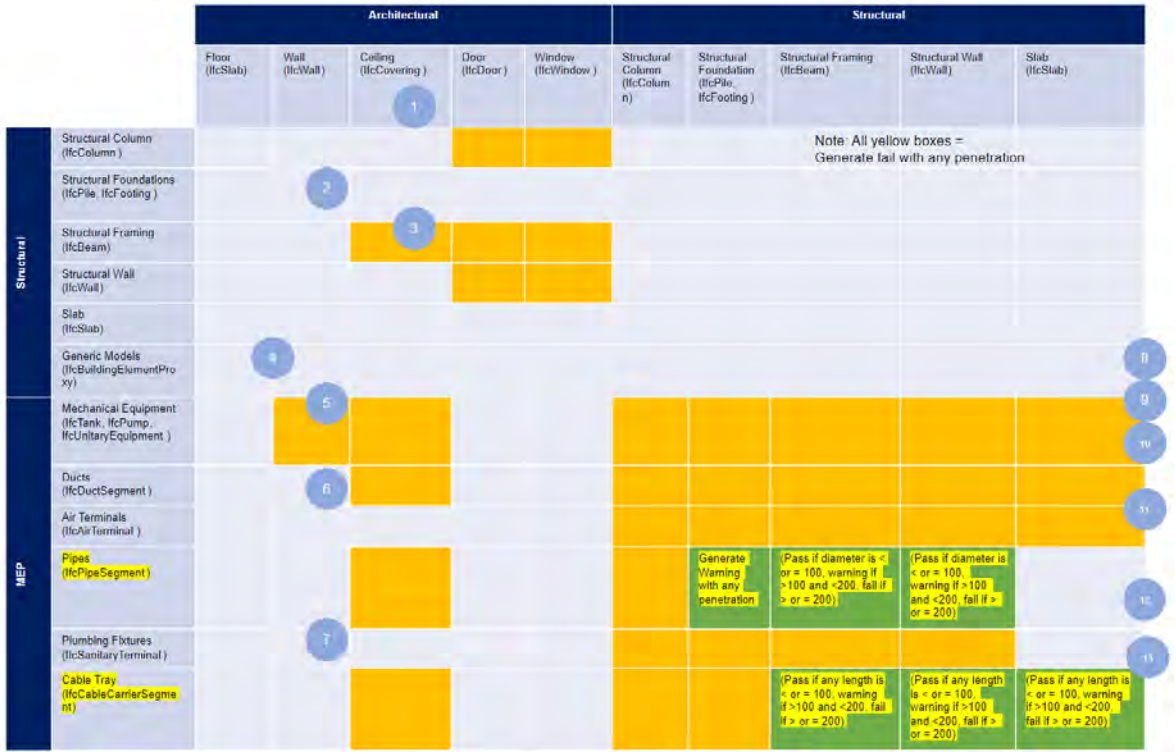
Step 2: FHQ evaluates if each of the IFC4 Entity has a geometrical clash with corresponding IFC4 Entity in the Clash Detection Matrix

Step 3: For certain IFC4 Entities, the clash would result in IssueType as Warning, depending on specific dimensions of these IFC4 Entities. For others, the clash would result in IssueType:Fail

Expected Outcomes

IssueTypes:

- **Fail Example**: An IfcDoor clashing with IfcColumn, QC 2 Report would state "Clash between Door and Column"
  Example: An IfcPipeSegment (Diameter >=200mm) clashing with an IfcWall, QC 2 Report would state "Clash between Pipe Segment and Wall"
- **Warning Example**: An IfcPipeSegment (Diameter >100 and <200mm) clashing with an IfcWall, QC 2 Report would state "Clash between Pipe Segment and Wall"



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Quality Check 02 – Clash Detection

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QC 3 – Parameter Value Analysis

Objective

To check for the **presence of parameters** associated with specific IFC4 Entities

Key Considerations

The Parameter Checks work with **user defined Excel sheets** to validate precise rules for checking parameters in your BIM models. By adjusting the values in the Excel table, you can create a quality assurance process that aligns with your project requirements.

(Refer to next slide for sample of Excel table for parameter checks.)

Verification Methodology

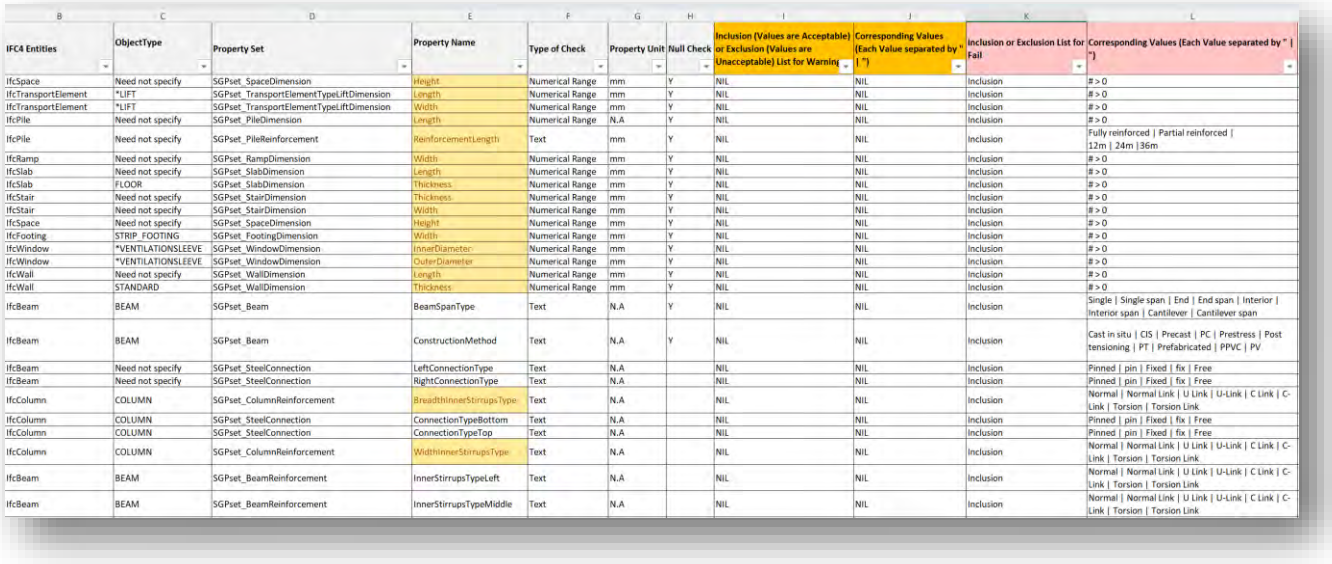
Step 1: Check for the presence of IfcEntity, ObjectType, Property Set and Property Name

Step 2: Depending on Type of Check indicated (Boolean, Null Check Only, Numerical Range, Regex, Text), corresponding checks are conducted for the identified IfcEntity

Expected Outcomes

IssueTypes:

- **Pass Example**: An IfcSpace with Parameter 'BarrierFreeAccessibility' contains the expected values for a Boolean Check, and QC 3 Report would state "BarrierFreeAccessibility contains True | False"
- **Fail Example**: An IfcBeam with Parameter 'ConstructionMethod' does not contain the expected values for a Text Check, and QC 3 Report would state "ConstructionMethod does not contain precast | prefabricated"
- **Warning Example**: An IfcSpace with Parameter 'Egress' does not contain the expected values for a Boolean Check, and QC 3 Report would state "Egress does not contain True | False"



IFC4 Entities	ObjectType	Property Set	Property Name	Type of Check	Property Unit	Null Check	Inclusion (Values are Acceptable) or Exclusion (Values are Unacceptable) List for Warning	Corresponding Values (Each Value separated by " | ")	Inclusion or Exclusion List for Fail	Corresponding Values (Each Value separated by " | ")
IfcSpace	Need not specify	SGPset_SpaceDimension	Height	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcTransportElement	*LIFT	SGPset_TransportElementTypeLiftDimension	Length	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcTransportElement	*LIFT	SGPset_TransportElementTypeLiftDimension	Width	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcPile	Need not specify	SGPset_PileDimension	Length	Numerical Range	N.A	Y	NIL	NIL	Inclusion	# > 0
IfcPile	Need not specify	SGPset_PileReinforcement	ReinforcementLength	Text	mm	Y	NIL	NIL	Inclusion	Fully reinforced | Partial reinforced | 12m | 24m |36m
IfcRamp	Need not specify	SGPset_RampDimension	Width	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcSlab	Need not specify	SGPset_SlabDimension	Length	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcSlab	FLOOR	SGPset_SlabDimension	Thickness	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcStair	Need not specify	SGPset_StairDimension	Thickness	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcStair	Need not specify	SGPset_StairDimension	Width	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcSpace	Need not specify	SGPset_SpaceDimension	Height	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcFooting	STRIP_FOOTING	SGPset_FootingDimension	Width	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcWindow	*VENTILATIONSLEEVE	SGPset_WindowDimension	InnerDiameter	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcWindow	*VENTILATIONSLEEVE	SGPset_WindowDimension	OuterDiameter	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcWall	Need not specify	SGPset_WallDimension	Length	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcWall	STANDARD	SGPset_WallDimension	Thickness	Numerical Range	mm	Y	NIL	NIL	Inclusion	# > 0
IfcBeam	BEAM	SGPset_Beam	BeamSpanType	Text	N.A	Y	NIL	NIL	Inclusion	Single | Single span | End | End span | Interior | Interior span | Cantilever | Cantilever span
IfcBeam	BEAM	SGPset_Beam	ConstructionMethod	Text	N.A	Y	NIL	NIL	Inclusion	Cast in situ | CIS | Precast | PC | Prestress | Post tensioning | PT | Prefabricated | PPVC | PV
IfcBeam	Need not specify	SGPset_SteelConnection	LeftConnectionType	Text	N.A		NIL	NIL	Inclusion	Pinned | pin | Fixed | fix | Free
IfcBeam	Need not specify	SGPset_SteelConnection	RightConnectionType	Text	N.A		NIL	NIL	Inclusion	Pinned | pin | Fixed | fix | Free
IfcColumn	COLUMN	SGPset_ColumnReinforcement	BreadthInnerStirrupsType	Text	N.A		NIL	NIL	Inclusion	Normal | Normal Link | U Link | U-Link | C Link | C-Link | Torsion | Torsion Link
IfcColumn	COLUMN	SGPset_SteelConnection	ConnectionTypeBottom	Text	N.A		NIL	NIL	Inclusion	Pinned | pin | Fixed | fix | Free
IfcColumn	COLUMN	SGPset_SteelConnection	ConnectionTypeTop	Text	N.A		NIL	NIL	Inclusion	Pinned | pin | Fixed | fix | Free
IfcColumn	COLUMN	SGPset_ColumnReinforcement	WidthInnerStirrupsType	Text	N.A		NIL	NIL	Inclusion	Normal | Normal Link | U Link | U-Link | C Link | C-Link | Torsion | Torsion Link
IfcBeam	BEAM	SGPset_BeamReinforcement	InnerStirrupsTypeLeft	Text	N.A		NIL	NIL	Inclusion	Normal | Normal Link | U Link | U-Link | C Link | C-Link | Torsion | Torsion Link
IfcBeam	BEAM	SGPset_BeamReinforcement	InnerStirrupsTypeMiddle	Text	N.A		NIL	NIL	Inclusion	Normal | Normal Link | U Link | U-Link | C Link | C-Link | Torsion | Torsion Link

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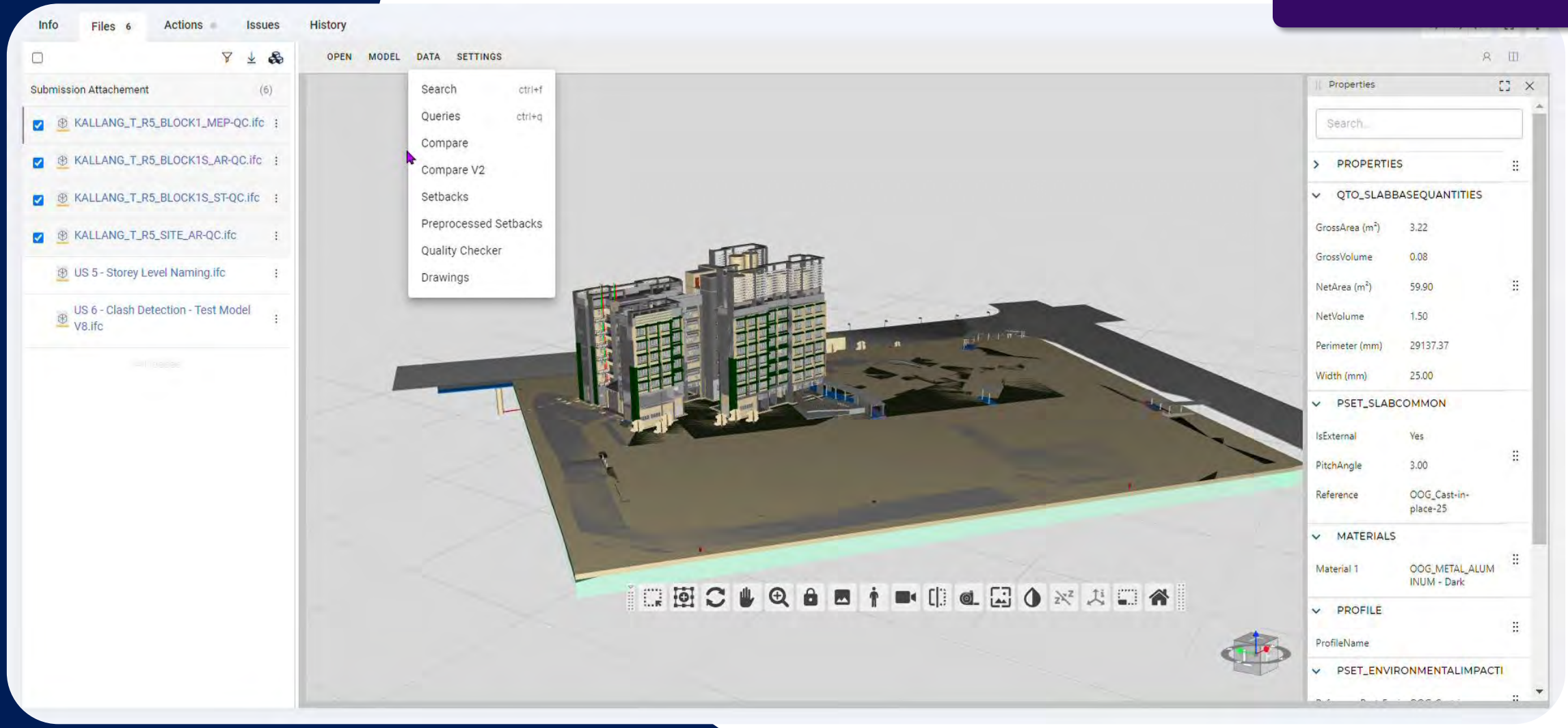
Quality Check 03 - Parameters



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QC 4 – Space Identification

Objective

To check that every slab area in the model has an **associated IfcSpace for identification.**

Key Considerations

All slabs should be **identified by an associated IfcSpace**

Taking into consideration IfcSlabs, whether sheltered or open-to-sky
However, there may be certain IfcSlabs that are small and do not warrant an association with IfcSpace

Verification Methodology

Step 1: Shortlist all IfcSlabs and IfcSpaces in the model

Step 2: IfcSlabs that are covered shall have an associated IfcSpace.

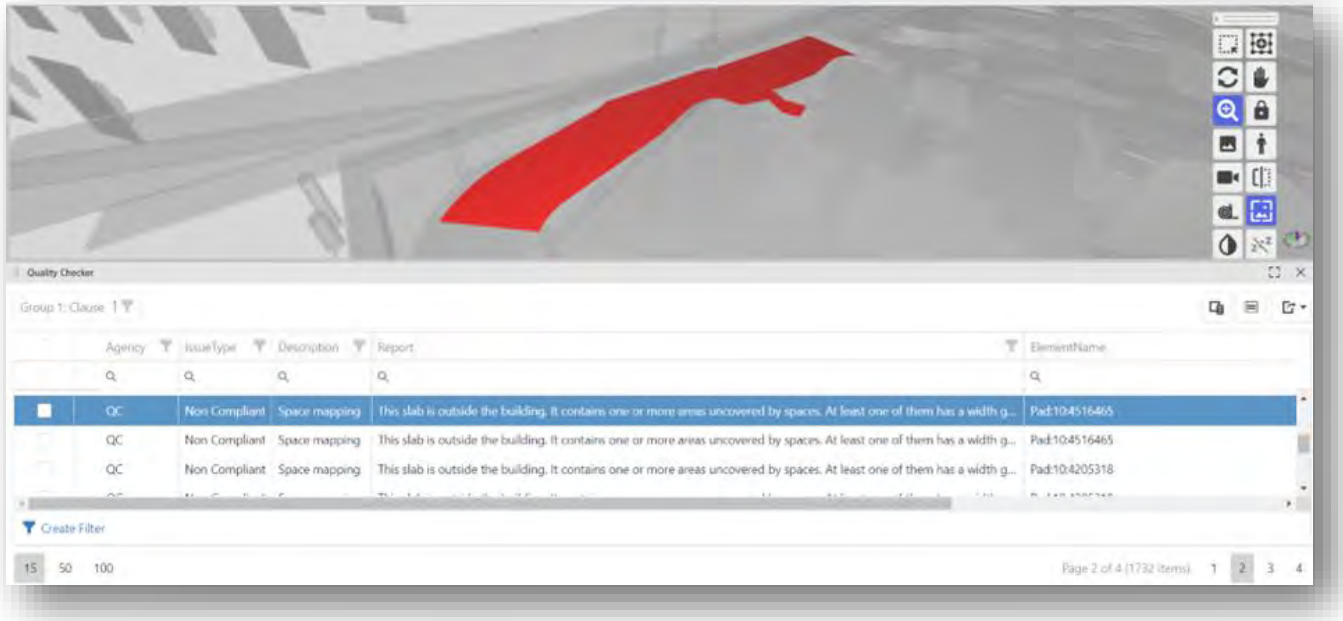
Step 3: IfcSlabs that are not covered, only those with a width of >1.5m would be analysed for an associated IfcSpace

Expected Outcomes

IssueTypes:

- **Pass Example**: An IfcSpace that is sheltered and fully in contact with IfcSpaces. The QC 4 Report would state "The entire slab is covered by spaces."

- **Fail Example**: An IfcSpace that is open-to-sky, with 41.23m2 area that is not in contact with an IfcSpace. QC 4 Report would state "This slab is outside the building. It contains one or more areas uncovered by Spaces. At least one of them has a width greater than 1.5m. Total remaining area: 41.23m2.



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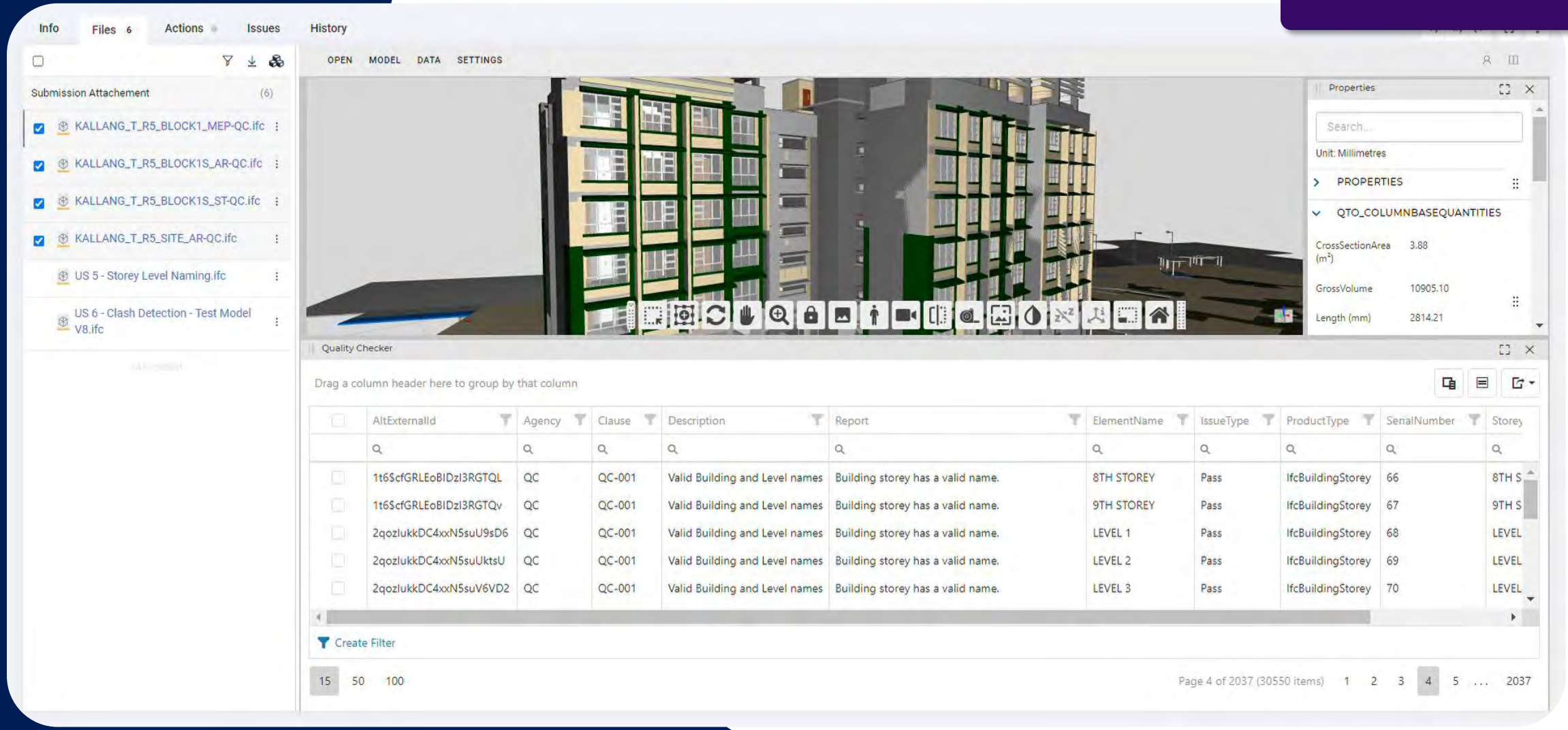
Quality Check 04 - Space Above Slabs



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QC 5 – Alignment of BIM Model Coordinates

Objective

To ensure submitted trade BIM models contain the **same model coordinates**

Key Considerations

Comparison of coordinates across all submitted models is necessary to ensure that the models are **geographically aligned** and can be federated as a project.

Verification Methodology

Step 1: Shortlist geographic (latitude and longitude) coordinates across all submitted models

Step 2: Verify if geographic coordinates are the same across all submitted models

Step 3: Shortlist cartesian coordinates across all submitted models

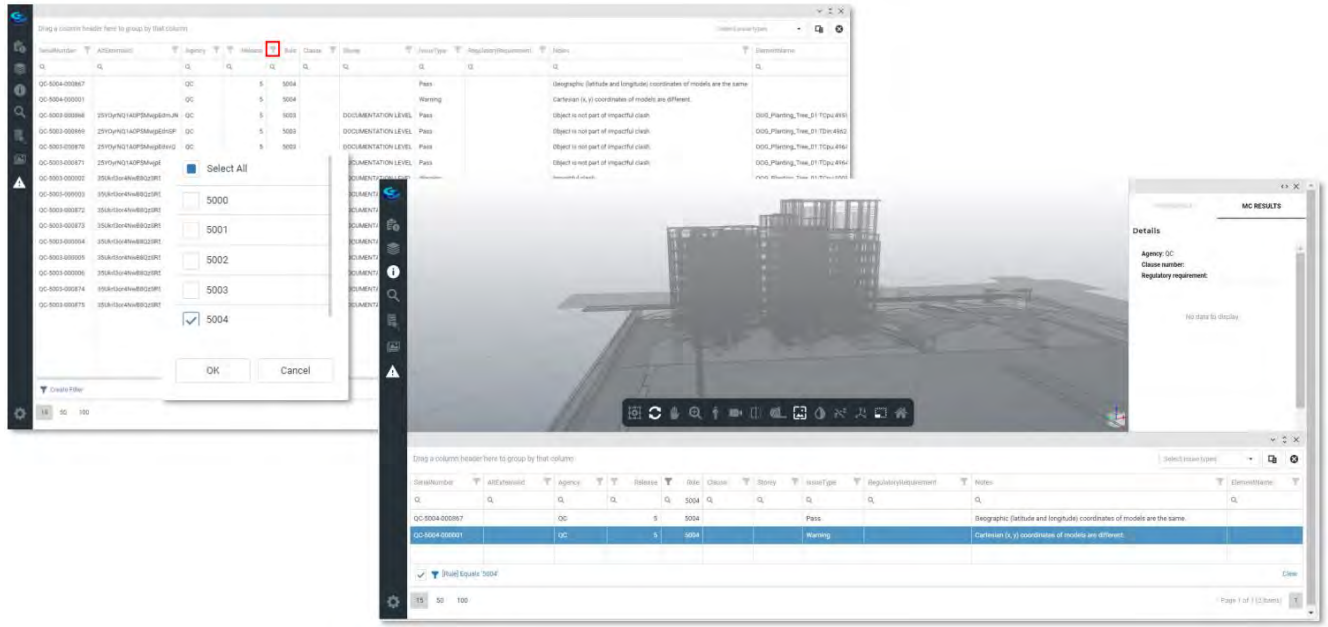
Step 4: Verify if cartesian coordinates are the same across all submitted models

Expected Outcomes

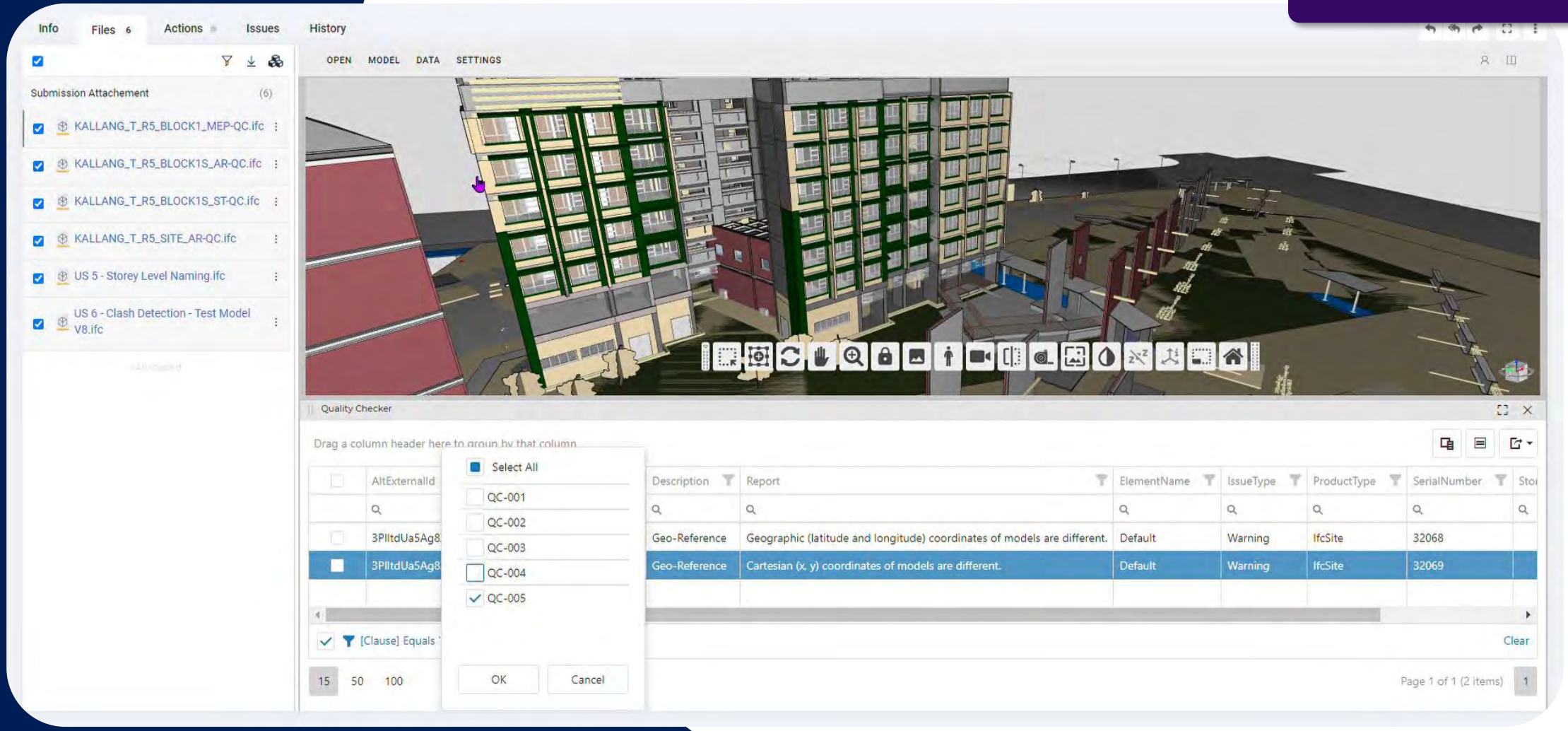
IssueTypes:

- **Pass Example**: Geographic coordinates are the same across all submitted models. The QC 5 Report would state "Geographic (latitude and longitude) coordinates of models are the same"

- **Warning Example**: Cartesian coordinates are not the same across all submitted models. The QC 5 Report would state "Cartesian (x,y) coordinates of models are not the same."



