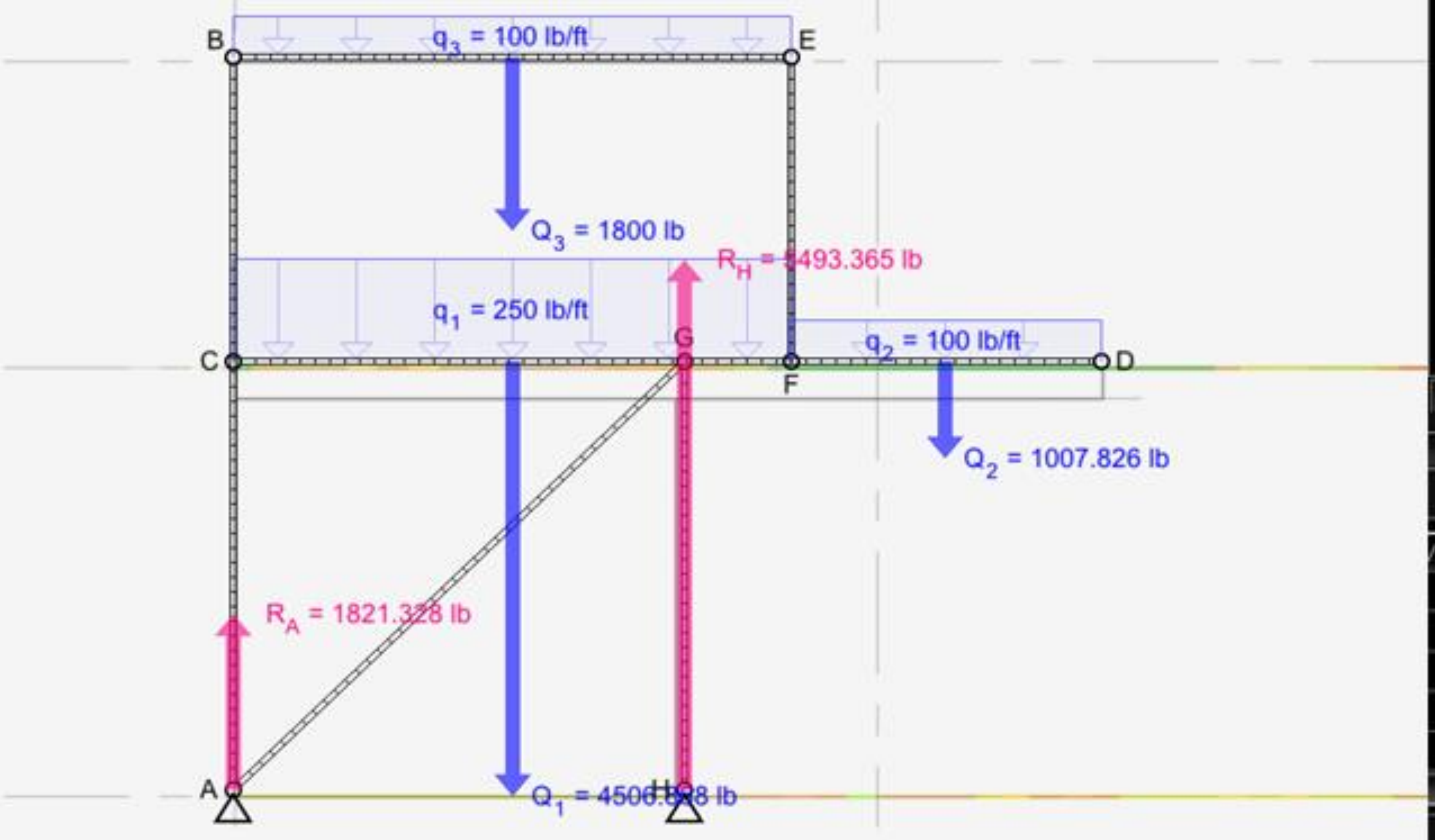
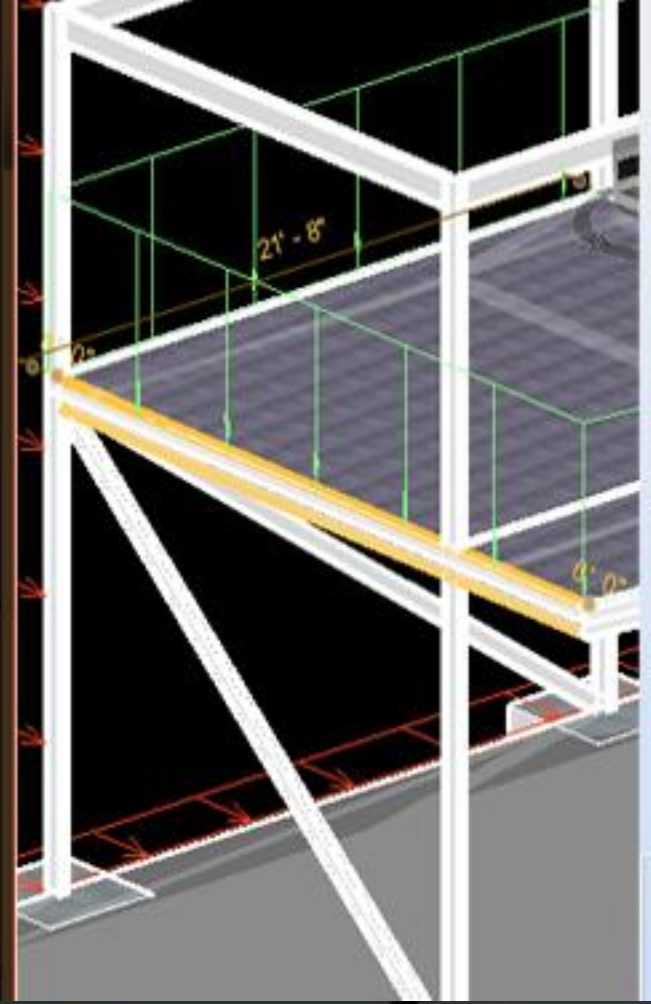
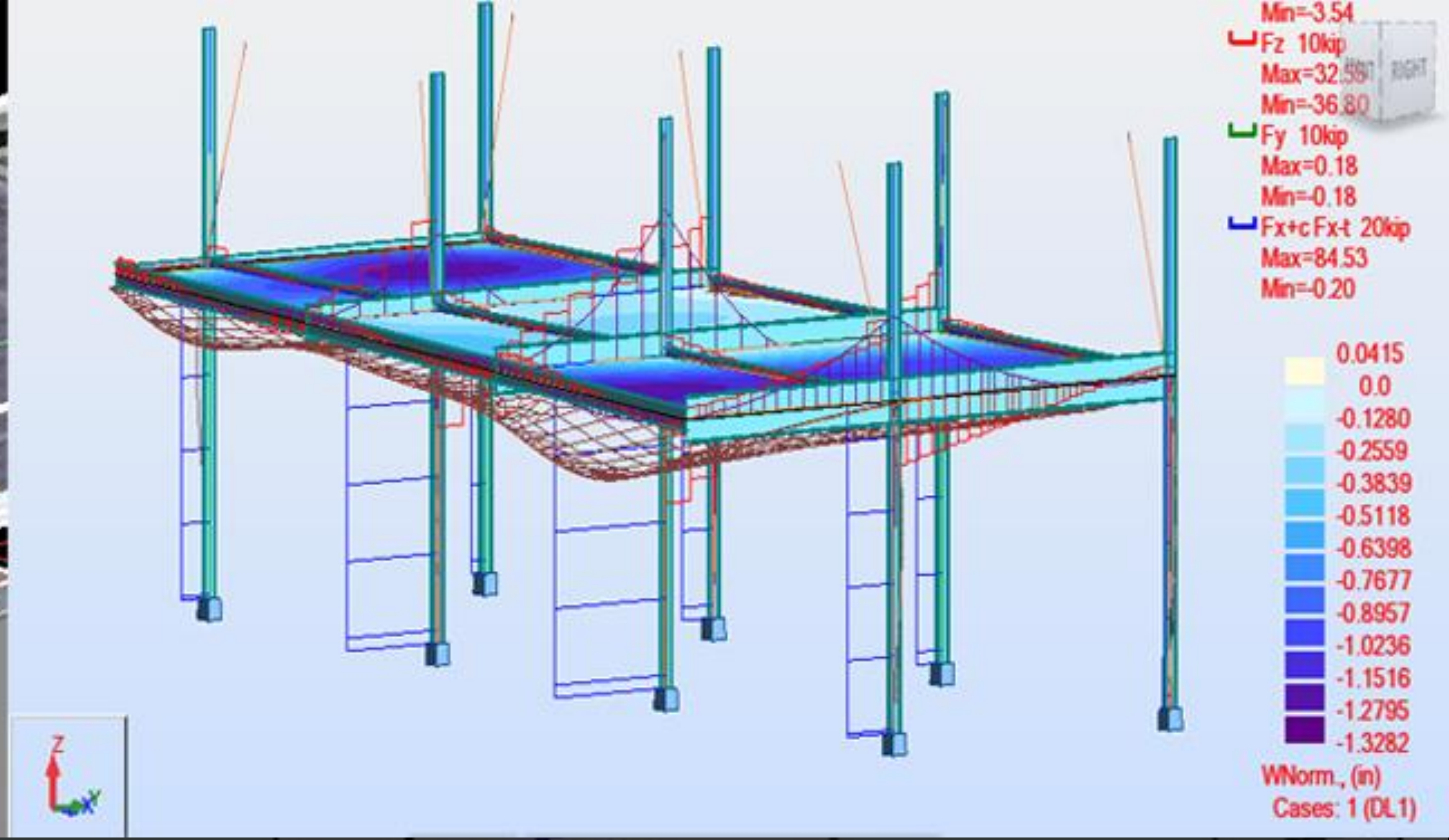






