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Interoperability Evaluation of BIM Data Transfer from Autodesk Revit to Robot Structural Analysis

Putu Egges Widiadnyana*, I Gusti Agung Adnyana Putera, Anak Agung Gde Agung Yana
Universitas Udayana, Indonesia
Email: eggeswidiadnyana@gmail.com*, apute@unud.ac.id, agungyana@unud.ac.id

Keywords	Abstract
bim; interoperability; data exchange; autodesk revit; robot structural analysis; manual adjustment.	The implementation of Building Information Modeling (BIM) in the construction industry demands efficient information integration across different disciplines. The integration between structural models and finite element models (BIM-to-FEM) has become crucial for data integration in structural analysis and modeling. The workflow from modeling to integration has a significant impact on the quality of the model output. This study aims to evaluate the level of interoperability in one-way data exchange from Autodesk Revit to Autodesk Robot Structural Analysis Professional (RSA) using the native API (Application Programming Interface) integration method. Testing was conducted through a case study involving the modeling of a multistory reinforced concrete building, with test parameters encompassing geometric consistency, material and section properties, structural connectivity, loading information, boundary conditions, and data loss. The evaluation results indicate that all data exchange indicators were fundamentally transferred successfully, achieving a 100% parameter accuracy rate. Nevertheless, this workflow does not run fully automatically and still requires significant manual adjustments and rework related to structural engineering logic. This study formulates standardized preprocessing steps to minimize misinterpretation errors before structural analysis computation is executed.

INTRODUCTION

The development of digital technology in the Architecture, Engineering, and Construction (AEC) sector has shifted massively from two-dimensional CAD-based documentation toward Building Information Modeling (BIM) (Ambe et al., 2022). The core concept of BIM relies on creating a single information-rich database, where a digital model represents not only physical visualization but also stores technical properties that can be utilized across various disciplines, including structural engineering.

However, the success of BIM workflow implementation depends not only on the use of the right software but also on the level of interoperability between the software systems used. Interoperability is the ability to exchange data between applications, streamlining workflows and enabling automation in data exchange and interpretation without losing critical information (Sacks et al., 2018). The benefits of implementing BIM with strong interoperability are significant. BIM enables data synchronization across disciplines, minimizes design errors, accelerates decision-making, and improves cost efficiency and implementation time.

Furthermore, BIM supports more realistic project visualizations, streamlines field coordination, and improves the quality of technical documentation. From a project management perspective, BIM also provides the ability to perform schedule simulations (4D), cost estimations (5D), and even building lifecycle analysis (6D). All of these benefits make BIM a strategic solution for driving the digital transformation of the construction sector (Ahn et al., 2016; Hussain et al., 2020; Krasovskaya et al., 2021; Stojanovska-Georgievska et al., 2022).

In conventional workflows, structural engineers often have to rebuild the analysis model from scratch using Finite Element Method (FEM) software, referencing two-dimensional drawings. This replication process is not only time-consuming but also prone to human error and data redundancy (Zhang et al., 2017). Autodesk Revit serves as a BIM modeling solution that simultaneously provides two model representations (Banfi, 2019; Niknam & Karshenas, 2017; Ning et al., 2018). The physical model is the primary model that contains all project information and is used for coordination as well as documentation, while the analytical model extracts only the information required by structural engineers and is generated automatically in the background of the physical model within Revit. The analytical model is the one utilized by structural analysis software. It is used for structural analysis and design, where structural loads, load combinations, and boundary conditions can be easily defined (Hadi et al., 2021).

The urgency of this research is driven by the increasing adoption of BIM workflows in structural engineering practice. With the continuous development of BIM and frequent software version updates, it is important to assess the extent of these changes and their impact on interoperability. Even when using the same software versions, inconsistencies still emerge during the integration process (Ilyas & Khan, 2017; Shahin et al., 2017; Woolf & Silver, 2017). Recent studies have demonstrated that structured workflows and careful management of native and IFC-based data transfers significantly improve model reliability and reduce design inconsistencies (Colajanni et al., 2025; Ren et al., 2025; Singh et al., 2024). Validation and quality control procedures remain necessary to maintain model accuracy in BIM implementations. There is also a low value-to-effort ratio for engineering analyses using BIM; for structural analysis, this ratio can even become negative, often prompting engineers to recreate models from scratch rather than reuse architectural BIM models.