Quality Check 05 - Georeference



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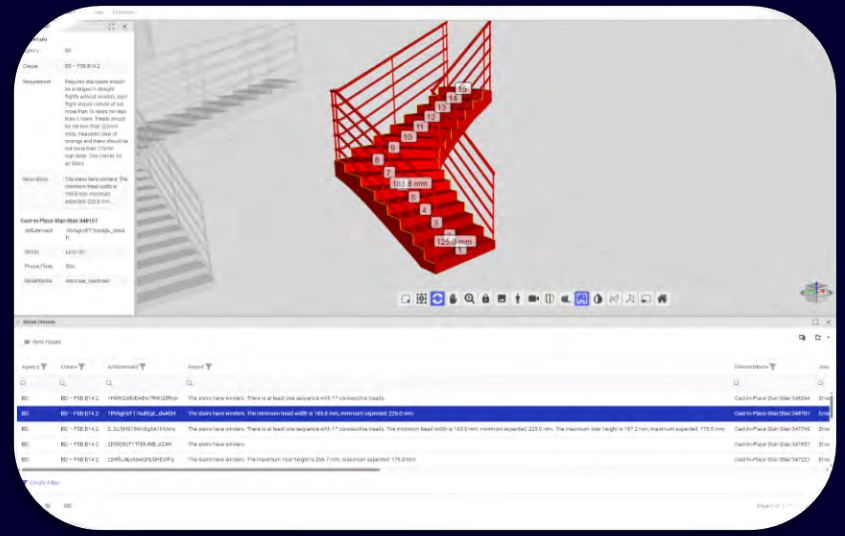
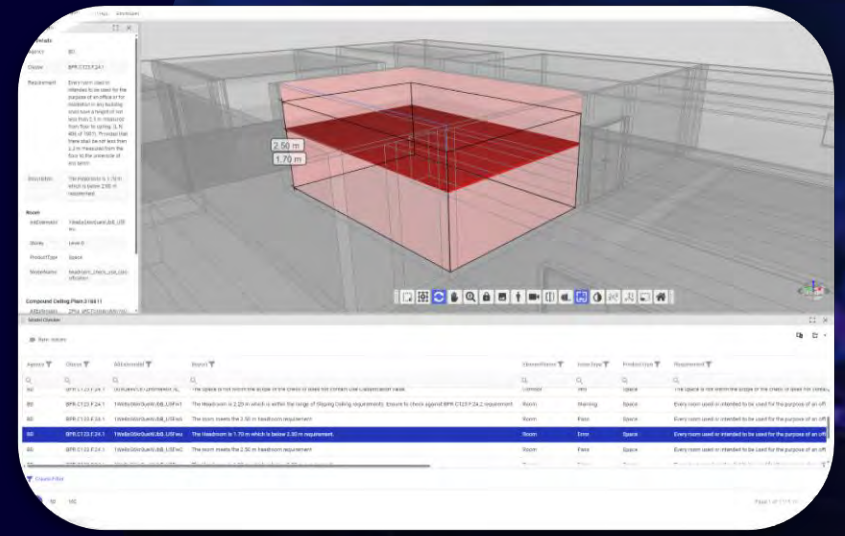
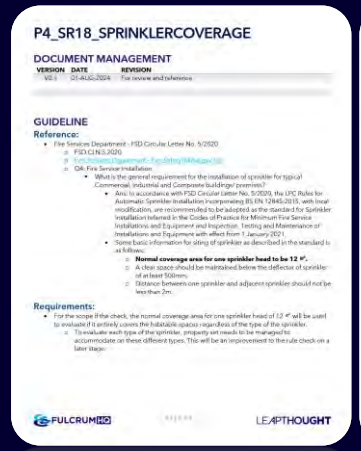
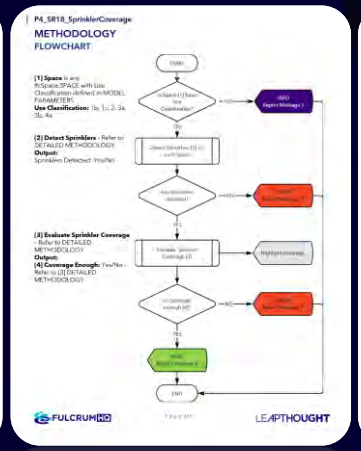
SBI-CIC Model Checker

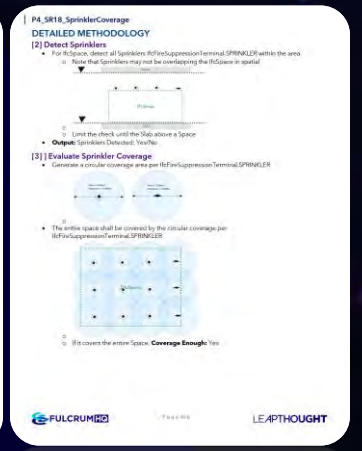
	Check Details	Status
P1	SR01_CICNamingCompliance	Live
P1	SR23_MEPNamingCompliance	Live
P1	SR02_OmniClass	Live
P1	SR03_BuildingElementProxy	Live
P1	SR08_UnallocatedSpace	Live
P1	SR09_CorridorWidth	Live
P1	SR10_CorridorHeight	Live
P1	SR13_StaircaseHeadroomExcMEP	Live
P1	SR14_StaircaseHeadroomIncMEP	Live
P1	SR15_WindowSillHeight	Live
P1	SR17_DoorOpeningClearance	Live
P2	SR05_BIMDiscipline	
P2	SR20_ColumnSettingOut	
P3	SR11_Headroom	
P3	SR12_StairRiserTread	
P3	SR21_WallSettingOut	
P4	SR04_ModelHygieneColumnWall	
P4	SR06_ModelHygieneElementType	
P4	SR07_ModelHygieneElementLevel	
P4	SR16_DoorThresholdHeight	
P4	SR18_SprinklerCoverage	
P4	SR19_StaircaseDiscrepancies	
P4	SR22_TopOfSlabDiscrepancies	
P4	SR24_HVACSetback	

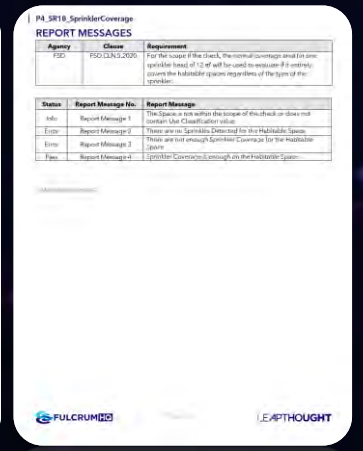












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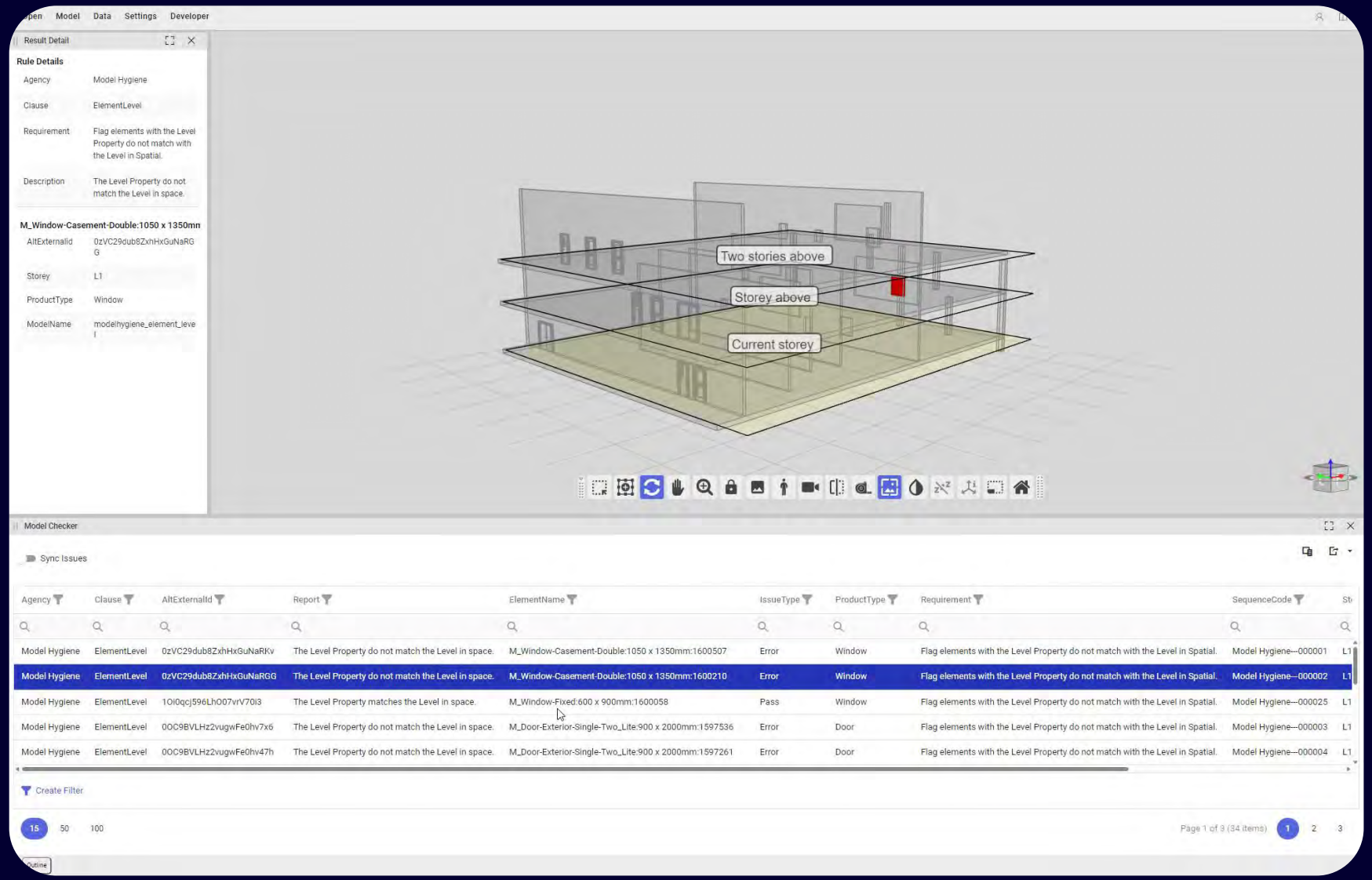
SBI-CIC Model Checker

	Check Details	Status
P1	SR01_CICNamingCompliance	Live
P1	SR23_MEPNamingCompliance	Live
P1	SR02_OmniClass	Live
P1	SR03_BuildingElementProxy	Live
P1	SR08_UnallocatedSpace	Live
P1	SR09_CorridorWidth	Live
P1	SR10_CorridorHeight	Live
P1	SR13_StaircaseHeadroomExcMEP	Live
P1	SR14_StaircaseHeadroomIncMEP	Live
P1	SR15_WindowSillHeight	Live
P1	SR17_DoorOpeningClearance	Live
P2	SR05_BIMDiscipline	
P2	SR20_ColumnSettingOut	
P3	SR11_Headroom	
P3	SR12_StairRiserTread	
P3	SR21_WallSettingOut	
P4	SR04_ModelHygieneColumnWall	
P4	SR06_ModelHygieneElementType	
P4	**SR07_ModelHygieneElementLevel**	
P4	SR16_DoorThresholdHeight	
P4	SR18_SprinklerCoverage	
P4	SR19_StaircaseDiscrepancies	
P4	SR22_TopOfSlabDiscrepancies	
P4	SR24_HVACSetback	



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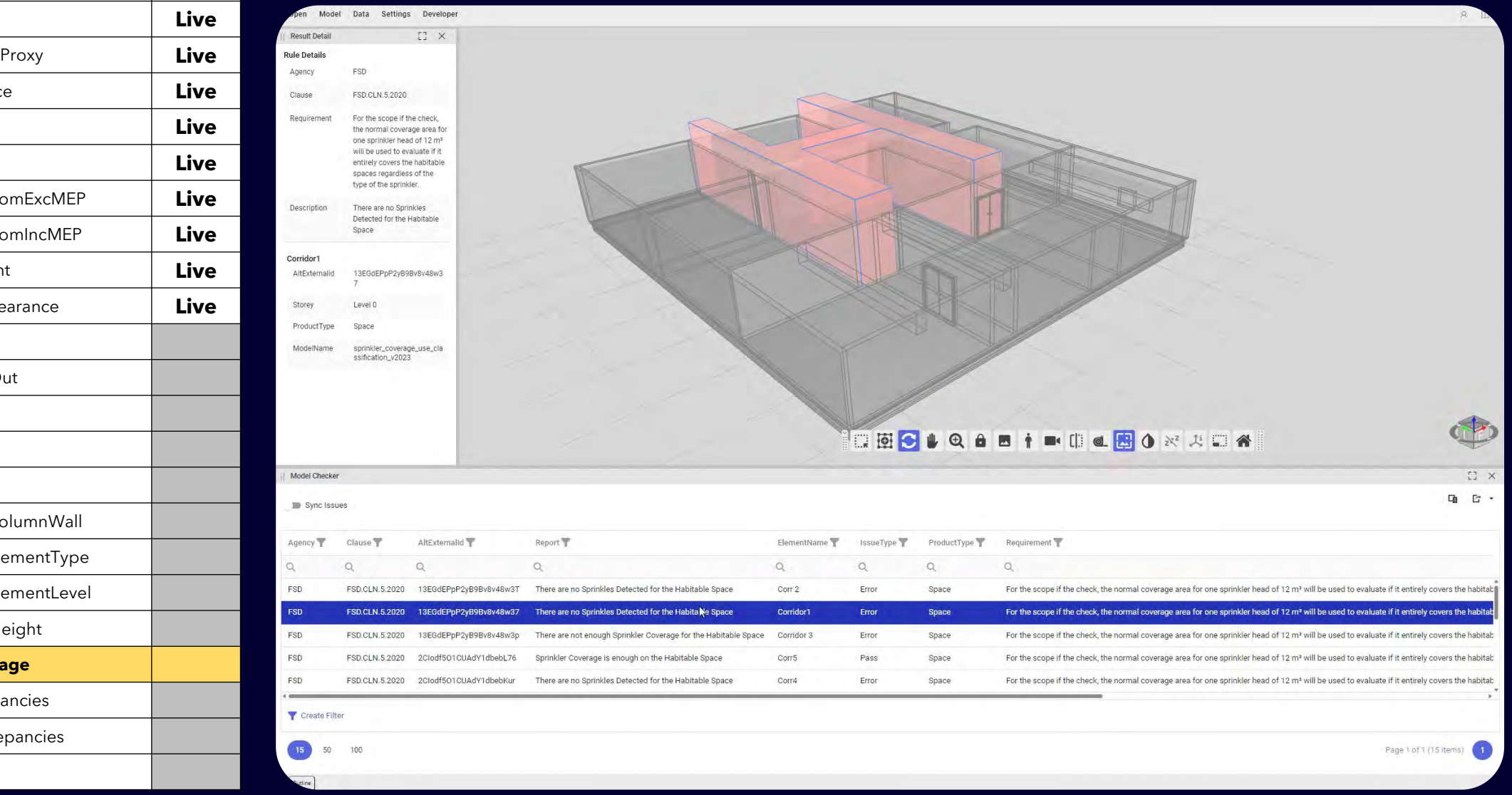
LEAPTHOUGHT

SBI-CIC Model Checker

	Check Details	Status
P1	SR01_CICNamingCompliance	Live
P1	SR23_MEPNamingCompliance	Live
P1	SR02_OmniClass	Live
P1	SR03_BuildingElementProxy	Live
P1	SR08_UnallocatedSpace	Live
P1	SR09_CorridorWidth	Live
P1	SR10_CorridorHeight	Live
P1	SR13_StaircaseHeadroomExcMEP	Live
P1	SR14_StaircaseHeadroomIncMEP	Live
P1	SR15_WindowSillHeight	Live
P1	SR17_DoorOpeningClearance	Live
P2	SR05_BIMDiscipline	
P2	SR20_ColumnSettingOut	
P3	SR11_Headroom	
P3	SR12_StairRiserTread	
P3	SR21_WallSettingOut	
P4	SR04_ModelHygieneColumnWall	
P4	SR06_ModelHygieneElementType	
P4	SR07_ModelHygieneElementLevel	
P4	SR16_DoorThresholdHeight	
P4	**SR18_SprinklerCoverage**	
P4	SR19_StaircaseDiscrepancies	
P4	SR22_TopOfSlabDiscrepancies	
P4	SR24_HVACSetback	



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LEAPTHOUGHT

Rule Interpretation (RI)

Interpretation of Regulatory Code Compliance with Stakeholders with Comprehensive Documentation, Test Scenarios and Models to Facilitate Rule Development

Agencies

URA Urban Redevelopment Authority

Land use planning and conservation agency.

BCA Building and Construction Authority

Built environment sector. Oversees safety, quality, inclusiveness, sustainability and productivity.

SCDF Singapore Civil Defence Force

Fire safety standards for local buildings and is used by the industry in designing fire safety works in buildings.

LTA Land Transport Agency

Planning, operating and maintaining Singapore's land transport infrastructure and systems.

PUB Public Utilities Board

National water agency, managing Singapore's water supply, water catchment, and used water in an integrated way.

NEA National Environment Agency

Environmental health concerns in the design of buildings.

NParks National Parks Board

Statutory requirements on greenery provision, tree planting and conservation for development projects in Singapore.

CORENETX Automated Model Checker
Pilot Phase (Completed)

150 Number of Rules Targeted

150 Number of Rules Interpreted

150 Number of Rules Delivered

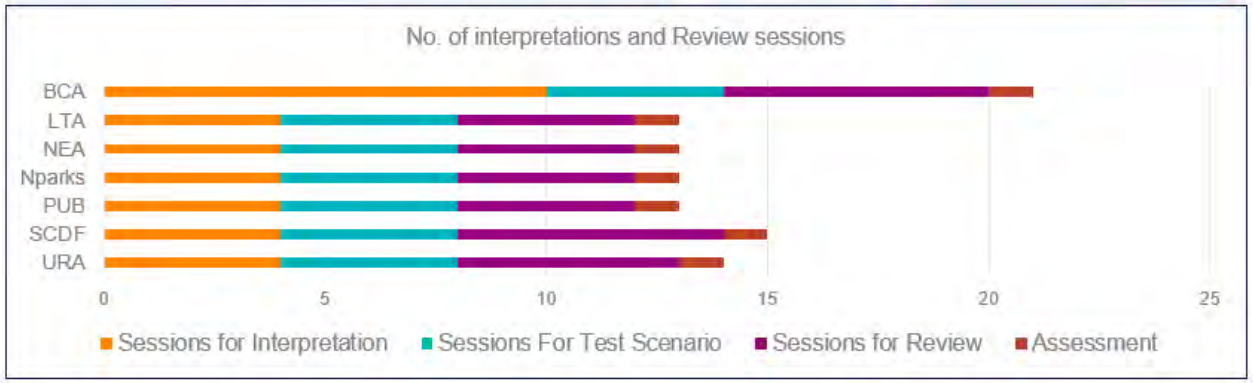
73 Number of feedback items addressed

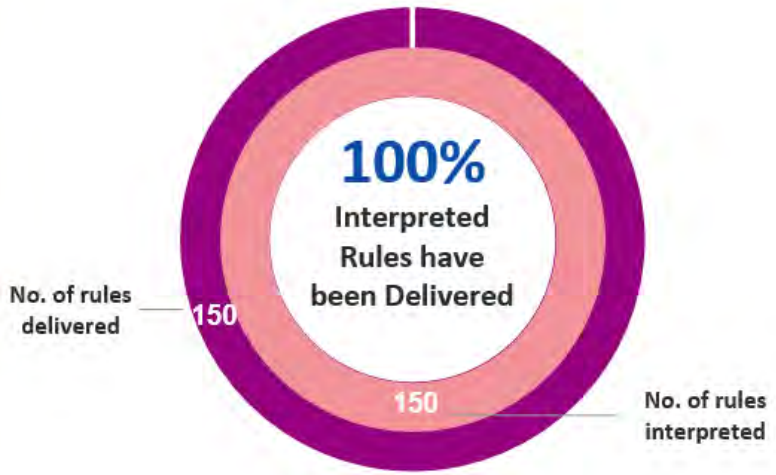
0 Rules under review

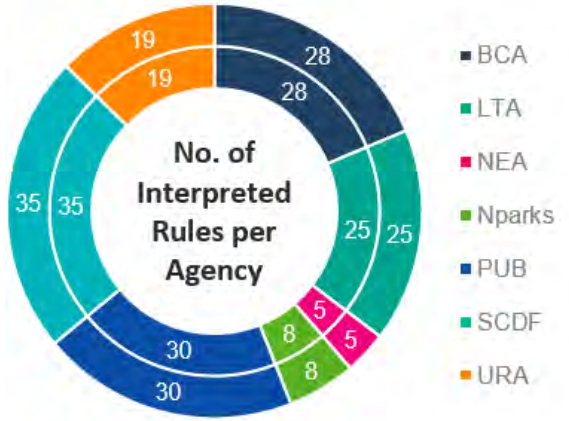
0 Under Development

7 Number of Agencies Participated

67 Number of Sessions (Interpretations and Demos)







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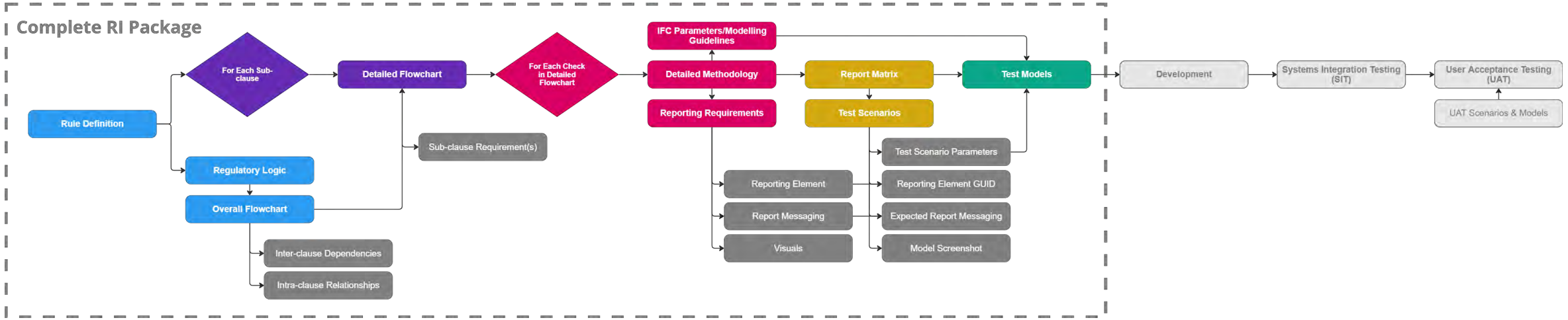
LEAPTHOUGHT

Rule Interpretation Process

Overview



Workflow of RI Package (Consisting of RI document, Test Scenarios, and Test Models)

Rule Interpretation Process

Interpreting the Code of Practice

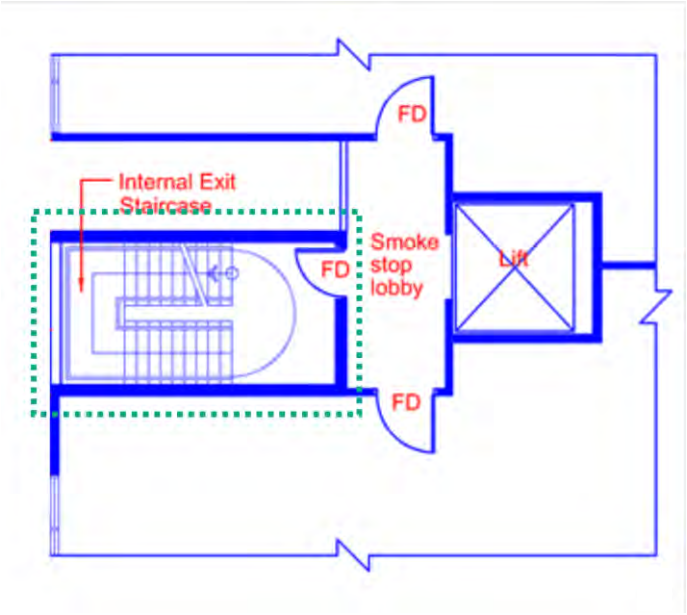
(4) Exception

(a) Single storey basement car park

Requirement 1 — Exemption

Exit staircases serving a single storey basement of PG II to VII buildings are not required to be protected with fire-rated enclosures, provided the travel distances in the car park measured to the exit doors at ground level comply with *Table 2.2A*.

