AUTODESK UNIVERSITY

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A Unique New-Build Family Home: Advanced Structural Engineering Workflows

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Learning Objectives

- Discover the potential for advanced engineering workflows to be applied to single-family residential projects
- Learn how to use a connected open workflow to enable analysis integration
- Learn about individual one-off designs in complex BIM workflows
- Learn how to maximize complex tools and techniques in an easy-to-use environment

Description

This session will cover a case study presented by engineers Martyn Sheard and Trevor Chou from CRAFT Engineering Studio, supported by Ralph Pullinger from IDEA StatiCa. We will show how CRAFT designed and coordinated a complex, single-family residence in Martha's Vineyard, MA. The structure was originally conceived primarily in steel, but both client and architect wished to move to a wood solution, requiring imaginative structural solutions and workflows.

Speaker(s)

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Introduction to CRAFT [https://craftengin.com/]

We are an internationally diverse team that operates as a studio to allow a free flow of skills and knowledge within our office environment. We rely on multidisciplinary backgrounds that include product design, architecture, and computation to augment our practice as structural engineers. Our passion for the arts allows us as engineers to more effectively engage and communicate with architects, artists and fabricators as clients. We understand the need to be open-minded and creative thinkers which leads to imaginative problem solving and innovative solutions. CRAFT caters to the client who challengers traditional notions of structural engineering consulting and seeks a creative and collaborative partner in the process of design and its execution.

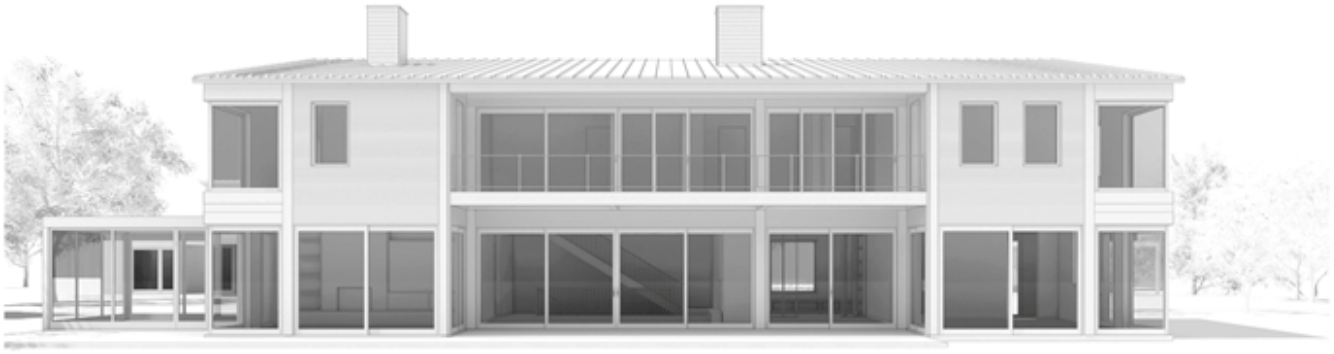
CRAFT employs cutting edge software for the analysis and documentation of our projects which allows us to collaborate with our clients to provide a seamless flow of information throughout a projects' life-cycle. Building Information Modeling technology is used iteratively to link documentation directly to analytical engines to create an efficient process of project design.

