3D Motion Graphics Using Blender to Illustrate Structural Concepts

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Many schools of architecture rely heavily on 3D graphics software such as Rhinoceros 3D, SketchUp, Revit, ArchiCAD and others. These programs are well tailored to developing and presenting architectural concepts, however they are relatively limited in motion graphics.

Similar in operation to Autodesk's Maya (which is geared toward the visual entertainment and game industry for the production of character animation, virtual worlds and visual effects), Blender is an open-source 3D graphics package. It is nearly as fully capable as Maya and has helped build virtual worlds in feature productions such as the Netflix series The Man in the High Castle, but as on open-source package it is free of the restrictions imposed by the software giants.

Blender has an immense worldwide following, and is under continual development by a dedicated nonprofit foundation. It is decidedly not focussed on architectural applications at all, nonetheless many professional architectural illustrators rely on it and there are numerous add-ons specifically geared toward architectural representation.

The strength of blender is that as a primarily mesh-modeling software this makes it uniquely suited to animations where every surface point can be manipulated directly. These furthermore can be combined with both static images as well as video as an overlay to explain the "hidden world" of structural forces within everyday structures.

This poster presents (albeit in static form) the types of visual graphic animations I've been using in basic structures classes to explain concepts such as load tracing, tension stress, compression buckling, torsion, shear, bending, structural typologies and more. The motion graphics aspect is intended to bring to life images that are normally static on a page.

Keywords: Structures, Pedagogy, Blender, 3D Graphics, Animation

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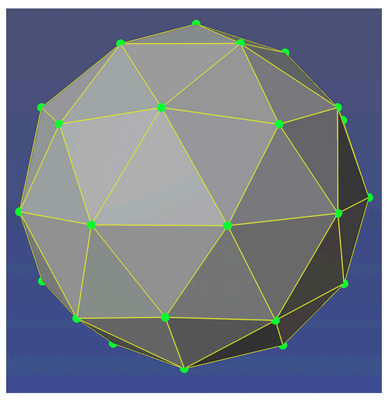
What is Blender?

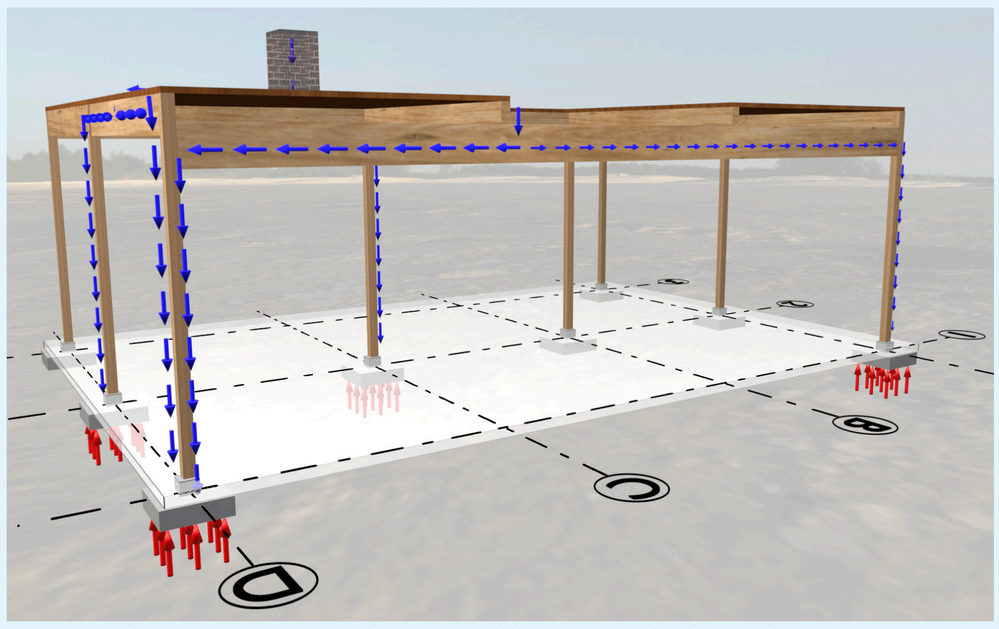
Unlike more commonly used software in architectural education that primarily define objects through mathematical operations such as NURBS (Non Uniform Rational Basis Splines), Blender is at its core a mesh modeling system (though it supports many other graphic types including NURBS). This means objects are constructed from sets of vertices in 3D space, which are connected by edges that form surfaces, which then interconnect to form 3D objects. Most importantly in this use case, Blender can animate the 3D illustrations in virtually unlimited ways. In this regard it is more similar to AutoDesk Maya than to NURBS modelers such as Rhinoceros 3D. Among other features are extensive capabilities for nondestructive modeling using operational modifiers.



