Formwork Efficiencies

Thinking ahead can result in savings

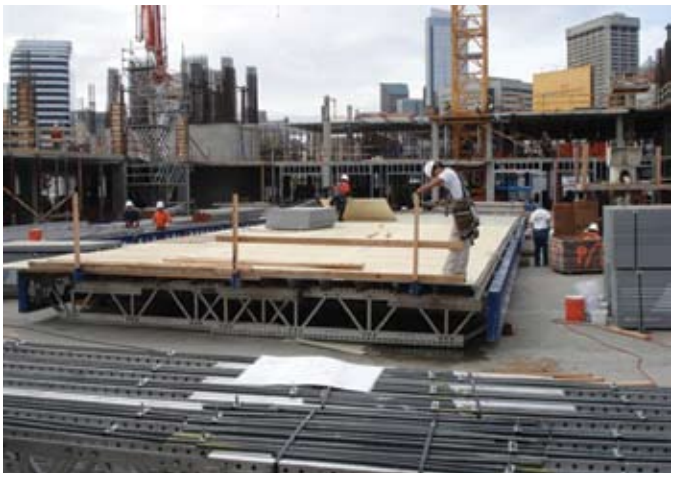
BY CARY KOPCZYNSKI

Formwork is not often at the forefront of a structural engineer's thinking when conceptualizing a cast-in-place concrete structure. Numerous design challenges during the conceptual and schematic phases divert attention away from constructibility. It's precisely during these early design phases, however, when constructibility thinking can reap the biggest rewards. Of those constructibility issues that a structural engineer has control over, formwork can make the biggest impact. In fact, the compatibility of modern, high-production forming systems with a building's structural layout often makes the difference between a project that is on time and on budget and one that falls short.

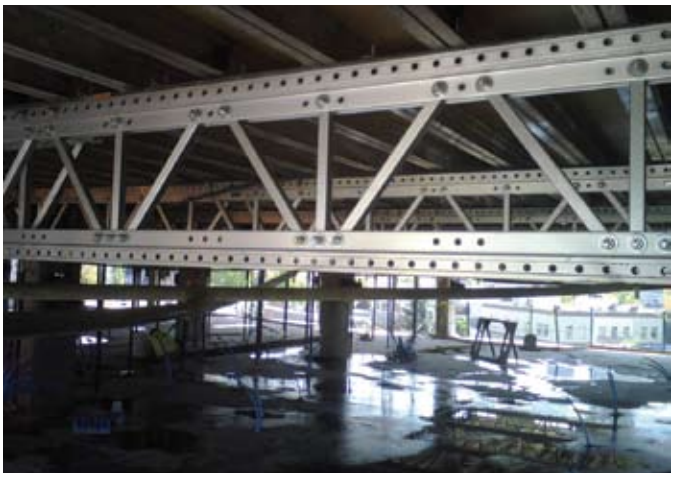
In the U.S. and other markets with high labor costs, formwork can be as much as one-third to one-half the total cost of a completed cast-in-place concrete structure. It's important, therefore, that formwork be carefully considered when laying out structural framing. Preplanning by the structural engineer and construction team well before groundbreaking is critical if efficient forming systems are to be used. Subtle and architecturally insignificant detailing changes at this stage can often create major improvements in constructibility and substantial reductions in forming cost. Structural engineers can help guide the successful outcome of a concrete project by being aware of the important relationship between a building's structural design and its forming system. The following are a few things to keep in mind.

COMMON ROADBLOCKS

- **Not understanding the importance of compatibility between the formwork and the structural system:** Ignoring formwork systems until the concrete contractor joins the project team is often costly. If a high-rise building's structural design incorporates awkward column placement, for example, flying forms or column-hung forming systems may not work without considerable modification.
- **Insufficient attention during schematic and design development phases:** The fast-track nature of today's projects can make it difficult to perform the required reviews at the front end. Often, the process moves so quickly that structural engineers have insufficient time to coordinate the structural layout with forming systems.
- **Lack of coordination with mechanical and electrical design teams:** It's important to stick with early decisions made regarding mechanical and electrical systems and their impact on the structure. Changing the location of a large mechanical penetration at the last minute, for example, can affect the configuration of a structural wall, resulting in time and cost penalties.
- **Public versus private projects:** It's often more difficult for structural engineers to gain insight from general contractors and concrete subcontractors in a nonnegotiated procurement process because the design typically must be complete before bids are let. The structural engineer should be aware of the challenges associated with public projects and understand that early construction insight may not be readily available.



