

Structural Analysis with Dynamo: From Parametric Modeling to Structural Calculation in a Few Clicks

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Abstract

This article presents a workflow that integrates Dynamo and Robot Structural Analysis to optimize structural analysis through parametric modeling. Through practical case studies—a beam, a truss, and a multi-story building—it demonstrates how this methodology improves modeling efficiency, reduces errors and streamlines the iterative design process. The article also highlights the need for an ethical and standardized adoption of these tools within the AEC (Architecture, Engineering, and Construction) industry.

Keywords: Parametric modeling; Dynamo; Robot Structural Analysis; BIM; Structural analysis.

1. INTRODUCTION

In today’s dynamic world, Structural Engineering, Architecture, and Construction must converge with precision and creativity, maintaining seamless communication throughout all stages of a project—from preliminary studies to commissioning. This is especially evident in complex projects, where interdisciplinary collaboration becomes crucial, as highlighted by Hu et al. [2], who emphasize the importance of improving interoperability between architectural and structural models.

Having shared digital tools and collaborative workflows is not a luxury but an essential requirement for making optimal structural design decisions. As Olaseni [3] stresses, the adoption of BIM methodologies has enabled significant advances in complex infrastructure projects and skyscrapers thanks to digital collaboration.

Due to the iterative nature of the design process, platforms that offer flexibility and encourage continuous exploration of solutions based on structural performance criteria are required. Proko [4] highlights how programmatic methods improve interoperability between models, enabling dynamic evolution of the design.

The integration of geometry and structural analysis within a common environment, with bidirectional communication, enables an intelligent design paradigm. According to Wang, Xu,

and Hu [5], the use of BIM-based tools for seismic analysis and structural performance visualization represents a significant transformation in how structures are conceived.

In this context, Dynamo emerges as an accessible and powerful visual programming environment which, together with Robot Structural Analysis, forms an ideal combination for parametric modeling, analysis, and optimization. This integration allows structural design professionals to anticipate, compare, and decide with unprecedented control, as proposed by Al-Mazeedi [1], who highlights the value of digital modeling and interoperability between platforms such as Revit and Rhino.

In line with this, the aim of this article is to demonstrate—through practical examples and concrete results—how this workflow can seamlessly transition from parametric design to structural analysis in just a few clicks.

2. METHODOLOGY

The methodology is based on a progressive and iterative workflow between Dynamo and Robot Structural Analysis (RSA), structured into three key stages. First, the connection between Dynamo and RSA is established, ensuring efficient transfer of structural information. Next, parametric models are developed in Dynamo using visual nodes, complemented with Python scripts when necessary, allowing for greater design flexibility and customization. Finally, the generated model is exported to RSA, where structural analysis is performed to evaluate internal forces, displacements, and reactions, thus validating the structural behavior of the modeled system.

2.1. Connecting Dynamo with RSA

The process begins with the installation of Robot Structural Analysis from Autodesk (Figure 1). RSA does not include Dynamo natively, so the “Dynamo for RSA” extension must be installed (Figure 2). This allows Dynamo to be launched from RSA, enabling direct transfer of structural data.



Figure 1: Software included in the AEC Collection

Tools such as “Structural Analysis for Dynamo” and “Dynamo for RSA” allow for the creation of complete structural elements directly from Dynamo, improving interoperability, as noted by Hu [2], when referring to the use of web-based tools to integrate architectural and structural models.