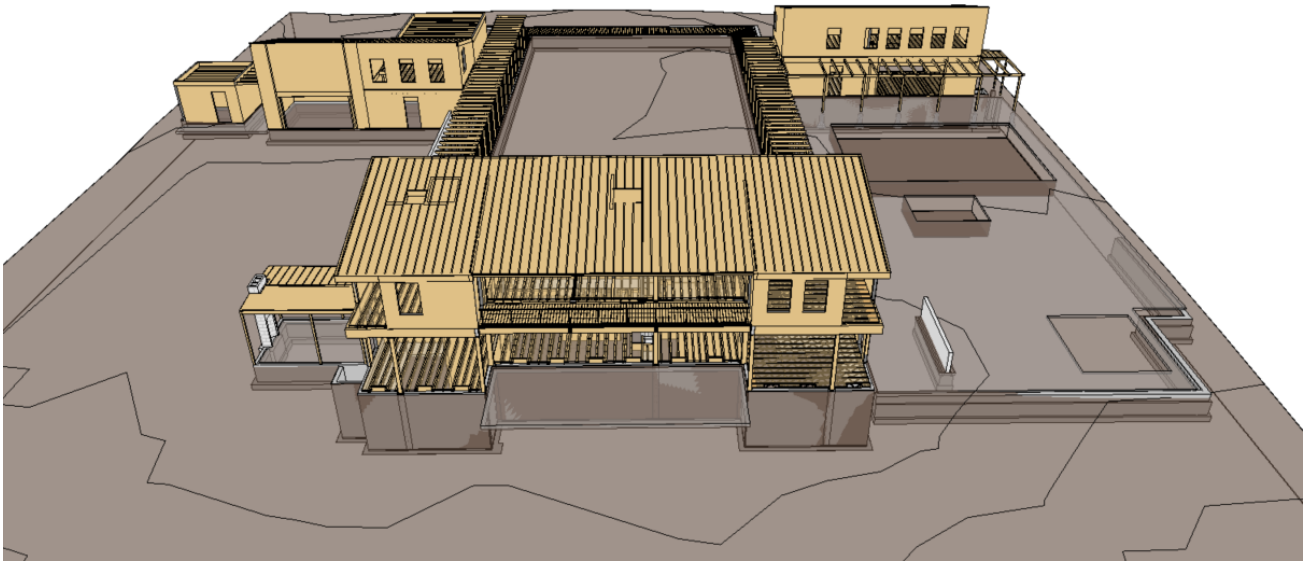
For the analysis of structures, CRAFT blends traditional experience and expertise with computational and analytical tools to offer solutions to clients that are efficient and practical yet innovative. Beyond traditional linear and non-linear techniques, CRAFT employs advanced analytical methods such as solid Finite Element Analysis for the structural design of components and assemblies within the scope of our projects. Computation empowers our approach to the form-finding, rationalization, and optimization of structures with complex geometries in a broad spectrum of materials.

The Project

Introduction

A new build single-family residence located in Martha's Vineyard, Massachusetts, USA with Selldorf Architects.





The Challenges

The site falls within a high wind region and the building sits above a steep bluff overlooking the ocean, placing significant challenges on the design of the lateral load resisting system.

These criteria combined with a distinctly open architectural design and a requirement for a thermally broken, unpropped balcony led to the framing for the ocean side elevation being proposed as a combined moment frame and cantilevered balcony system. Though originally all imagined in steel, the client & architect's aspiration was for a predominantly wood solution.