Requirement 2



Excerpt from SCDF Fire Code 2023 Cl.2.3.3a(4)(a). Exit staircases meeting Requirements 1 & 2 are qualified for non-provision of fire-rated enclosure, but not provision of non-fire-rated enclosure.

Rule Interpretation Process

Clause Dependencies

2.3.2 Exit passageways

a. Fire resistance

Exit passageways that serve as a means of escape or required exits from any building or storey of a building shall have the requisite fire resistance as specified under *Cl.3.3*.

b. Internal exit passageway

An internal exit passageway which serves as required exit of a building shall comply with the following requirements:

(1) it shall be enclosed with construction complying with the provisions of *Cl.3.3*;

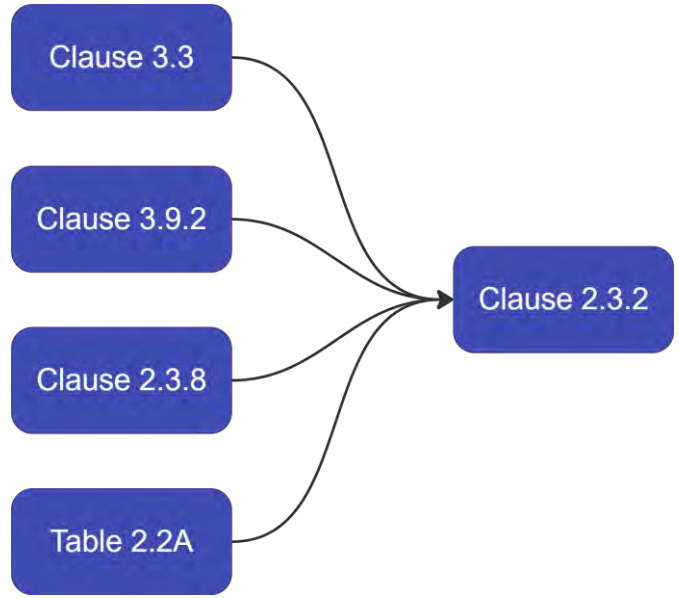
(2) the enclosure walls shall have not more than two exit doors, excluding the final discharge door and exit staircase door, opening into the exit passageway;

(3) exit doors opening into an exit passageway shall have fire resistance rating as required for exit doors opening into exit staircases, be fitted with automatic self-closing device and comply with the requirements of *Cl.3.9.2* for fire resisting doors;

(4) the minimum width and capacity of exit passageway shall comply with the requirements as provided in *Table 2.2A*;

(5) changes in level along an exit passageway requiring less than two risers shall be via a ramp complying with the provisions under *Cl.2.3.8*; and

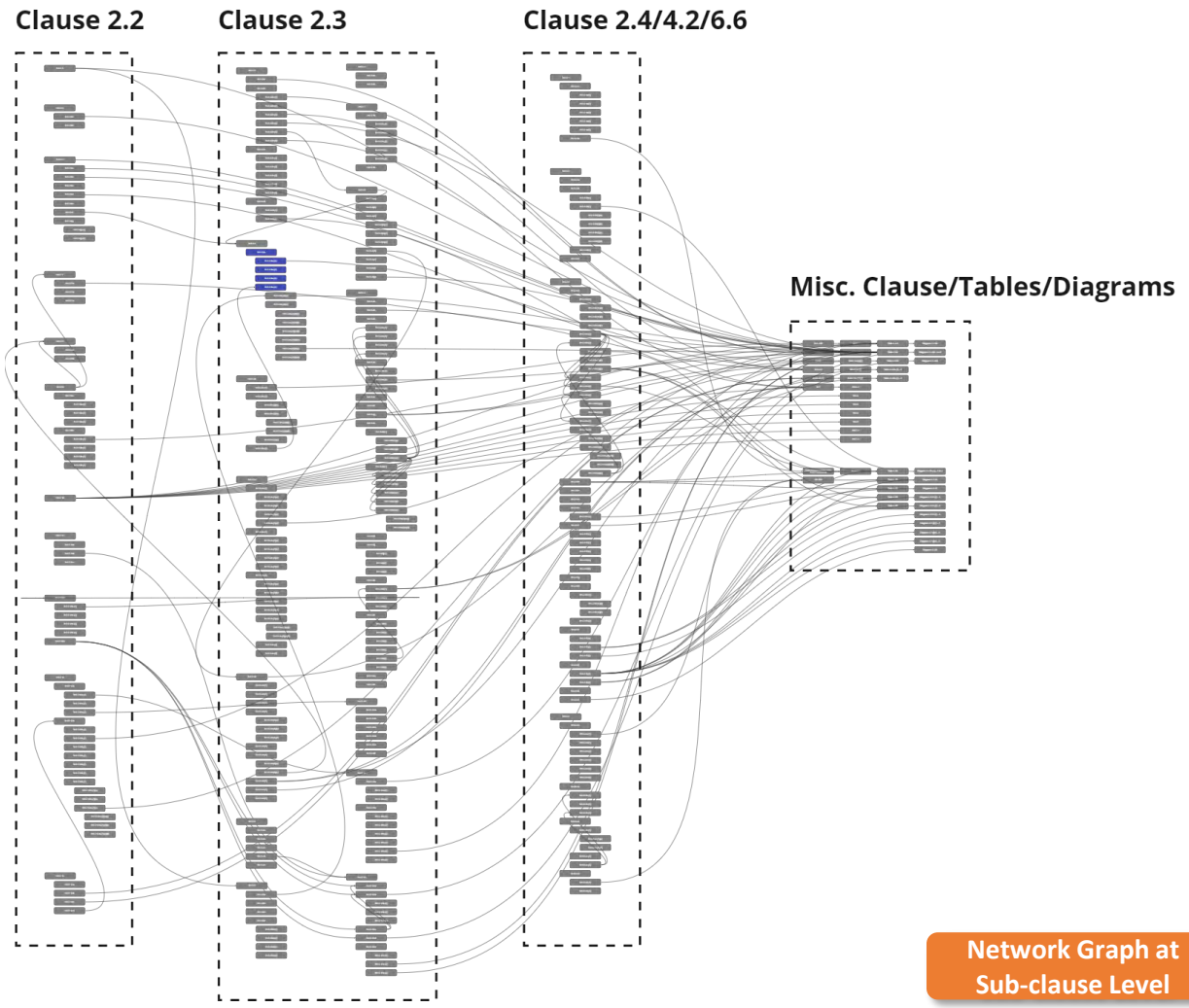
(6) if the exit staircase which connects to the internal exit passageway is pressurised, the internal exit passageway shall also be pressurised to comply with the requirements in Chapter 7.



Network Graph of Inter-clause Dependencies for 2.3.2a-b

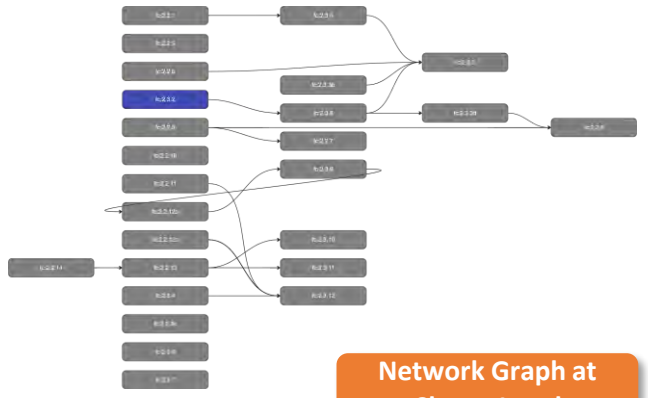
Rule Interpretation Process

Clause Dependencies



Network Graph at Sub-clause Level

- The clauses of each agency's COP can be densely interrelated.
- Some dependencies may not be explicitly stated in the COP, which requires agency's input to highlight.
- Having an overall mapping of clause dependencies is important to determine the order of the clauses to be developed.



Network Graph at Clause Level

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LEAPTHOUGHT

Rule Interpretation Process

Regulatory Logic

1

Regulatory Clause from Code of Practice

Agency provides accurate interpretation of clauses and the required conditions for checking.

2

1
Wall fire rating – if pass, end check. If fail, check if external facing.
Wall non com – if fail or pass, end check.
Door provision – if no door, check 2. If there is door, check rating.
Door fire rating – if fail or pass, end check.
2 doors – if fail or pass, end check.

2
IEP/EEP/EC –
Check if IEP.
If yes IEP, pass. If no, check for EEP/EC.
If yes EEP/EC, check for NV + opening validity. If no EEP/EC, check for 4a.

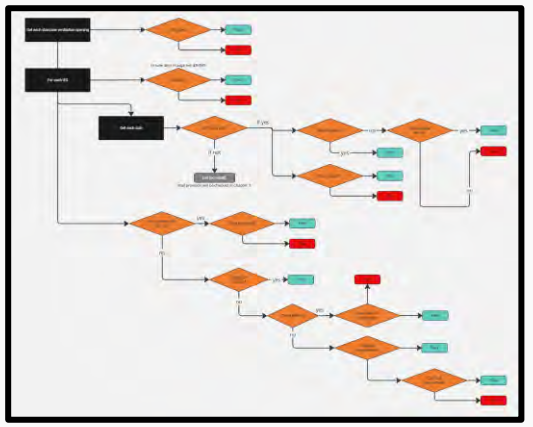
3
UPO – If pass or fail, end.

4a
Basement carpark, PG II – VII, Travel distance
If pass all 4a requirements, end check.
If fail any 4a requirements, check 4b.

Simplified Clause Description

The checking order of sub-clauses and conditions are reordered for simplicity and easier readability.

3



Detailed Flowchart and Methodology

The relationships detailed in the simplified description are transposed to form the overall flowchart.

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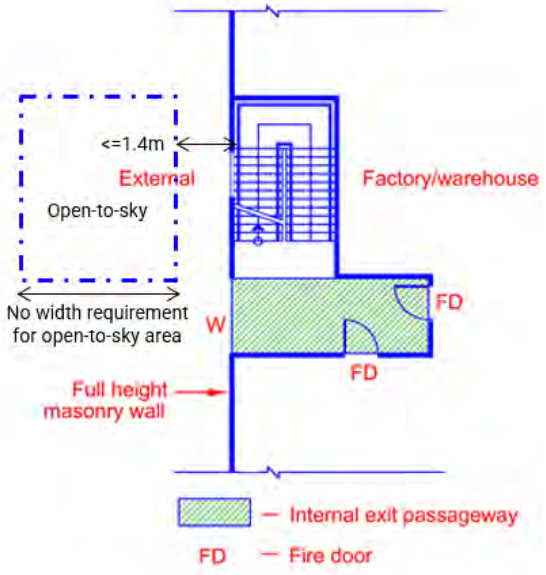
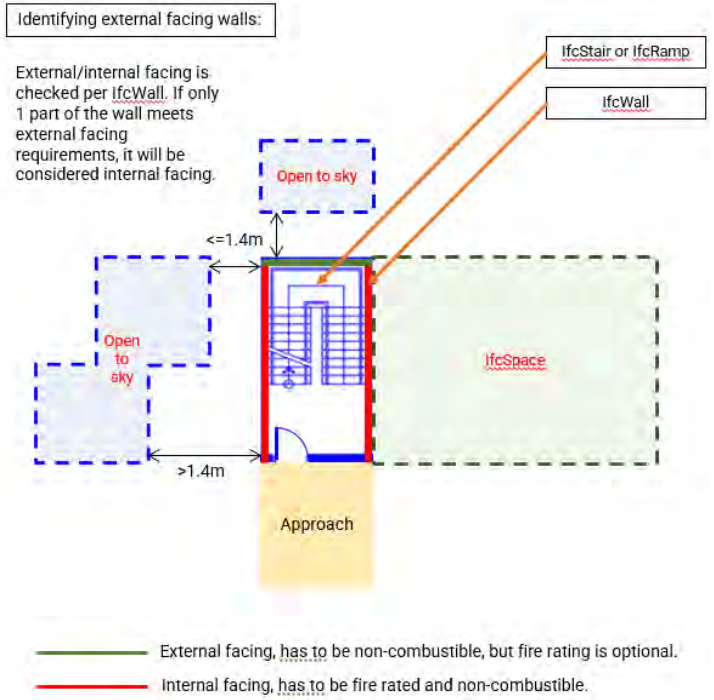
LEAPTHOUGHT

Rule Interpretation Process

Detailed Methodology



External of building here refers to areas which are not more than 1.4m away from open-to-sky areas, regardless if it is a void or a space with usage (e.g. open-to-sky roof garden).



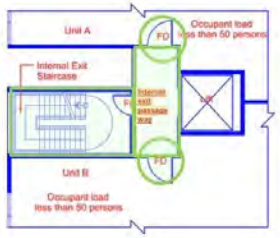
Example of diagrams illustrating the condition to be checked. Here, it details how to perform open-to-sky checks for external-facing walls. (SCDF fc:2.3.3a(1))

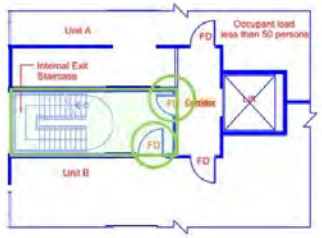
Rule Interpretation Process

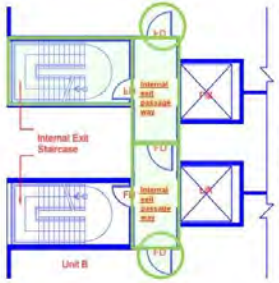
Reporting Requirements

PASS

Result to be reported per ifcSpace.SpaceName = Internal Exit Staircase or Internal Exit Ramp
ifcSpace.SpaceName = Internal Exit Staircase/Internal Exit Ramp, Internal Exit Passageway/External Exit Passageway/External Corridor, and doors to be highlighted in Green



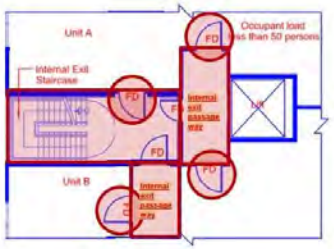


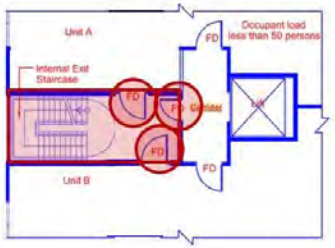


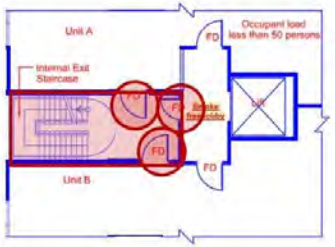
Each staircase will be checked individually. Results will also be shown for each individual IES.

FAIL

Result to be reported per ifcSpace.SpaceName = Internal Exit Staircase/Internal exit ramp
ifcSpace.SpaceName = Internal Exit Staircase/Internal exit ramp, Internal Exit Passageway/External Exit Passageway/External Corridor, and doors which are not complied to be highlighted in Red.



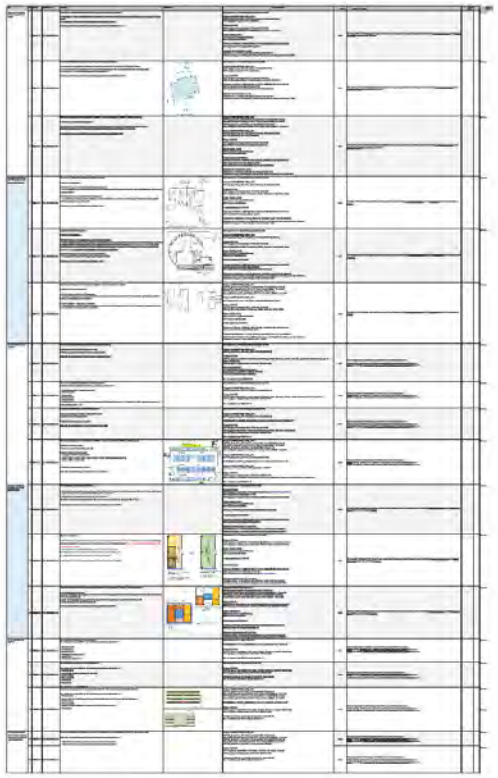


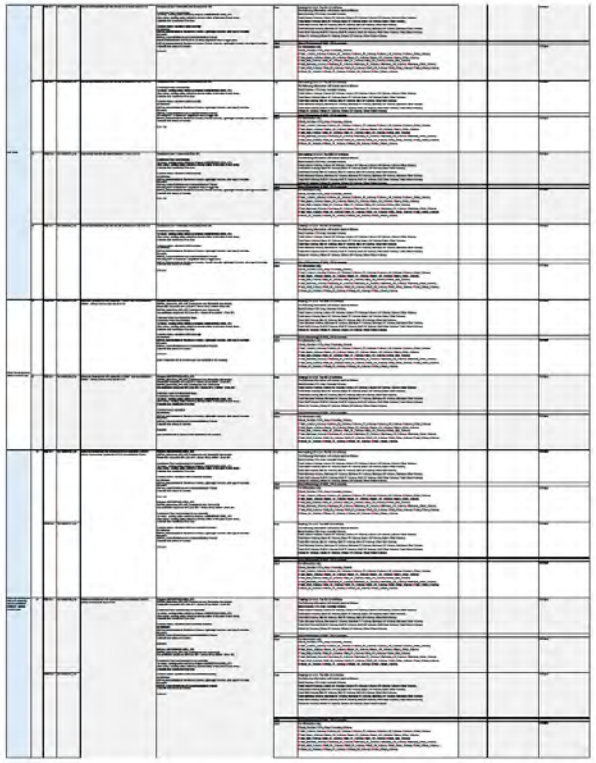


Example of expected reporting visualizations in ModelViewer for the provision check of fire-rated enclosures of exit staircases. (SCDF fc:2.3.3a(1))

Rule Interpretation Process

Test Scenarios

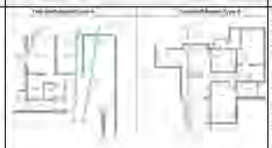




Example of detailed Test Scenarios for GreenMark Natural Ventilation, Concrete Usage Index (CUI), Residential Envelop Thermal Transmittance (RETV) rule checks.

Rule Interpretation Process

Test Scenarios

S/N	CLAUSE	SERIALISED NO.	SCENARIO	ILLUSTRATION	TEST PARAMETERS	RESULT	REPORT MESSAGE	GUID	PRODUCTTYPE
Coverage of all dwelling units' living spaces with good cross ventilation									
4	RBE 01-2	BC140020202_01a	Non-landed residential development without basement Total 40 residential units 20 units of Type A units: Living Room, 2 Bedrooms, study -->only Living Room c/w **Entrance Gate with lockable grille provided by developer and balcony with sliding door** having good cross ventilation 20 units of Type B units: Living Room, 3 Bedrooms -->only 1 Bedrooms with **operable windows on adjacent walls** have good cross ventilation, and 1 bedrooms with **operable window openings on opposite walls** Coverage of rooms with good cross ventilation ≥ 25%		Development use = Residential (Non-landed) (From SP) **IfcSpace.USERDEFINED.AREA_GFA** $GPset_SpaceArea_GFA.AGF_Name = Balcony, Dwelling Unit (Nett) **IfcSpace.SPACE** $GPset_Space.OccupancyType = Multi-unit residential $GPset_Space.SpaceName = Bedrooms, Master Bedroom, Living, Dining, Study **IfcDoor.DOOR, GATE** $GPset_Door.PercentageOfOpening $GPset_Door.MainEntrance **IfcOpeningElement.OPENING** **IfcWindow.WINDOW, USERDEFINED.LOUVRE, USERDEFINED.BAYWINDOW** $GPset_Window.PercentageOfOpening >0% Compute the total number of Living, Bedrooms and Study rooms in the development Determine the total number of Living/Dining, Bedrooms and Study Rooms with good cross ventilation Compute coverage of rooms with good cross ventilation ≥ 25%	Pass	Meeting ≥ 25% of dwelling units that provide good cross ventilation for #Value passing rooms out of #Value total rooms, the percentage is #Value.		IfcProject
5	RBE 01-2	BC140020202_01b	Landed residential development Total 30 residential units 10 units of Type A units: Living room, study room, 2 bedrooms -->Only 2 bedrooms with **curved facade non-fixed window** on one side, living Room with **balcony with sliding door, back door with gate which the distance between door and gate more than the width of the door** (will not consider as opening), **main entrance door with gate which the distance between door and gate is not more than the width of the main entrance door** (consider as opening) provided by developer with good cross ventilation 20 units of Type B units: Living room, study, 3 bedrooms. -->1 Bedroom **with fixed-window openings on opposite walls** Coverage of rooms with good cross ventilation <25%		Development use = Residential (Landed) (From SP) **IfcSpace.USERDEFINED.AREA_GFA** $GPset_SpaceArea_GFA.AGF_Name = Dwelling Unit (Nett), Balcony **IfcSpace.SPACE** $GPset_Space.OccupancyType = Multi-unit residential $GPset_Space.SpaceName = Bedrooms, Master Bedroom, Living, Dining, Study **IfcDoor.DOOR, GATE** $GPset_Door.PercentageOfOpening $GPset_Door.MainEntrance **IfcOpeningElement.OPENING** **IfcWindow.WINDOW, USERDEFINED.LOUVRE, USERDEFINED.BAYWINDOW** $GPset_Window.PercentageOfOpening>0% $GPset_Window.PercentageOfOpening=0% (fixed window) Compute the total number of Living, Bedrooms and Study rooms in the development Determine the total number of Living/Dining, Bedrooms and Study Rooms with good cross ventilation Compute coverage of rooms with good cross ventilation <25%	Fail	Not meeting ≥ 25% of dwelling units that provide good cross ventilation for #Value passing rooms out of #Value total rooms, the percentage is #Value.		IfcProject
6	RBE 01-2	BC140020202_01a	Mixed-use development with residential ≥ 2000m² and non-residential < 2000m² Total 40 units of two types units 20 units of type A: living room, 2 bedrooms -->bedroom 1 and living room having windows openings on opposite walls, bedroom 2 having window openings on adjacent walls, are having good cross ventilation 20 units of type B: living room, 2 bedrooms -->2 bedrooms are only have window openings on one side wall, living room having window openings on opposite of balcony with sliding door having good cross ventilation.		IfcSpace.USERDEFINED.AREA_GFA $GPSet_SpaceArea_GFA.AGF_DevelopmentUse: Residential (Non-landed) Residential component GFA (Use GFA + Bonus GFA) ≥ 2000m² (From SP) $GPSet_SpaceArea_GFA.AGF_DevelopmentUse: Commercial Non-residential component GFA (Use GFA + Bonus GFA)< 2000m² (From SP) IfcSpace.USERDEFINED.AREA_GFA $GPset_SpaceArea_GFA.AGF_Name = Balcony, Dwelling Unit (Nett) IfcSpace.SPACE $GPset_Space.OccupancyType = Multi-unit residential $GPset_Space.SpaceName = Bedrooms, Master Bedroom, Living, Dining IfcDoor.DOOR, GATE $GPset_Door.PercentageOfOpening $GPset_Door.MainEntrance IfcOpeningElement.OPENING IfcWindow.WINDOW, USERDEFINED.LOUVRE, USERDEFINED.BAYWINDOW $GPset_Window.PercentageOfOpening>0% Compute the total number of Living, Bedrooms and Study rooms in the development Determine the total number of Living/Dining, Bedrooms and Study Rooms with good cross ventilation Compute coverage of rooms with good cross ≥ 25%	Pass	Meeting ≥ 25% of dwelling units that provide good cross ventilation for #Value passing rooms out of #Value total rooms, the percentage is #Value.		IfcProject

Each Test Scenario is detailed with testing and modelling parameters, as well as reporting requirements. This identifies the expected checking and reporting capabilities of ModelChecker to be developed and tested.

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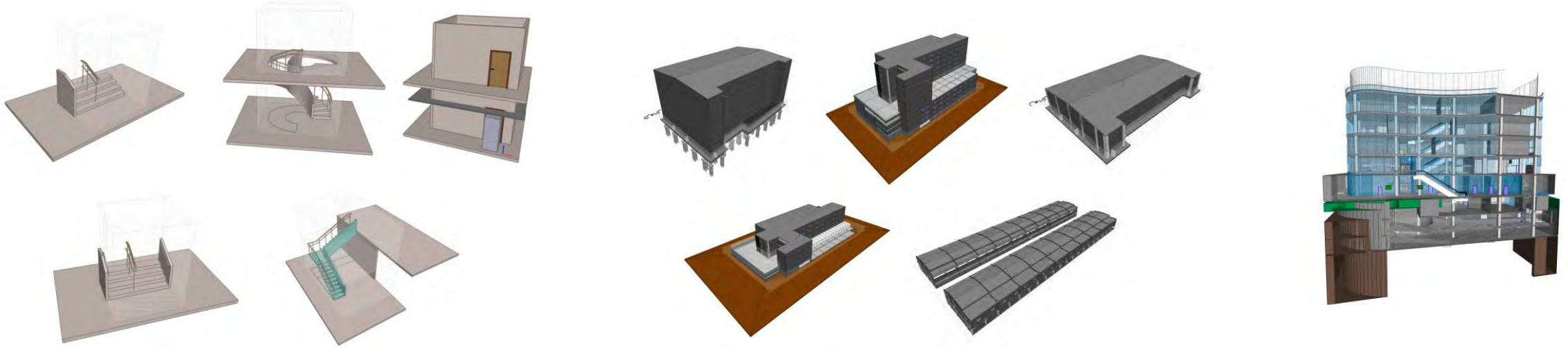
LEAPTHOUGHT

Rule Interpretation Process

Test Models



Example of Test Models demonstrating a wide range of scales, from unit test models (left) to project-sized models (right).