The novelty of this research lies in its comprehensive evaluation of one-way interoperability from Autodesk Revit to Robot Structural Analysis based on six primary indicators: geometric consistency, material and section properties, structural connectivity, loading information, boundary conditions, and data loss. Unlike previous studies that primarily focused on identifying issues, this research extends the discussion by formulating standardized preprocessing steps and technical mitigation strategies to minimize misinterpretation errors before structural analysis computations are executed. The study also specifically examines version 2027 of both applications, providing updated insights into the current state of interoperability.

Although both the modeling software (Autodesk Revit) and the analysis software (Robot Structural Analysis) are developed by the same vendor and connected via a direct Application Programming Interface (API), one-way data integration still faces technical interpretation challenges. Misalignment of analytical axis coordinates and changes in support behavior are frequently encountered when data is transferred from one platform to another. Therefore, this study focuses on conducting a comprehensive evaluation of one-way interoperability from Autodesk Revit to Robot Structural Analysis based on six primary indicators: geometric consistency, material and section properties, structural connectivity, loading information, boundary conditions, and data loss. This research aims to map data transfer reliability while formulating necessary technical mitigation steps.

METHOD

This study implements a quantitative experimental method utilizing a case study of a multi-story reinforced concrete building. The evaluation focuses on mapping data accuracy and identifying the need for manual intervention immediately after the model is imported into the Robot Structural Analysis (RSA) environment. The experimental workflow is divided into four main stages:

1. Modelling Stage : Development of the physical building model in Autodesk Revit, accompanied by the configuration of the supporting analytical model. This step includes defining cross-sectional dimensions (columns, beams, slabs) and concrete material specifications, followed by generating the analytical model, applying boundary conditions to the structure, and inputting loads.

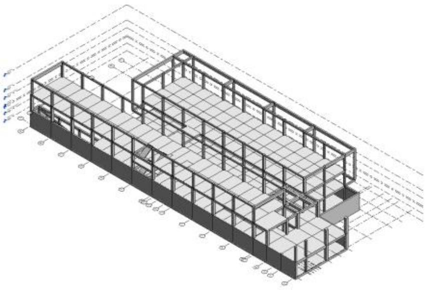


Figure 1. Revit Physical Model

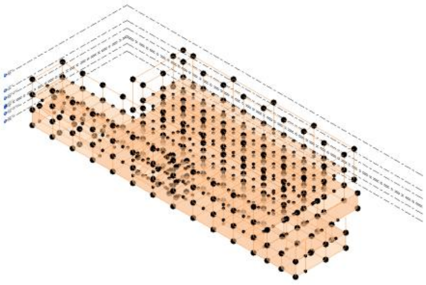


Figure 2. Revit Analytical Model

2. Data Integration/TransferStage : Executing the data exchange using the native API link integrated within the software environment to push the model from Revit to RSA.

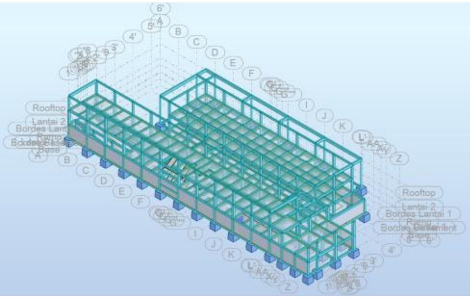
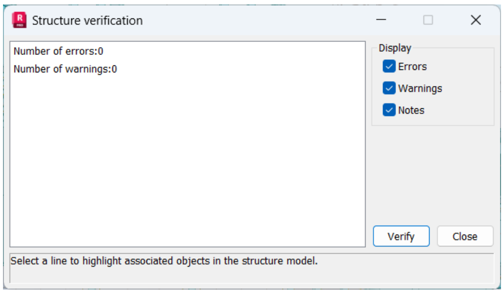


Figure 3. Robot Structural Analysis Model

3. Interoperability Evaluation Stage : Analyze data variations based on objective assessment instruments consisting of 6 main Indicators: geometric consistency, material and section properties, structural connectivity, loading information, boundary conditions, and data loss.