Structural Simulation for Architects:

An Introduction to Structural Thinking for Design Students.

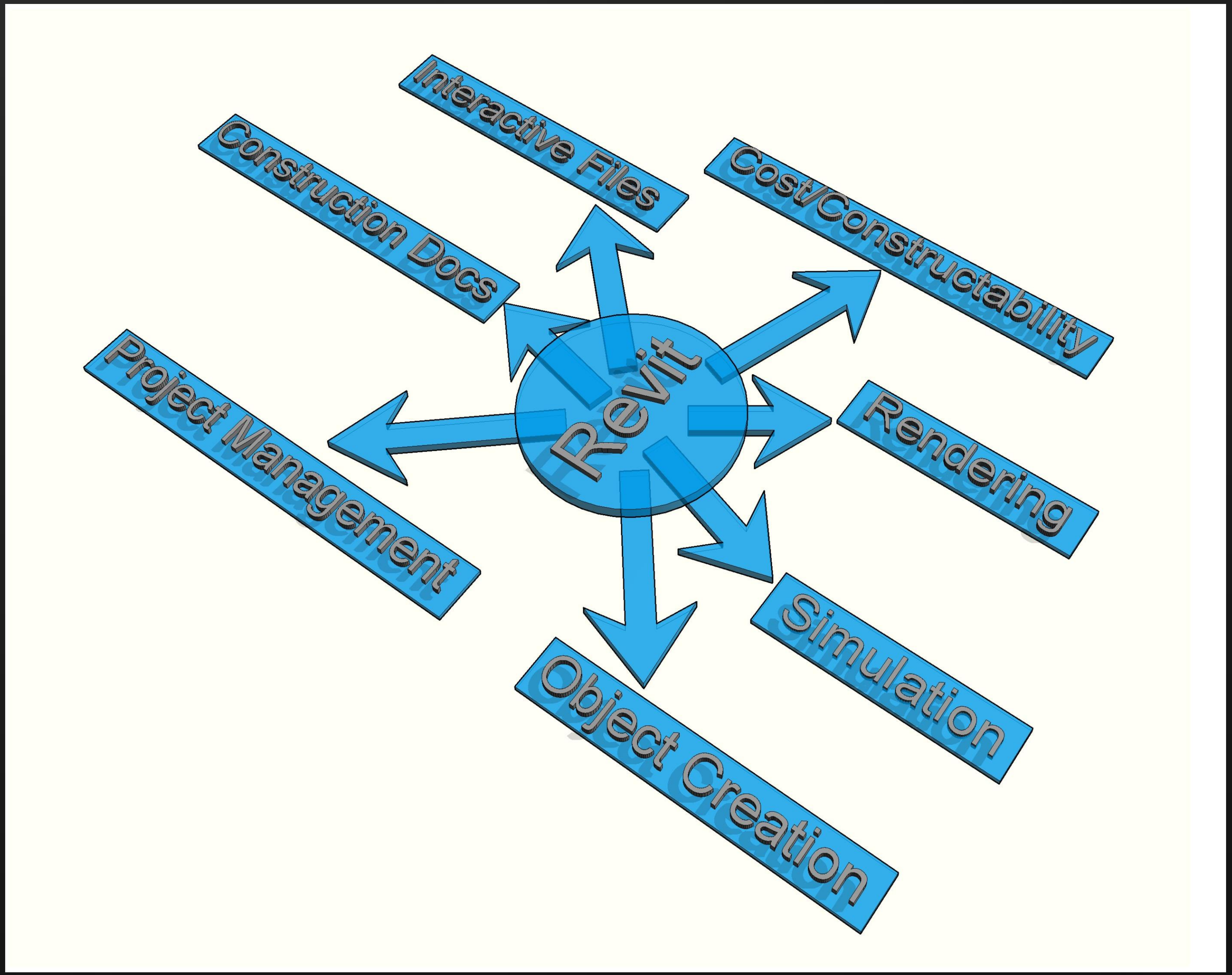
David R Beach and Keith Hedges

Hammons School of Architecture at Drury University

Class Summary

Two points of marriage in the research - Pedagogy and Practice:

- A methodology within a BIM environment to inform the design process.
  - Simulation analysis
  - Revit hub
- Bowling Balls and Boats:
  - The Analytical vs. The Visceral



Learning Objectives:

At the end of this class, you will be able to:

- Understand the process of modeling with the structural tool set in Revit.
- Apply structural simulation tools as part of a design process.
- Modifications and enhancements that a simulation process can create in learning structural design.
- Understanding, reading, and applying simulation data as part of a design process.

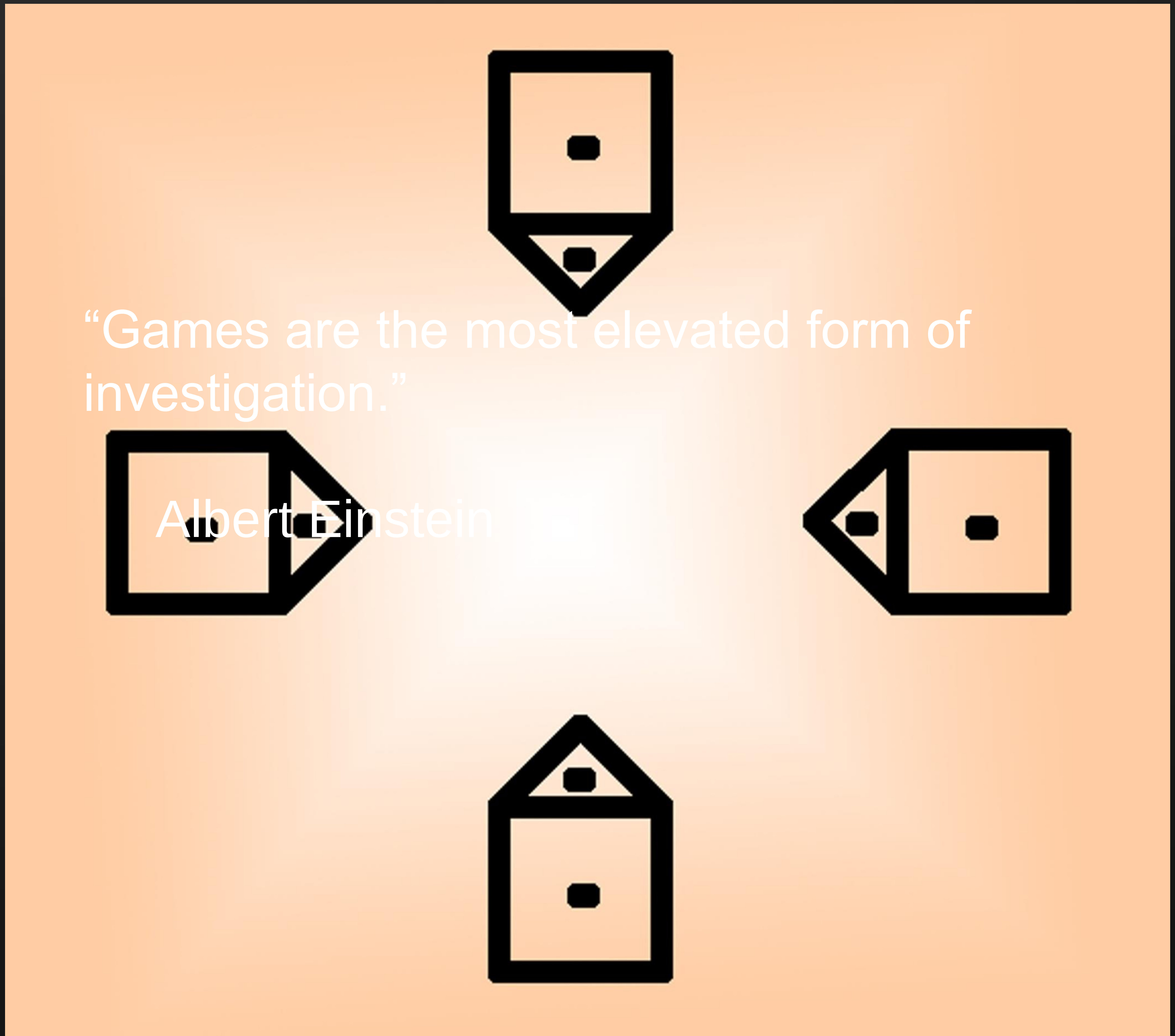
-dave. is:

- Assistant Professor of Architecture at Drury University – Hammons School of Architecture
- Passionate about education (in the blood)
- 10 Years of digital design instruction
- 15 years of practice, couple of design awards…yadda yadda yadda
- Career in 3d/digital design took me through the professional use of: FormZ®, TrueSpace®, AutoCAD®, Lightwave®, SketchUp®, Autodesk Revit®, 3ds Max®, and Project Vasari®
- Digital Design Philosophy:

A Digital Design Pedagogy:

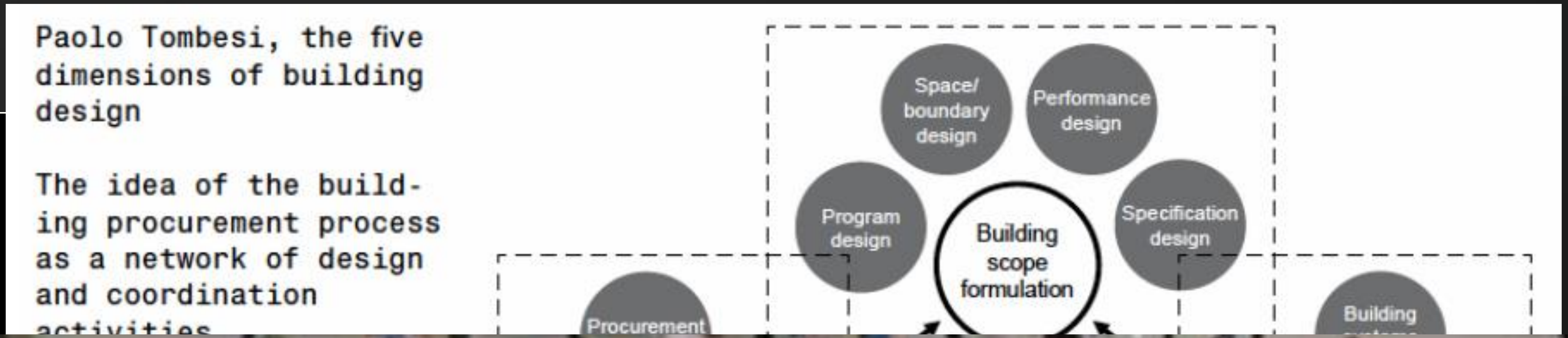
The Model Within a Digital Design Pedagogy:

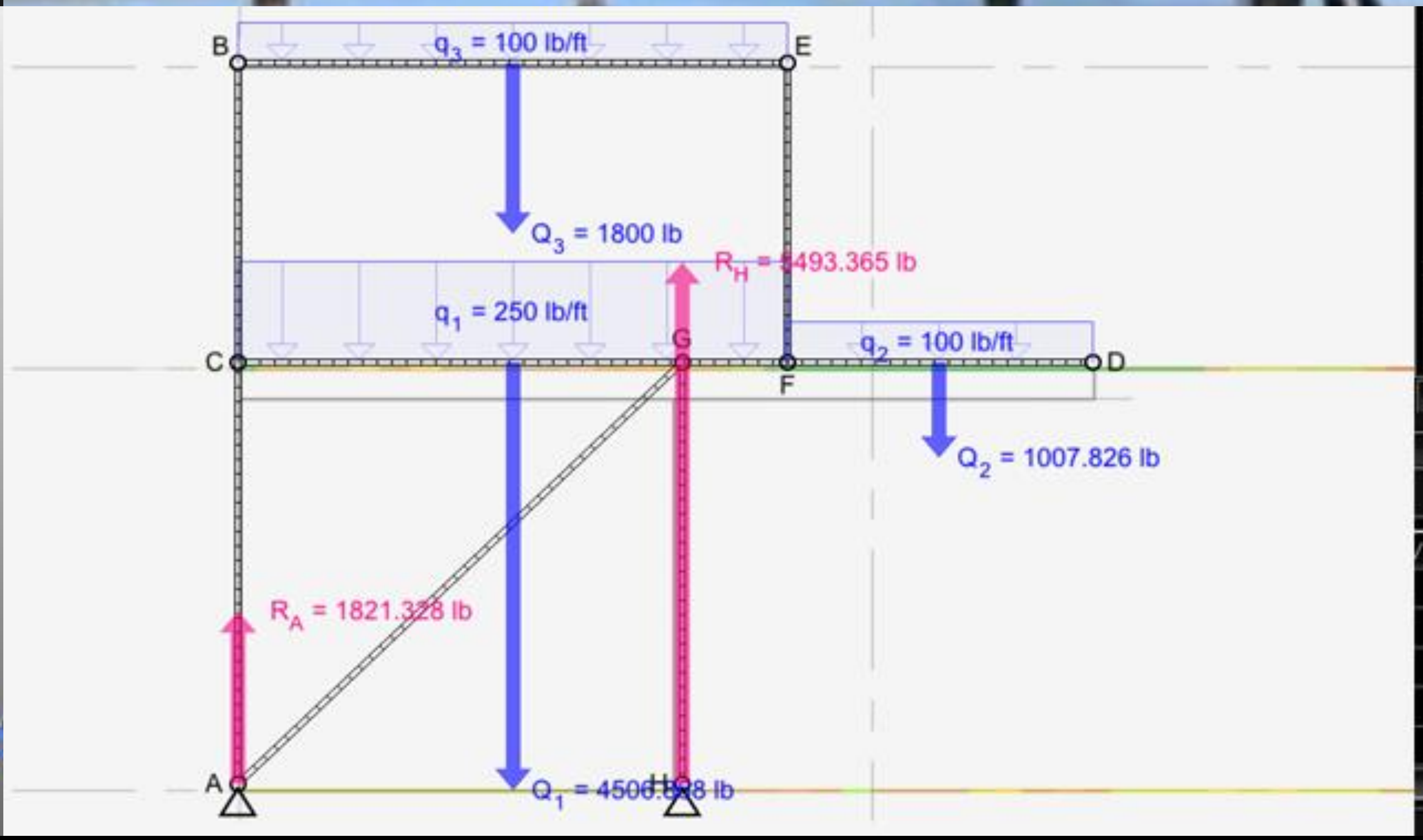
- *Thinking about Space in Space(s).*
- *Blank Screens = Blank Thoughts.*
- *Design Criticality.*
- *Think.Experiment.Design.Play.*