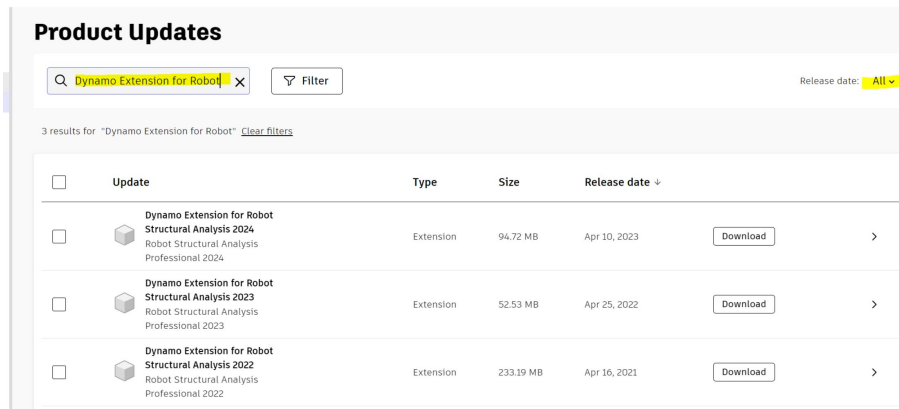


Figure 2: Dynamo for RSA extension. Taken from [6]

2.2. Generating Parametric Models in Dynamo

Dynamo enables the creation of models through a visual node-based interface [6], where parameters such as dimensions, materials, and loads are defined. According to Al-Mazeedi [1], this capability facilitates work even for users without programming backgrounds by offering an accessible and flexible environment.

Additionally, by incorporating Python, Dynamo expands its functionality for advanced users. This supports Olaseni's [3] argument on the importance of collaborative tools that increase productivity without compromising precision. Nevertheless, Dynamo can be used without coding, relying solely on its block-based interface, which provides an intuitive workflow for users with little or no programming experience.

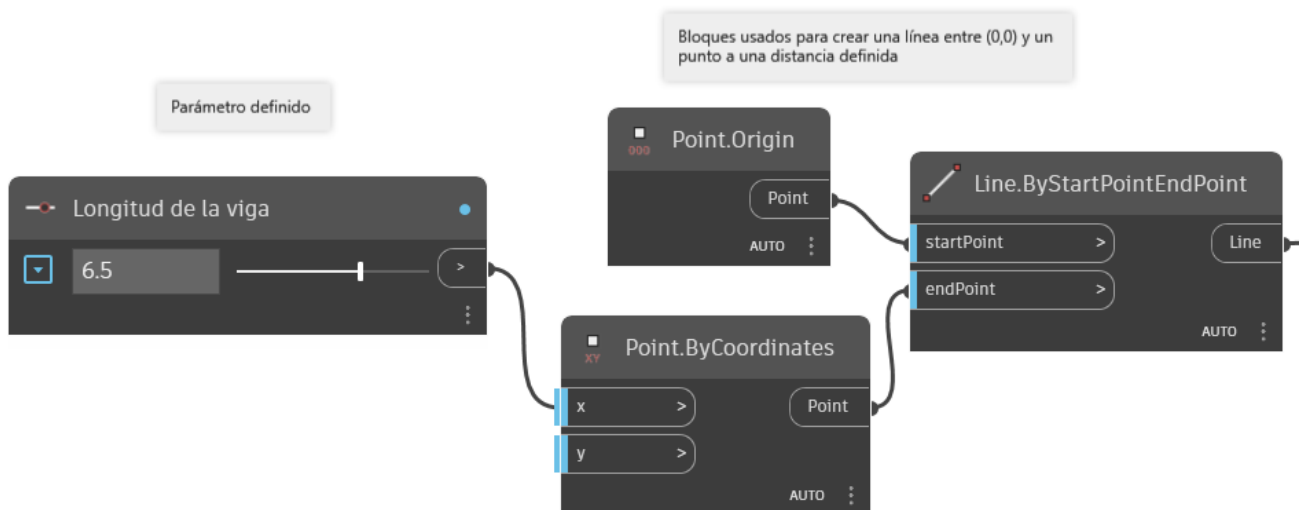


Figure 3: Example of blocks used to create a simple beam in Dynamo. Author's own

2.3. Analyzing the Model in RSA

Once the model is transferred to RSA, structural analysis is performed. The software interprets geometry and boundary conditions, providing results on internal forces, deformations, and reactions. As demonstrated by Wang, Xu, and Hu (2025), this integration is especially valuable for assessing the seismic behavior of reinforced concrete structures.