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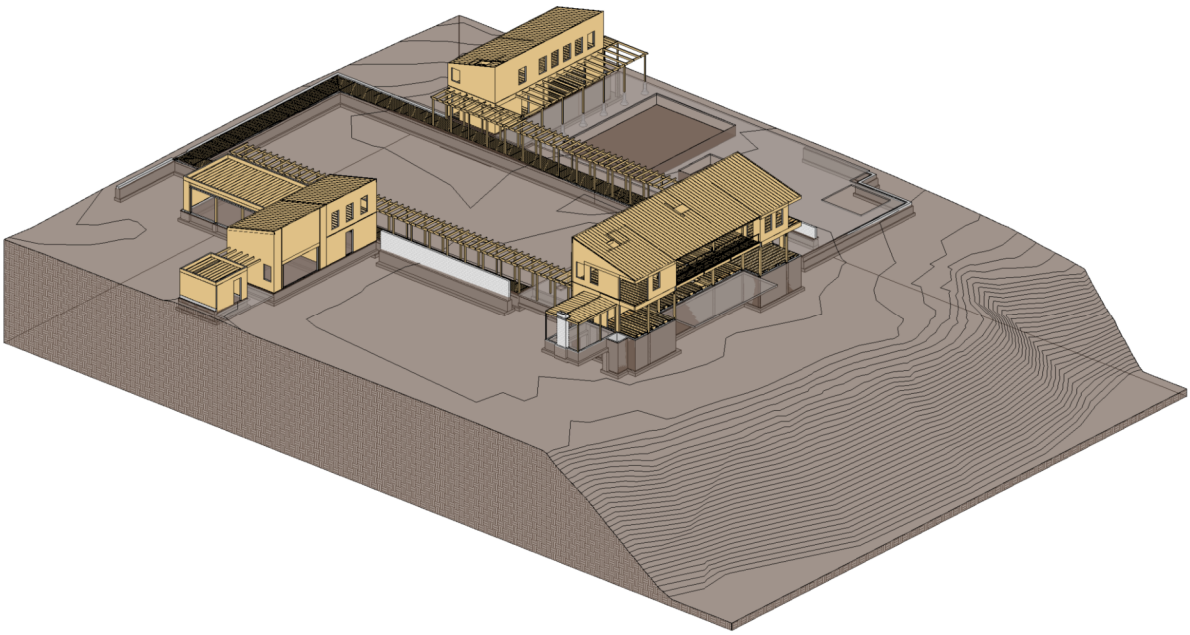
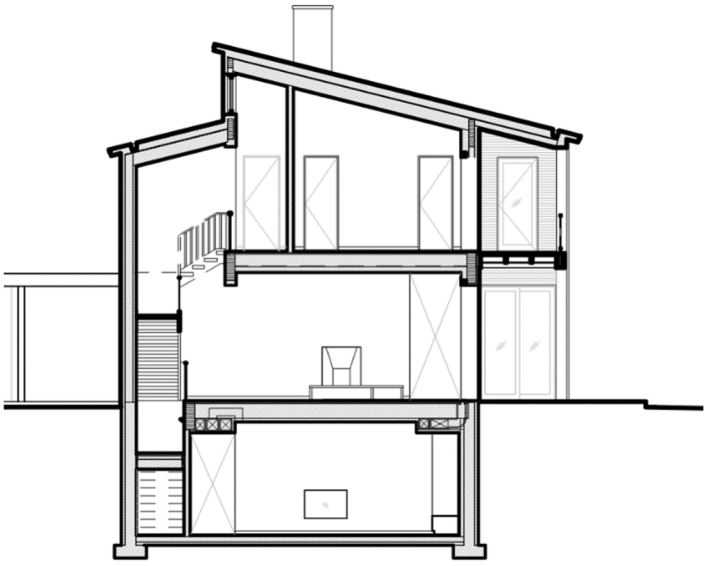
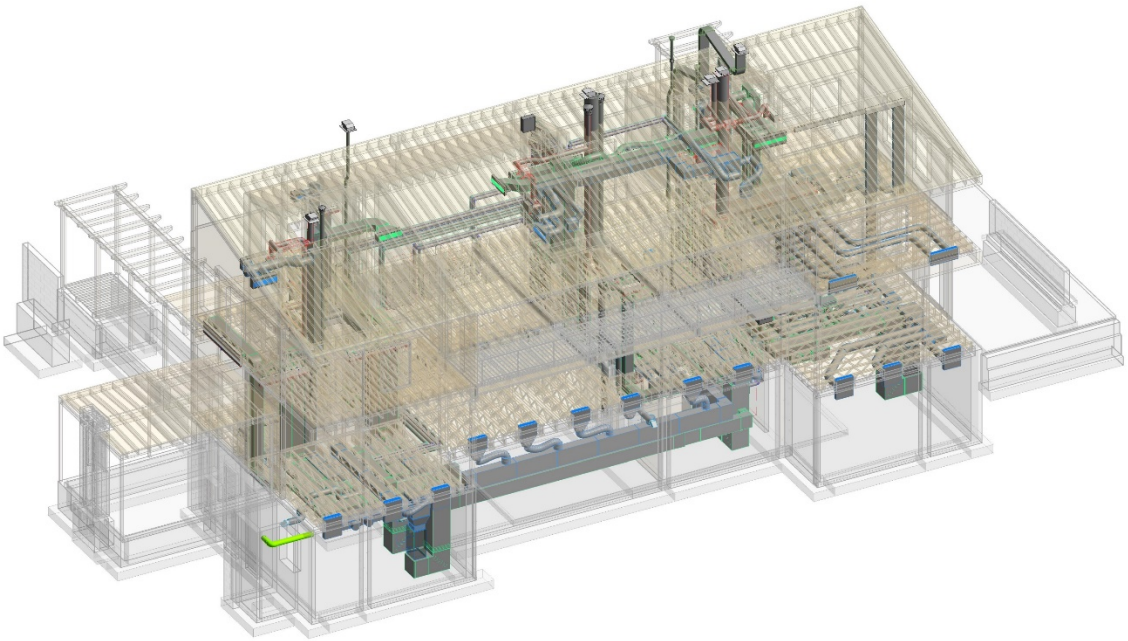