4. Verification Process Stage: The model imported into Robot Structural Analysis is directly verified using the internal checking feature (Calculations/Verification). This process aims to detect geometric errors, unread loads, and analytical discontinuities.



Number of errors:0
Number of warnings:0

☑ Errors
☑ Warnings
☑ Notes

Select a line to highlight associated objects in the structure model.

Figure 4. Verification Process

RESULTS AND DISCUSSION

Before heading to the interoperability evaluation the user need to know the diffrences between BIM in Revit and FEM in Robot Structural Analysis. A fundamental understanding of the differences in interpretation of levels, elevations, and element lengths between Autodesk Revit and Robot Structural Analysis (RSA) is crucial for structural designers to avoid fatal modeling errors. In a BIM environment, Revit defines building levels as stories or flexible working levels that can be combined with vertical offset systems (such as minus-elevation landing beams). In contrast, RSA, as FEM software, immediately locks the lowest level as the absolute global reference (Base), which often shifts the naming of levels above it. This discrepancy is exacerbated by the way RSA interprets geometry. The analysis program will always refer to analytical lines based on the element's center of gravity, rather than following the visual top profile as displayed in Revit. Ignoring this difference can lead to misreading of effective column heights and bar lengths (system length vs. cut length), which are the basis for the structural stiffness matrix.

Furthermore, successful integration depends heavily on engineers' understanding of the differences in the treatment of joints and interfaces between physical objects. Revit prioritizes visual aesthetics and material volume accuracy through Join Geometry features (such as Miter, Square Off, or Butt joins) to prevent double-counting of concrete volume at beam-column intersections for cost estimates. On the other hand, RSA completely ignores these visual aesthetics and interprets the overlapping areas of physical elements as rigid joints that connect the analytical lines axis-to-axis to mathematically transfer loads. If the user does not verify the alignment of this analytical model before performing calculations, the transferred internal forces risk being misdirected due to disconnected nodes.

The interoperability evaluation of one-way BIM data transfer from Autodesk Revit to Robot Structural Analysis was analyzed and categorized using six key technical indicators. The fundamental findings of this study indicate that all indicators were successfully transferred with a parameter correctness rate of 100%, meaning no information or physical parameters were lost. However, manual adjustments (rework) were absolutely necessary to reconcile differences in interpretation between software before the analysis could be run.

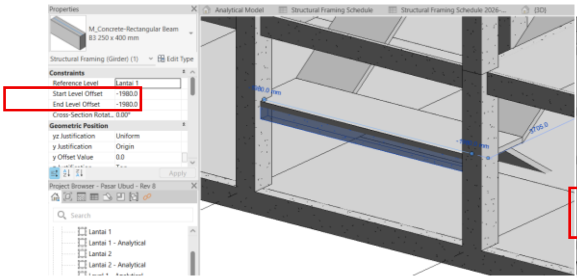
The improvements were made through improvements to the workflow stage to achieve a 100% integration interoperability level for the model. The improvements were as follows:

Table 1. Interoperability Evaluations

No	Indicator	Revit Workflow Stage	Interoperability Evaluation	Interoperability Rework / Adjustment
1	A. Geometric Consistency	Creating levels according to design height	Level elevation / height	Manual addition of missing levels
2		Creating grids according to design spacing	Grid position and coordinates	Manual addition of missing grids
3	B. Material & Section	Adjusting element cross-sectional dimensions	Element length or area	Configuration of element-to-element joins
4	C. Structural Connectivity	Analytical Model Inspection	Analytical nodes	Configuration of analytical automation tools
5		Examining beam-column connections	Beam-column joint/connection integration	Implementation of staged analytical automation

