Current Trends in Economical Concrete Construction

Part 2: Cost Savings and Formwork

By Jim Delahay, P.E. and Brad Christopher, P.E.

This is Part 2 of a three-part series that provides an overview of current trends that lead to economical reinforced concrete construction. This article discusses strategies for Cost Savings on Labor vs. Materials, as well as tips on Formwork. Part 1 (STRUCTURE®, July 2007) covered floor framing and lateral-resisting system concepts.

Figure 1a: Repetitious Pan Layout.

Cost Savings on Labor versus Cost Savings on Material

Labor is a significant cost in all aspects of reinforced concrete construction. What this means to the designer is *simplify, simplify, simplify*! Design to minimize labor in formwork and reinforcing steel placement.

Consider formwork: the cost of labor to handle formwork (i.e., installation, removal, shoring and re-shoring) approaches three times the cost of the formwork material.

Tapering or stepping walls, changing column sizes and beam sizes, or the addition of non-standard void spaces in floor systems to save concrete will result in more formwork labor and will thus be more costly.

Similarly, designers often mistakenly seek cost savings by designing the precise amount of reinforcing steel required for each individual member; however, using non-uniform reinforcement patterns or bar selections just to save a few pounds of reinforcing steel is not cost-effective. Engineers are typically trained in school to optimize materials. Determining the smallest member sizes, tightest stirrup spacing, and least number of reinforcing steel bars are the goals of individual member design assignments. In practice, creating a balance between reasonable reinforcing steel selections and common formwork sizes for the overall building is a challenge to all designers. Again, *simplicity and repetition* are the keys to economy.

Economizing Formwork

Formwork (including labor) can account for more than half the cost for a cast-in-place reinforced concrete frame. Therefore, designing with a clear understanding of how the structure will be formed is a crucial factor in economical concrete construction. A reinforced concrete frame will cost significantly less if the design maximizes the reuse of forms and permits use of standard material sizes with minimal cutting and fitting. In most cases, expenditure on additional materials (e.g., in terms of larger member sizes) is justifiable in order to maintain simplicity, uniformity and repetition of forms. For additional information about economical formwork, see Concrete Reinforcing Steel Institute (CRSI) Engineering Data Report 47, *Formwork Digest*.

Formwork Systems

For joist-and-slab floor construction, many contractors prefer *pan formwork systems*. These forming systems include both one-way and two-way joists; the voids between the joists are formed with "pans" or "domes" of standard

Figure 1b: Repetitious Pan Layout.

widths and depths. For common sizes, see CRSI Engineering Data Report 46, *Wide-Module Joist Systems*. These systems have been around for years and continue to be a popular forming choice. Ease of installation and re-use of forms are two of the advantages of these systems. See *Figures 1a* and *1b* for examples of repetitious pan layout.

Custom plywood forms for beam-and-slab construction are often a viable alternative to the steel or fiberglass pan formwork systems. Some general contractors prefer to self-perform the forming on their reinforced concrete projects. For this to be most effective, the contractor should be involved at the beginning of a project to aid in the framing layout. Voids between beams are formed using wood trusses or sometimes wood I-joists

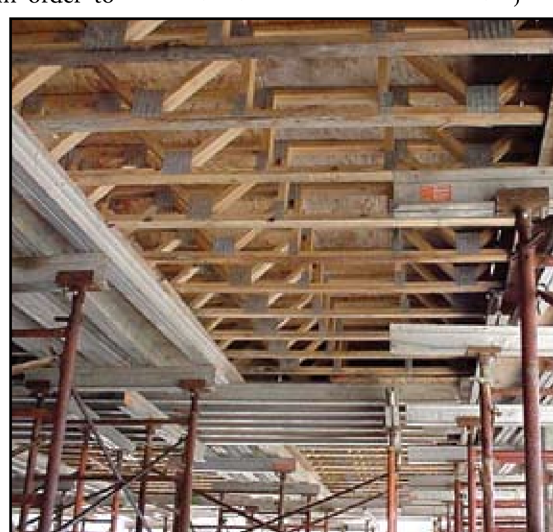

Figure 2: Formwork Trusses.

Figure 3: Beams and Girders – Same Depth.

Figure 4: Large Sections of Formwork.

– see *Figure 2* for examples of a wood truss formwork system. Contractors using this system need to have input on the void widths and depths based on availability of their formwork. These voids are usually multiples of 2 feet in order to minimize plywood waste; an 8-foot-wide void is popular to match a 4-foot by 8-foot sheet of plywood. To minimize formwork costs, a key to the economy of all these systems is to have beams and girders of the same depth (*Figure 3*).

Flying forms are large sections of formwork (which may include supporting trusses, beams, and/or scaffolding units) designed to be lifted as a unit and moved from place to place. They are most commonly used for repetitious slab form systems. The key to justifying the use of a flying form system is to have repetitious formwork on multiple floors. *Figure 4* shows large sections of pan formwork that are put together on the ground and flown into place. Similar to flying forms, *gang forms* are large sections of wall formwork pre-assembled and set with a crane. The use of gang forms can greatly reduce the cost of forming walls – if the walls have a uniform thickness and layout. This is one of the many reasons it is more economical to use a wall of constant thickness in lieu of tapered or stepped walls. It is often more economical to use concrete masonry units stacked in front of a wall to support brick or cast stone than to form a brick ledge in the wall itself.

Sequence and cycle times

Many contractors prefer a one-week cycle time when building typical office buildings and parking decks. Where multiple pours are required to complete a floor, the size of each pour and the associated quantity of formwork and shoring required by the contractor is calibrated to make as much progress as possible in one week. Where manageable, contractors pre-tie girder and column reinforcing cages on the ground while the formwork is being erected and then fly the assembled cages into place.

Of growing popularity, *night and early morning pours* are often scheduled to take advantage of more efficient concrete delivery (i.e., less traffic on the roads) and to mitigate evaporation and curing concerns due to higher daytime temperatures and direct exposure to the sun during the finishing operation.

A future issue of STRUCTURE magazine will conclude with Part 3, which will include tips on reinforcing steel and concrete, along with closing remarks on other influential factors such as building codes and project delivery systems.▪

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