The Workflow

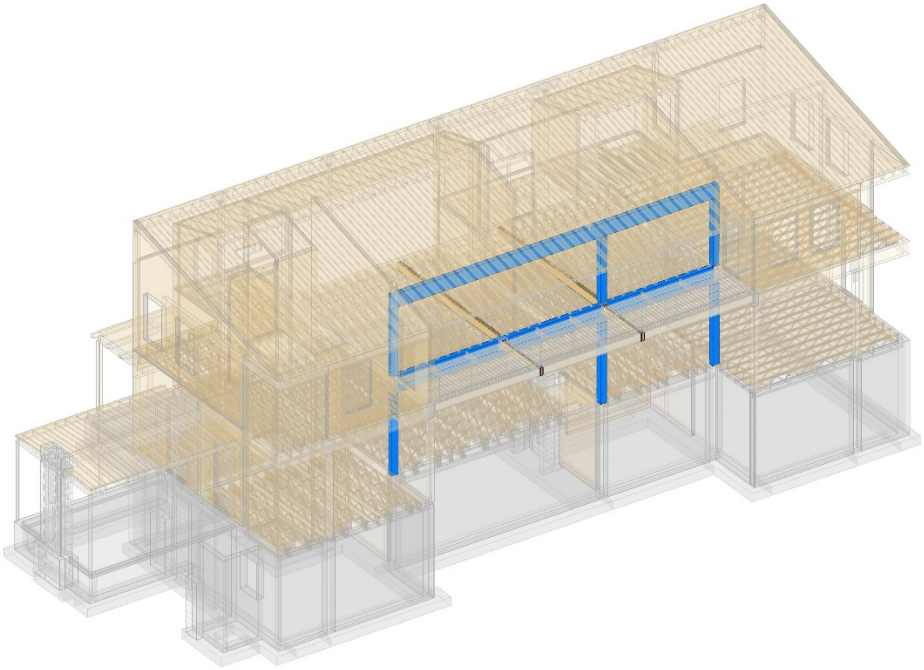
It was clear from the outset that a project of this nature required a collaborative and iterative workflow that would allow us to rapidly test, describe and update options and to then embed the resulting solutions into the next phase of the workflow. We turned to the tools that we typically use for such projects (the Autodesk suite supplemented with specialist third party software such as IDEA Static) and adapted the workflow to tailor it to an expressive, all wood structure. This was achieved through the integration of our own in house timber connection design sheets and including 'round-trip' feedback loops.

Through the use of BIM 360 we were also able to collaborate with the MEP Engineers to fully incorporate the services systems within the structural zones of the floors and walls – another aspect that would have been very difficult without the use of these tools.

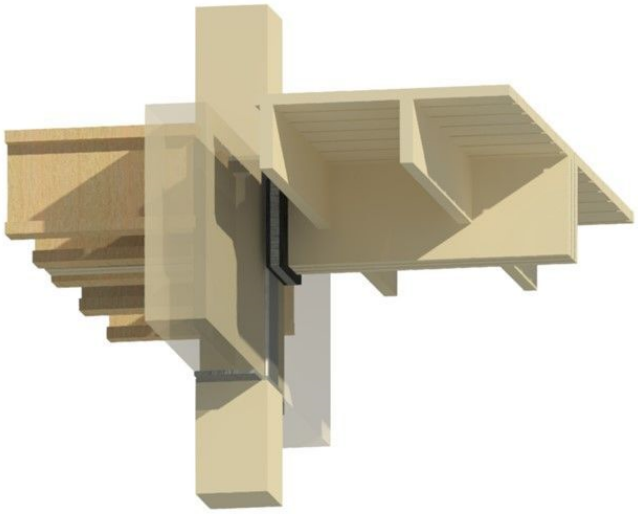


The Solutions

The two-story moment frame consists of two spans of 21 ft and 14 ft, with an average floor height of 10 ft. Deep, multi-LVL timber girders intersect with orthogonal flitch beams forming the cantilevers and backspans to the balcony.