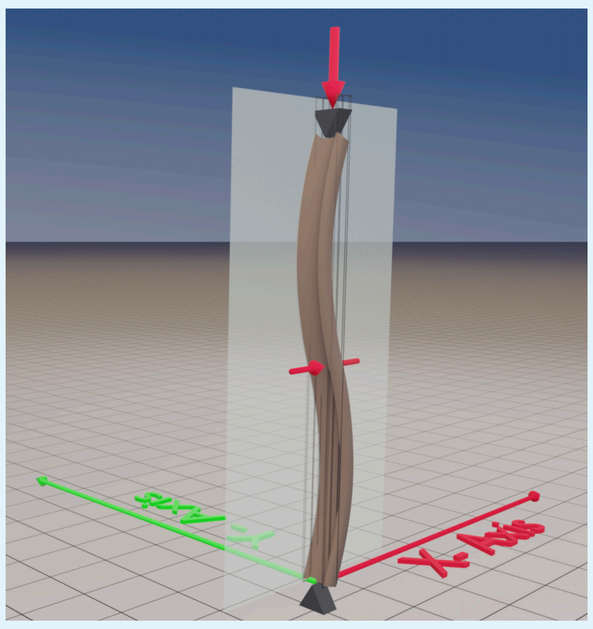
Primitive icosahedron object illustrating mesh object vertices

Making the Invisible Visible

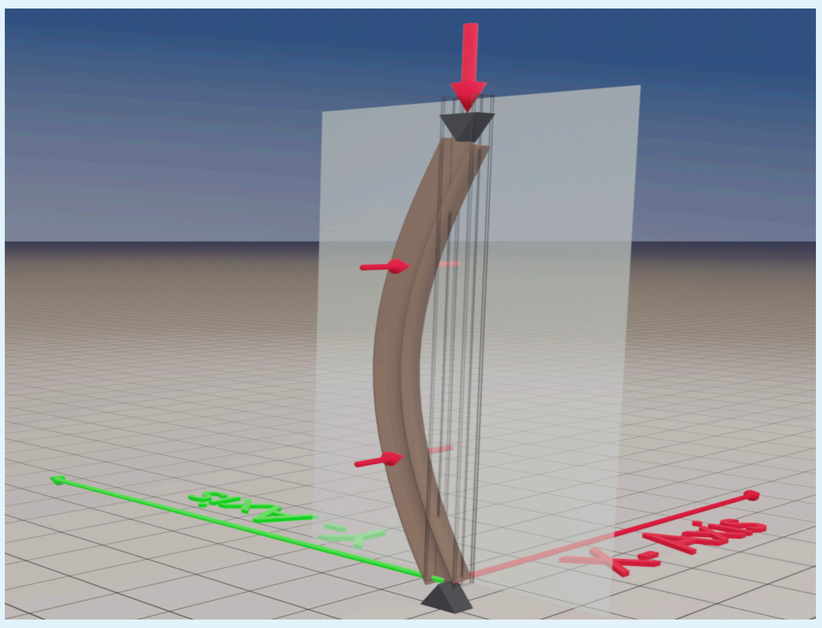
The impetus for this project was to support student comprehension of structural actions as commonly described by basic engineering principles. Certain structural actions that cannot be directly visualized, such as load tracing and column buckling among others, are common areas of challenge for beginning structures students to fully comprehend. The digital structural models are a supplemental learning tool, supporting other educational experiences such as physical models and basic engineering computations to help develop a 'structural intuition' in the beginning student. **Limitations:** These are not "structurally accurate" models in the sense of being derived from structural analysis. They are rather interpretations designed to facilitate learning.



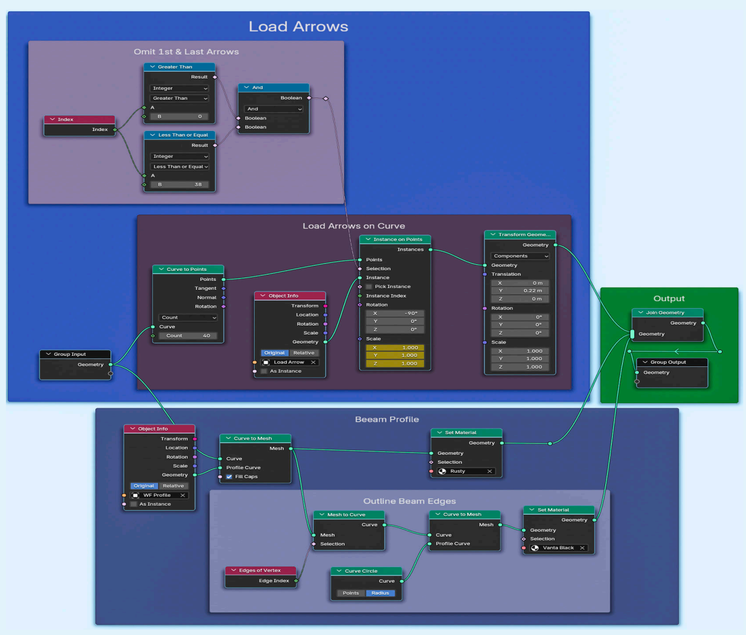
Load tracing conceptualization of force transfer through a structure