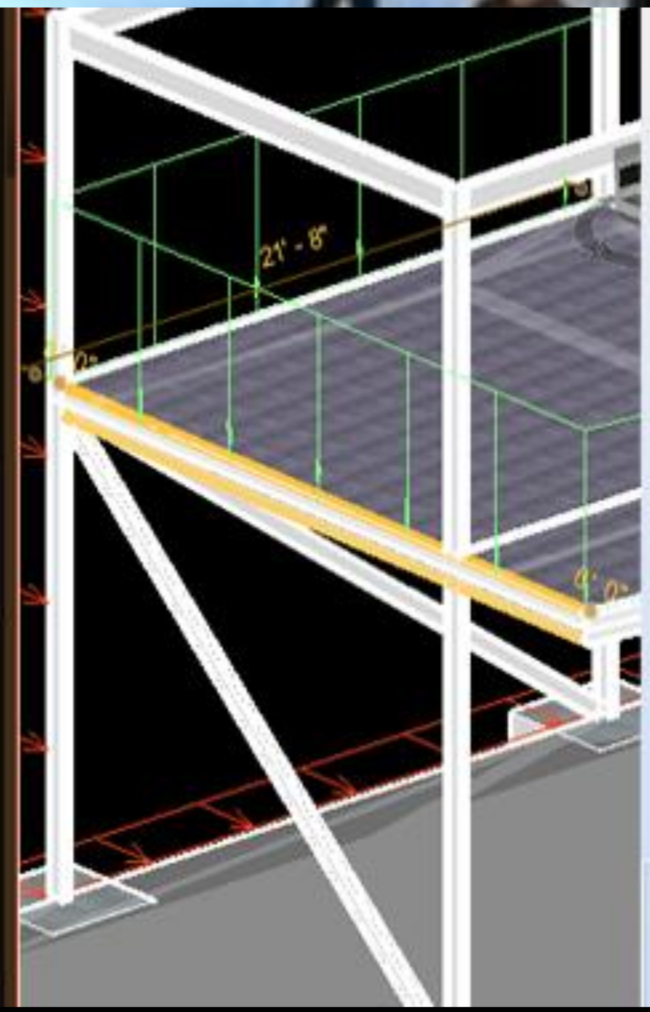


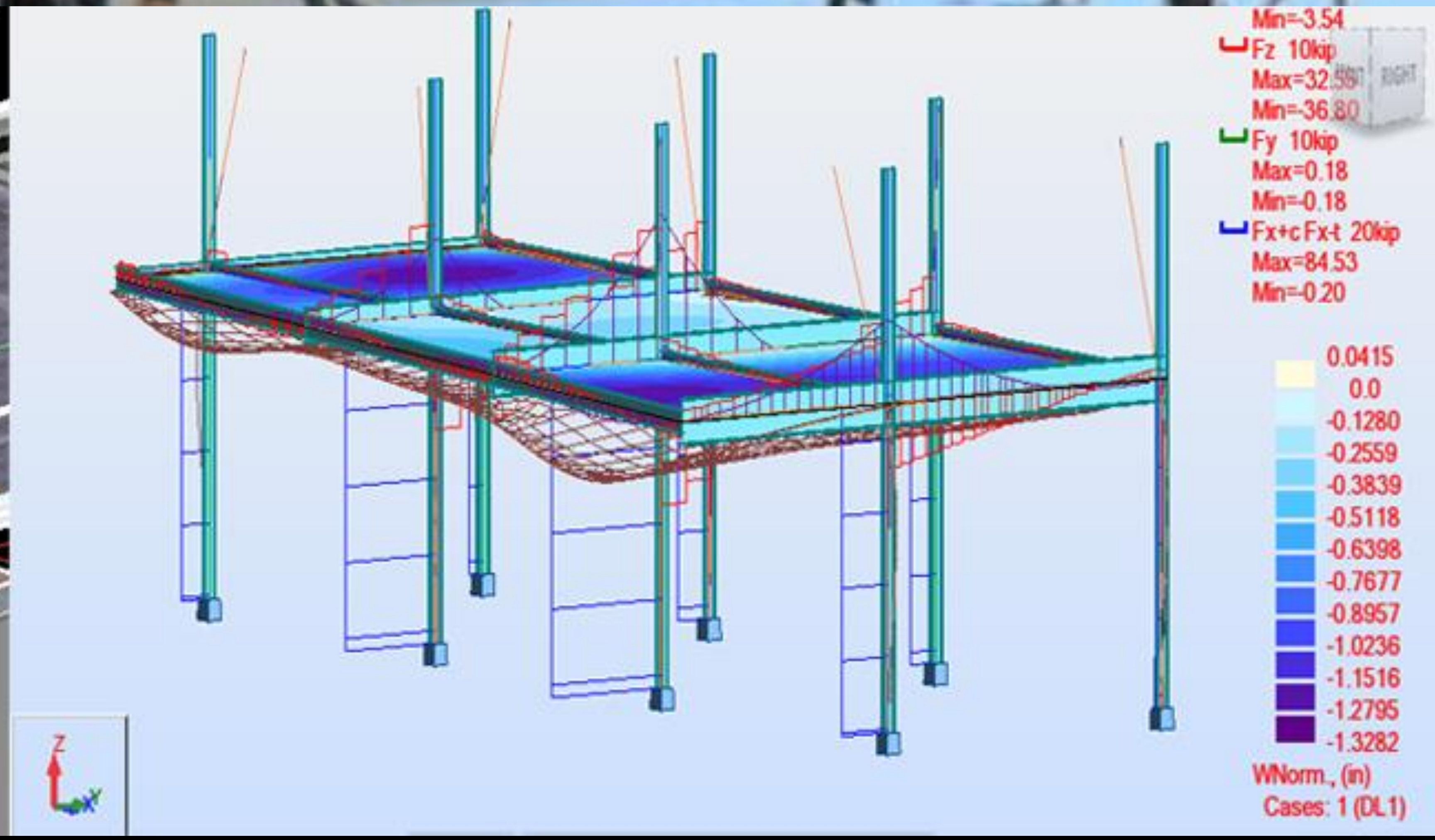
Relevance - Design Thinking with Analytical Data:

- Phil Bernstein, FAIA:
- The Pedagogy of Analysis (Research Focus):
  - Predesign Building Simulation,
  - Structural Simulation
- Now:
- Coming:
- Change:





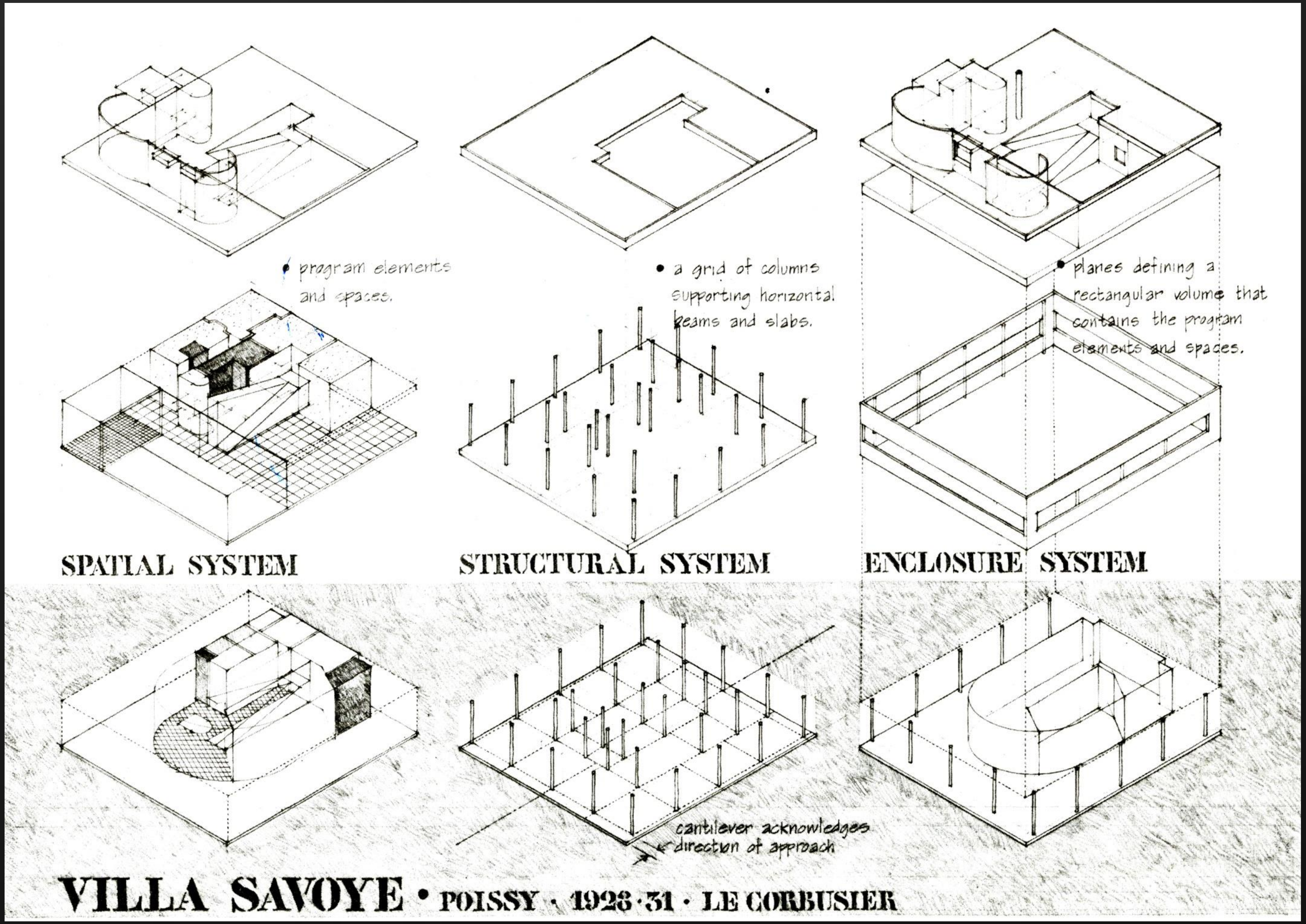




Structural Design Thinking:

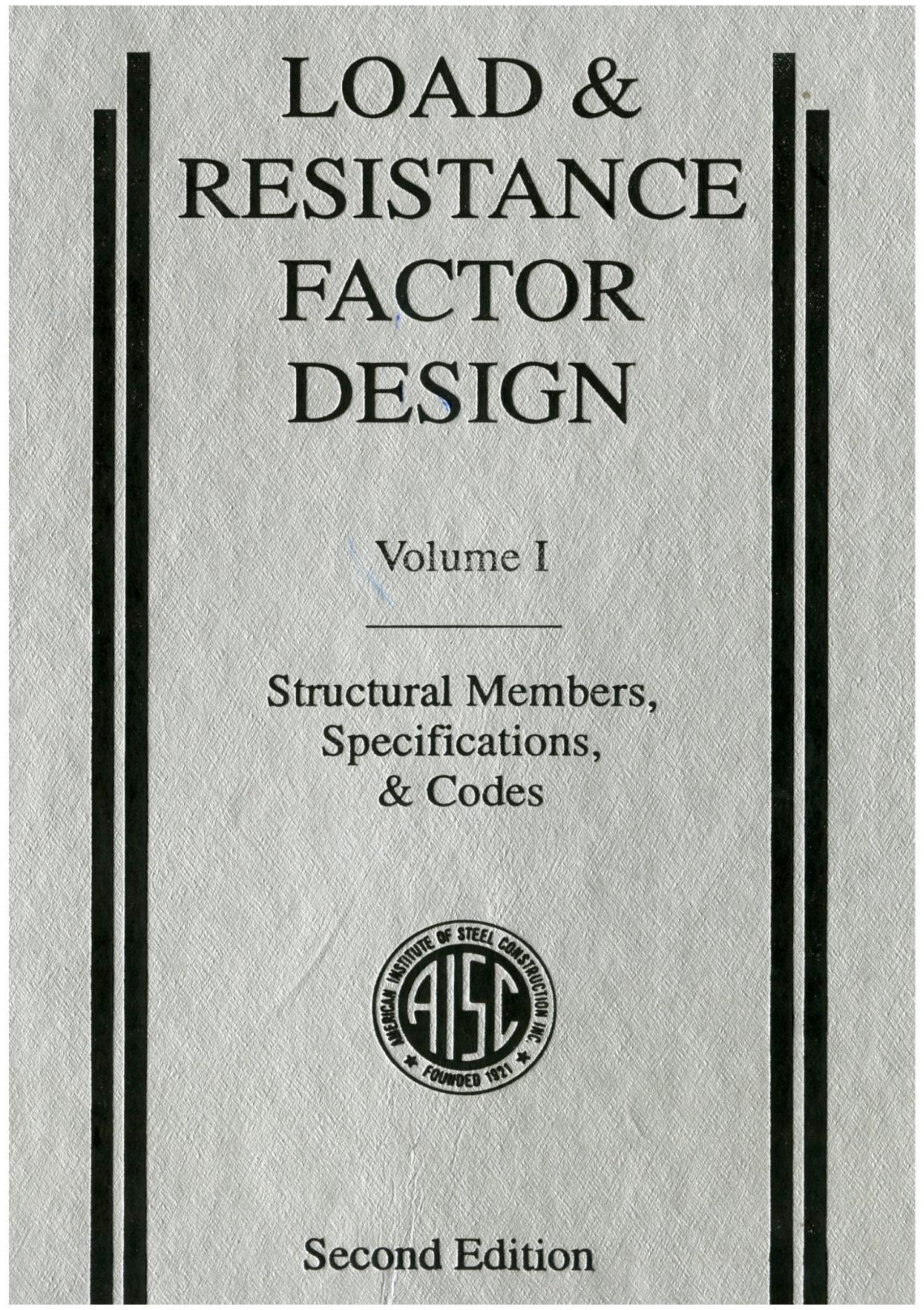
Design Tools:

- Ching (1979): *Architecture: Form Space and Order.*
  - Three elemental formal tools:
    - Space.
    - Enclosure.
    - Structure.



Three Realms of Structural Thinking:

- What structural education for architects has been:
- The resultant of the process: Passive Aggressive Design Thinking.



$$X_2 = \frac{4C_w}{I_y}\left(\frac{S_x}{GJ}\right)^2 \quad \text{(F1-9)}$$

$$M_r = (F_y - F_r)S_x \quad \text{(F1-7)}$$

$M_p = Z_x F_y$

F_r = 10 ksi for rolled shapes

The unbraced length in the charts m[illegible] be either the total span or any part of the total span between braced points. The plots shown in these charts were computed for beams for which $C_b = 1.0$. When a moment gradient exists between points of bracing, C_b may be larger than unity. (See Table 4-1.) Using this larger value of C_b may provide a more liberal flexural strength for the section chosen if the unbraced length is greater than L_m. In these cases, the design moment can be determined using the provisions of Section F1.2a of the LRFD Specification.

$$\phi_b M_n = \phi_b C_b \left[M_p - (M_p - M_r)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \le \phi_b M_p$$

The unbraced length L_r, ft, with the limit indicated by an open symbol ○, is the maximum unbraced length of the compression flange beyond which the design moment is governed by Specification Section F1.2b. For unbraced lengths greater than L_r:

$$\phi_b M_n = \phi_b M_{cr} = \phi_b C_b \frac{\pi}{L_b}\sqrt{EI_y GJ + \left(\frac{\pi E}{L_b}\right)^2 I_y C_w} \le \phi_b C_b M_r \text{ and } \phi_b M_p$$