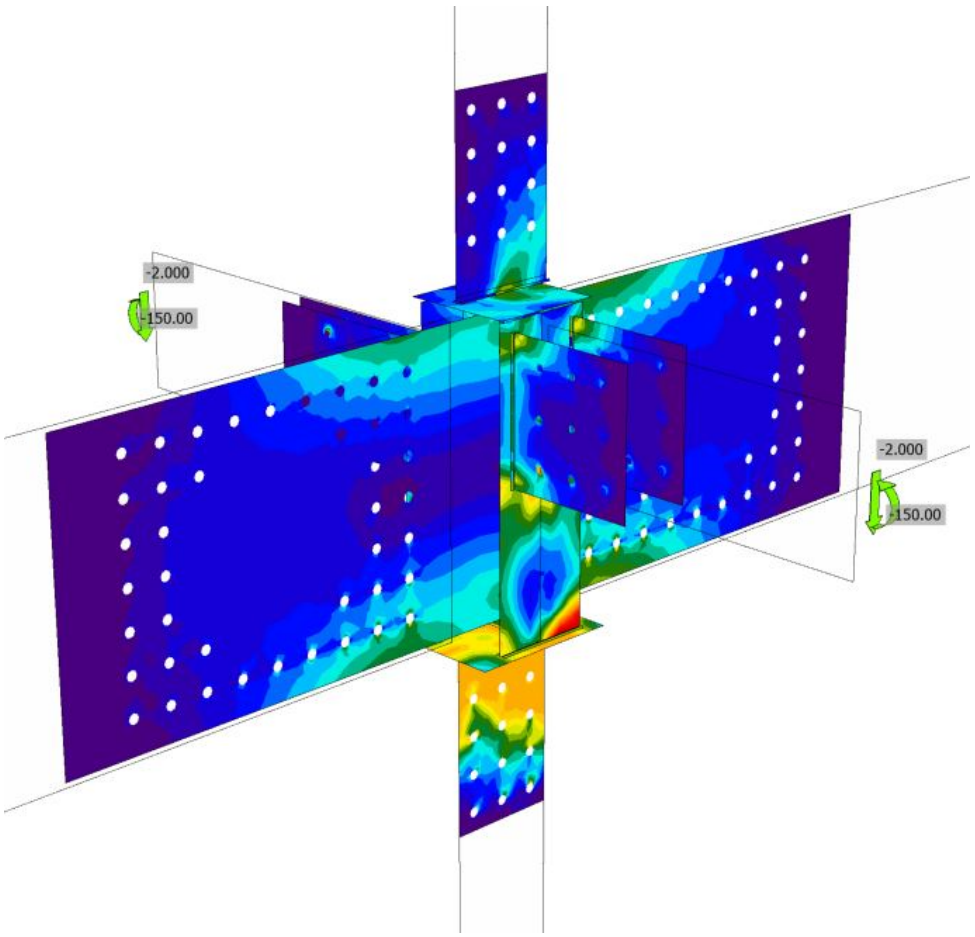


The resulting steel node joint is designed to resist forces and moments in the two orthogonal axes. A central hollow section hub was proposed but was found to be unable to resist the high moments from the moment frame girder due to insufficient out-of-plane stiffness in the box section walls. The steel joint was redesigned with a wide flange section to maintain continuity in both axes whilst ensuring a more direct transmission of forces and moments to the center of the hub.



Because the balcony members require steel to run continuously through the thermal line of the building, a thermal break pad is included to reduce heat loss and condensation risk. We were able to create a customized material for the thermal break pad and include it in the analysis within IDea StatiCa.

Framing members were analyzed and designed using Autodesk Robot Structural Analysis. For the design of the intricate connections in multiple materials, IDEA StatiCa was an ideal supplementary tool. The software has the flexibility to create custom materials and elements with complex geometries and templates for wood-to-steel connections that greatly reduced the time required to set up the model. Although code checks for wood members is not supported by IDea StatiCa, the bolt force outputs were easily transferrable to in-house spreadsheets for verification.



Through our use of IDea StatiCa and close collaboration with architect, thermal consultant and fabricator, we were able to evolve a full steel frame into a hybrid wood solution, thus reducing the quantity of steel required and keeping the structure of the building more in line with traditional construction for the locality.