A. Geometric Consistency

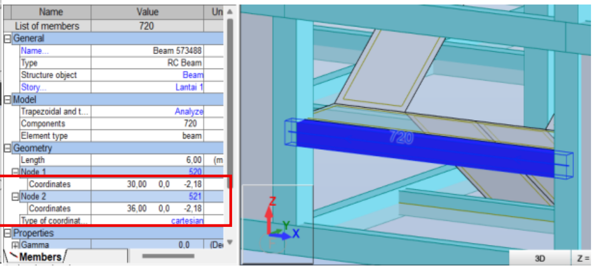
In the evaluation of the geometric consistency indicator, an issue was identified where certain elements were positioned at incorrect levels after integration. Specifically, the level of beam B3 was -1980 mm in Revit, but after integration, it shifted to -2180 mm. This differences occurs because Revit uses the top level of the beam as its level reference, which should ideally be interpreted as the level in Robot. However, Robot reads the centroid of the beam, resulting in a level difference of 200 mm.



Properties
M_Concrete-Rectangular Beam
B3 250 x 400 mm
Structural Framing (Girder) (1)

Constraints	
Reference Level	Lantai 1
Start Level Offset	-1980.0
End Level Offset	-1980.0
Cross-Section Rotat...	0.00°
Geometric Position	
yz Justification	Uniform
y Justification	Origin
y Offset Value	0.0

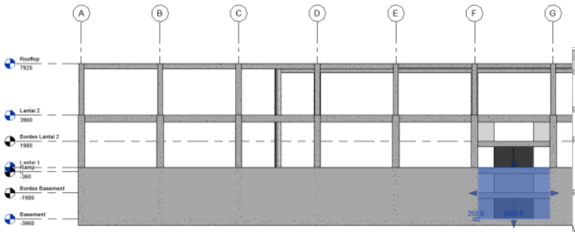
Figure 5. Level of Beam B3 in Revit



Name	Value	Un
List of members	720	
General		
Name...	Beam 573488	
Type	RC Beam	
Structure object	Beam	
Story...	Lantai 1	
Model		
Trapezoidal and t...	Analyze	
Components	720	
Element type	beam	
Geometry		
Length	6,00	(m
Node 1	520	
Coordinates	30,00 0,0 -2,18	
Node 2	521	
Coordinates	36,00 0,0 -2,18	
Type of coordinat...	cartesian	
Properties		
Gamma	0,0	(De

Figure 6. Level of Beam B3 in Robo

The improvement made was by adding a level to Revit to make block B3 be at the level point it should be because the analytical model tends to be at the modeled level when converting the physical model to analytical.



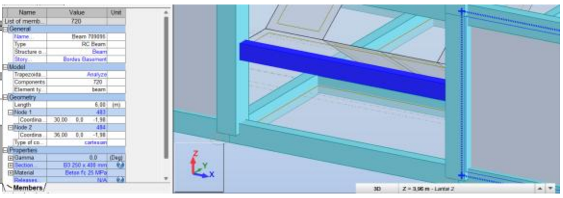
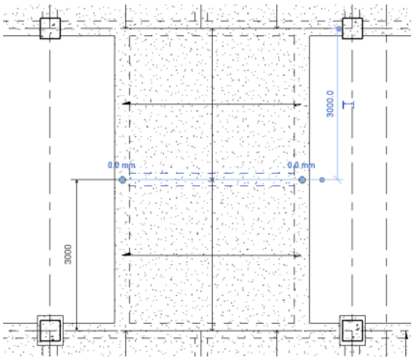


Figure 7. Addition of Level **Figure 8.** Level of Block B3 on Robot After Repair

In addition to the level differences in this indicator, there are differences in position or coordinates between the Revit and Robot models. It can be seen that the initial distance of block B3 from the grid was 3000 mm, but after integration, the distance changed to 3045.83 mm.