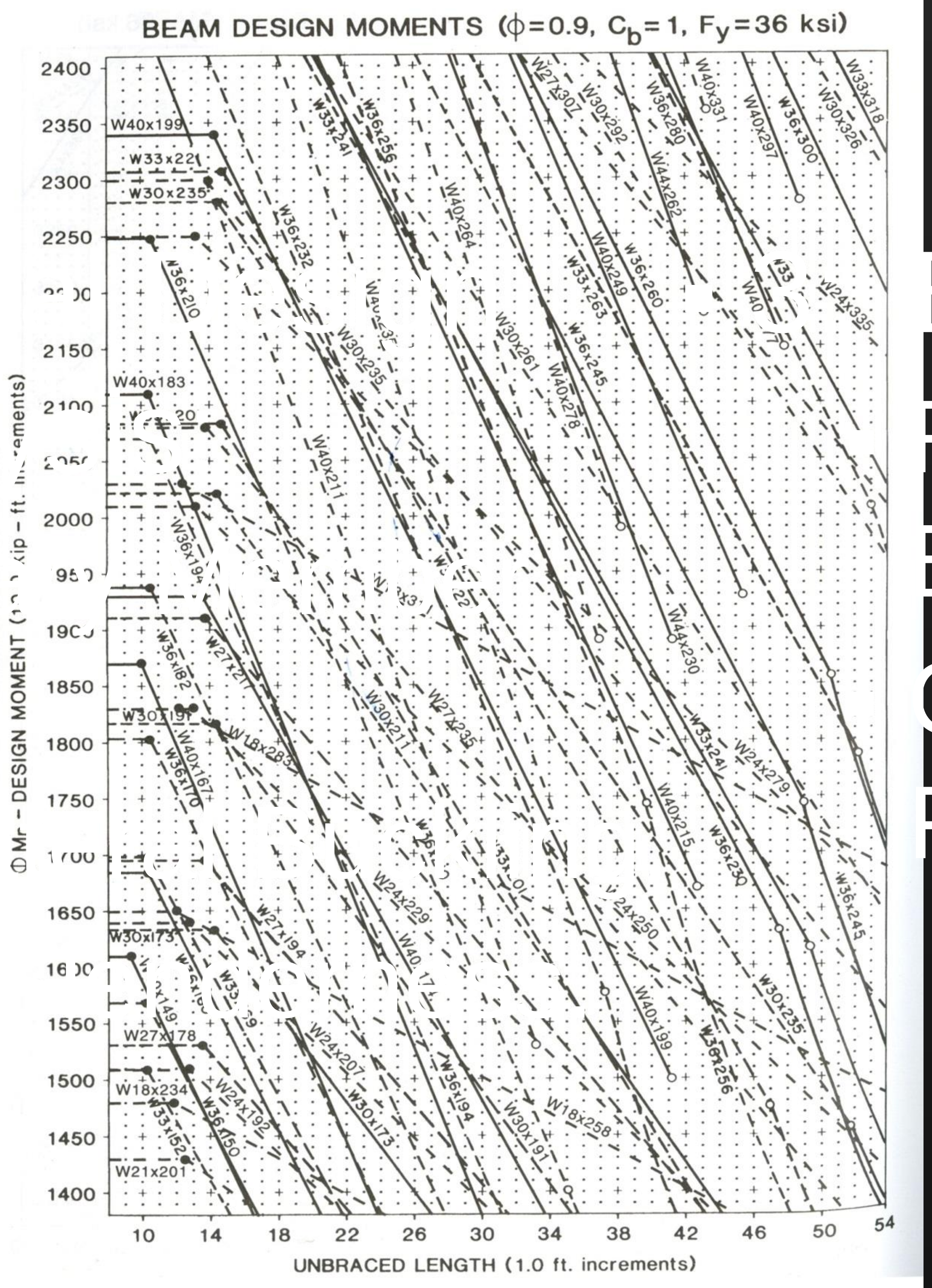
In computing the points for the curves, C_b in the above formulas was taken as unity, E = 29,000 ksi and G = 11,200 ksi. The properties of the beams are taken from the Tables of Dimensions and Properties in Part 1 of this LRFD Manual. The beam strengths have been reduced by multiplying the nominal flexural strength M_n by 0.9, the resistance factor ϕ_b for flexure.

Over a limited range of length, a given beam is the lightest available for various combinations of unbraced length and design moment. The charts are designed to assist in selection of the lightest available beam for the given combination.

The solid portion of each curve indicates the most economical section by weight. The dashed portion of each curve indicates ranges in which a lighter weight beam will satisfy the loading conditions.

The curves are plotted without regard to shear strength and deflection criteria, therefore due care must be exercised in their use. The curves do not extend beyond an arbitrary span/depth limit of 30.

The following examples illustrate the use of the charts.

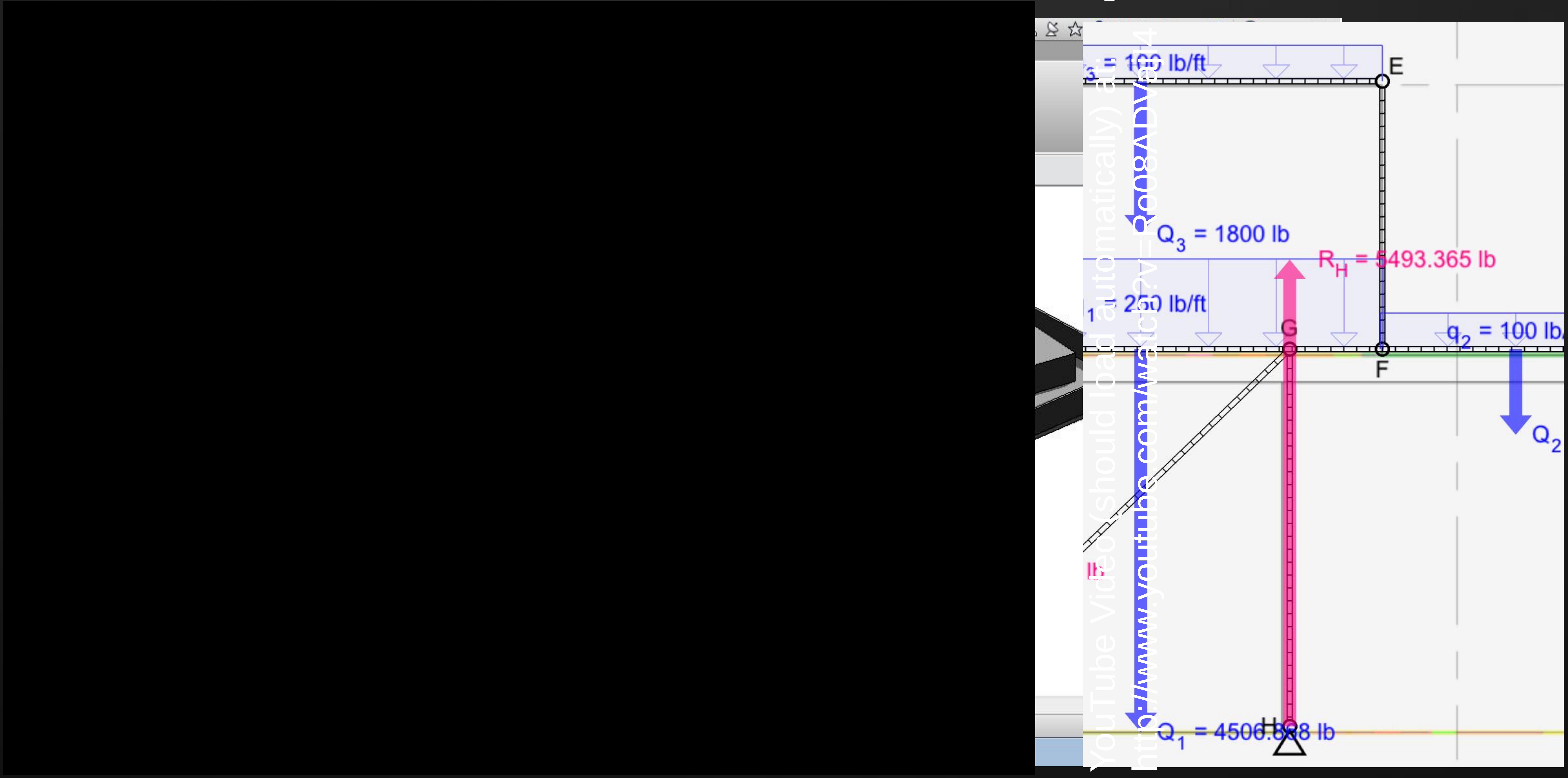


Building Stabilization:

Rigid and Braced Buildings.

Centers of Lateral Forces and Stiffness.