Rule Interpretation Process

Configurable Parameters

Items	IFC Entity	IFC Properties	Data Type	Reference
Number of doors opening into Internal Exit Staircase (<=2)	IfcDoor, EGRESSINDICATORBOX, and/or IfcOpening	N/A	N/A	2.3.3a(1)
Fire-Rating of IES enclosure wall (>=1h)	IfcWall	FireRating	Real	2.3.3a(1), 3.8
Fire-Rating of IES doors (>=0.5h)	IfcDoor	FireRating	Real	2.3.3a(1), 3.8
Distance from unprotected openings (<=3m, <=1.5m)	N/A	N/A	N/A	2.3.3a(3)
Accepted PG of exit staircase	IfcSpace	OccupancyType		2.3.3a(4)(a)
No. of storeys of standalone carpark (<=5)	N/A	N/A	N/A	2.3.3a(4)(b)(i)
Clear width of exit opening (850-1000mm)	EGRESSINDICATORBOX	N/A	N/A	2.3.3a(4)(b)(ii)
Clear height of exit opening (<=2m)	EGRESSINDICATORBOX	N/A	N/A	2.3.3a(4)(b)(ii)

Each RI document comes with a list of configurable parameters that agencies can use to modify the check to adapt to future COP changes, after ModelChecker goes live.

Automated Model Checker (AMC)

Preview of CORENETX AMC's Suite of Rule Checks, Methodologies and Use Cases

FULCRUMHQ

LEAPTHOUGHT

CORENETX
AUTOMATED MODEL CHECKER

Computational BIM enabled Quality Control

Computational automated checks driving conformity against modelling guidelines, AIR, EIR on Project Information and Asset Information models.

Computational BIM enabled Compliance Checks

Computational automated checks driving conformity against regulatory and design requirements.

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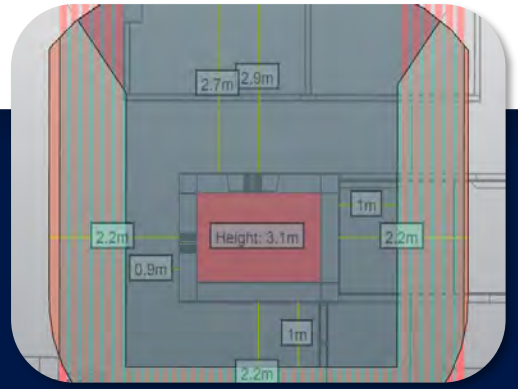
LEAPTHOUGHT

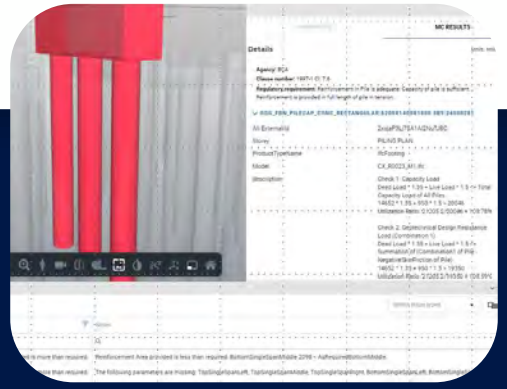
Geometric Analyses

Removes dependency on user-defined attributes or parameters for specific rules



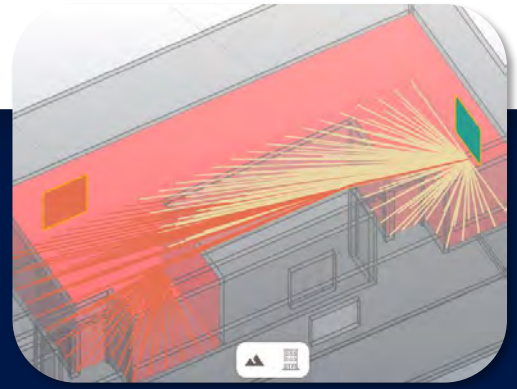
Parametric Analyses

User-defined parameters can be checked directly by the system given required value ranges.



Pathfinding Analyses

With known starting and ending points, the pathfinding algorithm determines path lengths and best possible path based on various criteria



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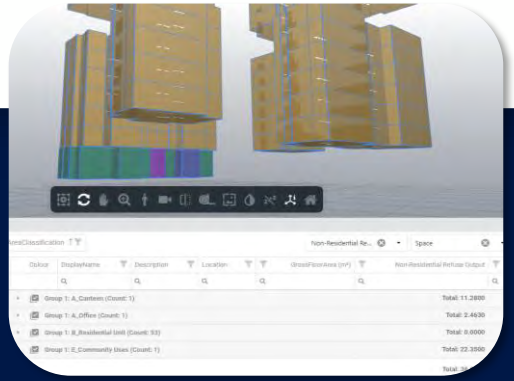
LEAPTHOUGHT

Setback and Projection Analyses

The algorithm is able to pick up various model elements and generate setbacks and projections to check for any clashes.

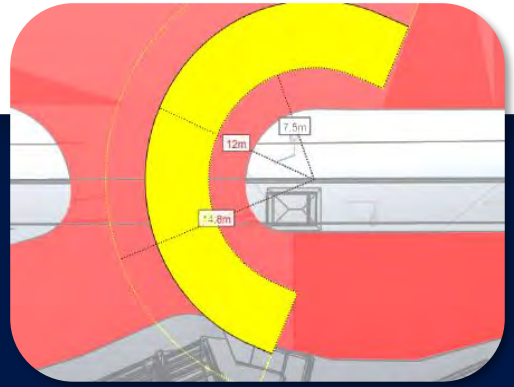
Computational Analyses

FulcrumHQ is capable of computing vast amounts of values based on model properties



Shape-related Analyses

The system is capable of generating shapes determined by a combination of requirements such as turning radius, to consider suitability of driveways, roads and fire engine accessways.

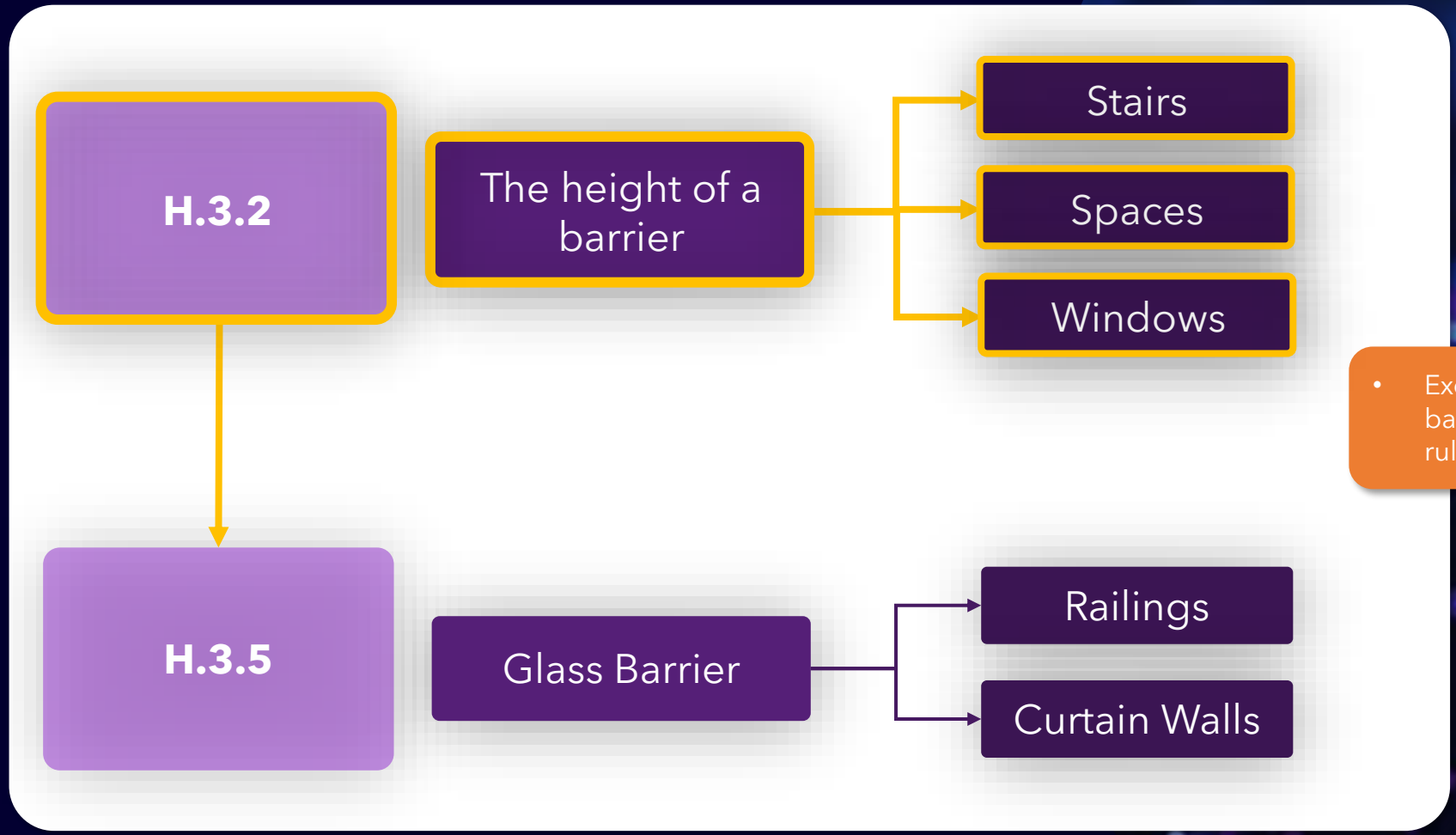


FULCRUMHQ

LEAPTHOUGHT

Height of Barrier

Geometric and Parametric Check



The height of a barrier shall not be less than –

(a) 1.0 metre; or

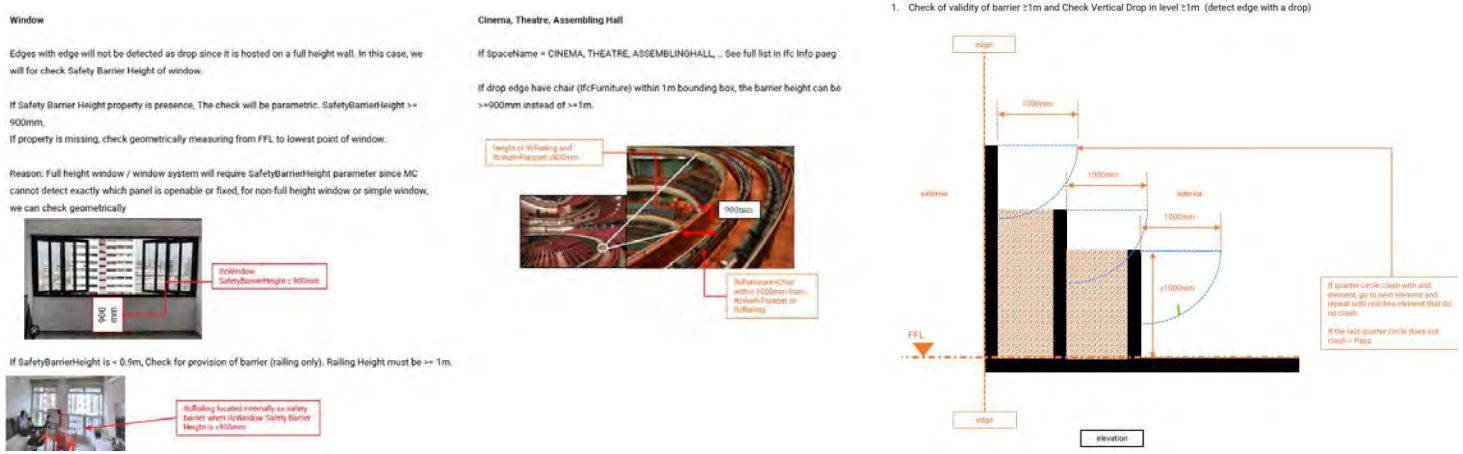
(b) 900 mm at the lower edge of the window and gallery or balcony with fixed seating in areas such as theatres, cinemas and assembling halls.

- Execution of the H.3.2 rule stores a list of barriers that can be accessed by another rule

Height of Barrier

Geometric and Parametric Check

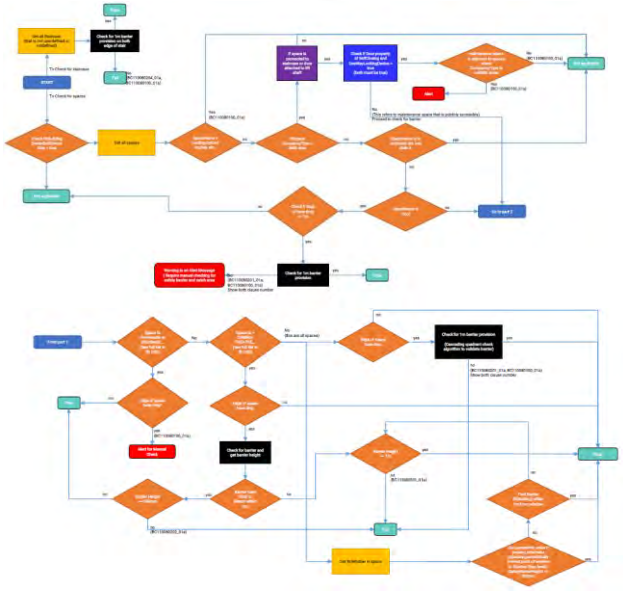
1



Methodology

Qualifying IfcEntities to be checked, IfcSpaces to be exempted or subject to specific height requirements, checking validity of barrier

2



Flowchart

The relationships between IfcEntities, processes or methods, and results based on conditions.

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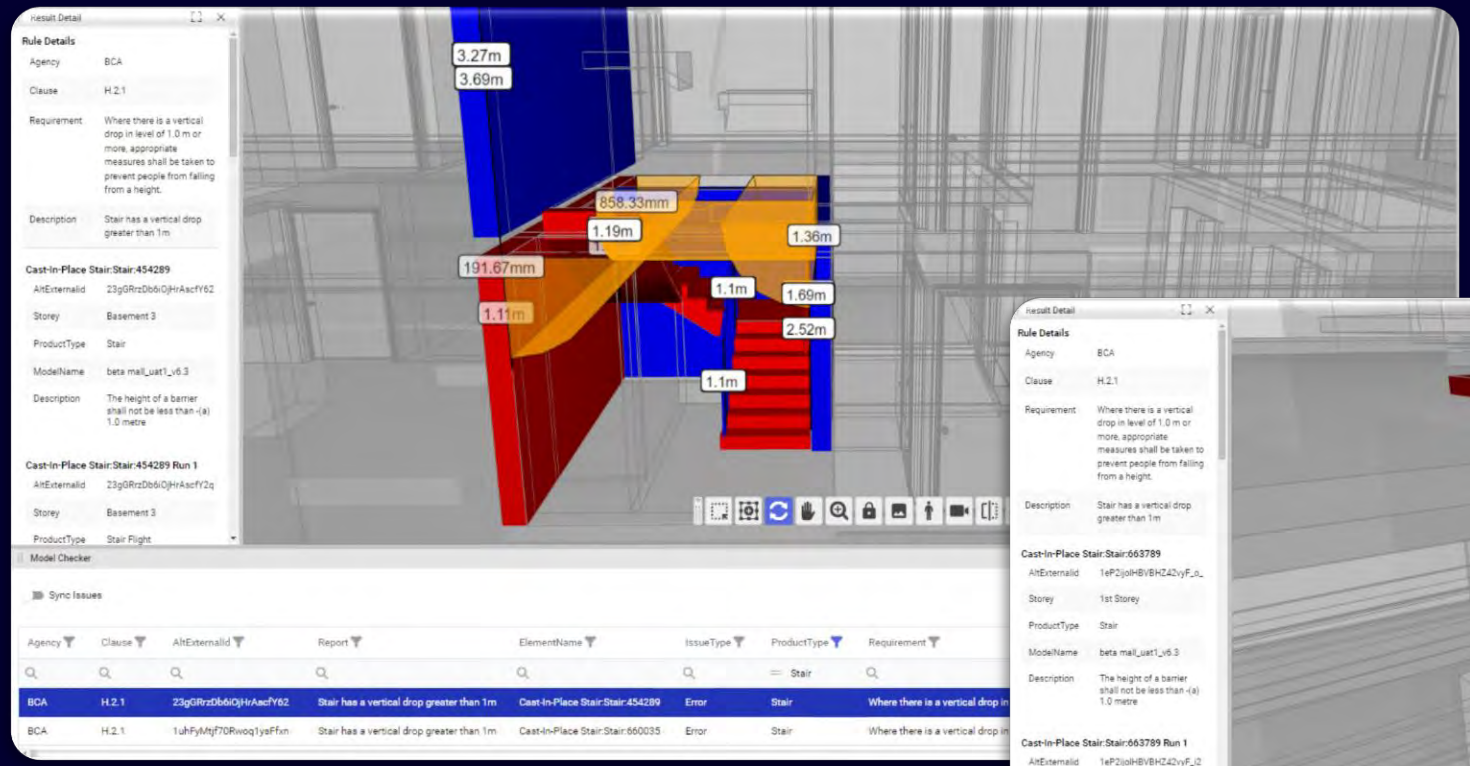
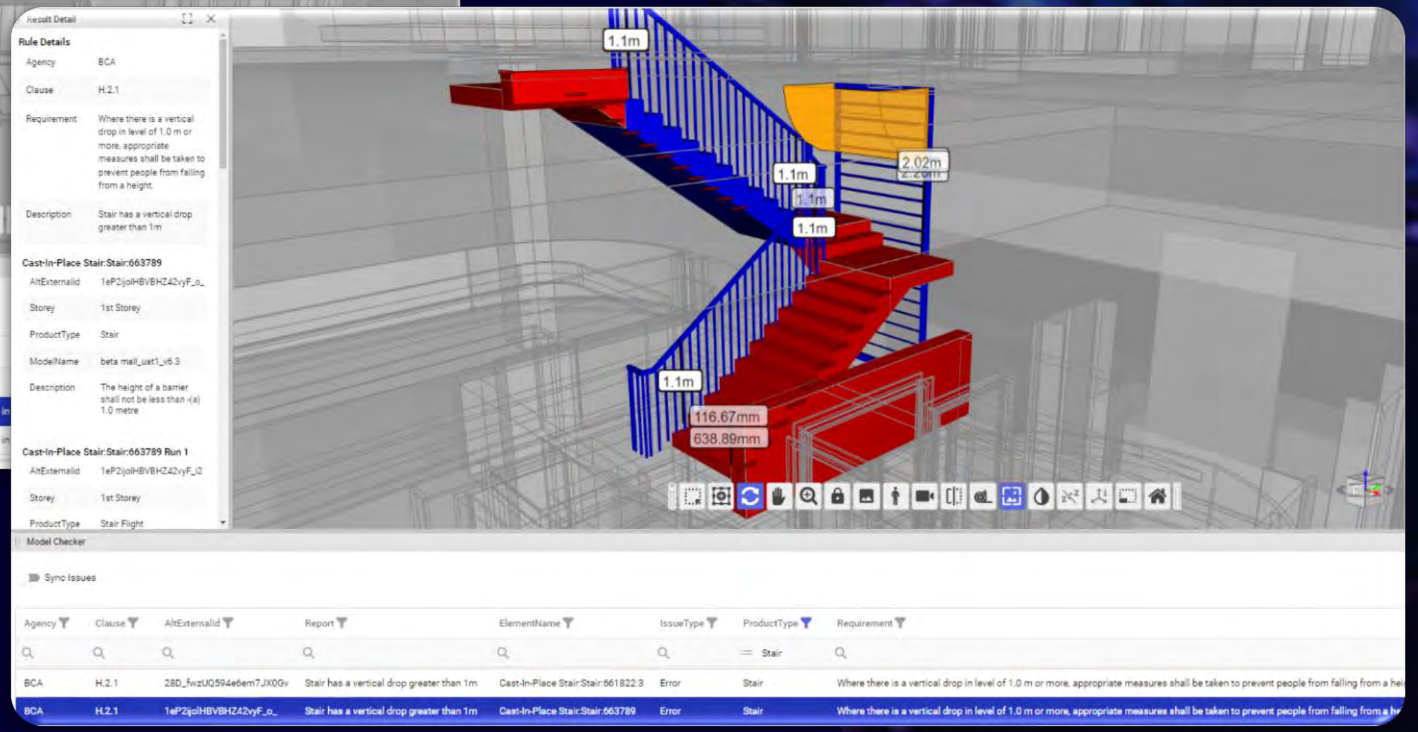
LEAPTHOUGHT

Height of Barrier

Stairs

- 1m quadrant extrusion to check validity of barrier.





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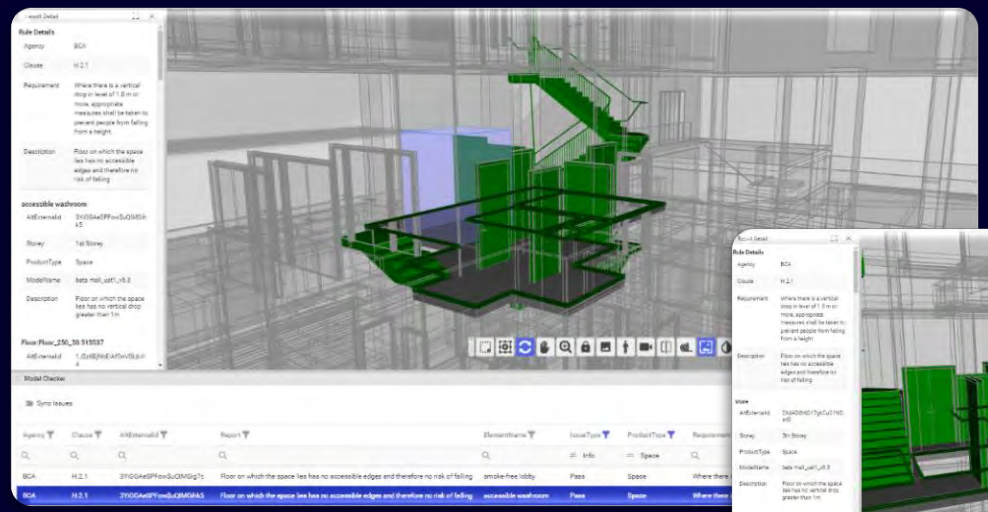
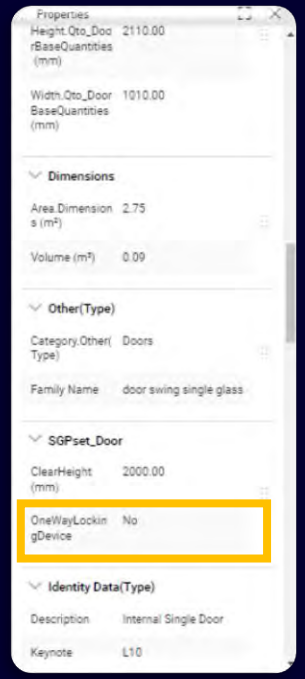
LEAPTHOUGHT

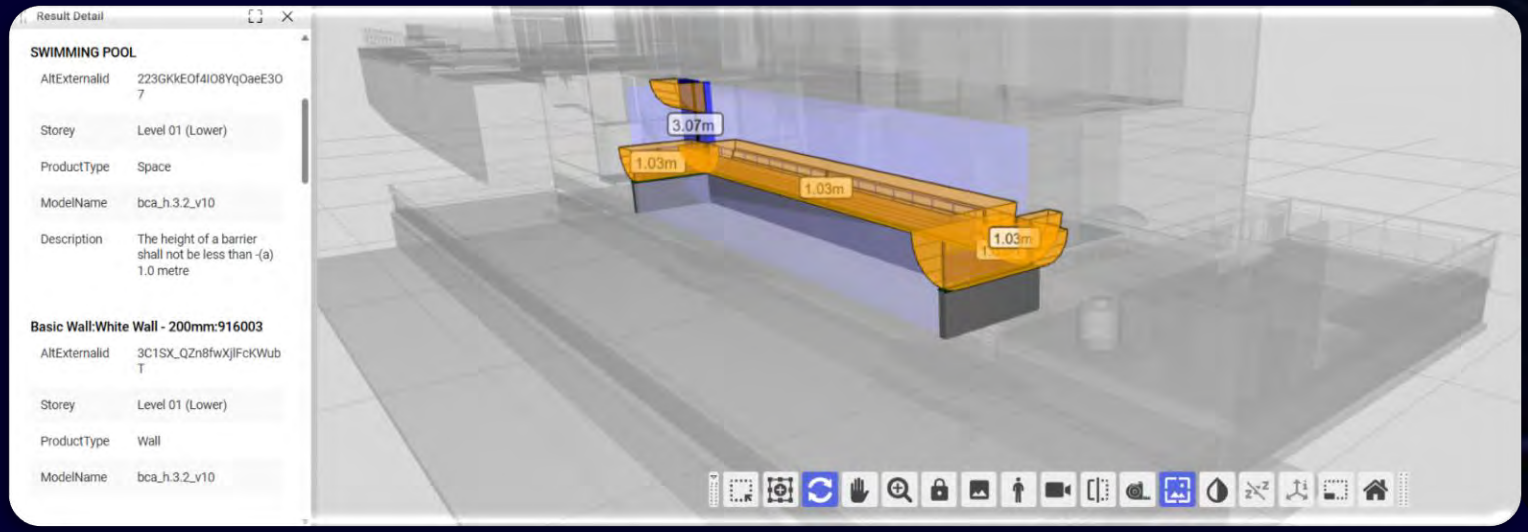
Height of Barrier

Spaces



- Slab associated with space is checked for drops.
- If space is connected to staircase or door attached to lift shaft, doors will be checked for SelfClosing and OneWayLockingDevice property.
- Check if edge of space has drop, and if so, check for barrier and barrier height.





