

Engineering is not all WL%... or is it? Unless they've been to a university with a good cooperative education program where they acquired some good practical work experience, many young engineers leave school with only an academic impression of structural engineering, based mainly on the core university technical curriculum. (To refresh yourself on what the suggested curriculum is today, visit www.STRUCTUREmag.org and click the Resource tab.) Over my almost 50 years of practice experience, I have learned quite the contrary – that structural engineering is a multi-faceted gem. When I left school, I had no idea I would be designing seismic mounts and containment vessels to move priceless art objects around the world, and other such things. Have you ever thought, as you passed by objects like those shown in *Figure 1* and *Figure 2*, about the structural engineering that went into supporting that artist's concept? This article deals with yet another interesting commission – a cable supported tree.

Cable Supported Tree

A client called and said, "I have an artist who needs to support some trees in an open space so that the public can view the trees and the roots as if they were walking through the ground beneath the objects. Can you do it for me?" Before I agreed to get involved, I learned, through discussions with the artist, that the client thought the trees and roots could be supported on a cable system having a 12-inch on-center grid, and that the artist would of course like the small diameter cables to be nearly "invisible". If you're like me, you'd probably think, sounds like an interesting project, let's do it. A major drawback – I was on vacation with only my cell phone calculator and my client says "time is of the essence" (always is) and that he needs to make a presentation tomorrow.



Figure 1.

Where does one start on such an unusual commission? What does the root mass look like? How many trees are there and what do they weigh? What does "nearly invisible" really mean? What do these cables look like and what do they connect to? How much cable sag is the artist willing to tolerate?

Fortunately, my client is experienced in dealing with unusual circumstances and can ferret out much of the detail, thus making the engineering task a more straightforward process. Nonetheless, I need to start somewhere and my client isn't a structural engineer, so he doesn't think like I do. He could, however, readily provide space constraints, site location, and through the artist, a general idea of the number of trees, approximate locations and root structure.

continued on next page

Back of the Envelope Engineering

A Structural Engineer's Experience

By Craig E. Barnes, P.E., SECB

Craig E. Barnes is the Founding Principal of CBI Consulting Inc. Craig is also a member of the STRUCTURE Editorial Board. Mr. Barnes can be reached via email at cbarnes@cbiconsultinginc.com.



Live Matter exhibition at Harvard's Radcliffe Institute for Advanced Study. Concept and design by Rosetta S. Elkin. Photos by Kevin Grady.



Figure 2.

But if you think this is the time to put “pencil to paper”, which in today’s world means opening up a sophisticated three-dimensional computer program and embarking on a dizzying array of what-ifs (and I don’t know).... you’re wrong! This is a perfect time to fall back on “back of the envelope” engineering. Simple calculations and some approximate cable sizing will quickly tell me whether this artist’s idea is as unusual as it first seemed, or actually something that I can pull off in a reasonable way in the time permitted. If I had been at the office, I might have gone half-way and dusted off an old textbook (or class notes on cables if I had them, which I don’t) as a refresher. But remember I am on vacation, so I can’t do that anyway. I recall what cable theory is $WL^2/8$, so I should be good to go with some approximate figures and cable loads. I figure the young engineers back at the office can refine the idea later and “prove” I am right. After a quick Google search on cables and what they might look like (wire rope, aircraft cable, piano wire, non-metallic systems, etc.) and who makes them, I am ready for a chat with my client not only about cable options but also membrane versus mesh versus grid supports.

In the short time span of two hours, my client, now armed with knowledge that he didn’t have when he first called me, is in a far better position to discuss with the artist how art and structure come together. Their discussion came back to me for refinement of the system and hand sketches (Figure 3) to be used by my client and the artist.

Vacation is over and, with the continued desire on the part of the artist and my client (the institution) to move forward, a field visit was established to view how the cable loads would be transferred to the existing surrounding structure. I knew in advance that the presentation space had been used previously for art shows and that the walls were drywall

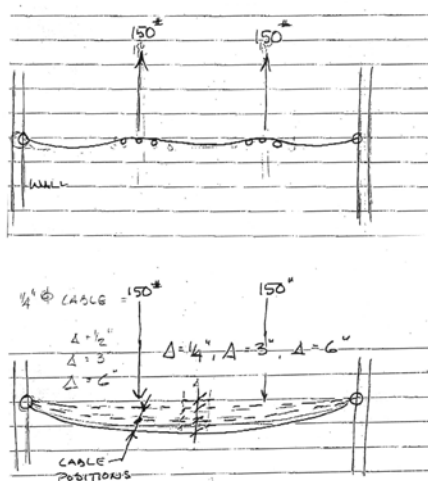
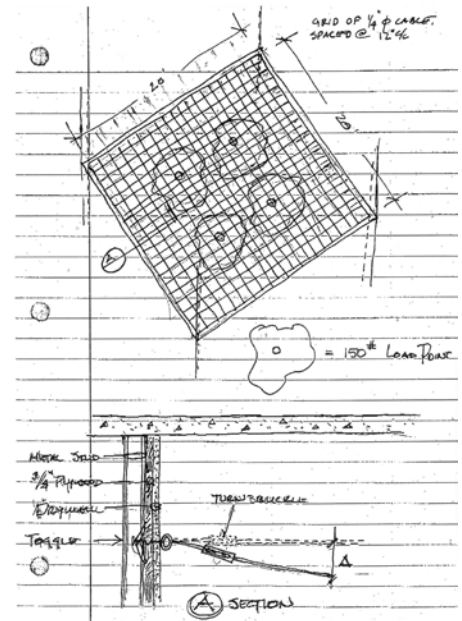


Figure 3.

on plywood supported by cold formed studs. This of course was insufficient data to be able to determine what load support capacity the system possessed, but provided me with comfort that the facility had been built with the anticipation of supporting some level of wall loads. Once on site, I was advised that the structure on three sides of the room was available for cable connection. However, on the fourth side, the room needed to be narrowed by the erection of a fourth wall containing a 10-foot opening on one end to create a controlled entry for viewers. Fortunately, the design cable system could be connected to the walls approximately 18 inches from the top so that what turned out to be rather flimsy 20 gauge metal studs could be loaded more in shear than bending, and my design would still



work. In addition, the artist was amenable to taking the concentrated loads directly to the structure above. The design of the new wall and the entry header were easy to accomplish, since it was up to me.

When all was said and done, the cable system and the “back of the envelope” design process was, in our opinion, as interesting as the art work itself. ■



SOFTWARE AND CONSULTING FLOOR VIBRATIONS

FLOORVIBE v2.20

- Software to Analyze Floors for Annoying Vibrations
- Demo version at www.FloorVibe.com
- Calculations follow AISC Design Guide 11 and SJI Technical Digest 5 2nd Edition Procedures
- Analyze for Walking and Rhythmic Activities
- Check floors supporting sensitive equipment
- Graphic displays of output
- Data bases included

CONSULTING SERVICES

- Expert consulting available for new construction and problem floors.

Structural Engineers, Inc.

Radford, VA 540-731-3330 tmurray@floorvibe.com