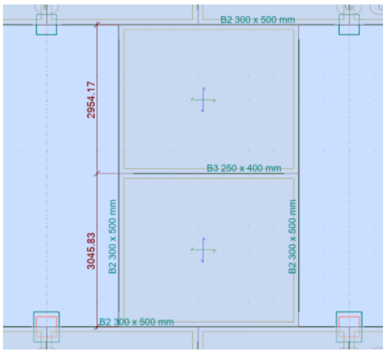
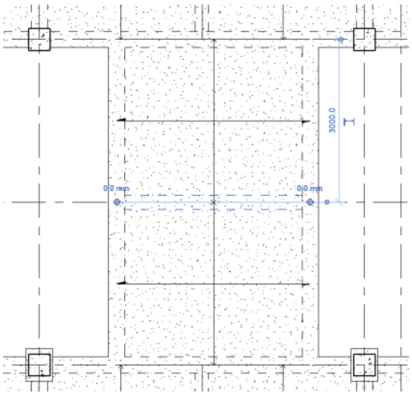


Figure 7. Position of Beam B3 in Revit **Figure 8.** Position of Beam B3 in Robot

The correction was made by adding a grid to the B3 beam axis, as the analytical automation feature tends to move elements to the grid. This ensures that the B3 beam is positioned exactly at 3000 mm.



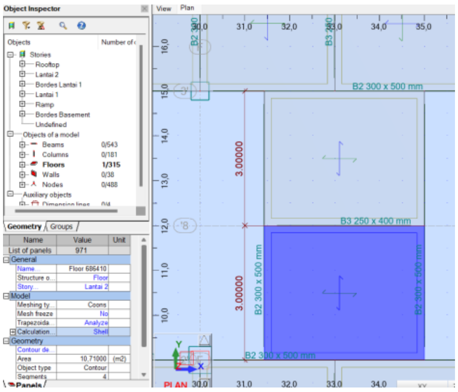
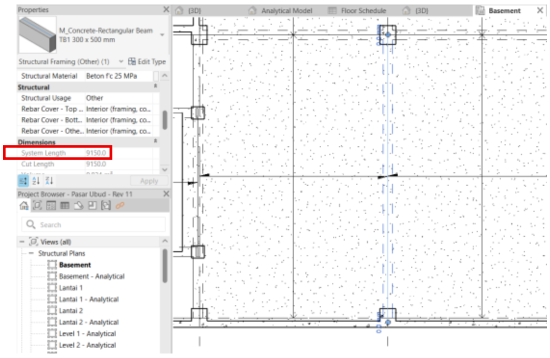


Figure 9. Addition of Grid to B3 **Figure 10.** Position of Block B3 on Robot After Repair

B. Material and Section Properties

Evaluation of this indicator found differences in element length and area in the model before and after integration. This kind of problem already been faced in the older version of Revit study by Sampaio (2021) demonstrate an error is detected when the geometric boundaries of an element do not coincide with the analytical boundaries, meaning that there is a difference between the positions of the physical element and the analytical element to be integrated. This difference in position will also impact the dimensions, both length and area, of the element.

The difference in length occurs because element TB1 is connected to another element that is offset from the grid, so TB1 automatically follows the joins that connect it to this other element and the calculation of the leght is 9150 mm. To solve this, element joins are set by default to "allow joins," which automatically connects between elements. Therefore, it is necessary to disable this feature by changing it to "disallow joins" so that connections are not automatically made to adjust the element length and the leght of TB1 changed to 9000 mm.



Structural Material: Beton f'c 25 MPa

Structural

Structural Usage: Other

Rebar Cover - Top ...: Interior (framing, co...

Rebar Cover - Bott...: Interior (framing, co...

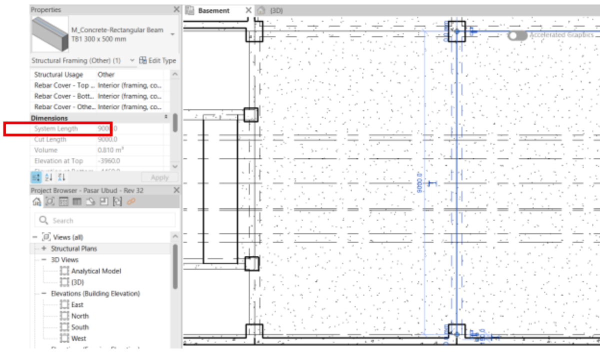
Rebar Cover - Othe...: Interior (framing, co...

Dimensions

System Length: 9150.0

Cut Length: 9150.0

Figure 11. Initial Length of TB1



Structural Usage: Other

Rebar Cover - Top ...: Interior (framing, co...