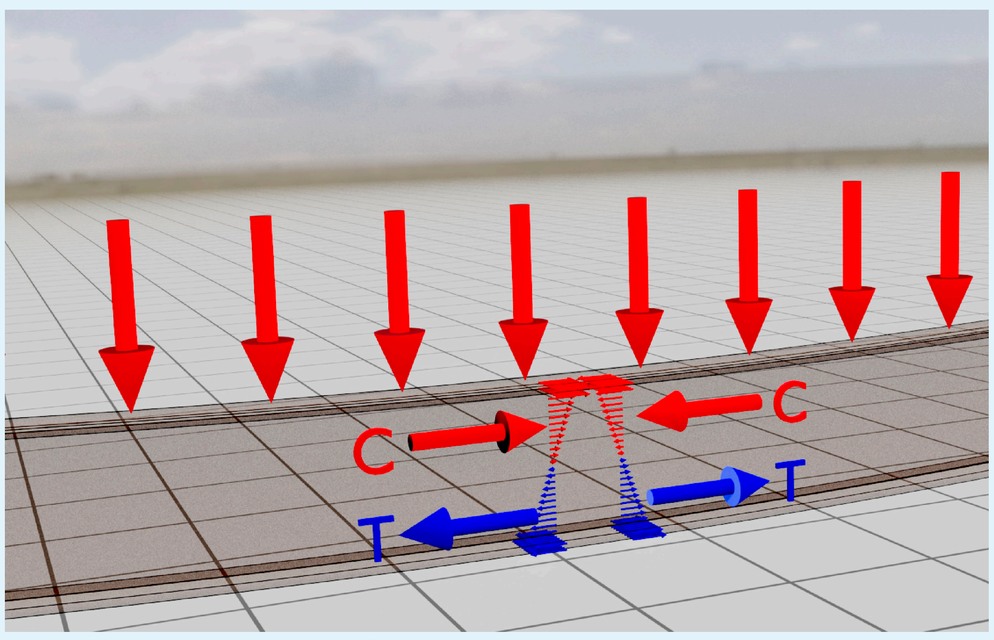
Minor axis buckling with mid-height bracing



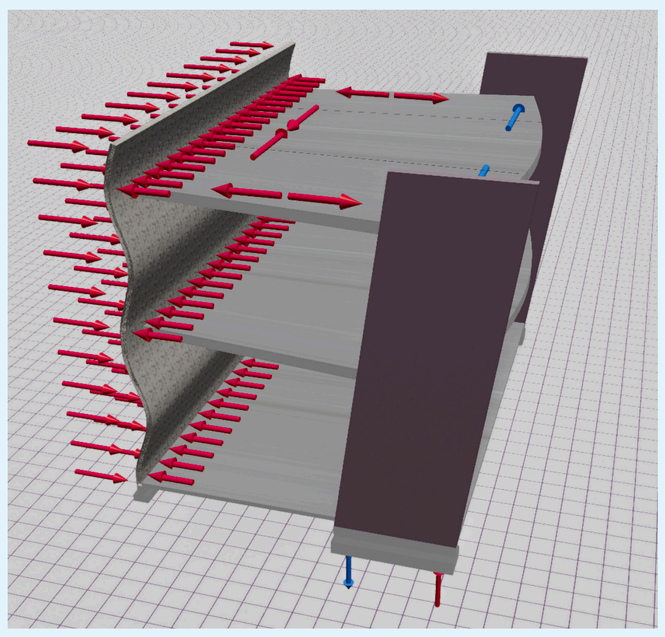
Forced major axis buckling from doubly-braced minor axis