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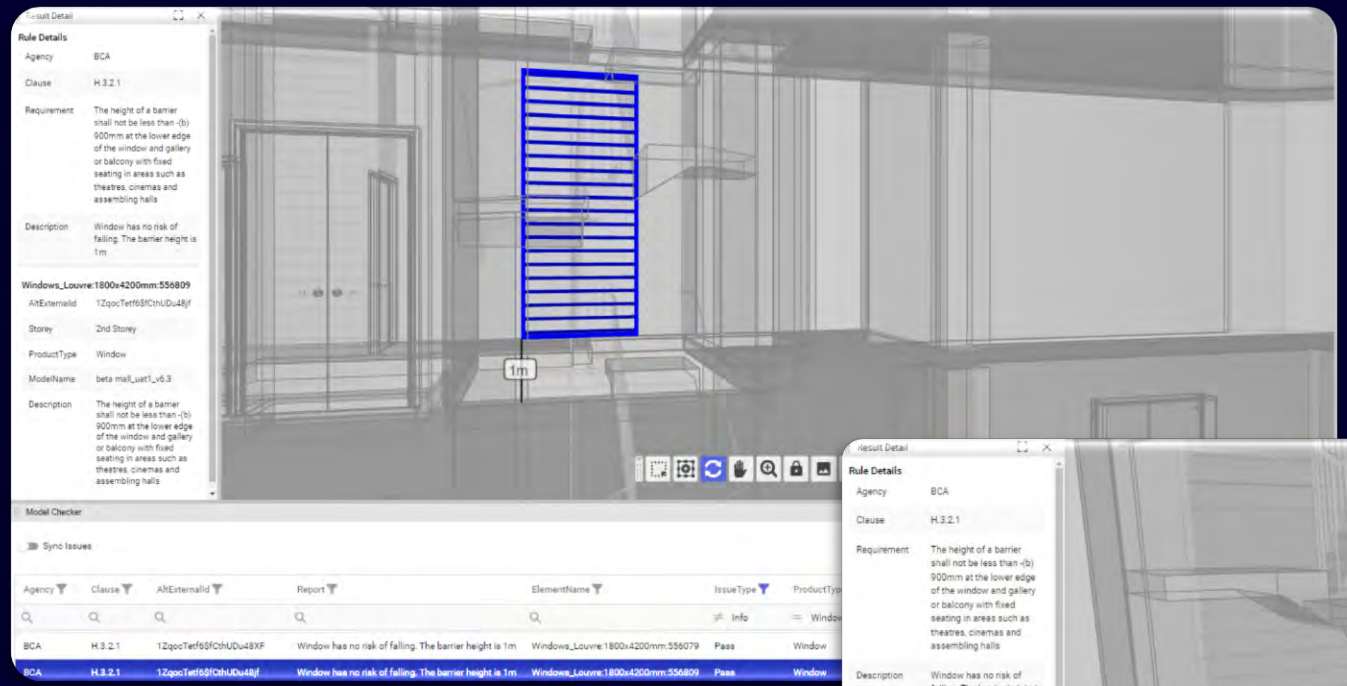
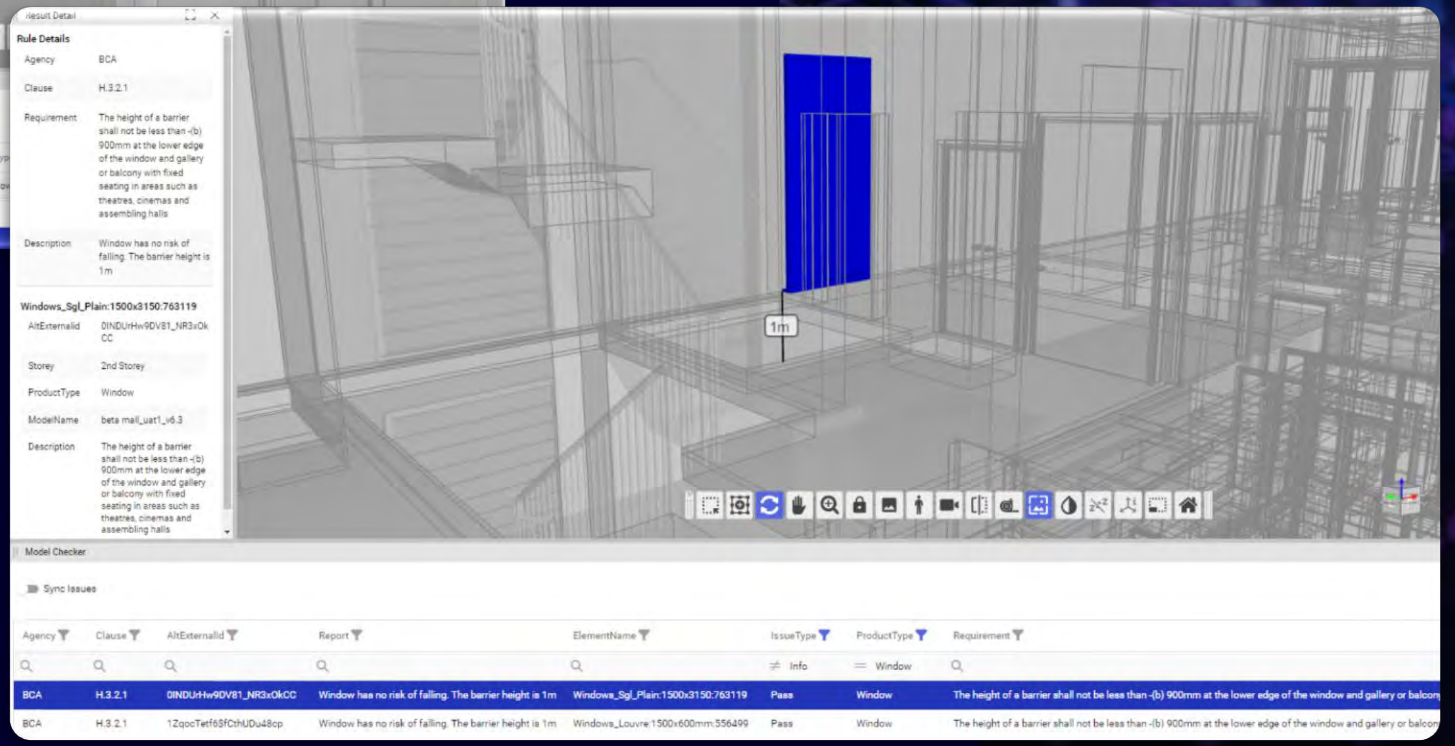
LEAPTHOUGHT

Height of Barrier

Windows

- Search for presence of parameter: SafetyBarrierHeight >= 900mm
- Otherwise measure geometrically (lowest point of window to finished floor level).





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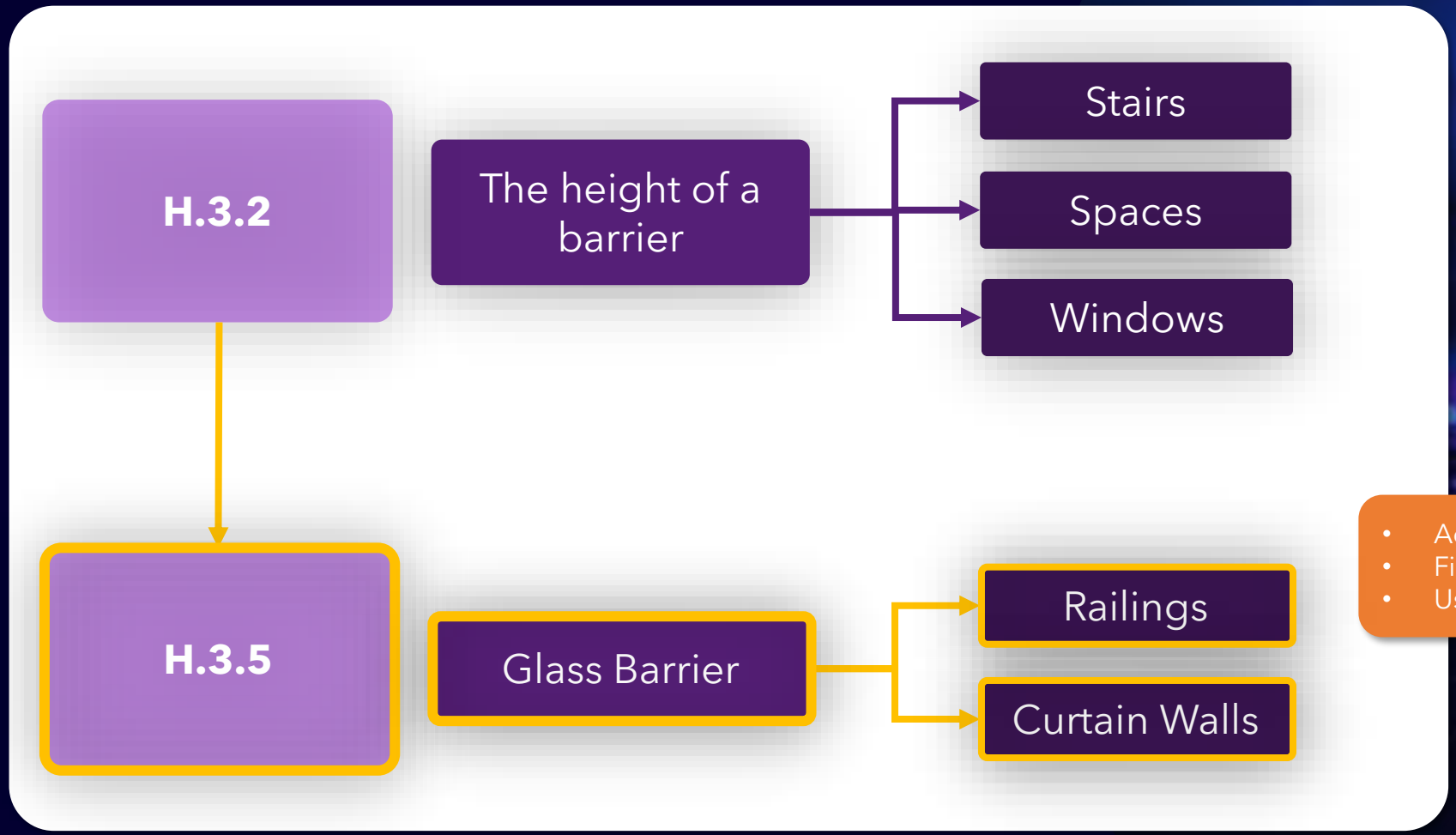
LEAPTHOUGHT

Glass Barrier

Parametric Check



- Access list of stored barriers
- Filter for IfcRailing and IfcCurtainWall
- Use as input for H.3.5 check

Where glass is used as a part or whole of a barrier, laminated glass shall be used.

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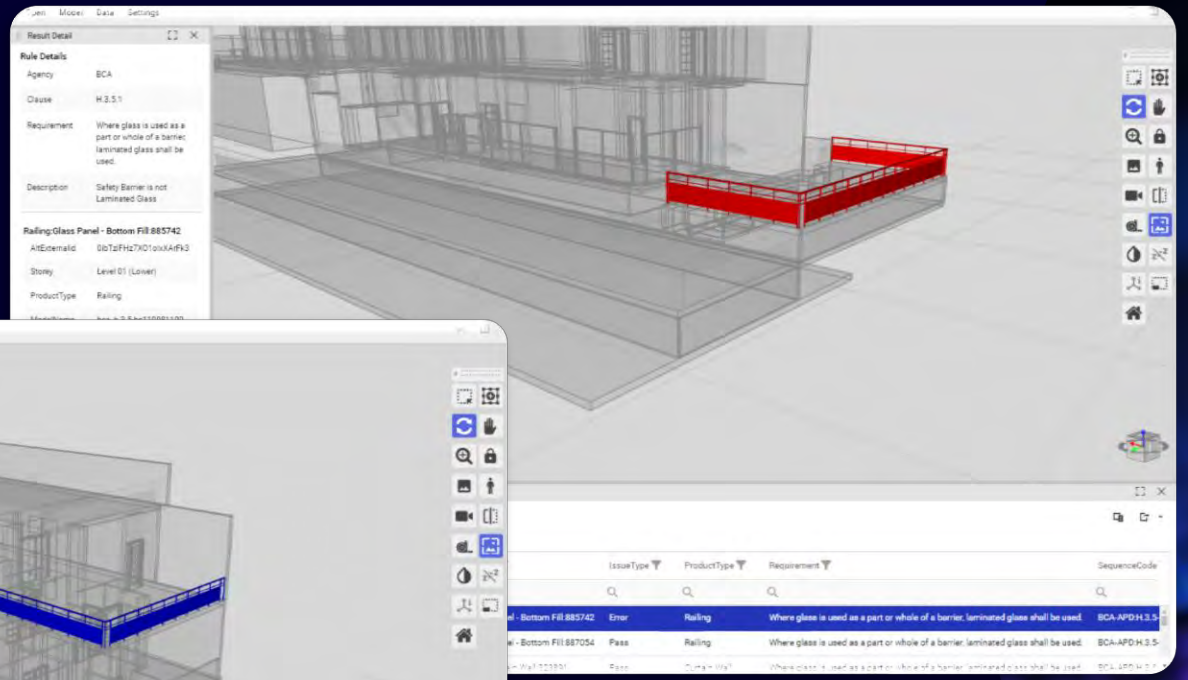
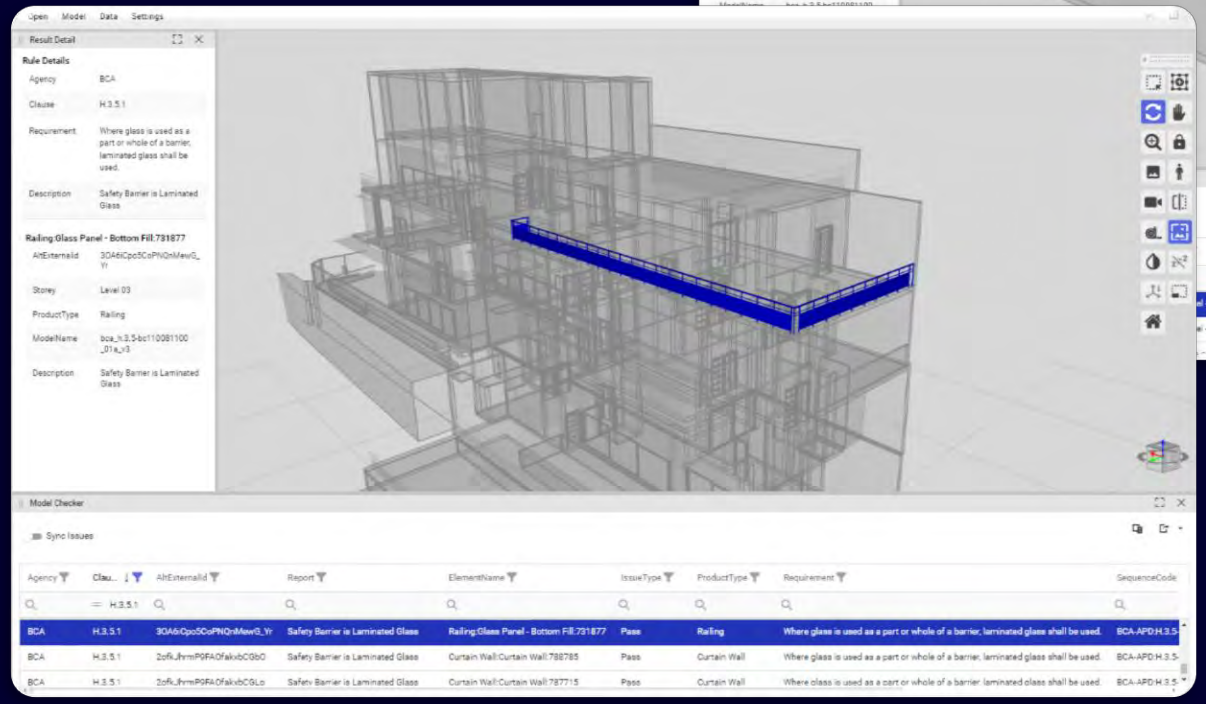
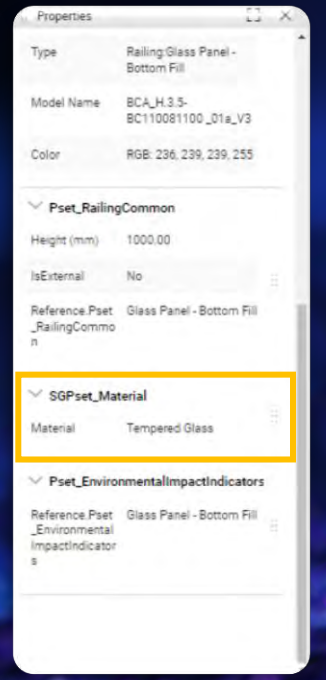
LEAPTHOUGHT

Glass Barrier

Railings







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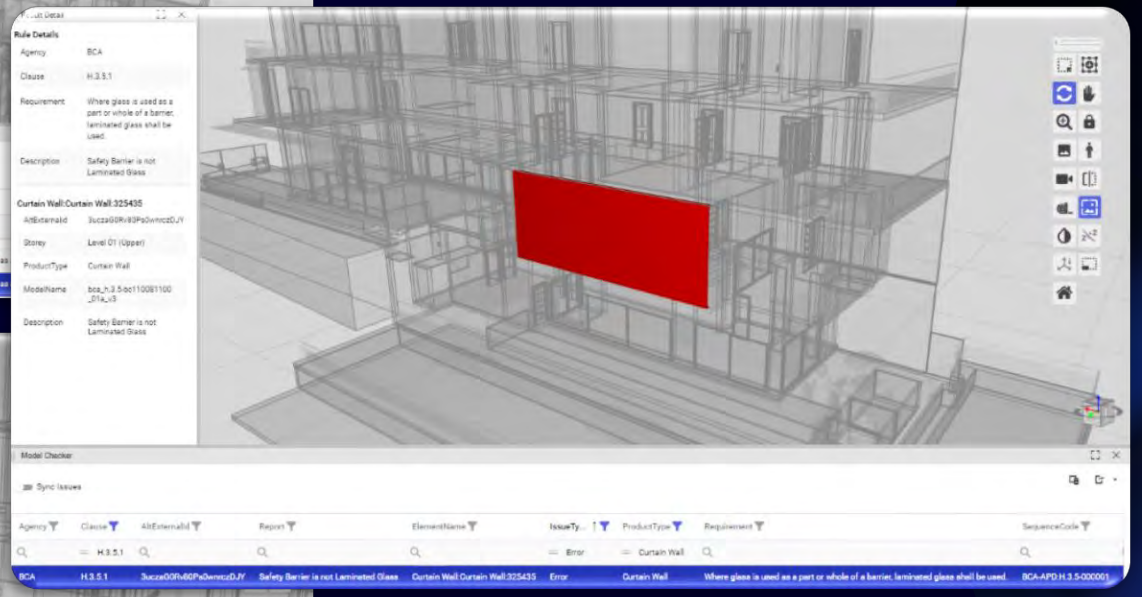
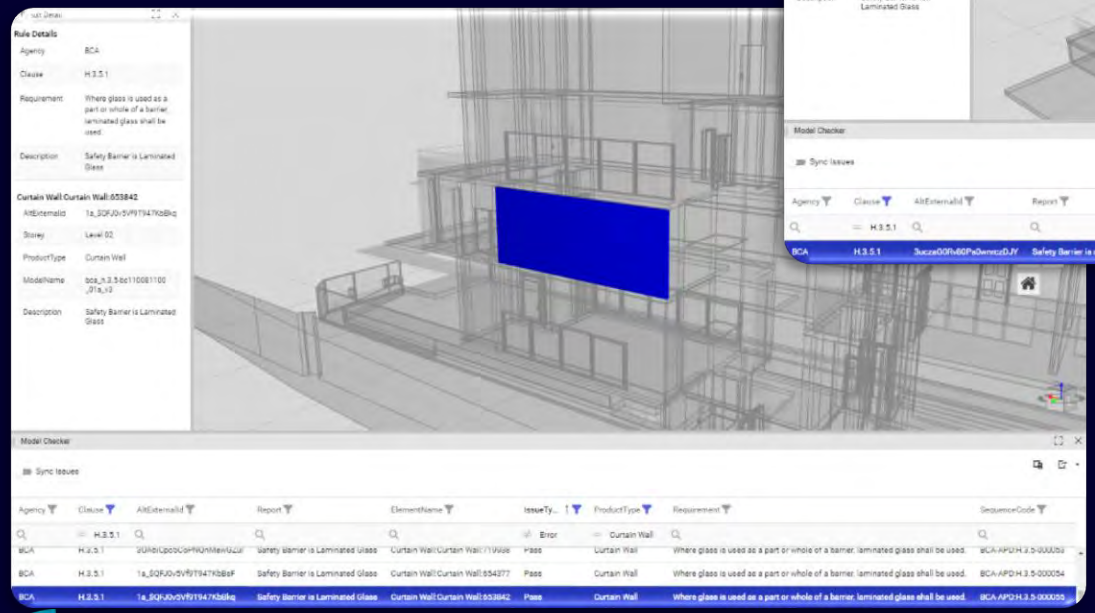
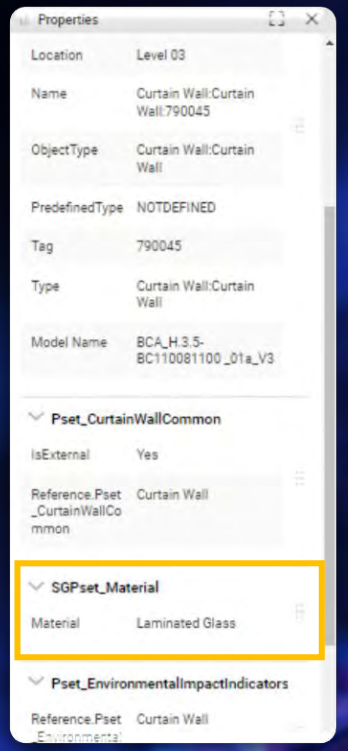
LEAPTHOUGHT

Glass Barrier

Curtain Walls







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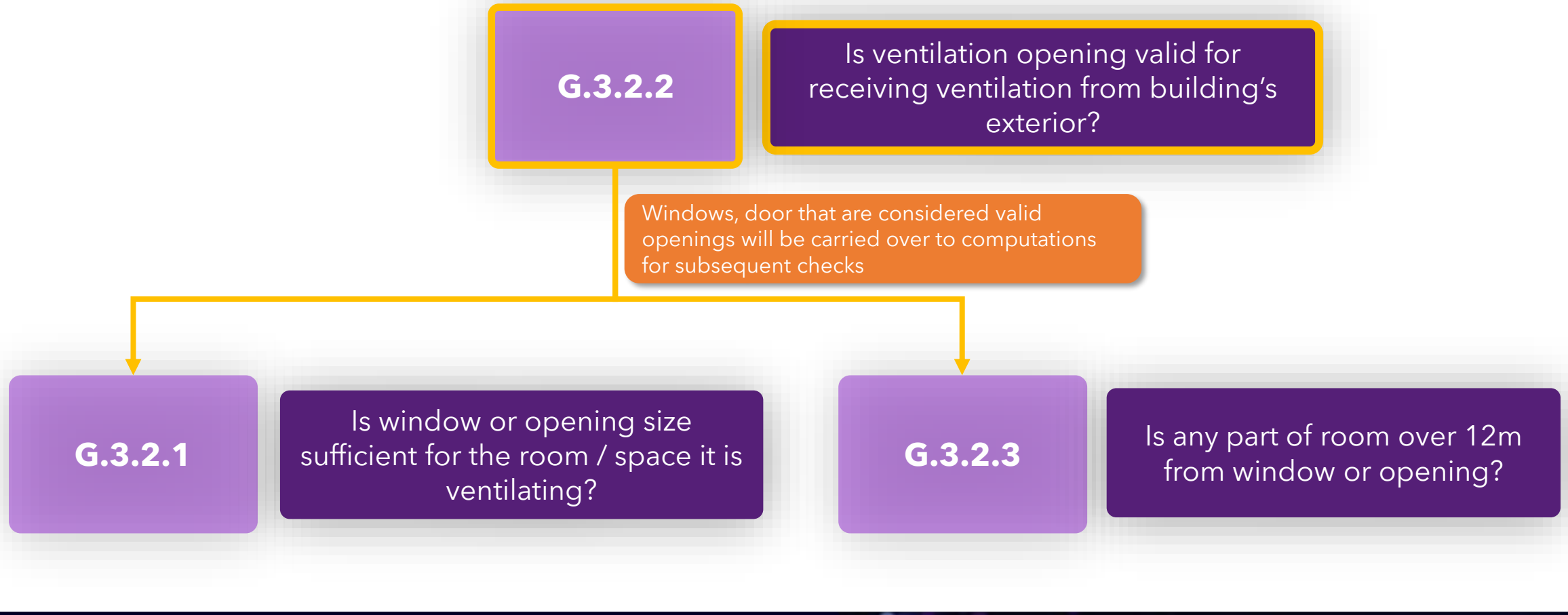
LEAPTHOUGHT

Natural Ventilation

Geometric Check, Shape Generation, Computation and Pathfinding



Natural Ventilation

Valid Ventilation Opening - Geometric Check, Shape Generation

G.3.2.2 All windows and openings intended for natural ventilation shall be located such that they open to –

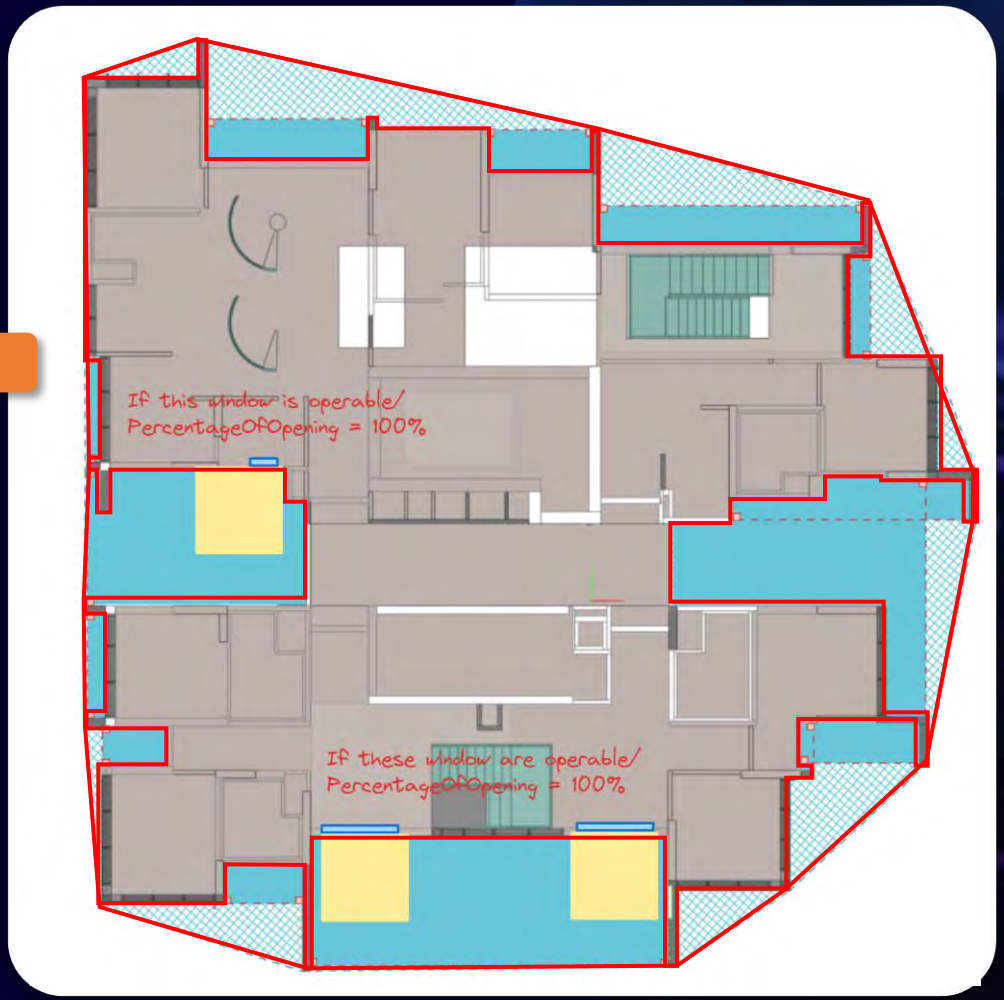
(a) the exterior of the building;

(b) an airwell with a minimum width of 3.0m and a minimum area open to the sky complying with Table G.3.2.2(a); or

(c) a recess, exceeding 3.0m from the external building wall, and of minimum width 3.0m. See Figure G.3.2.2(b) for illustration.

