

Think Formwork – Reduce Costs

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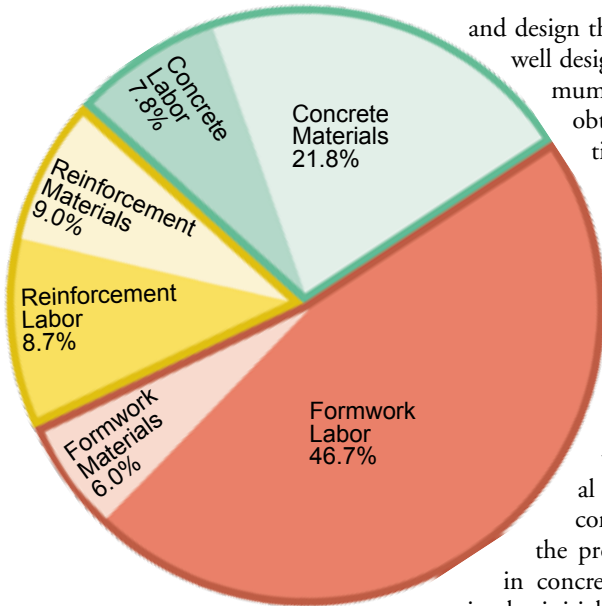


Figure 1: The real cost of in place structural concrete

Every project has unique features, requirements and challenges. As the design of structural concrete projects becomes more and more complex, a simple method for reducing the cost of construction is too frequently overlooked. Presently, as well as in the past, the most common approach to reducing the cost of a structure was solely to search for ways to reduce the amount of permanent material under the assumption that “less is best”. However, this approach overlooks the most important component in concrete structure cost which is the concrete formwork. Concrete formwork consists not only of formwork materials, but also the cost of the labor required to use this material.

Concrete formwork cost is significant. The cost of formwork amounts to anywhere from 40 to 60% of the cost of a concrete structure. As shown in Figure 1, the cost of concrete formwork and labor can exceed the combined total cost of concrete and reinforcement materials and labor. Formwork materials are only a small percentage of the total concrete formwork costs. The major cost is the formwork labor – the costs associated with the installation and removal of the formwork. Therefore, any effort to reduce the costs of a concrete structure must include the construction process. The concrete structural design engineer must be aware of the cost of construction

and design the structure accordingly. A well designed structure utilizes optimum concrete formwork, which obtains fast paced construction while keeping costs at a minimum. A structure that is easy to build reduces the required labor and leads to potential cost savings.

Designing For Cost Savings

There are numerous ways the concrete structural design engineer can design construction cost savings into the project. The primary savings in concrete formwork often occurs in the initial concrete design stage. An efficiently designed structure obtains these savings at the initial bidding and throughout the construction process. An efficiently designed structure has the ability to reduce costs in several areas, especially in the design of the floors, columns, and walls.

Due to the amount of concrete formwork required for the floor system, it is here that the greatest potential of cost savings exists. Several structural floor systems may be designed to support the structural loading requirements, but frequently certain designs are more

economical. From a concrete formwork point of view, the most economical system is the flat slab or constant soffit. In this system, the formwork has limited interruptions, and is the most easily assembled and removed. Any drop below the soffit elevation, be it for drop beams or depressions, causes a break in the formwork operation. The formwork must stop at this point, possibly change direction and be cut to fit. Any change in operation leads to a decrease in formwork productivity and an increase in cost. Concrete deep beams also require additional beam side formwork not needed in the level soffit design. Deep beams may also increase the overall height of the structure and require additional cost in the vertical direction. A variable height structure may require different vertical formwork in the floor support, and also different column and wall forms. If at all possible, increase the reinforcement in the slab to act as a wide beam at the same depth. Dropheads are frequently needed at column slab intersections. An optimum design eliminates these dropheads completely by increasing the reinforcement shearheads in the floor slab. If the dropheads can not be avoided, size the vertical drop so that standard lumber dimensions may be utilized. For example, an optimum design specifies a 4 1/4 inch vertical drop which



Figure 2: Clamping mechanism wall formwork

is formed by 4x lumber along with 3/4 inch plywood. Drainage slopes also have different costs on concrete formwork. A drainage slope which is only on the top surface and maintains the constant soffit elevation is the most cost effective. The added concrete required for a top surface slope is far less costly than constructing a one way or two way sloped formwork system. If it is necessary to use a one way slope, also slope the beams to maintain a constant beam side dimension. A two way slope, where both the top and bottom of the slab slopes with valleys and ridges in two directions, has to be carefully reviewed for formwork costs. The numerous start and stop intersections required of the formwork greatly reduces construction productivity and should be avoided if possible.

Columns are another area in the structural design where potential cost savings can be obtained. Strive for few changes in column size and limit the different size columns in the structure. Review the possibility of increasing the concrete strength and reinforcement instead of increasing the column size to carry the higher loads at the lower levels. Alternately, limit the reduction in size of the columns at the upper levels, even if additional concrete is required. This additional concrete is usually minor in cost as compared to changing the column formwork. By limiting the different column sizes in the structure, the same formwork may be used for every column and reduces the corresponding material cost. Column layout can also influence concrete formwork costs. Certain structures are constructed with large ganged formwork systems which are very labor productive since the formwork system is used multiple times from pour to pour or level to level. Columns which are aligned as to provide an open area for gang formwork systems is another way the structural design can reduce construction costs. Even maintaining consistent column orientation to the building grid will reduce the formwork cut and fit, which lowers labor productivity and increases construction costs.