RSA also allows for modal and spectral analysis, adding a critical layer for evaluating structures under seismic loads, thus strengthening the robustness of the design from the early stages.

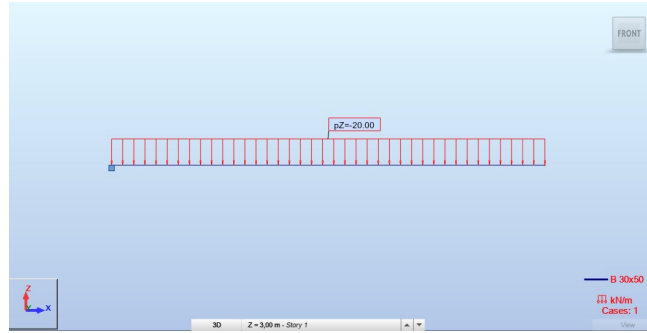


Figure 4: Dynamo model in RSA. Author's own

Readers interested in exploring and practicing with this tool can find a wide variety of examples and tutorials directly from Dynamo's interface. Simply go to the "Help" section and access the proposed examples, which cover a range of practical cases from basic concepts to advanced workflows. These resources are especially useful for those who wish to master the use of Dynamo in structural analysis and parametric design contexts.

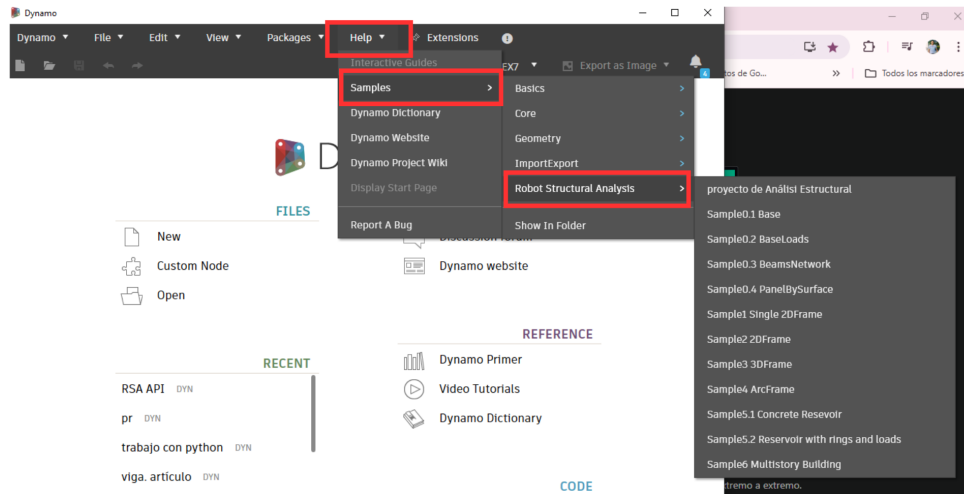


Figure 5: Examples of Dynamo application for structural analysis

3. RESULTS AND ANALYSIS

The development of parametric models and their subsequent structural analysis in Robot Structural Analysis confirmed the effectiveness of the proposed workflow. Through three representative structural typologies (a beam, a truss, and a multi-story building), the system's ability to generate accurate models, transfer information seamlessly, and perform robust structural analyses in optimized timeframes was evaluated.

3.1. Fixed-End Beam

The reactions at the fixed support and the maximum deflection of the beam shown in Figure 4 were evaluated. The results were consistent with theoretical calculations, validating the automated workflow described by Wang et al. (2025).

Table 1: Results for fixed-end beam with different lengths. Author's own

Length (m)	Reaction (kN)	Max Deflection (mm)
4	80	8
5	100	20
6	120	41

Table 1 shows the structural analysis results of a fixed-end beam subjected to a uniformly distributed load due to self-weight, considering three different lengths: 4 m, 5 m, and 6 m. These lengths were automatically applied in RSA by varying the length parameter in Dynamo (Figure 3).