Regulatory Clause from Code of Practice

What constitutes building outline to be able to inform “exterior of building”?



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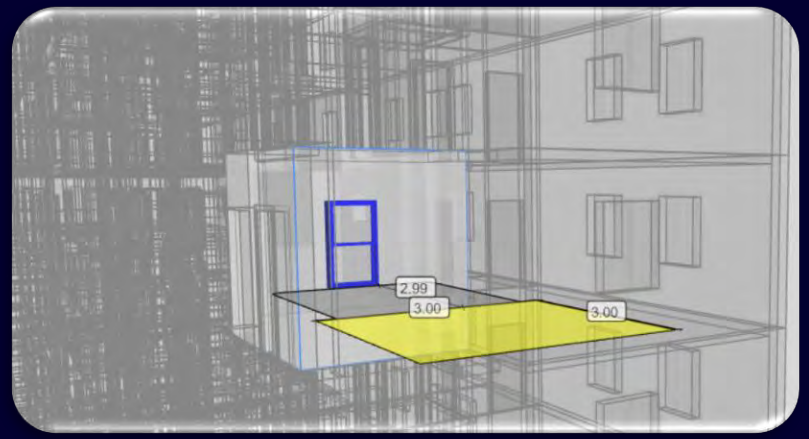
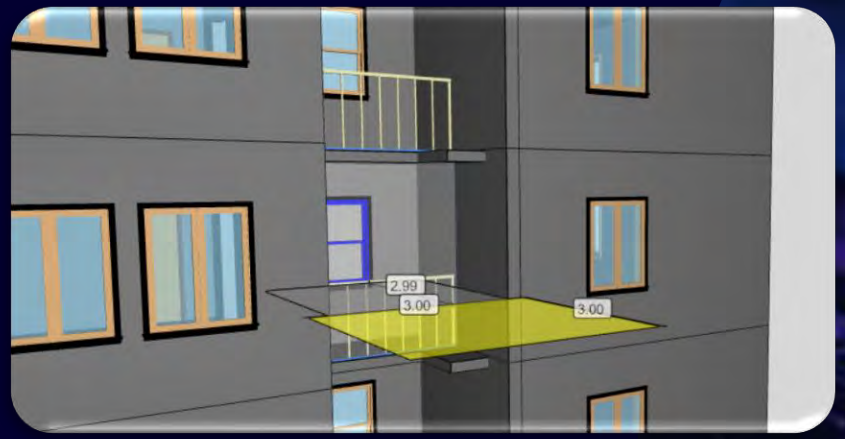
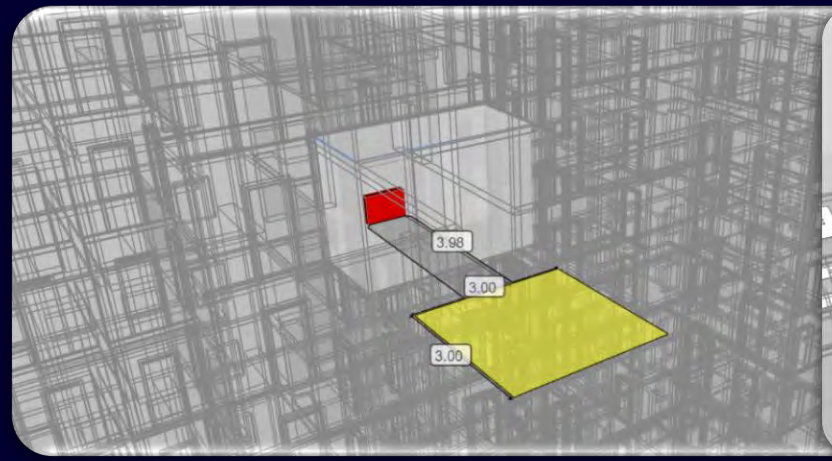
LEAPTHOUGHT

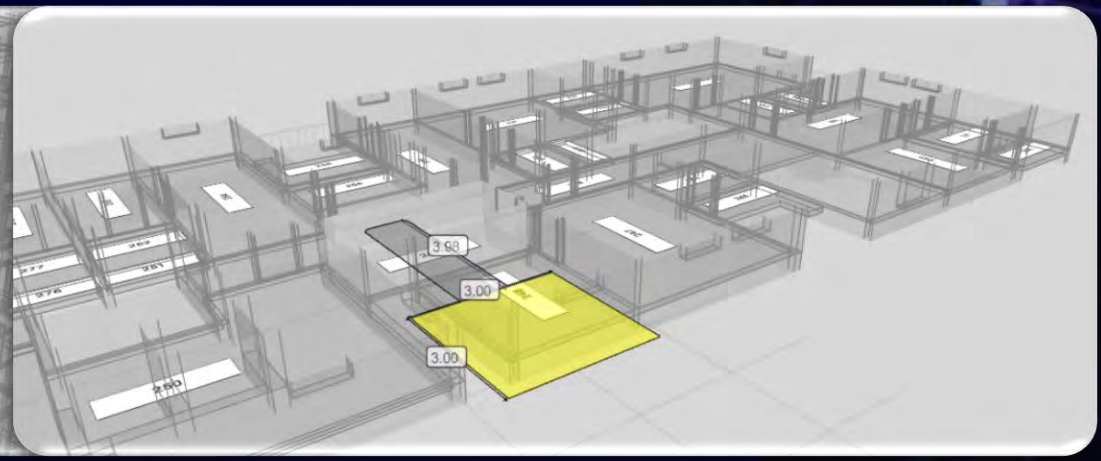
Natural Ventilation

Valid Ventilation Opening - Geometric Check, Shape Generation





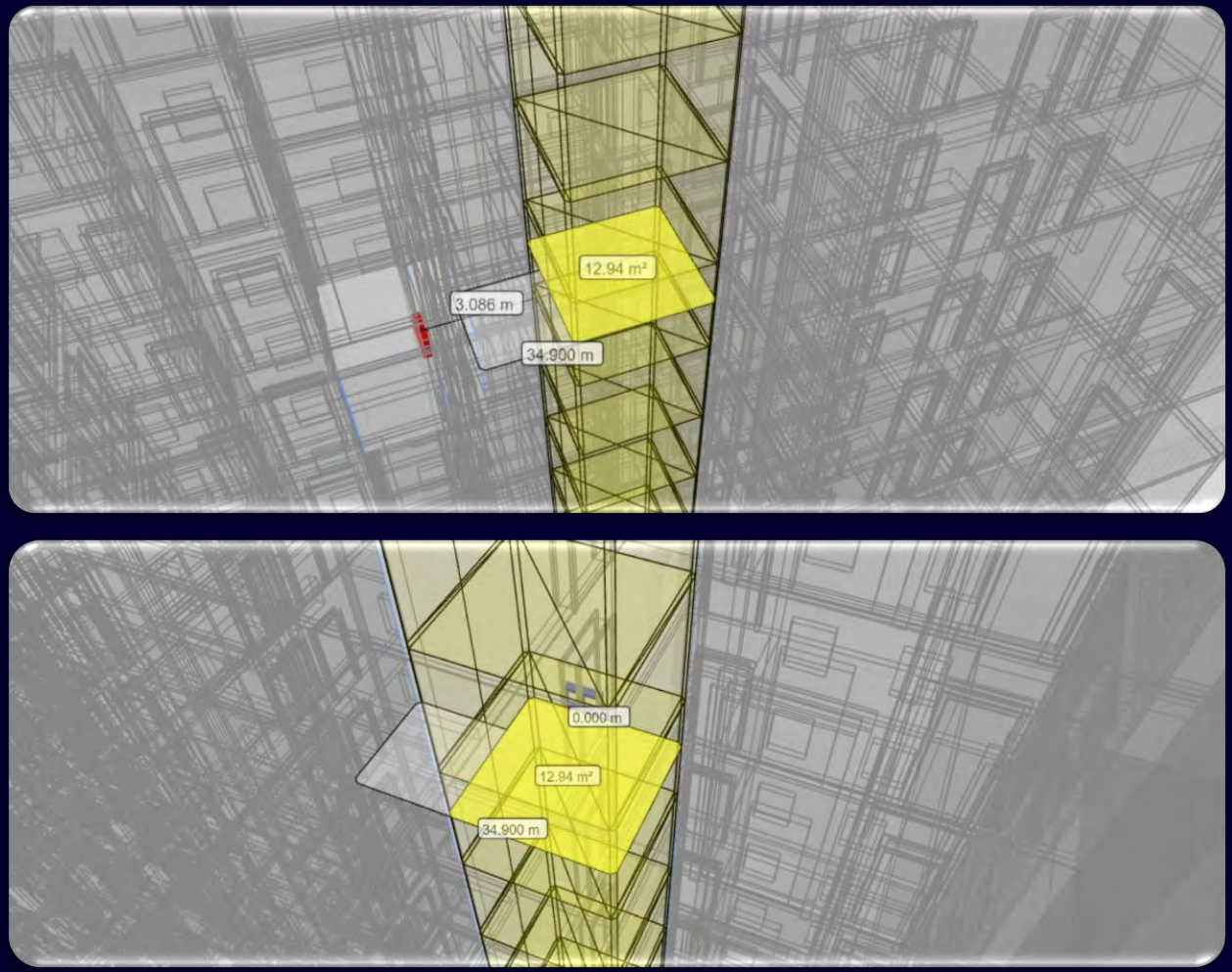




Opening that opens to a recess from external building wall.

Natural Ventilation

Valid Ventilation Opening - Geometric Check, Shape Generation



Opening that opens to an airwell.

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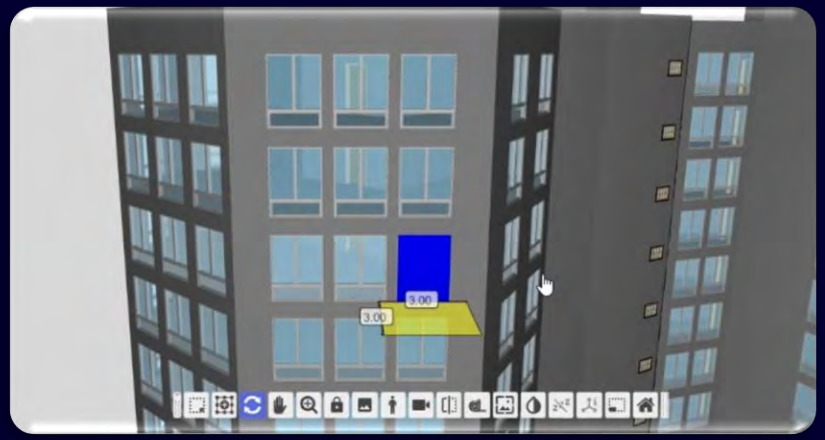
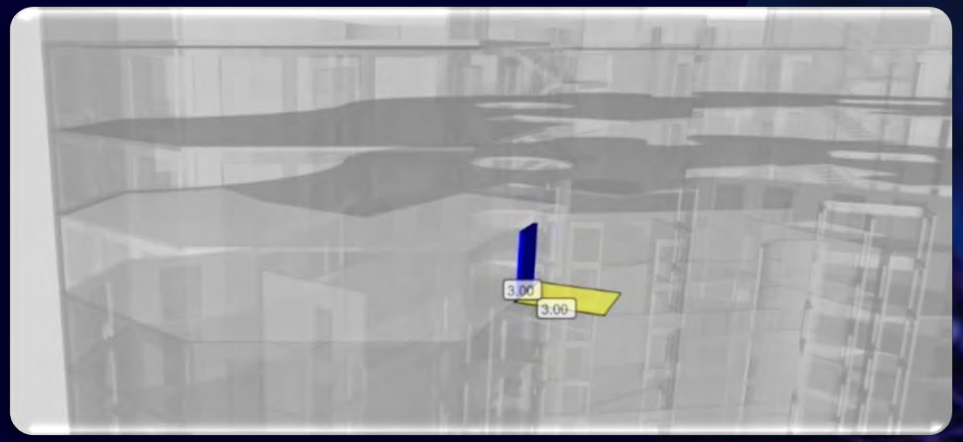
LEAPTHOUGHT

Natural Ventilation

Valid Ventilation Opening - Geometric Check, Shape Generation





Opening that opens to exterior of building.

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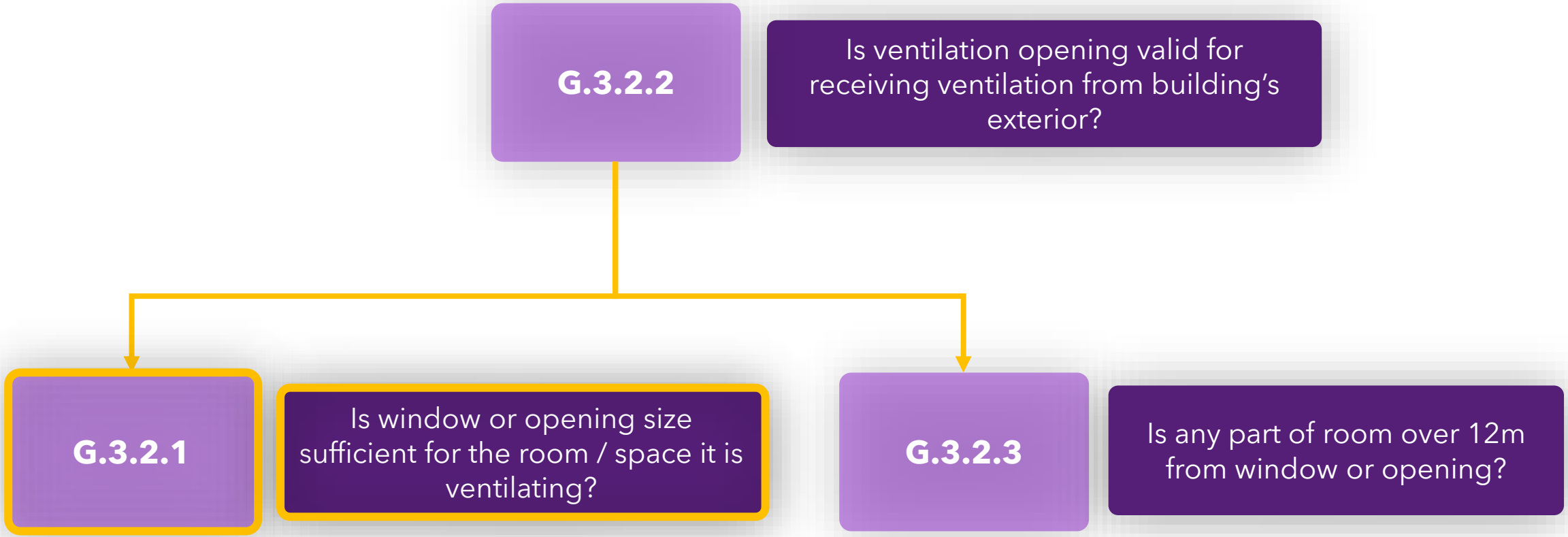
LEAPTHOUGHT

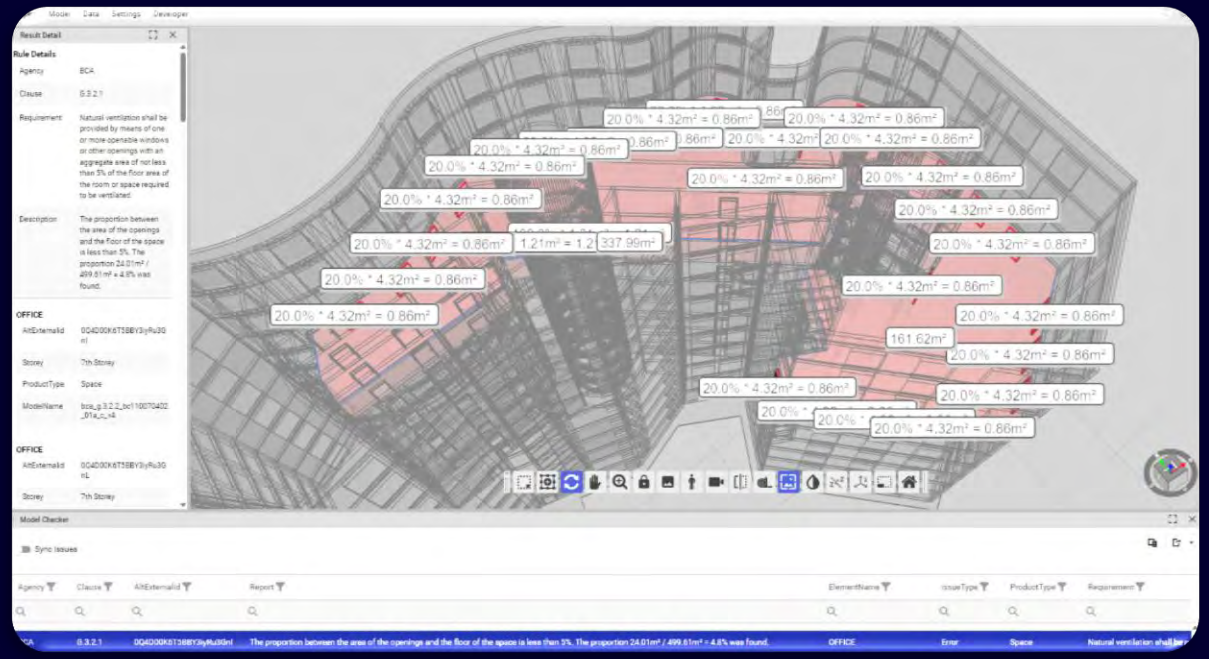
Natural Ventilation

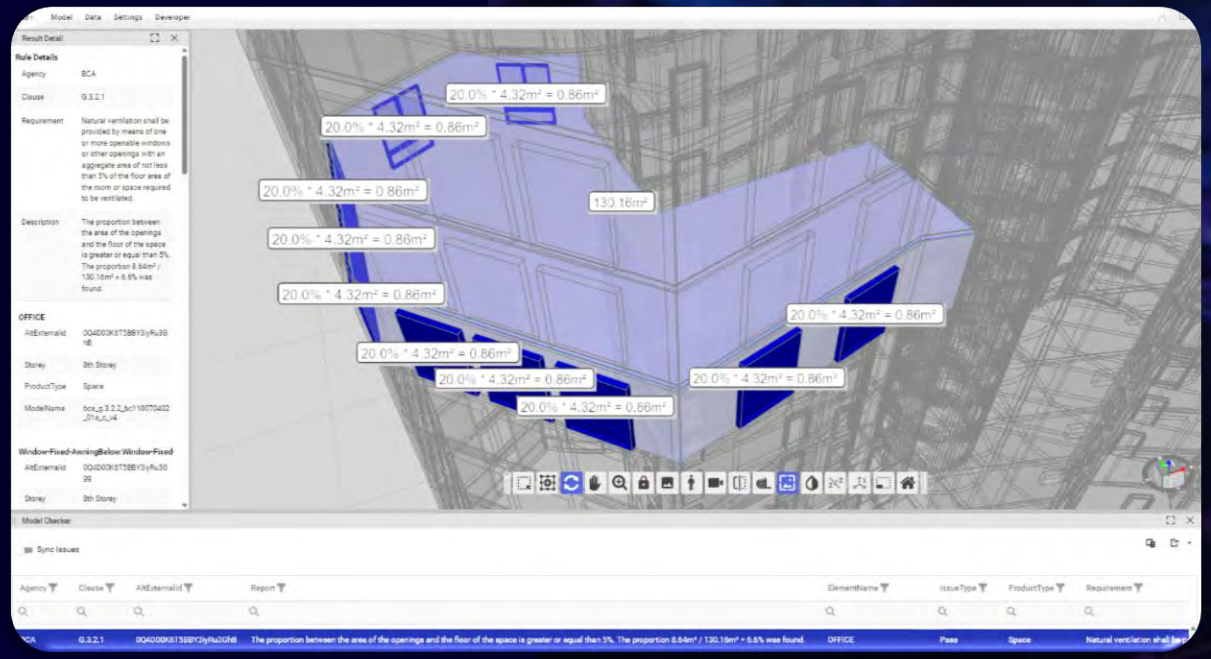
Geometric Check, Shape Generation, Computation and Pathfinding



Natural Ventilation

Ratio of Ventilation Opening to Floor Area - Computation





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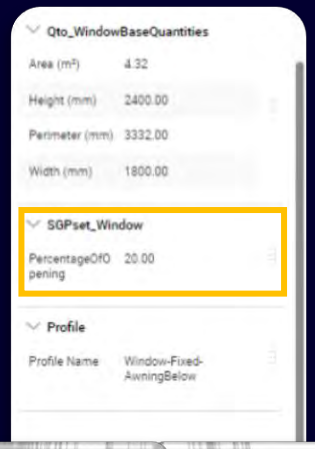
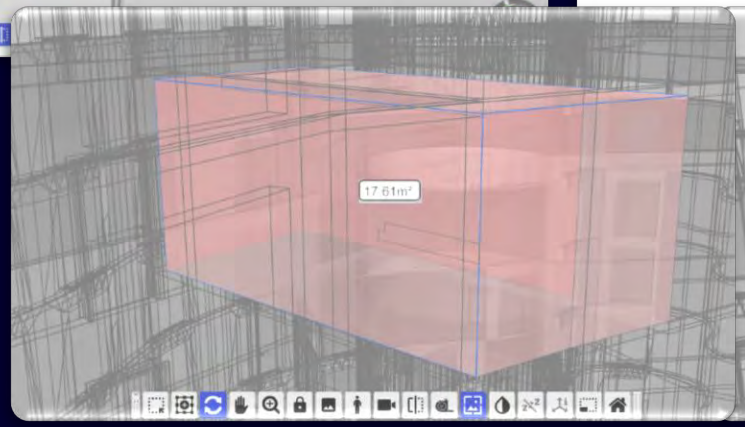
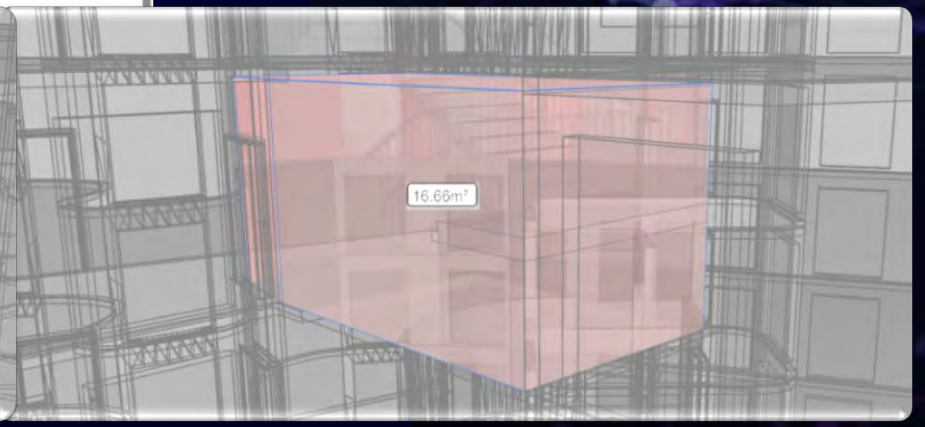
LEAPTHOUGHT

Natural Ventilation

Ratio of Ventilation Opening to Floor Area - Computation







Agency	Clause	AltExternalId	Report	ElementName	IssueType	ProductType
BCA	G.3.2.1	0Q4D00K6T5BBY3iyRu3GfI	The proportion between the area of the openings and the floor of the space is less than 5%. The proportion 0.00m² / 17.61m² = 0.0% was found.	INTERNAL EXIT STAIRCASE	Error	Space
BCA	G.3.2.1	0Q4D00K6T5BBY3iyRu3GfL	The proportion between the area of the openings and the floor of the space is less than 5%. The proportion 0.00m² / 16.66m² = 0.0% was found.	INTERNAL EXIT STAIRCASE	Error	Space