Cost savings can also be obtained in the economical design of structural concrete walls. An efficient way to reduce costs in concrete walls is by combining structural functions. Re-

view if concrete wall pilasters can be eliminated by adding wall reinforcement to create a wall column. Deleting the pilaster permits straight wall formwork to be utilized at a lower cost. If pilasters can not be omitted, strive to make the pilaster size and grid spacing uniform and typical. Pilasters of uniform size and typical grid spacing permits consistent formwork material to be used without modification, thus increasing the reuse factor, increasing productivity, and lowering construction cost. Concrete wall openings add to the formwork costs. Strive to replace multiple small openings with fewer, larger openings.

Also strive to use uniform opening sizes and positions which permits greater reuse of the formwork system.

Minimal Considerations

In order to obtain economy in concrete formwork, four basic considerations must be contemplated. *The concrete formwork must be simple.* This concept is based on the formwork being simple to erect, use, and dismantle. An overly complex formwork system leads to reduced production and higher costs. Use the simplest formwork that

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Figure 3: Adjustable column formwork

will do the job. *The concrete formwork must be easy to handle.* The concrete formwork must be of a size and weight that can be easily handled. If the formwork is to be man handled, a light weight, ergonomic system will lead to increased productivity and cost saving. Furthermore, if the formwork is to be crane handled, a structure designed for easy formwork movement reduces costs by increasing the reuse potential. *The concrete formwork must be standardized.* If the concrete formwork utilizes industry standard sizes, assembly costs are minimized. If custom or special sized formwork is avoided, material cost is held to a minimum. *The concrete formwork must be reusable.* If the design permits concrete formwork to be easily removed and repositioned, costs are again minimized. A designed structure that requires little formwork modification and limits potential formwork damage saves construction time and costs.

Another option to provide an economical design is to base the design around a concrete formwork system. This method of design frequently is utilized in the design-build project delivery system. A working partnership with the owner, design engineer, and the contractor often leads to an optimum concrete structure design. The contractor is aware of potential cost savings which maybe obtained through the vari-

ous formwork systems in the market-place. A project designed to capture the increased productivity of various formwork systems leads to an economical structure. There are multiple ways to design a concrete structure. However, by selecting a design scheme which recognizes the potential cost savings from a productive formwork system, an economical project can be delivered to the owner. Specialized formwork systems, such as tunnel form where the concrete walls and floor are cast simultaneously or column mounted where all floor shoring is suspended from the columns, are prime examples where the concrete engineer designs the structure based on the formwork system going to be used in the construction.

Current Innovations

The concrete formwork industry is constantly developing innovative systems to increase construction productivity by minimizing the amount of labor required to use the formwork material. New formwork products for concrete walls, columns and floors are frequently used for their cost saving potential and their ability to be readily used for various concrete designs.

For concrete walls, newer panel form systems have been introduced into the marketplace which can be gang formed to speed construction while reducing utilization costs. A major innovation is the elimination of the bolted assembly of the formwork by replacing the bolts with clamping mechanisms. These clamping mechanisms have the ability to fasten, align, and tighten the concrete wall formwork in one step with only a hammer. The wall form can also be easily modified in both the vertical and horizontal directions using only a hammer.



Figure 4: Light weight, quick strip floor formwork

These crane positioned panels are also delivered to the construction project ready for use. Panels delivered in the morning are able to be poured against that afternoon (Figure 2, see page 14).

For concrete columns, an innovative column form which is shop assembled has recently been introduced. Based on the "pinwheel" principle, these column forms have the ability to be easily site adjusted in 2-inch increments from 8 inches to 32 inches, or 24 inches to 48 inches. If the concrete design does not permit constant column sizes, this column form provides a method of forming along with high production savings. The column form hinges and moves as a complete unit from column to column providing additional cost savings (Figure 3).

For concrete floors, a light-weight panel form system is being used more frequently for its high productivity. Consisting of aluminum framed panels, the entire system can be quickly assembled only using man handling. As an added benefit, all horizontal modules are able to be quickly dismantled while maintaining vertical load carrying support of the freshly placed concrete. In certain instances, the formwork for concrete slabs can be stripped as soon as one to two days after the concrete pour and recycled to the next concreting position. This quick stripping has the ability to reduce the required formwork for the project by up to 70% (Figure 4).

Conclusions

Ultimately the structural engineer must design the concrete structure to serve the required functions with a structural system that offers an economical cost while meeting all load requirements. Concrete formwork plays a major role in the cost considerations of the structure. A structural engineer who is aware of the cost of complexity and is aware of potential formwork costs has the advantage to pursue a structure that obtains the aesthetics, quality, and function at a reduced cost — a benefit to the owner, engineer and contractor. ■

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PERI Formwork Systems is one of the largest suppliers of formwork and shoring for the concrete construction industry worldwide.