Three Realms of Structural Thinking:

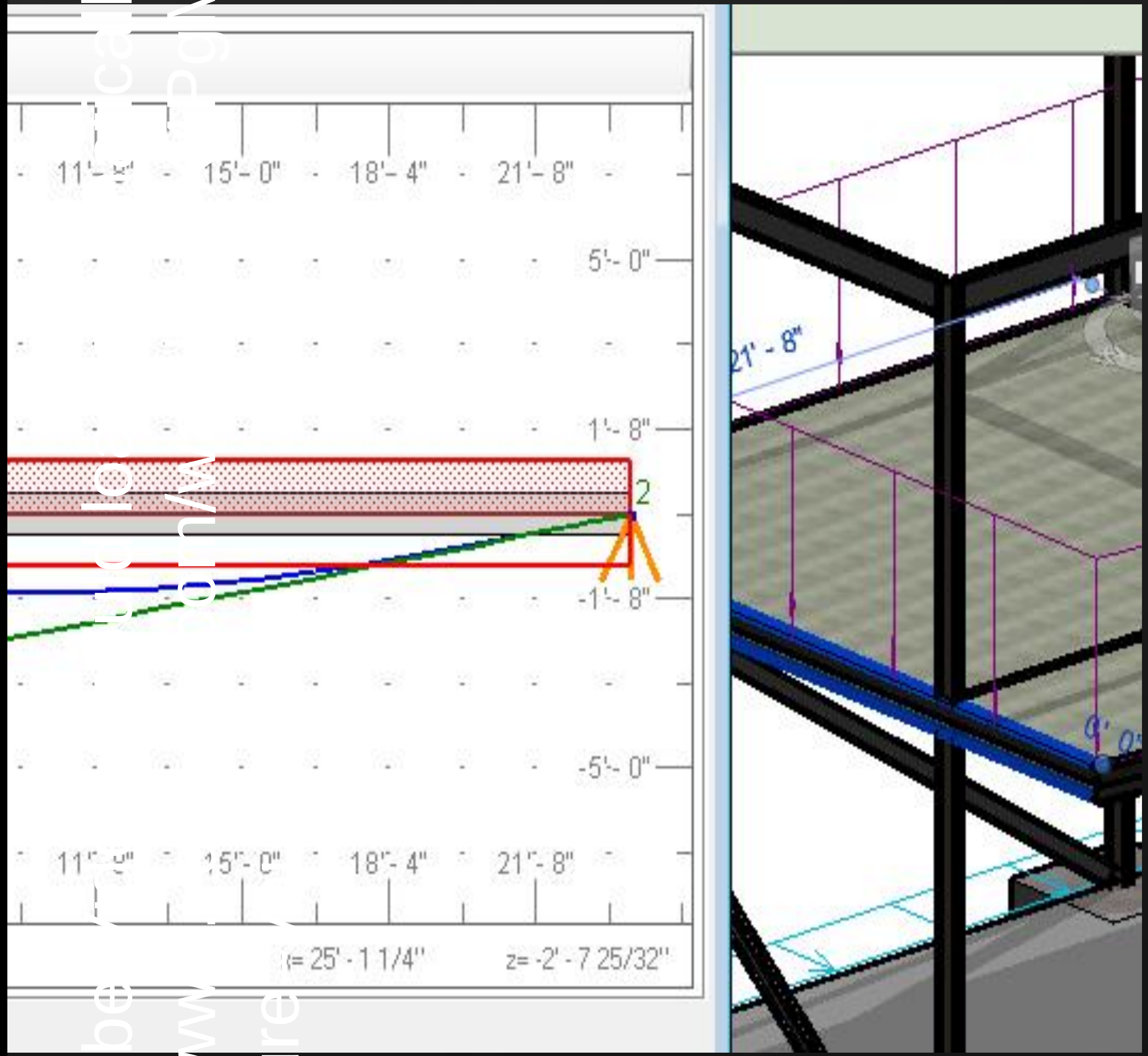


Three Realms of Structural Thinking:

- Santiago Calatrava:
  - "If we consider engineering an art – as I believe it is – and if we go back to a time when there was no difference between the art of architecture and the art of engineering…then we can consider that it is in ourselves, and especially in the new generation, that a rebirth of art happens."
    - MIT Lectures (2002)

- Transformative and transforming stage backdrop for the NY Ballet by Calatrava. Image Source: http://architecturelinked.com/profiles/blogs/calatrava-and-the-nyc-ballet

Three Realms of Structural Thinking:



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http://w... PgMscIX88
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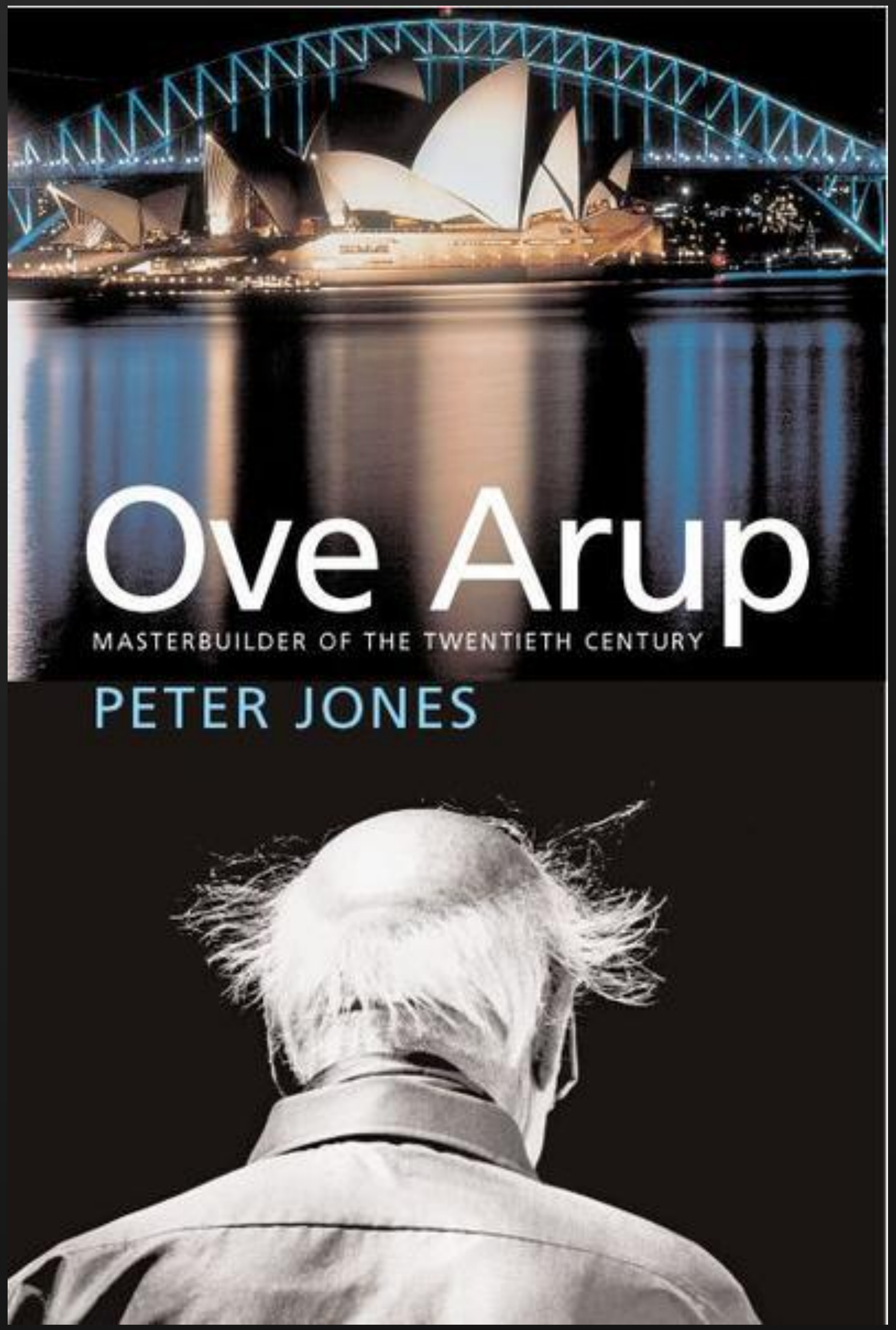
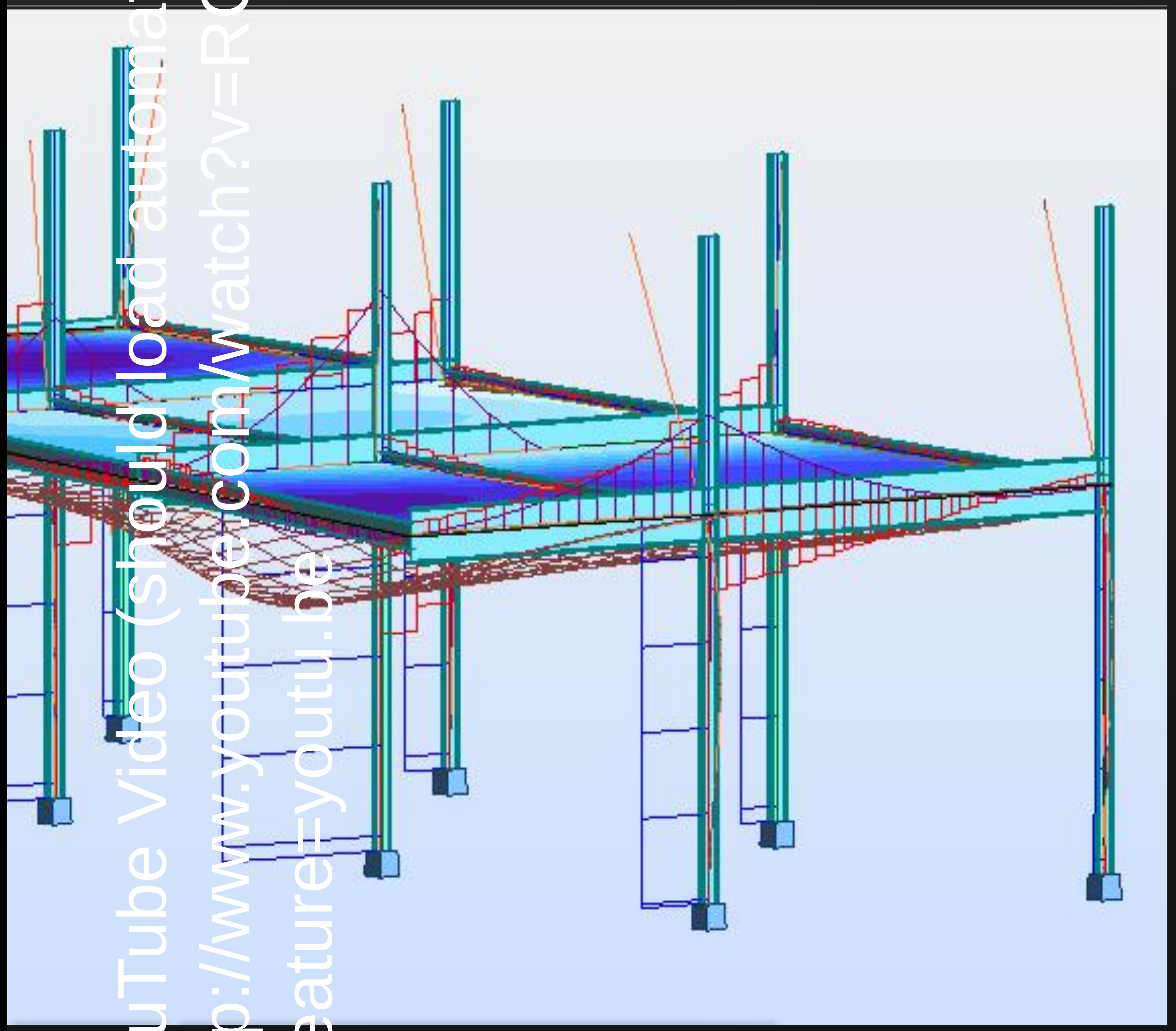
Three Realms of Structural Thinking:

- From Ove Arup to Walter Gropius:
  - "the conceptual process (is) a total entity, form, structure and economy being inseparable within it….Education of architects, engineers, and artists alike must then, first of all, be directed towards understanding and accepting the collaborative process….Within this process the final control will fall to that individual who has the broadest scope and is willing to accept from his teammates everything which can enrich the total conception."



- Image Source: http://www.dhub.org/ove-arup-masterbuilder-of-the-twentieth-century/

Three Realms of Structural Thinking:

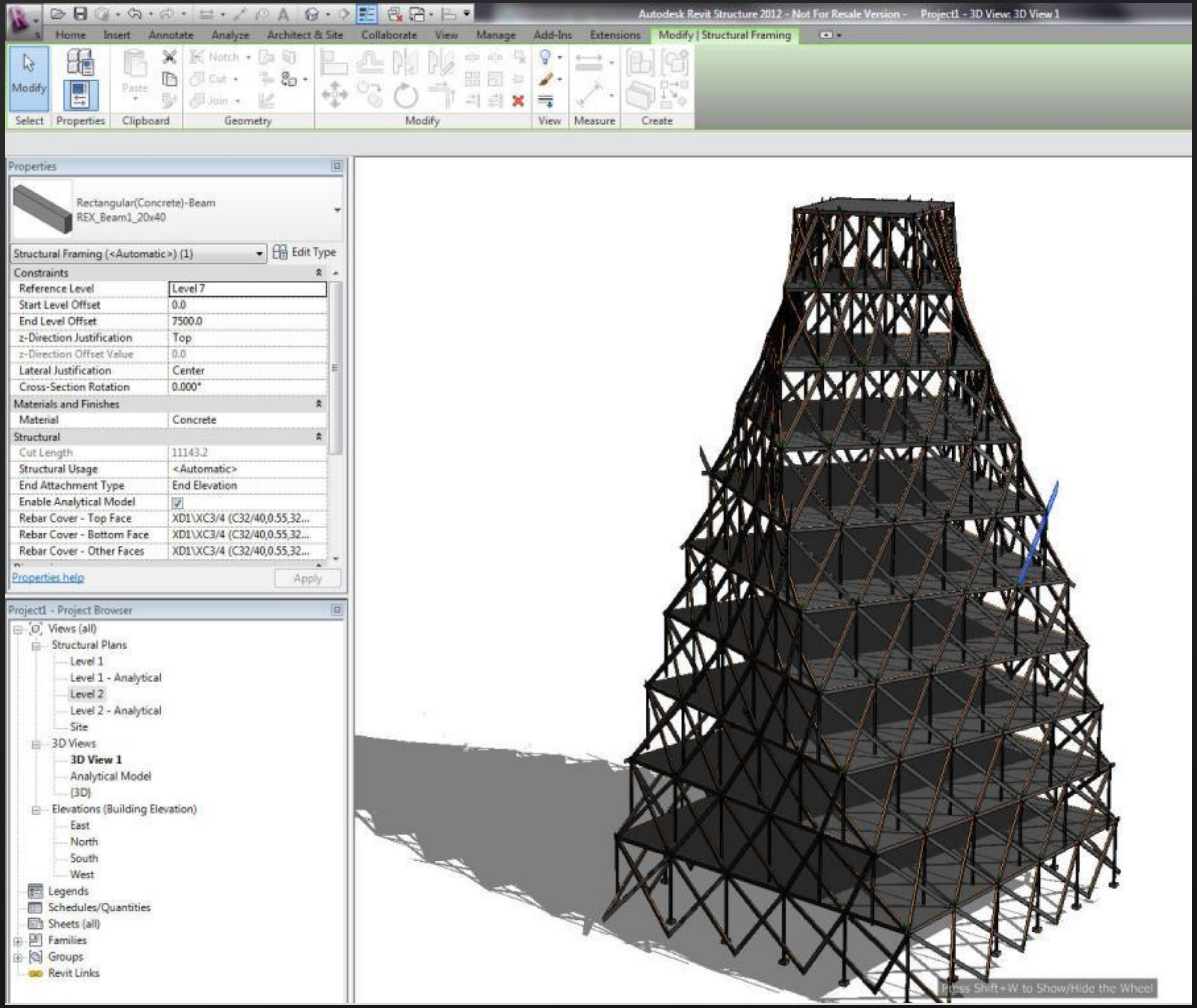


YouTube Video (should load automatically) at:
http://www.youtube.com/watch?v=RCbxcBqiATk
&feature=youtu.be

Structural Thinking:

- Rafael Bras:
- “The divorce of architecture and engineering is long standing and new, at least in the United States, almost ubiquitous. This divorce injures both parties. The ambition of architects to build well is diminished. Engineering becomes formulaic and uncomprehending of its social, environmental, and aesthetic dimensions.”

- Future:
  - Iterative parametric structure building on free form massing models.
  - Multiple material/method studies and analysis running in parallel.
  - Real-time simulation.



- Image Source: – From James Kunstler’s Famous TED Talk: How Bad Architecture Wrecked Cities: http://www.ted.com/talks/james_howard_kunstler_dissects_suburbia.html

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