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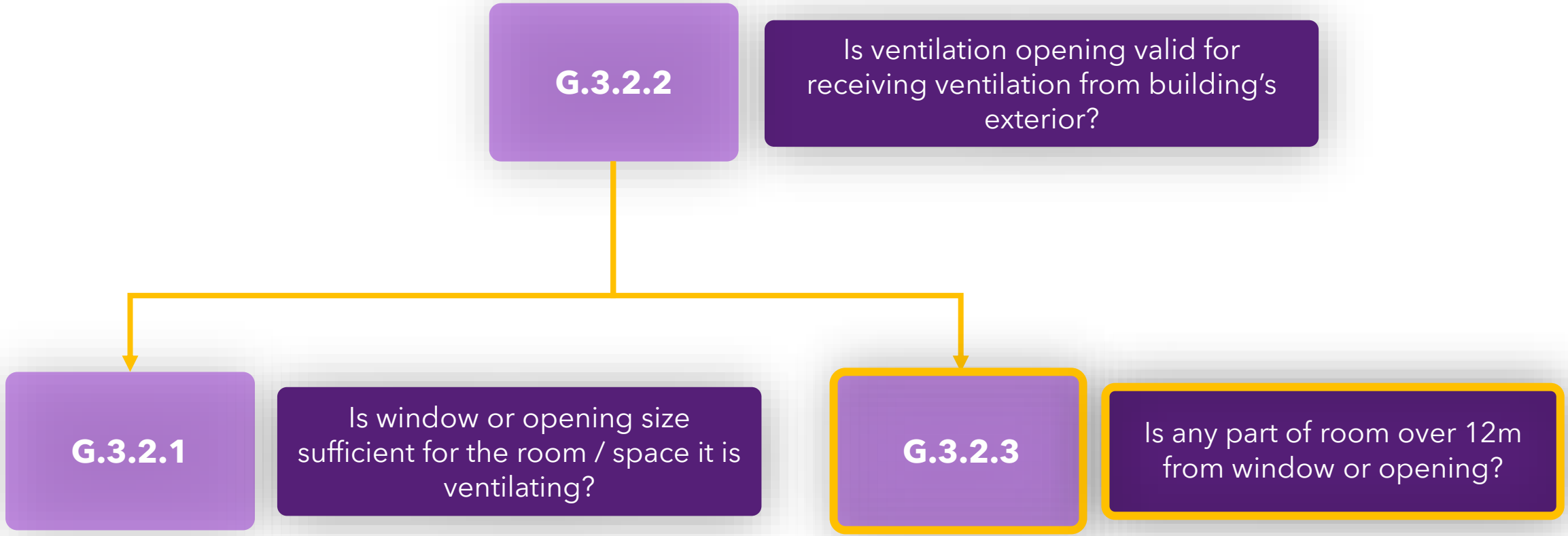
LEAPTHOUGHT

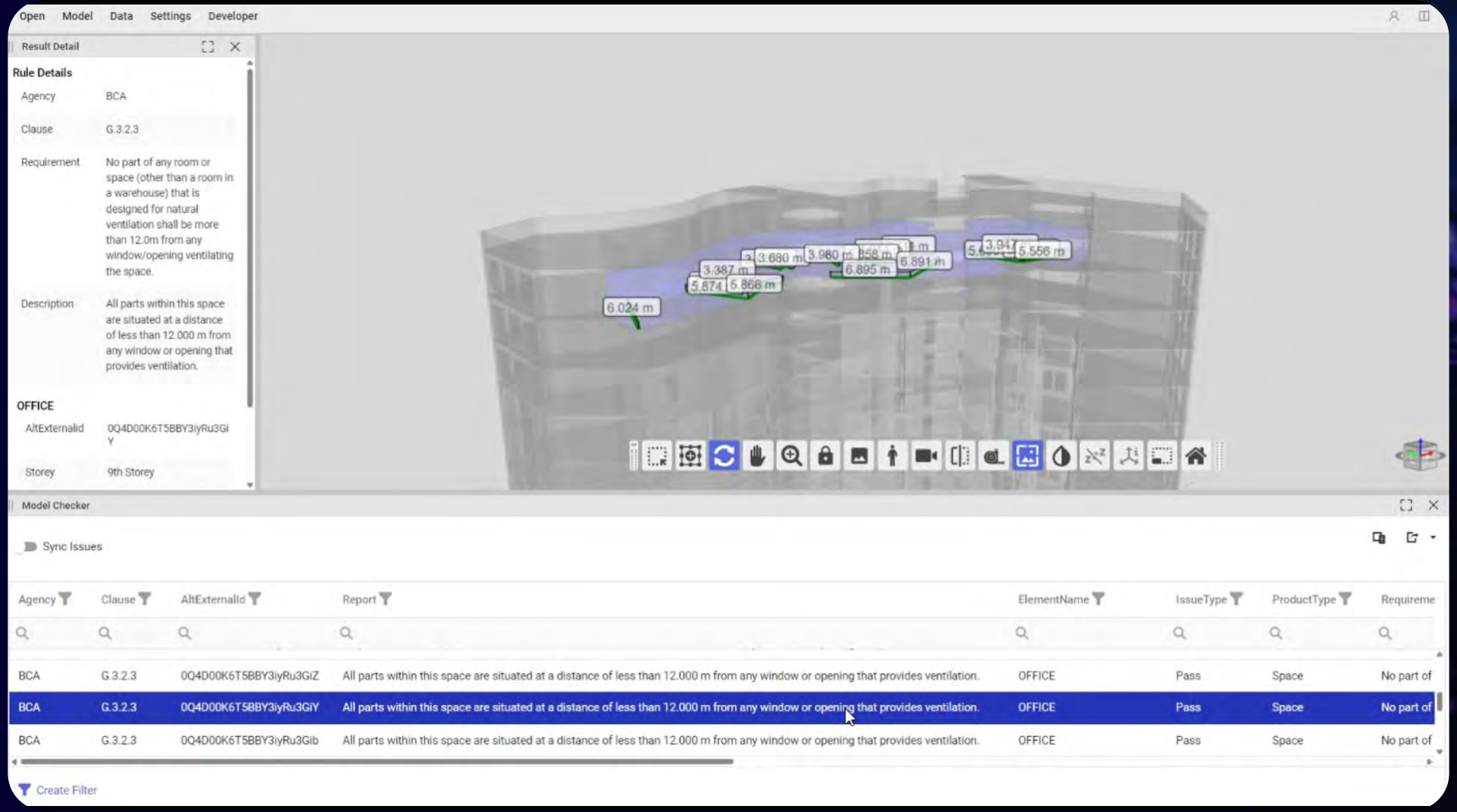
Natural Ventilation

Geometric Check, Shape Generation, Computation and Pathfinding



Natural Ventilation

Distance between Ventilation Opening and Part of Space/Room - Pathfinding



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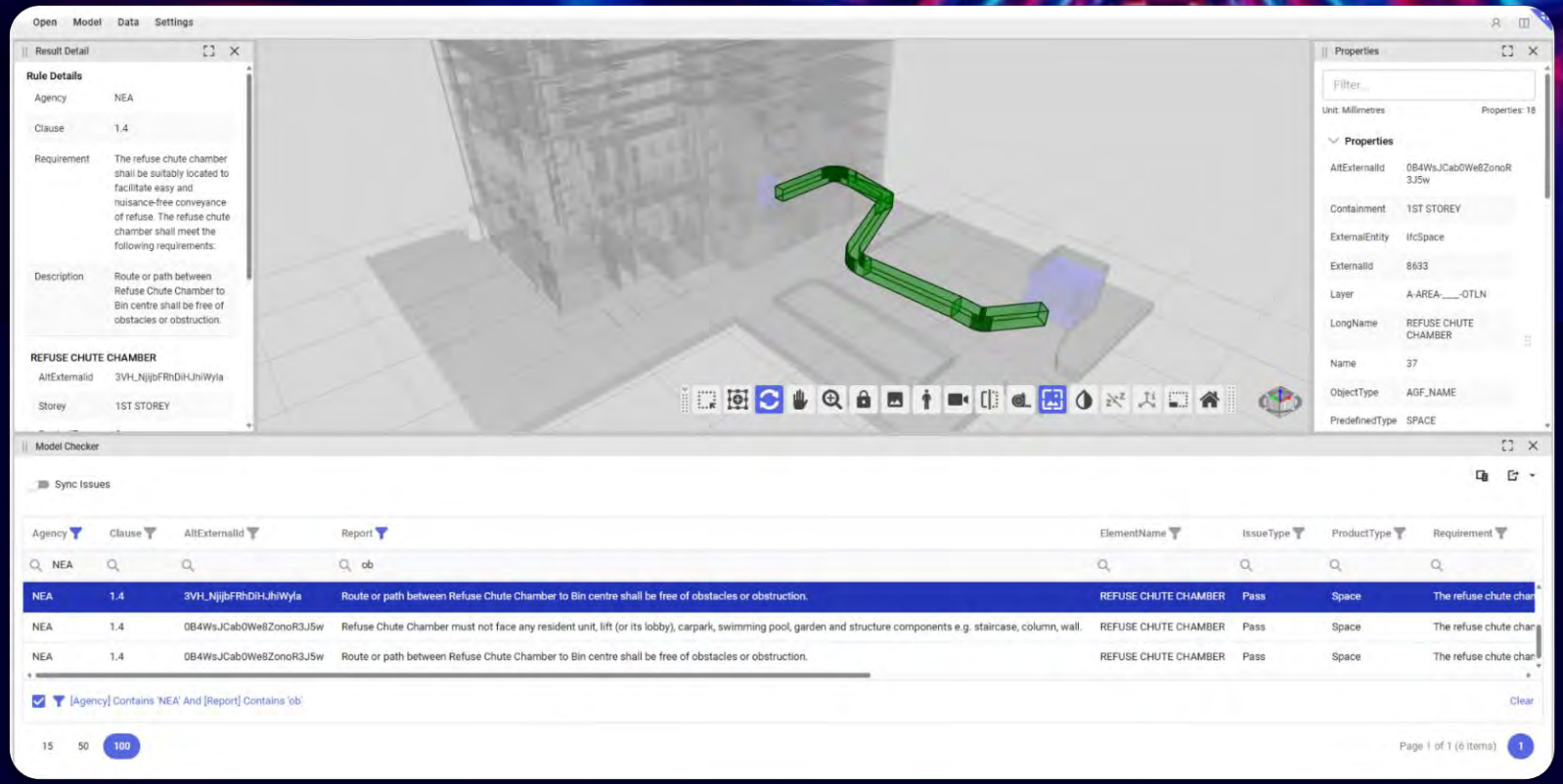
LEAPTHOUGHT

Clear Path from Refuse Chute Chamber to Bin Center

Pathfinding



1

Generating Shortest Path

Shortest path between 2 predefined IfcSpaces: Refuse Chute Chamber room and the Bin Centre

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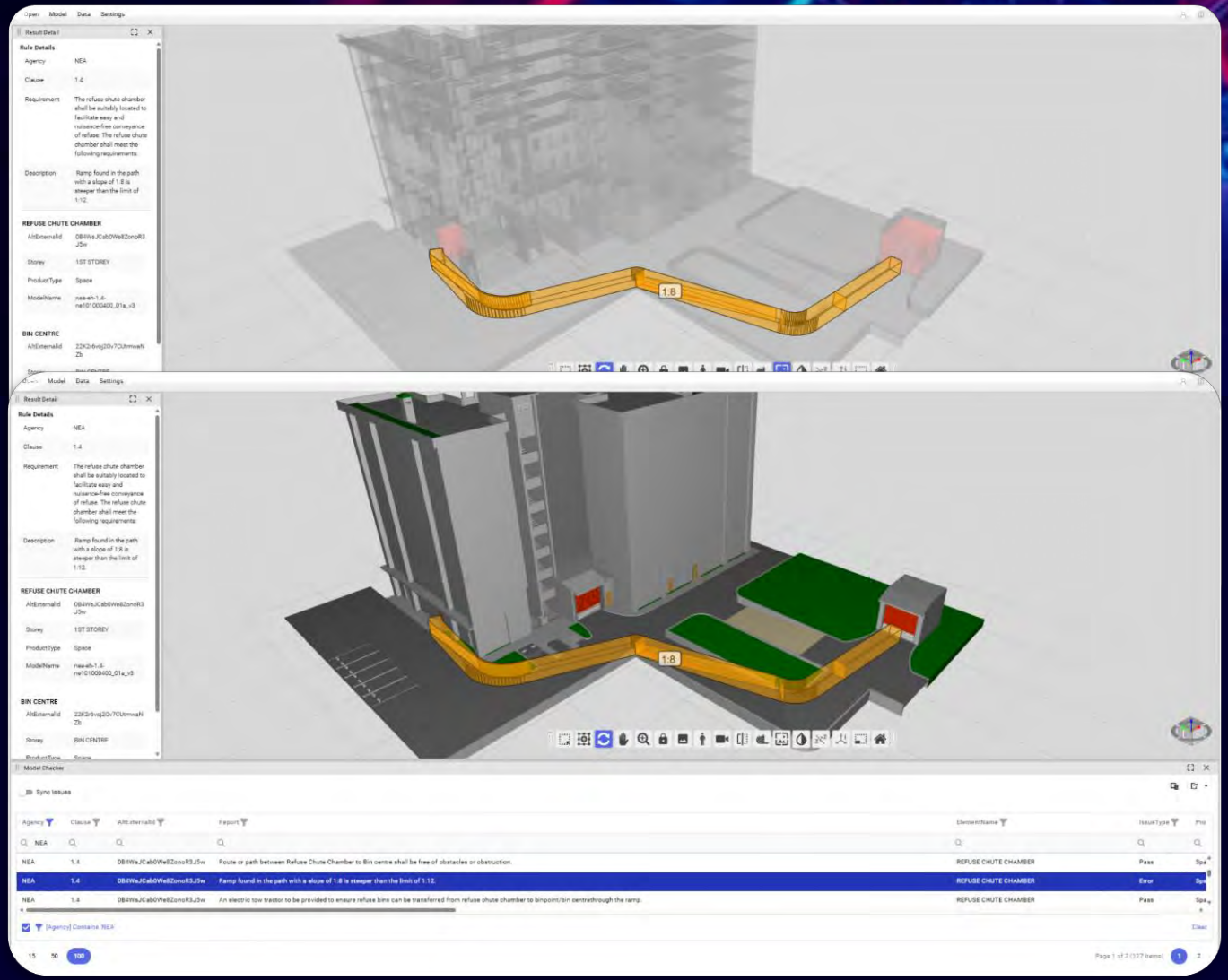
LEAPTHOUGHT

Clear Path from Refuse Chute Chamber to Bin Center

Pathfinding

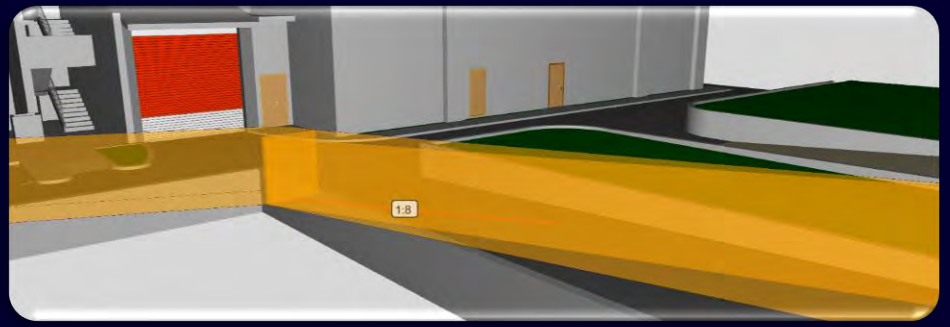


1 Generating Shortest Path

Shortest path between 2 predefined IfcSpaces: Refuse Chute Chamber room and the Bin Centre

2 Checking Gradient

Gradient of shortest path is measured, and checked against max. allowable gradient



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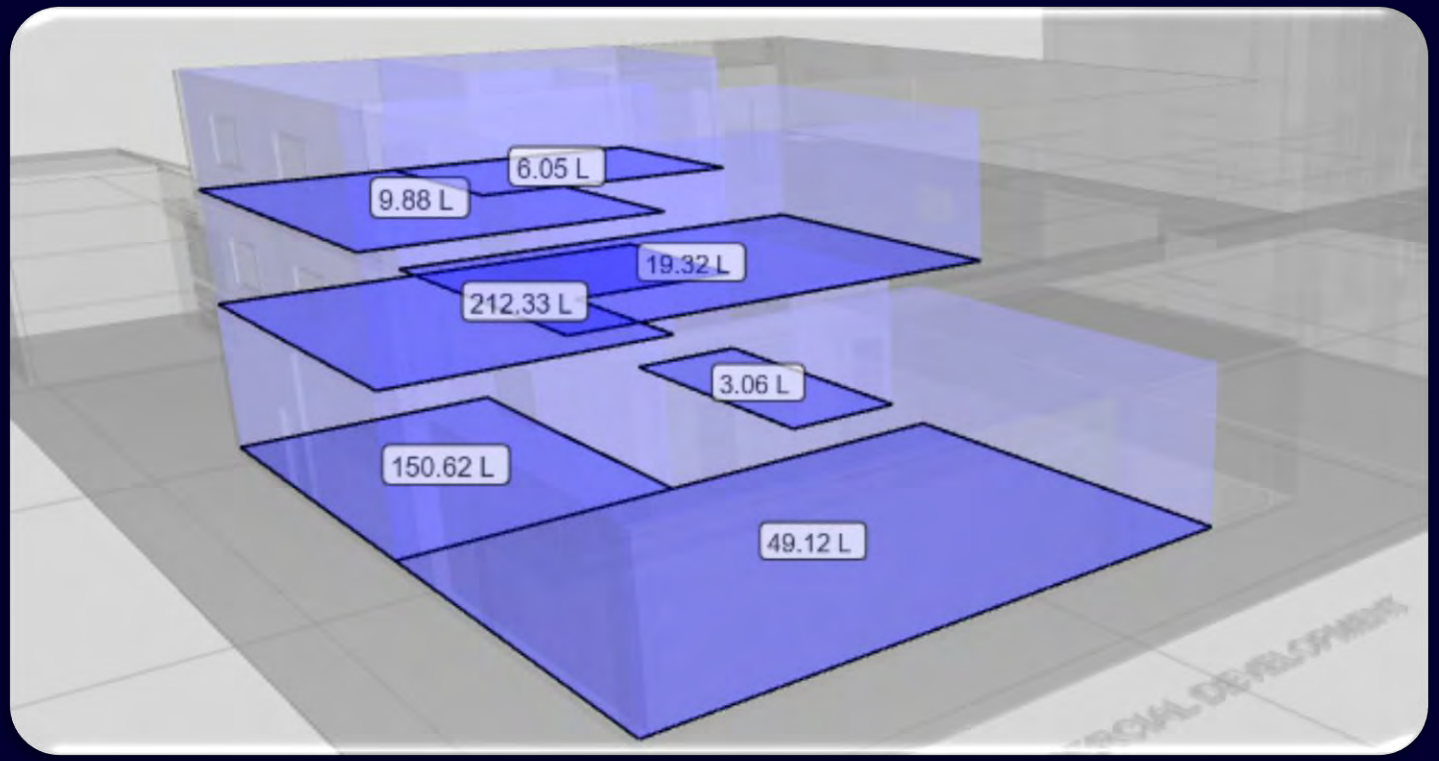
LEAPTHOUGHT

Total Refuse Output

Calculation



Different Space usage has an equivalent Refuse Output which is based on two different computation

Fixed Value

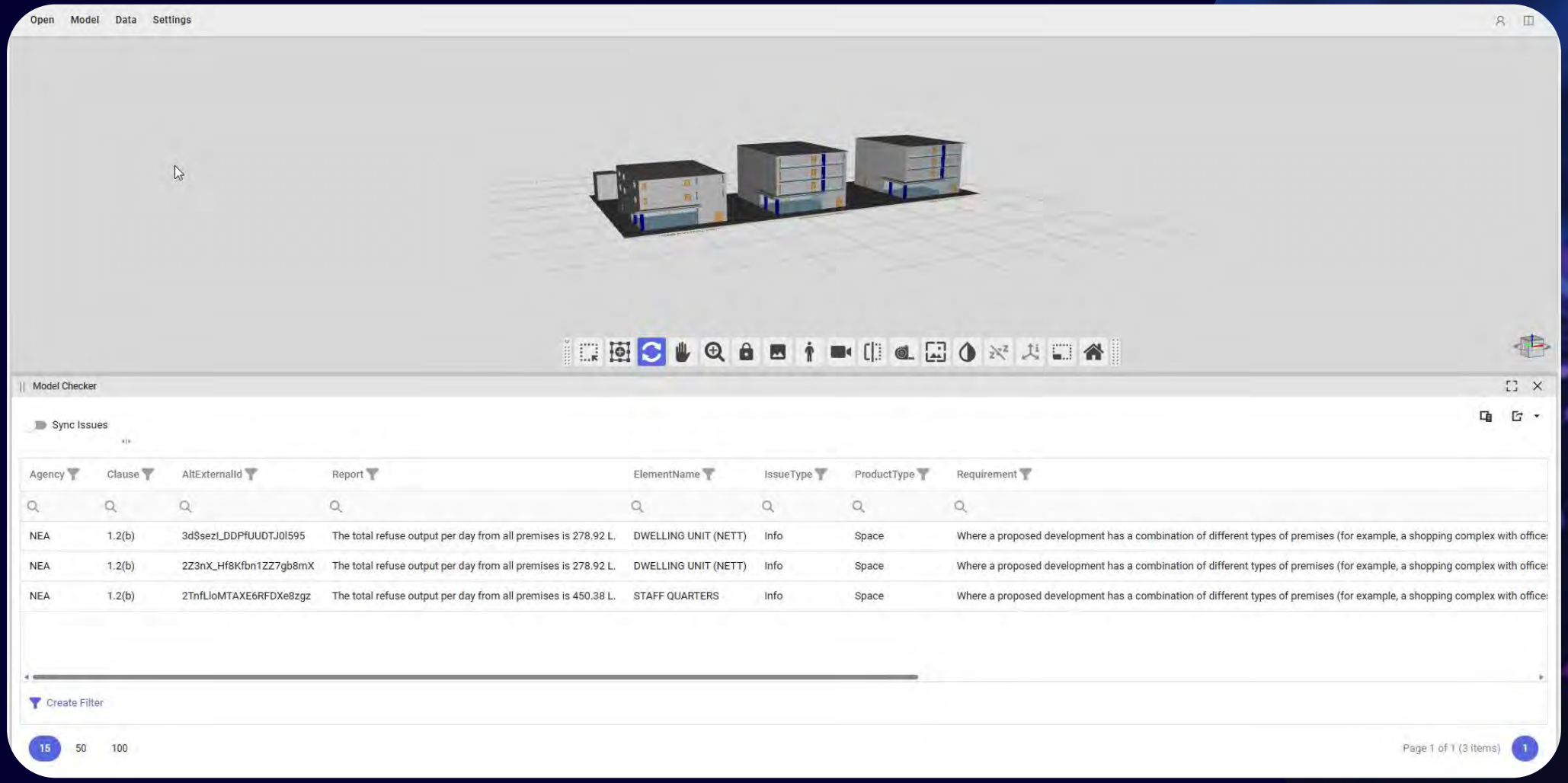
Eg. Each Dwelling Unit will have an output of 20L per day

Per Area

Eg. An Office space will have an output of 0.15L per sqm per day

Total Refuse Output

Calculation



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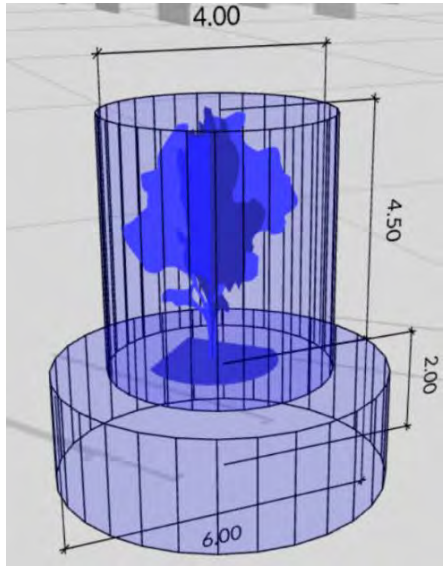
LEAPTHOUGHT

Tree Protection Zone

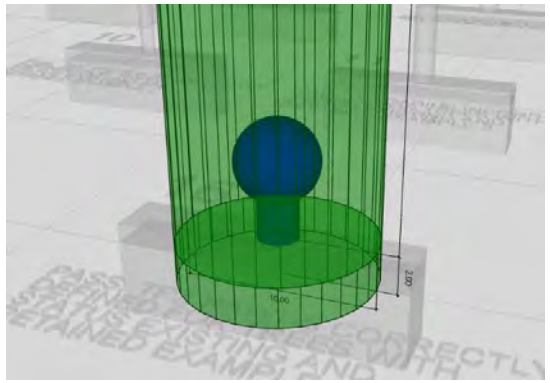
Collision Check with Generated Radius

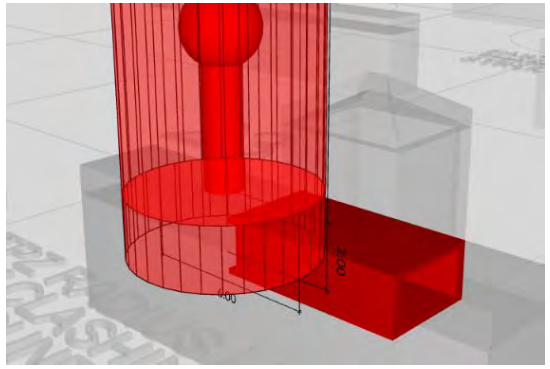


Minimum Protection Zone from the Centre of a Tree

Girth (m)	Minimum Protection Zone
≤1.0m	2.0m
>1.0m but ≤1.5m	3.0m
>1.5m but ≤2.0m	4.0m
>2.0m	5.0m

Source: https://www.nparks.gov.sg/-/media/nparks-real-content/partner-us/developers-architects-and-engineers/gdp-handbook-aug-2018.pdf





- The set-back on Tree Protection Zone (TPZ) is based on the Girth size of the Tree.
- Permanent Structures that are not allowed to be built within the TPZ.
- New trees cannot be planted nearby existing or propsed permanent structures.
- Other Application: Heritage Tree

Cylinder is generated based on girth of tree. The TPZ is then checked for clashes.

