Areas Where Teaching Structures Should Be Strengthened

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For nearly fifty years I have been pleased to provide structural consulting to architects on building projects throughout the United States and the Mideast, and in size from smaller than a house to as large as a city[b]

Most of the preliminary designs an architect brings to me for structural services are pretty well thought out in terms of appropriate column spacing and allowance for beam depths, and have suitable locations to accommodate the structural frame. In subsequent discussions an appropriate framing scheme usually develops without a great deal of conflict. Sometimes, knowing what the architect is trying to achieve, a unique structural arrangement becomes obvious, and if the architect can incorporate that in his plans, a strikingly new form evolves[c].

Having said that, there are some common planning weaknesses that occur frequently. They are: 1) Building stability and lateral bracing, 2) Structural frame vertical organization, 3) Tolerances between the structural frame and the architectural finish, 4) Site considerations, and 5) Floor vibration and comfort performance.

Lateral Bracing

If he has thought about lateral forces at all, the architect will often say, "Well, I will allow you bracing in the core," as if that were the end of the matter. Core bracing alone makes the width or depth of the core become *the structural depth* of the building, regardless as to how wide or how long the building is. Accordingly, the core becomes a flagpole, or mast, that braces the entire building, and which may be too slender for acceptable sway performance in taller structures. In addition, lateral forces eccentric from the core may twist the building back and forth uncomfortably because the core alone cannot provide sufficient torsional stiffness. Even though the building may have sufficient *strength*, the inability of the core alone to provide sufficient *stiffness* can result in undesirable building motion, slapping of elevator cables against sidewalls, sloshing of water in toilet bowls, swinging doors, binding windows, squeaks, groans and mal-de-mer.

Another popular, but ineffective, location for lateral bracing is the exterior wall corner bays of the building, which are the worst exterior wall locations because the corner columns are the most lightly loaded and therefore have the least gravity weight to offset overturning uplift.

Vertical Alignment

Another common planning weakness is structural frame discontinuity in the vertical direction. Think of a building with

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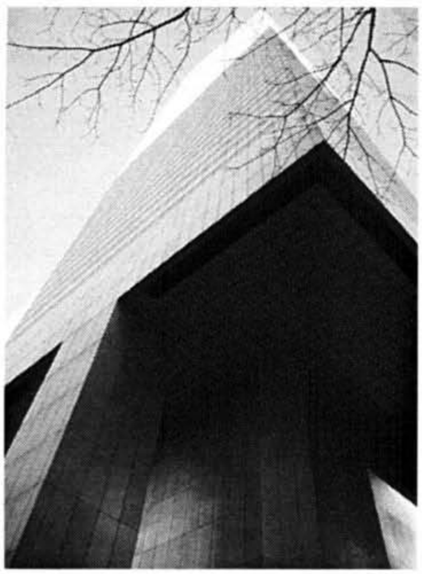
upper level apartments above lower level office spaces, all over ground floor commercial spaces with basement parking underneath. Each occupancy has its own optimum structural module, which, if rigorously applied, results in massive transfer girders or story-deep trusses and each change of occupancy.

Teaching should include planning of an efficient structural module that can be threaded through the differing occupancy levels.



Tolerance

The need for tolerance between the structure and the architectural finish is often not considered. The actual depth of a steel column may be as much as two inches larger than the nominal depth. Splice plates, connections and bolts can make the structural cross-section even deeper, and fireproofing, where required, adds to that. Base plates will be larger than the column they support for welding and area requirements, and commonly sit atop a bed of grout.

Remember, too, that concrete has a way of hardening up and a slightly misplaced wall or anchor bolts have to be accommodated.

Teaching should include the necessity for providing "float" between the structure and the architectural finish when preparing preliminary sketches, especially where concrete work joins the superstructure.

Site Considerations

Site constraints may influence the choice of structural module or type. Most architects practicing within a region are aware of its special requirements. Hurricanes (Southeast), earthquakes (West coast), tornadoes (Midwest), expansive clays (Texas), permafrost (Alaska), and extreme temperature or humidity variation (Mideast) represent localities with special requirements. Sometimes availability of materials or lack of skilled labor will govern the design vernacular.

As important, site constraints or subgrade conditions may strongly affect the structural system and even the architectural form.

On good soils, the structure can be founded on simple footings. Where the building location is underlain with organic material, soft clays and the like, special foundation systems are required, differential settlements and control of groundwater considered, and these may influence the choice of the superstructure system, including column spacing, to achieve an optimal system.

Floor Vibration and serviceability

Today's buildings are lighter and more gossamer than their ancestors. With today's high-strength materials, composite construction, and lightweight concretes, floor spans can be made longer, and *stiffness*, rather than *strength*, often governs the structural depth. As a consequence, floor vibration, cambering, and careful deflection control become important factors for occupancy comfort, especially in large, column-free spaces without damping partitions. Often floor vibrations are not sensible to walkers, but become intolerable to a person sitting, as in an office.

All too often thin, long span floors are envisioned, but which must be deepened (stiffened), or otherwise damped against excessive vibration.

How these can be taught

A good way to teach these areas of structural planning (and structures in general), I think, is to choose a building of interest that has been built and study its structure. How has the architect and engineer collaborated to make it successful? What constitutes the lateral bracing system? What were the site constraints, if any, and how did they influence the design? What is the column grid module and what is the floor system depth for its spans?

If a student studies two or three built projects a semester, each illustrating a type of building the student is likely to encounter in practice, and if the student is made to keep a notebook of sketches and notes relative to each type of building, he will have then studied structural solutions in context with the architectural problem, and will also have a useful future reference upon graduation.

Endnotes:

a. King Kahlid Military City, Saudi Arabia
b. Citicorp, NYC; Gymnasium, Philips Exeter Academy, Exeter, NH; Fiduciary Trust Bldg, Boston, MA