Rebar Cover - Bott...: Interior (framing, co...

Rebar Cover - Othe...: Interior (framing, co...

Dimensions

System Length: 9000.0

Cut Length: 9000.0

Volume: 0.810 m³

Elevation at Top: -3960.0

Figure 12. Length of TB1 After Repair

The difference in element area occurs in the retaining wall element where the stand-alone retaining wall, without columns, intersects. There is a difference in perception between the element area measurements. The difference occurs due to the increase in length due to the use of joins at the retaining wall junction. The length and height measurements are correct, but the area results differ due to the influence of the joins. In the first wall the simple area calculation is 47,52 m^2 but due to the joins its calculated to 48.31 m^2 had an additional area 0.79 m$^{2.}$ Also happening in second wall from 11.88 m^2 to 12.28 m^2. This was confirmed directly by Autodesk Assistant, which is an AI (Artificial Intelligence) in Revit.

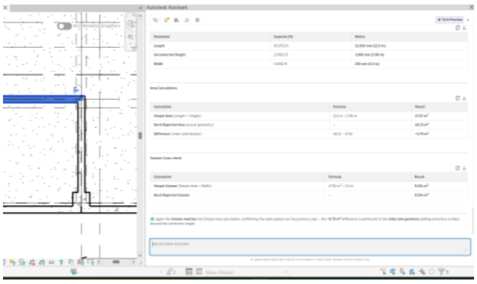


Figure 13. Area of RW1

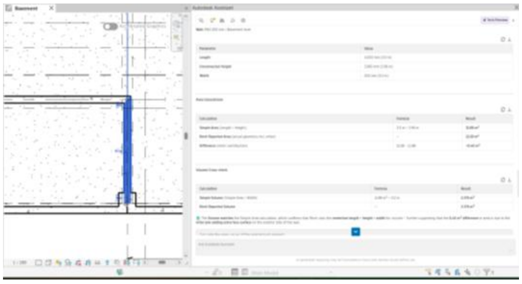


Figure 14. Area of RW1

C. Structural Connectivity

Structural connectivity evaluates the continuity of the analytical model, particularly the intersection points between element axes (node intersections), to ensure proper load distribution. Evaluation of this indicator revealed that some elements were not connected to their proper nodes. This problem occurred due to shifting of analytical elements during the conversion process using the analytical automation feature. It's important to note that this automation feature, driven by a Dynamo-based script running in the background, operates entirely using a distance tolerance algorithm. Study by Gomes (2022) says the high failure rate of analytical automation processes requires project owners/designers to perform comprehensive validation and partial remodeling of missing or misinterpreted elements. This relates to how analytical automation feature capabilities can impact integration outcomes.

In principle, the system determines connectivity between elements based on user-defined distance thresholds. If the physical distance between elements falls below this tolerance threshold, the system automatically connects the analytical elements. The solution to this problem is to increase the sensitivity of the analytical model to shift to the nearest grid by increasing the sensitivity level of the element alignment factor in the horizontal plane, from the default value of 1.

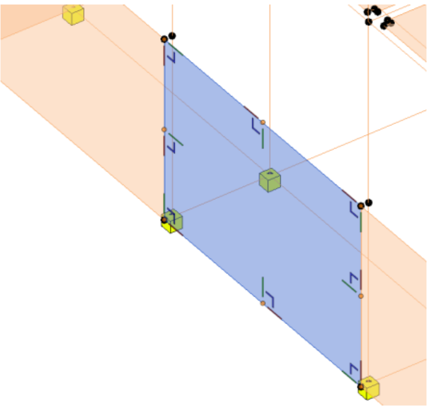
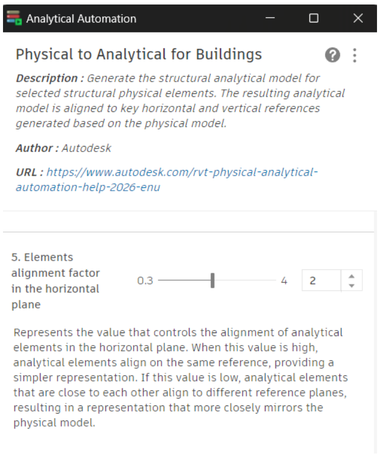