As expected, both the reaction and the maximum deflection increase with the beam length. The reaction increases from 80 kN to 120 kN, representing a 50% increase, while the maximum deflection shows a more significant rise: from 8 mm to 41 mm, suggesting a non-linear relationship between length and deflection.

3.2. Arch-Shaped Truss

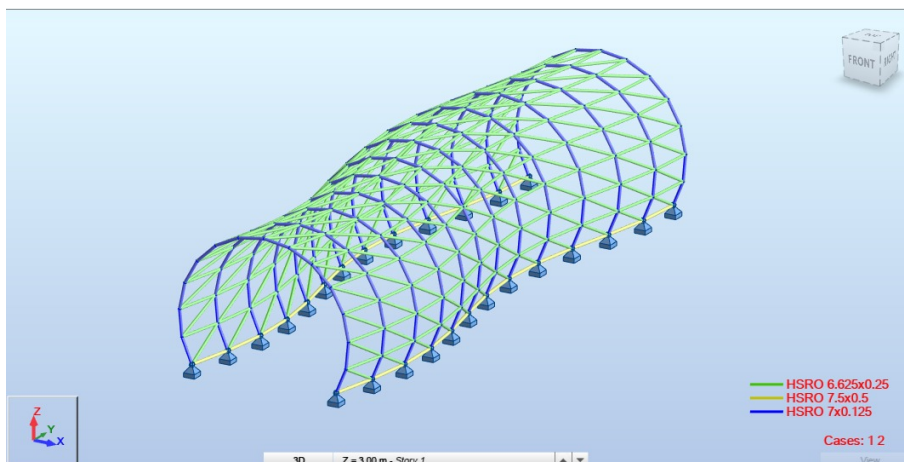


Figure 6: Truss with a height of 8.4 m. Adapted from [6]

For this case, characterized by having many elements, the reactions at the supports were evaluated, identifying the maximum reaction and the corresponding node of application. This analysis reflects the usefulness of the automated approach, as proposed by Proko (2023) in his study on structural interoperability.

It is important to note that, in a conventional workflow, modifying the height of a structure would require manually editing a large number of individual elements: columns, beams, truss members, levels, associated loads, boundary conditions, and more. This process is not only tedious but also prone to human error and consumes valuable time.

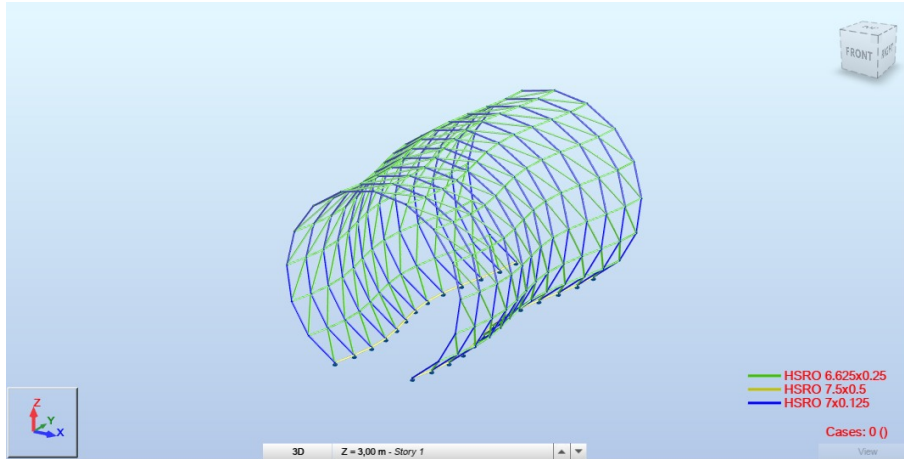


Figure 7: Truss with a height of 20 m. Adapted from [6]

In contrast, using Dynamo, this same change is reduced to a simple adjustment of a parameter within a parametric model. That is, only the desired height is modified, and Dynamo automatically regenerates the entire structural geometry and exports the new model to Robot Structural Analysis.