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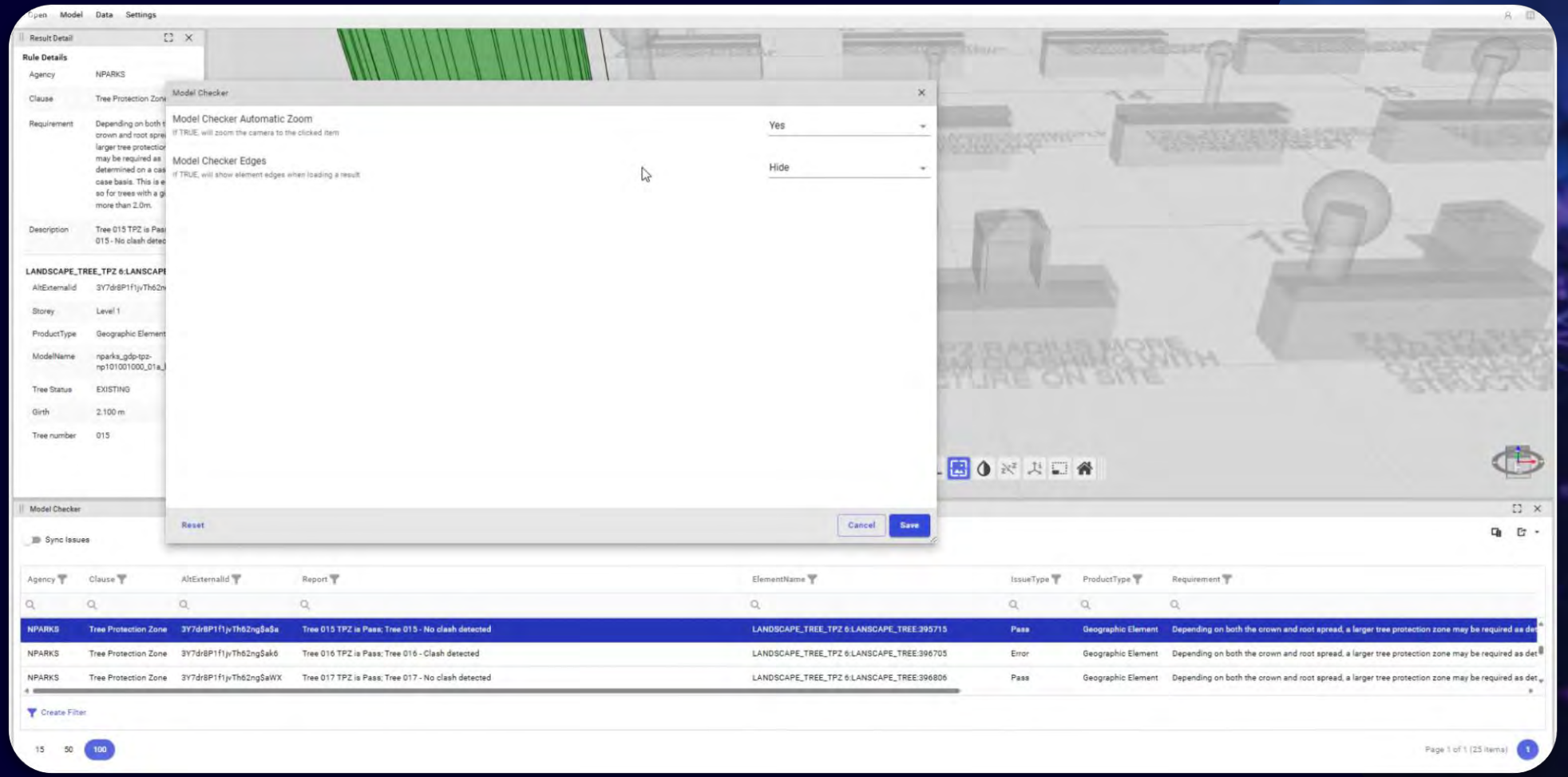
LEAPTHOUGHT

Tree Protection Zone

Collision Check with Generated Radius



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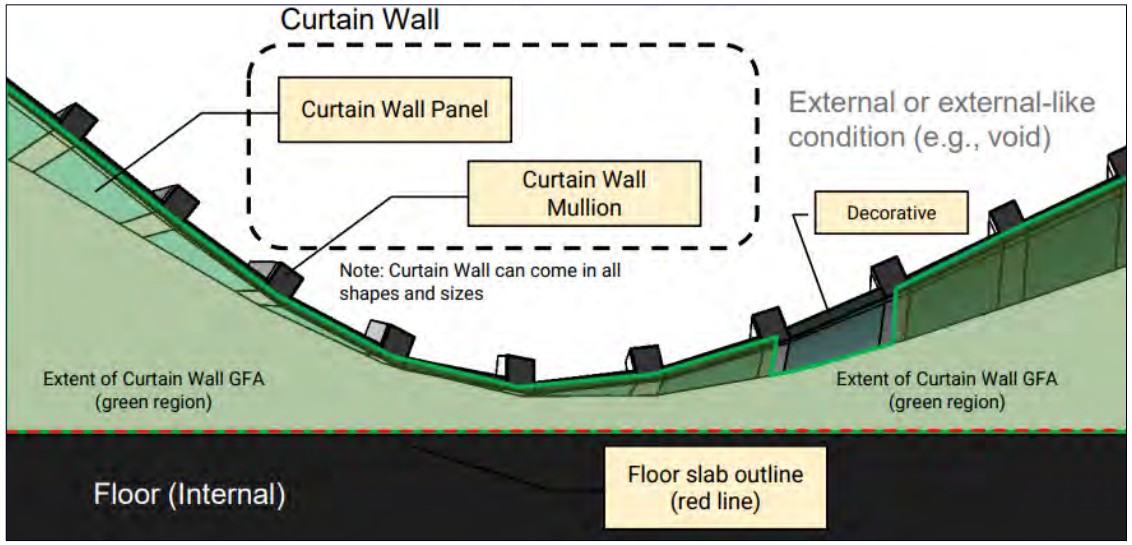
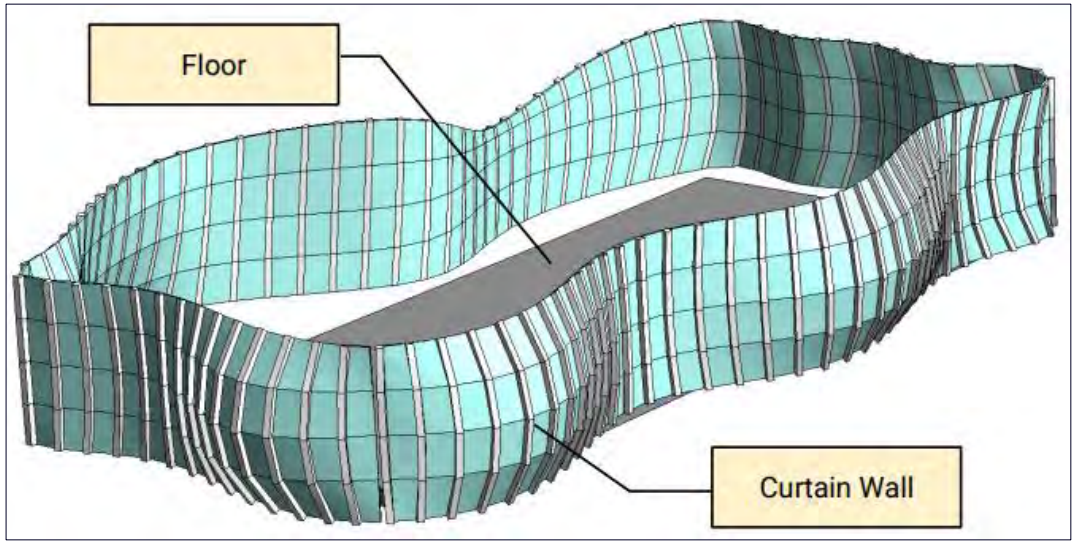
LEAPTHOUGHT

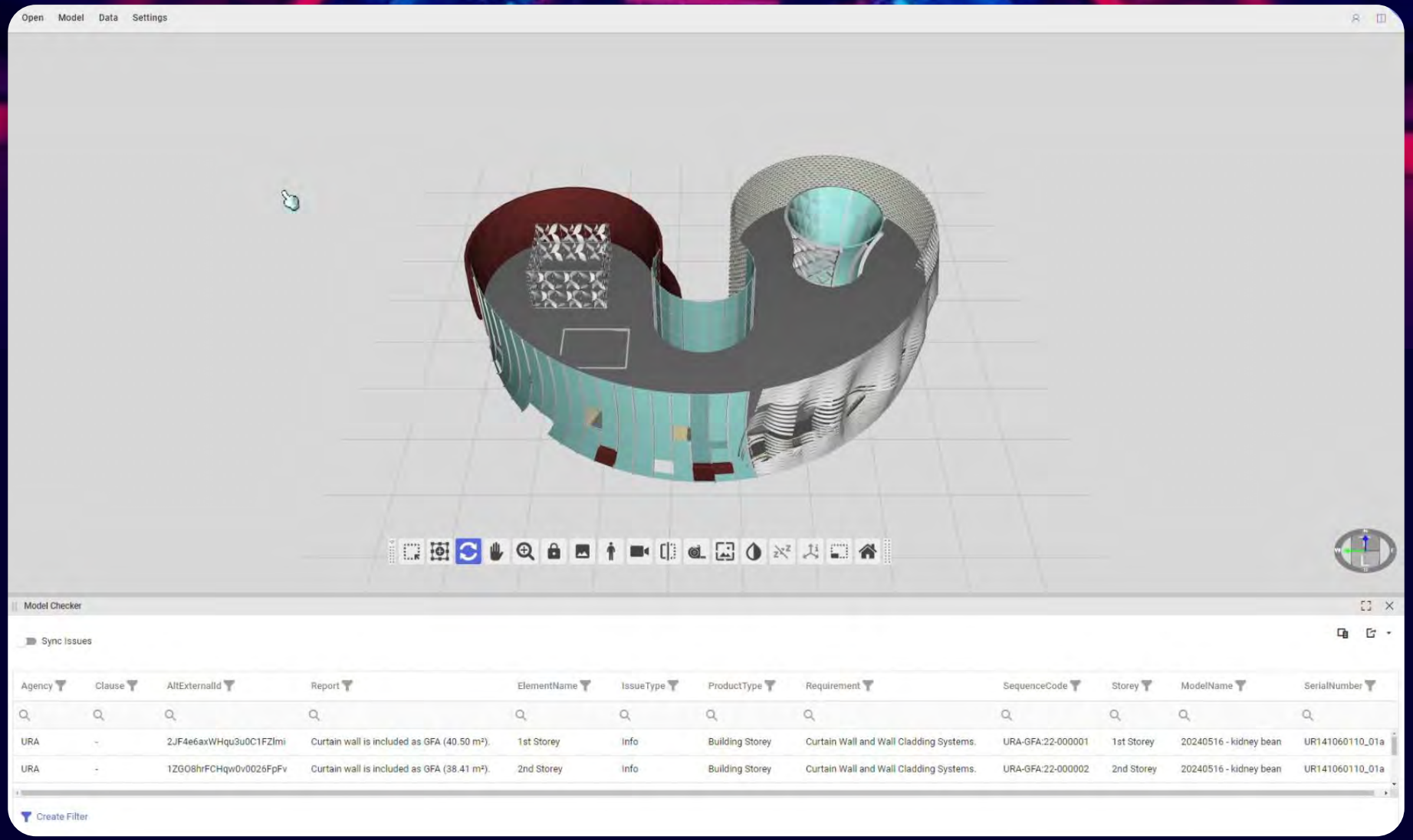




Curtain Walls are included as GFA – area between floor slab outline and centerline of vertical façade element.

Finding the region formed by the floor slab outline and the centre of the Curtain Wall's outermost vertical facade element by generating medial axis.

GFA Curtain Wall



Agency	Clause	AltExternalId	Report	ElementName	IssueType	ProductType	Requirement	SequenceCode	Storey	ModelName	SerialNumber
URA	-	2JF4e6axWHqu3u0C1FZlmi	Curtain wall is included as GFA (40.50 m²).	1st Storey	Info	Building Storey	Curtain Wall and Wall Cladding Systems.	URA-GFA:22-000001	1st Storey	20240516 - kidney bean	UR141060110_01a
URA	-	1ZGO8hrFCHqw0v0026FpFv	Curtain wall is included as GFA (38.41 m²).	2nd Storey	Info	Building Storey	Curtain Wall and Wall Cladding Systems.	URA-GFA:22-000002	2nd Storey	20240516 - kidney bean	UR141060110_01a

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LEAPTHOUGHT

Location
Balconies shall be located away from M&E areas

Openness
Continuous perimeter opening of at least 40%

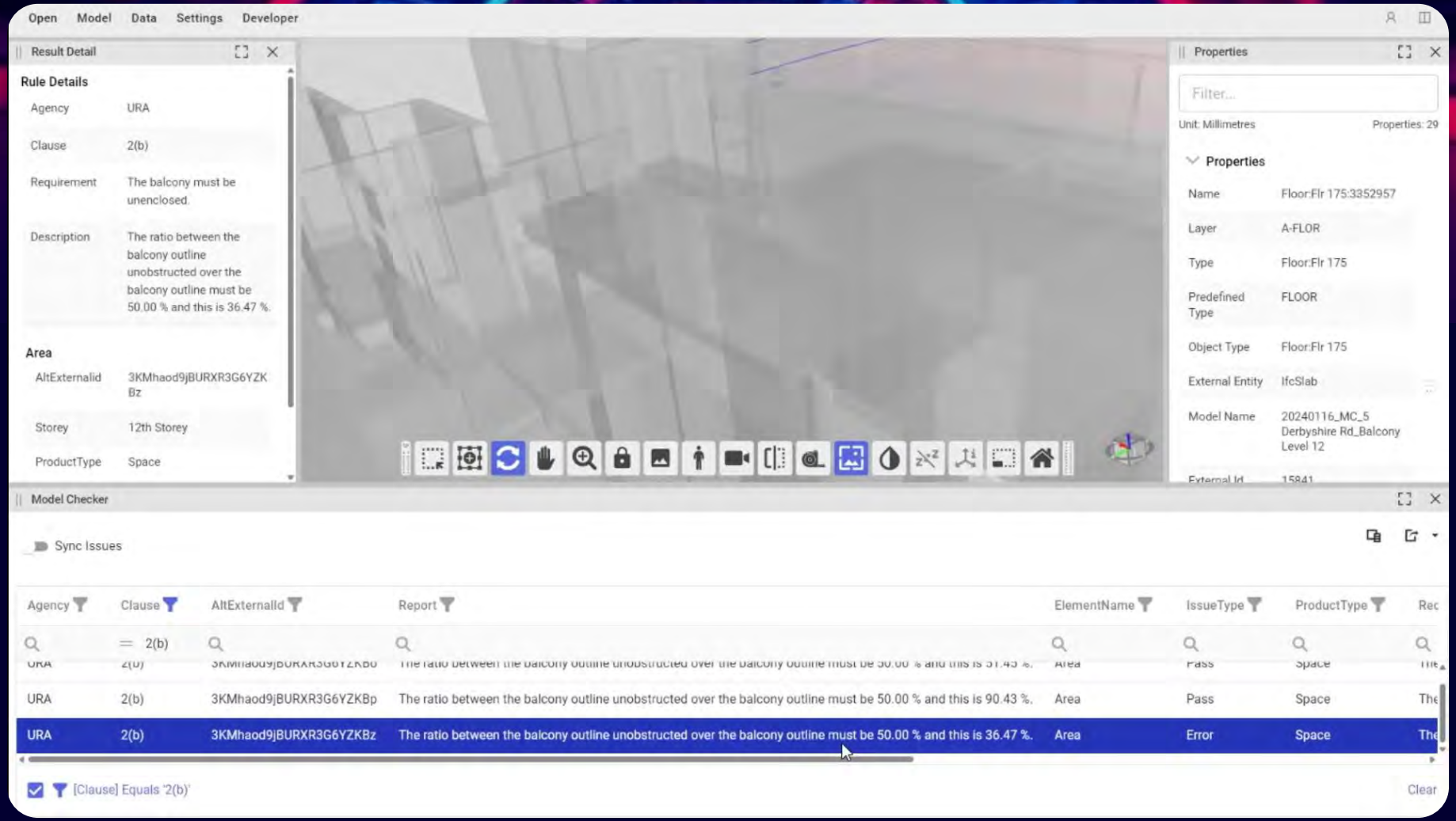
Size
Capped at 15% of the internal nett dwelling unit size

Width
minimum width of 1.5m as measured from the external building wall

Access
Balconies with exclusive access from the kitchen/yard/utility space are treated as service balconies

Screens
Balconies shall not be enclosed with walls or glass panels

To include balcony's area as GFA, the balcony designs shall adhere to certain guidelines and submission requirements.



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LEAPTHOUGHT

Residential Envelope Transmittance Value

Computational Analysis

1. **Identifying Relevant Areas**
   non-basement blocks
   living areas vs non-living areas

2. **Determining External Facade**
   Checking that walls are not abutting any IfcSpaces
   Walls abutting IfcSpace:Airwell or Abutting spaces are naturally ventilated and width of space < storey height

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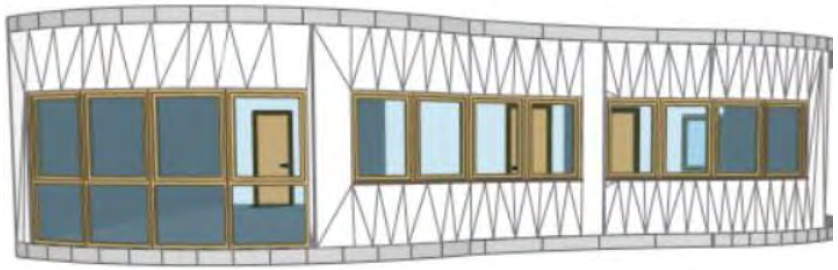
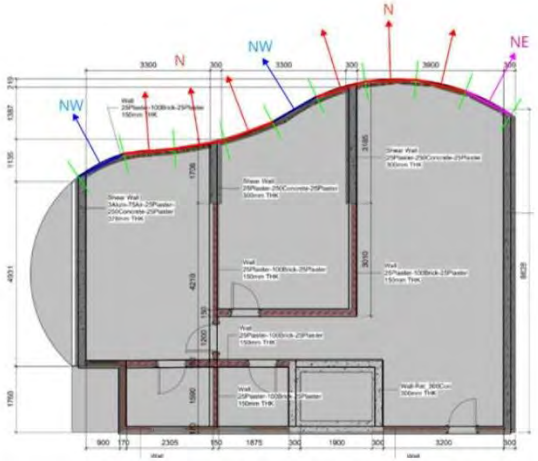
LEAPTHOUGHT

Residential Envelope Transmittance Value

Computational Analysis





1 Identifying Relevant Areas

non-basement blocks
living areas vs non-living areas

2 Determining External Facade

Checking that walls are not abutting any IfcSpaces
Walls abutting IfcSpace:Airwell or Abutting spaces are naturally ventilated and width of space < storey height

3 Determining Orientation of Walls and Fenestrations

Using surface normal to categorise facades into one of 8 directions(N, NE, E, SE, S, SW, W, NW)

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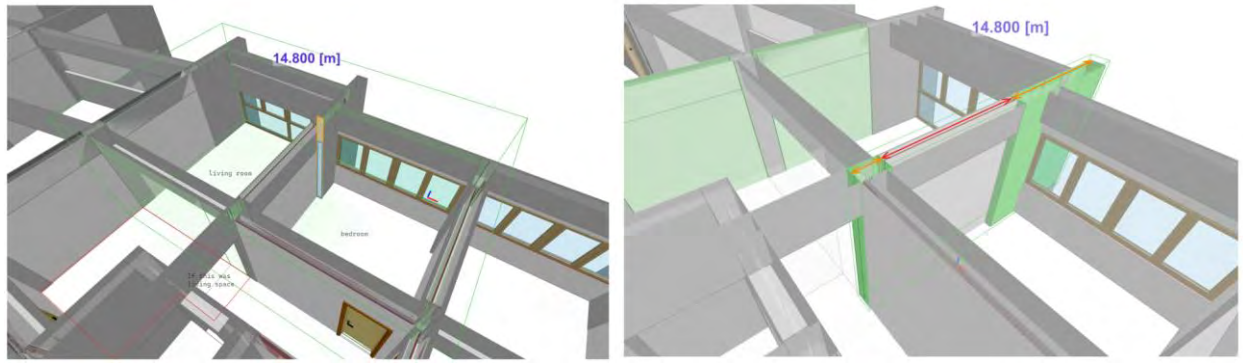
Residential Envelope Transmittance Value

Computational Analysis



4

For Each Orientation

- Compute U values for Walls and Fenestration
- Assigning default values for elements without material property
- Compute area of Walls and Fenestration
- Calculate RETV for single direction

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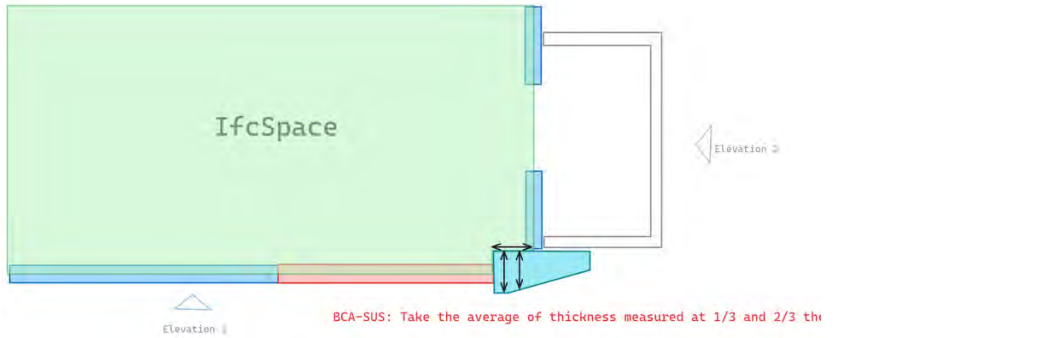
Residential Envelope Transmittance Value

Computational Analysis



4

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Residential Envelope Transmittance Value

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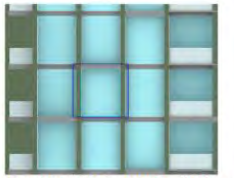
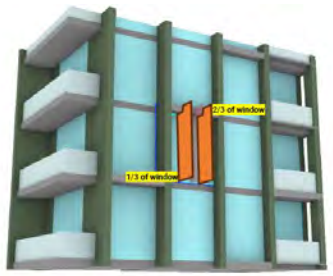
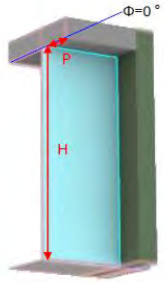
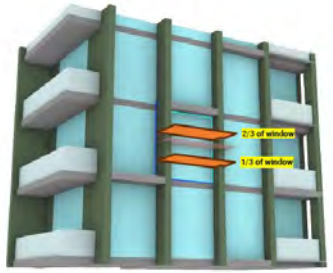


Blue rectangle denotes boundary offset from window that will be analyzed for shading device.

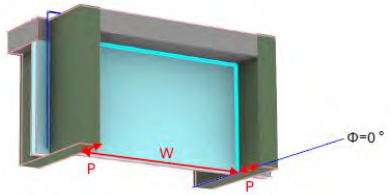


Vertical clipping plane (red) to assess horizontal projections.





Horizontal clipping plane (red) to assess vertical projections.



4

For Each Orientation

- Compute U values for Walls and Fenestration
- Assigning default values for elements without material property
- Compute area of Walls and Fenestration
- Calculate RETV for single direction

5

Compute Overall RETV of Development

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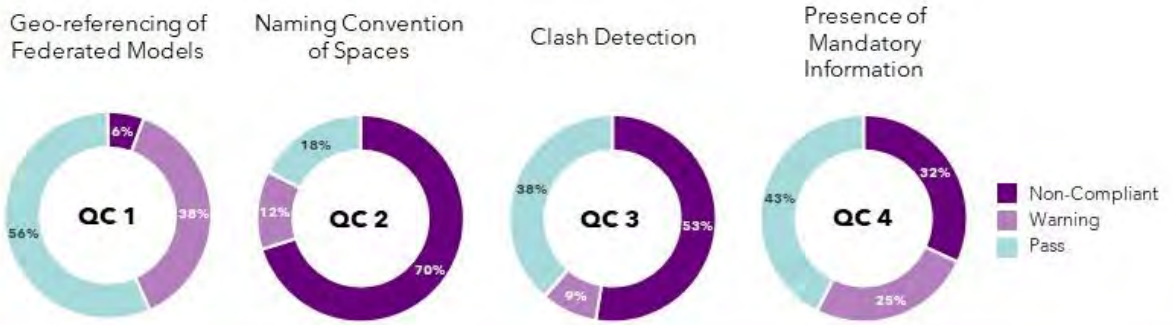
BIM Quality Checks

8 Number of Models Federated

5276 Number of Elements Checked

21,104 Number of Results from QC 1 to 5



Regulatory Compliance Checks

150 Number of Compliance Rules

369, 320 Total Number of Results

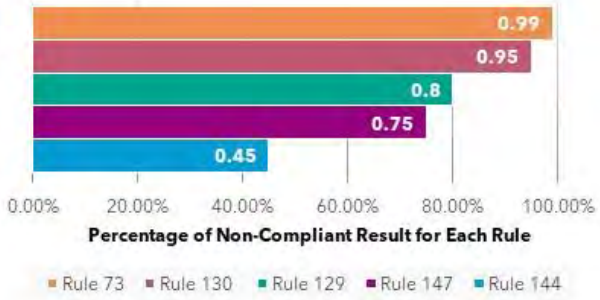
153, 304 Total Number of Pass Results

114, 969 Total Number of Non-Compliant Results

Compliance Rules
(Ranked by highest to lowest percentages of Non-Compliant Results)

Rank	Rule Number	Agency & Requirement
1	73	SCDF - FEA Access to Façade
2	130	BCA - Natural Ventilation
3	129	BCA - RETV
4	147	SCDF - Travel Distance
5	144	NEA - Refuse Handling Capacity

5 Showing 1 to 5 of 30 1 2 3 4 5 Next



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