Figure 15. Analytical Elements Not Connected



Physical to Analytical for Buildings

Description : *Generate the structural analytical model for selected structural physical elements. The resulting analytical model is aligned to key horizontal and vertical references generated based on the physical model.*

Author : *Autodesk*

URL : *https://www.autodesk.com/rvt-physical-analytical-automation-help-2026-enu*

5. Elements alignment factor in the horizontal plane: 0.3 — 4, 2

Represents the value that controls the alignment of analytical elements in the horizontal plane. When this value is high, analytical elements align on the same reference, providing a simpler representation. If this value is low, analytical elements that are close to each other align to different reference planes, resulting in a representation that more closely mirrors the physical model.

Figure 16. Analytical Automation

The evaluation results of the physical model conversion process into an analytical model indicate that the floor-by-floor conversion method yields a higher level of accuracy than the direct conversion of the entire building. This difference is evident in the quality of structural element connectivity, the consistency of analytical line positions, and the geometric stability of the analytical model after the integration process.

After integration, the beam positions at the ramp level were observed to be inconsistent. This was due to the excessive number of elements converted into the analytical model, which reduced the conversion accuracy.

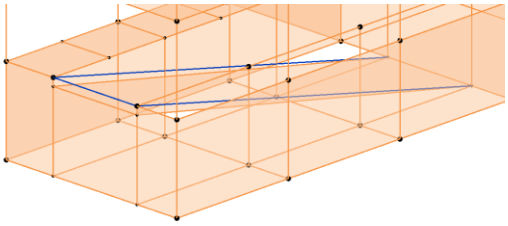


Figure 17. Analytical Model of Ramp Beam

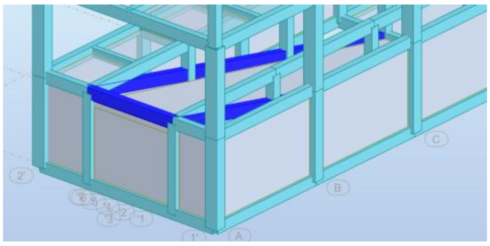


Figure 18. Ramp Model in Robot

The solution to this problem is to convert only the three elements that have undergone this position change. First, delete the elements in the analytical model to prevent overlapping of duplicate elements. Then, use the analytical automation feature to select these three elements. After converting only three elements, the positions of these elements are clearly at the ramp level in both the analytical model and the robot model.

Model Validation

Validation and corrections are still necessary to maintain model quality, as noted by Colajanni (2025), where inconsistencies such as node breaks, partial loss of element properties, or incomplete transfers often require additional modeling time for manual correction, and this effort increases proportionally with the number of affected elements. This statement inline with Huda (2025), who stated that validation and quality control procedures are still necessary to maintain model accuracy in BIM implementations.

Given the continued development of BIM annually and the continuous updating of versions, it is important to assess the extent of changes. For example, in this study, where the application versions used were Autodesk Revit and Robot Structural Analysis version 2027, inconsistencies still emerged in the integration process between the two applications.

CONCLUSION

he interoperability integration between Autodesk Revit and Robot Structural Analysis using the built-in API demonstrates very high parameter reliability, with a reported data accuracy rate of 100% and no data loss. Although interoperability requirements were satisfied across 23 test parameters, the integration workflow still requires manual refinement to improve overall interoperability performance. This can be achieved by adding additional reference levels for several elements, creating structural grids to lock element positions and prevent unintended shifts during integration, adjusting element joins to ensure precise intersections without altering element lengths or areas, and configuring analytical automation settings to achieve optimal results when converting physical models into analytical models.

The quality of the model is also determined by the user's workflow during modeling. The more complex the model, the greater the level of adjustment required. Similarly, the more detailed and specific the data input, the higher the overall model quality. Users must also understand the differences in data interpretation between BIM and FEM models, particularly in terms of levels, nodes, element segmentation, and software-specific features in Autodesk Revit and Robot Structural Analysis.

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