Table 2: Maximum and minimum reactions at nodes of the structure. Author’s own

	FX (kN)	FY (kN)	FZ (kN)
MAX	490.050	1538.160	883.420
Node	8	5	12
MIN	-532.900	-1620.390	-1371.880
Node	5	10	8

The analysis of maximum and minimum nodal reactions along the three axes (FX, FY, FZ) demonstrates how the structure responds to applied loads, once the height parameter is adjusted. This information is crucial for decision-making regarding reinforcements or local redesigns.

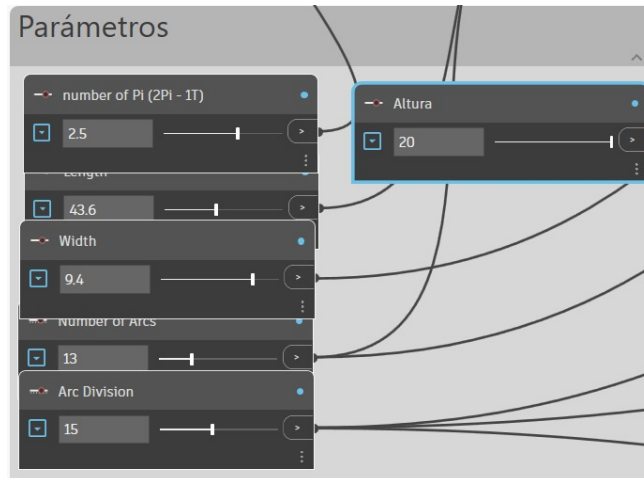


Figure 8: Truss parameters that can be adjusted in Dynamo. Adapted from [6]

3.3. Multi-Story Building

For this phase of the study, a parametric model of a multi-story building was generated in Dynamo, where key variables such as the number of floors, spacing between columns, and the total height of the structure were controlled. The geometric and structural information was exported directly to Robot Structural Analysis.

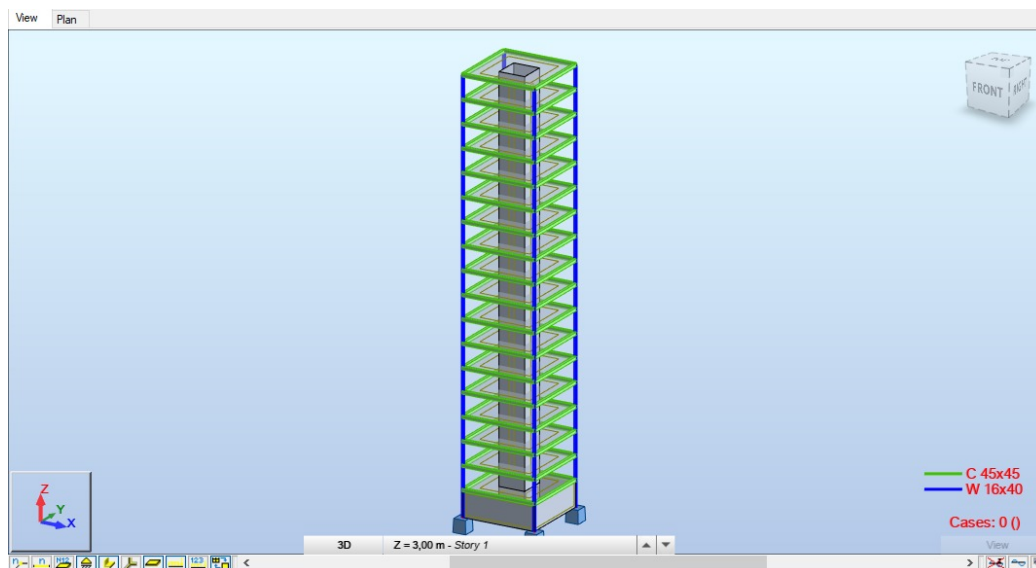


Figure 9: Test building modeled in Dynamo. Adapted from [6]

The next step in this test was to introduce rotation between floors to study how these conditions influence the distribution of forces and reactions in the structure. This change is achieved in just a few steps thanks to the parametric approach enabled by Dynamo, as modifying the geometry—in this case, rotation—simply involves adjusting a parameter, without the need to reconstruct the model or manually edit dozens of structural elements.