Column-hung flying deck forms being built up on a job site. Trusses span between girders that will be supported by columns



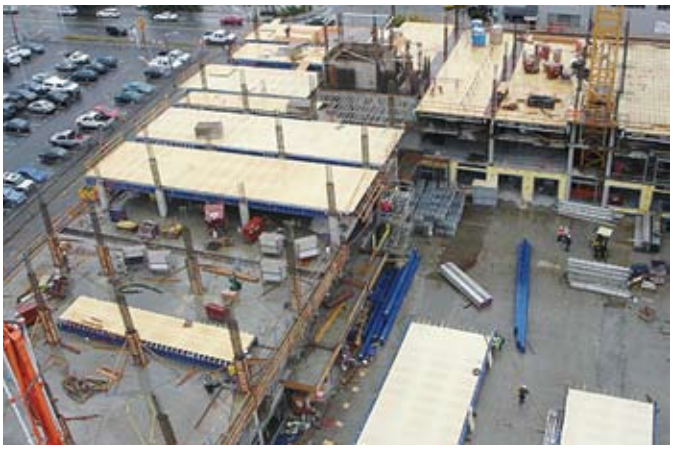
The trusses supporting these flying deck forms are fully adjustable, allowing versatility in span and spacing

START EARLY

During a project's conceptual and schematic phases, structural engineers should be thinking about how a building's structural system will accommodate high-production forming systems. To collaborate effectively with other disciplines in these early design phases, a common misconception must first be confronted. Many architects assume that structural constructibility is a win-lose proposition and that the only way to achieve a simpler structure is to compromise the architecture. In most cases, however, the architect, mechanical engineer, and others will be minimally affected by a structure designed with constructibility in mind. For example, slight shifts in column placement can mean the difference between a structure that accommodates a flying form system and one that does not. These slight changes in column location, if coordinated early in the design process, can typically be managed with minimal architectural impact.

The most common mistake made when designing a building's structural frame is waiting well into the construction document phase to focus on formwork. By the time construction documents are underway, however, little can be done. If the design is incompatible with high-production formwork, layout changes are often necessary. Most often, the time required to backtrack and make design changes isn't available, so the forming system is compromised by an unnecessarily awkward structure. The inevitable result is added time to the construction schedule and cost to the project.

Column-hung flying deck forms prior to placing the slab. All slab loads are carried directly by the columns, resulting in open decks below the forms with no shores or reshores. This allows workers to move about freely



Aligned columns facilitate a clean formwork layout and maximize productivity

FOCUS ON UNIFORMITY

Changes to member sizes from one floor to another can negatively impact the speed and cost of a forming system. For example, structural designers frequently vary column sizes as loads increase or decrease. For large

projects, this fine tuning of column sizes leads to costly formwork. Although concrete material is optimized, increased forming costs more than cancel the material savings. In most cases, a better strategy is to work with several uniform column sizes and vary the concrete strength to accommodate varying loads.

Horizontal framing systems fall victim to the same scenario. For example, depending on the forming system used, the designer may choose to design beams that are wider than the columns, narrower than the columns, or the same width. Structural engineers should attempt to determine the beam design approach that is most appropriate for their project before proceeding to construction documents.

As building loads, spans, and uses change, it's easy to fall victim to solving structural issues independent of one another. This can lead to numerous structural systems that each require different forming systems. Keep the big picture in mind.

GET INVOLVED WITH THE CONTRACTOR

Early discussions with the general contractor or concrete subcontractor are vital when determining structural system and formwork compatibility. Many large general contractors have concrete specialists on board who can offer information on subcontractors suitable for the project and the availability of different types of forming equipment, both of which may affect the structural design.

Not all general contractors have the resources to provide constructive information, however, and some may have a limited understanding of the nuances of formwork. In these cases, concrete subcontractors can offer insight into their preferred forming systems. Information gathered through such outreach can help structural engineers design systems that will be compatible with the resources available to the building team.

UNDERSTAND THE BUILDER'S SKILL SET

Until recently, high-rise concrete towers were nearly always built with flying form trusses or column-hung forming systems. Some contemporary contractors, however, are finding that productivity rates and costs are just as competitive with modern hand-set systems using pre-engineered components, even on multi-story high-rises. Such hand-set formwork allows greater architectural and structural design flexibility because column alignment is not required to allow effective use of these systems.

Every general contractor and concrete subcontractor favors a particular forming system and sequence. As structural engineers, taking the time to familiarize yourself with specialty forming systems and the preferences of your builder will offer invaluable information when designing the structure.

Conventional flying form trusses immediately after flying. Reshores will be installed prior to placing the slab

Structural engineers have plenty to think about when designing concrete buildings. Giving thought to formwork when laying out a structure may seem like an added burden, but ensuring formwork compatibility in the early design phases will go a long way toward helping your project meet its budget and schedule goals.

Selected for reader interest by the editors.

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