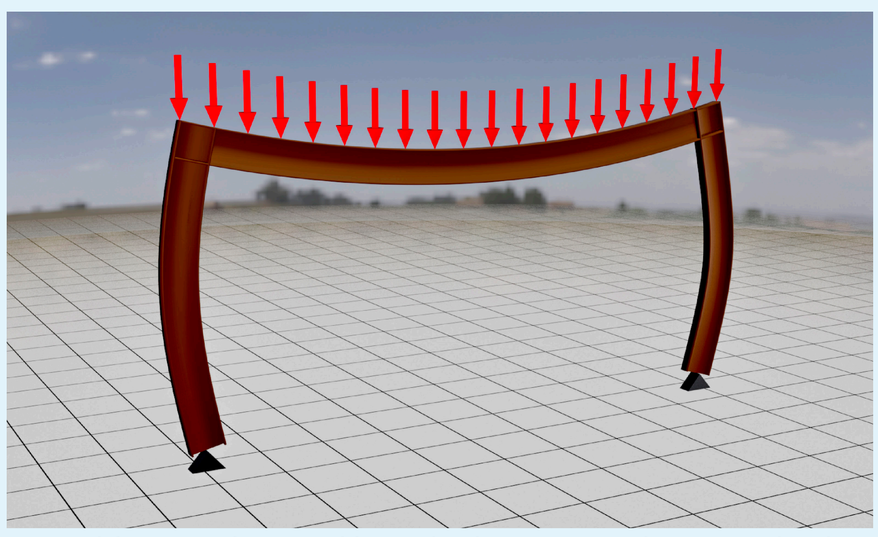
"Geometry Nodes" system used to generate a beam bending animation using parametric controls. This node system is similar to Grasshopper in Rhinoceros 3D or Dynamo in Revit and is one of Blender's strengths.



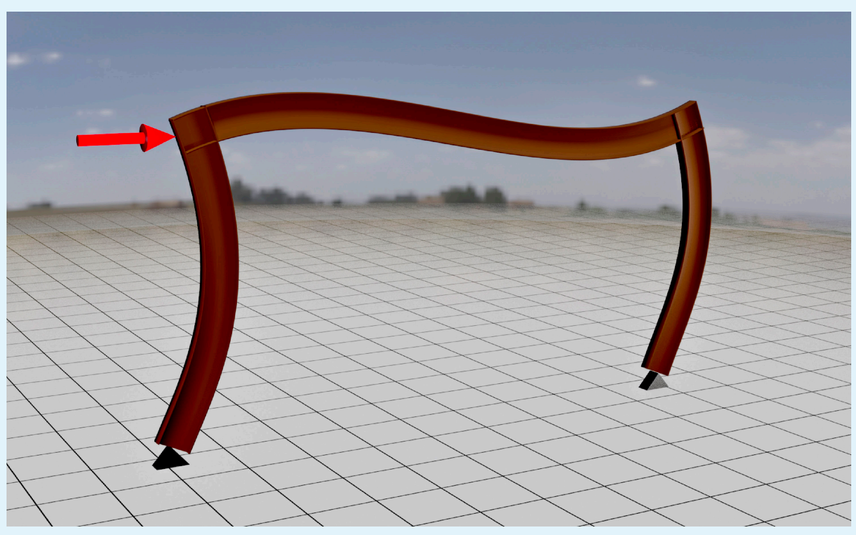
Basic flexural stress visualization



Lateral load transfer on flexible horizontal diaphragms are a consistent challenge for beginning structures students



Rigid frame with pinned base displacement under gravity loads



Lateral rigid frame with pinned base displacement

Experiencing Blender

This software has proven to be a real learning adventure. The examples presented here represent only the surface of possibility. Essentially, whatever can be imagined can be created in Blender. The main issue though, is *how*. Often operations produced unexpected or unpredictable results. Extensive knowledge of more traditional software used in architecture seemed of no benefit. Blender's independent development history has led to unique and quirky operations that have no real counterpart in other software. Furthermore, creating models such as those showing the internal stress on a beam or illustrating the deflection of a frame seemed simple enough but proved to be more challenging than anticipated. And with each step new rabbit holes opened up. The software's deep capabilities are not superficial...they require intensive study and practice to master.

There are boundless tutorials online by independent creators, but for the very specific types of models in these examples it was very much "trial and error figure-it-out" with few similar examples to follow. But having now developed a basic facility, this opens the possibility more complex future graphic projects. It's been a steep learning curve, but a fascinating experience.

Pros

- Highly capable. Used in major productions such as *The Man in the High Cast https://btes.org/wp-content/uploads/2017/02/cropped-BTES_Logo_Color1.jpg le* and 2025 Academy Award winner for Best Animated Feature, *Flow*
- Open-source software available free of charge (donations to Blender foundation encouraged for professional use)
- Freedom from stranglehold of major software giants, expensive fees, cumbersome licensing requirements
- Lightweight and small installation
- Used worldwide...huge range of amateur and pro tutorials available
- Countless plugins to enhance capabilities
- Extremely flexible modeling environment. Can basically create and animate anything. Infinitely customizable.

Cons

- Steep learning curve
- Troubleshooting is time intensive
- Unique interface requires acclimation time
- Largely dependent on keyboard shortcuts instead of drop-down menus or icons, which means a high degree of 'muscle memory' required and shortcuts may conflict with existing operating system shortcuts
- "Wild West" of software...extreme flexibility with software makes it challenging to learn very specific modeling examples
- Not designed as a 'precision' modeling tool. Some simple operations on software like Rhino 3D can be overly complex to do in Blender

Scan to see animation examples
https://tinyurl.com/StructVids