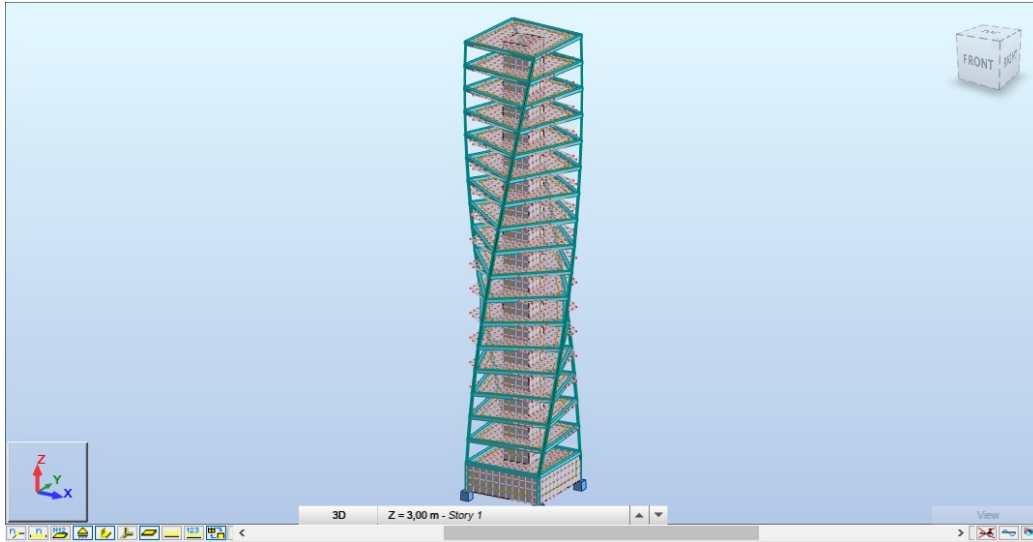


Figure 10: Test building with inter-story rotation. Adapted from [6]

4. CONCLUSION

The integration of Dynamo with Robot Structural Analysis has proven to be a powerful solution for optimizing structural workflows within BIM environments. Throughout the different evaluated cases, a significant improvement was observed in modeling speed, data transfer accuracy, and the ability to iterate over design alternatives without starting from scratch. This automation allows a simple change—such as modifying a building’s height—to immediately affect all related elements without the need to manually edit nodes, bars, or load conditions, representing an invaluable advantage in large and complex projects.

The observed benefits include reduced human error, traceability of key parameters, ease of implementing advanced seismic analyses, and the ability to compare structural variants in a matter of minutes. Dynamo acts not only as an automation tool but also as a real-time structural experimentation platform, where each decision can be quantitatively verified before construction begins. This capability is especially valuable in projects with high regulatory, budgetary, or time constraints.

However, it is crucial to emphasize that the use of these tools must be guided by responsible professional practice. Automation does not replace the engineer’s judgment; rather, it frees them from repetitive tasks so they can focus on critical analysis, interpretation of results, and the creative and engineering resolution of structural challenges. Technical judgment, professional ethics, and a deep understanding of structural behavior remain irreplaceable.

As a recommendation, both academic institutions and industry companies should begin establishing standards and guidelines based on BIM technology. This will enable AEC professionals to stay up to date with the latest technological advancements and fully leverage the benefits these tools offer in terms of productivity, efficiency, and quality in structural design and analysis.

AUTHOR CONTRIBUTIONS

Martínez Sebastián and Hernández José: Conceptualization, Methodology, Validation, Software Development, Writing – Original Draft, Review and Editing of the manuscript. All authors contributed equally to the manuscript. All authors have read and approved the final version of the manuscript for publication.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding this work.

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