

Architectural Cast-in-place Concrete

What Does An Architect or Engineer Need to Know About Architectural Concrete?

by Dan Dorfmueller

Concrete is a monolithic material, but does not give a perfectly monolithic appearance. It is impacted by formwork, concrete mixture, changing weather conditions, color of cement from manufacturer to manufacturer, aggregate supplies, moisture content, admixtures and many other items.

As a young architect student, I used concrete as a material of choice because it could be formed into anything I imagined. It is natural for architects to think in terms of *form, function, texture, space, and order*, because these are the concepts that an architect uses to create unique environments. After I took some engineering courses, I began to understand the impact of structural loads and their implications that require the concrete to have minimum depths and maximum spans. Engineers think in terms of *loads, material strengths, and structural layout*, because these concepts are needed to design a safe and durable structure.

Thus the famous challenge: have form follow function.

Concrete is used in all building construction. It may simply provide structure to the building, or be used as an element of statement to define space and/or create unique features of the building or structure. When concrete is used to create anything more than the functional support of the building, it begins to move toward Architectural Concrete.

ACI 303 *Guide to Cast-in-Place Architectural Concrete Practice* is a solid reference that assists the designer when constructing Architectural Concrete in a variety of applications. Below are some highlighted items the architect/engineer may need to consider while working on the design of a CIP Architectural Concrete Wall.



Figure 1: Curved form mock-up for the Urban Carpet Roll a featured curved concrete structure on the Rosenthal Center for Contemporary Arts. Concrete contractor Baker Concrete Construction, Inc.



Figure 2: Cathedral of Our Lady of the Angels, Los Angeles, CA, Mock-up of different formed elements, including angled wall. Contractor Morley Builders

The Mock-up

A mock-up is the best way to prepare for a successful architectural concrete wall project. A mock-up needs to be full scale, constructed on the site by the contractor selected to build the structure, using all proposed equipment, materials, and construction procedures. The mock-up incorporates both horizontal and vertical forms, liners if required, accessories, and all joint details. More than one lift may be required so that horizontal joints and lifting procedures can be experienced and resolved.

The process has to be shown to be repeatable. As shown in *Figure 1*, the contractor was successful with the first mock-up trial, yet it took three more attempts in which several changes were made to create another successful placement. The reinforcing steel should be fully represented in the mock-up so that any congestion problems, concrete placement, and vibrating procedures can be experienced. The structure should be constructed with the craft people that are going to do the final work in the field. This will provide them with invaluable experience and feed back to the construction team on possible improvements.

Architects and engineers should specify a detailed mock-up so that contractors will bid the job expecting to build a mock-up. Also, it is prudent to use the mock-up to determine how a repair would be made if the structure is damaged. The entire mock-up procedure should be reviewed and accepted so the construction team has a clear direction of how to proceed with the project.

Mock-ups are expensive. But considering the information learned and the expense of a tear-out that can occur if the final product is deficient, they can be a good value. See *Figure 2*.

The Right Formwork System

Concrete is basically a liquid that needs to be confined; formwork is the envelope that defines the final shape. How this formwork is detailed, such as where the vertical and horizontal joints are located, and wall tie spacing and hole details, affect the final look. The design conditions impose limitations on the selection of forms and forming materials. Satisfactory results are more likely when the architect and engineer understand the capabilities and limitations of the formwork materials, since the forming system is vitally important to the success of an architectural concrete project. The formwork materials, erection and stripping can cost up to 80% of the in-place cost of structural concrete.

The Right Concrete Mix

The architect and engineer need to consider a concrete mix that will provide adequate workability, flowability, durability, and strength. In addition, the ability to properly consolidate the fresh concrete is critical to the final look.

Getting the concrete into the form is the challenge of the contractor. This job can be made more challenging if the available area at the job site is tight, or the amount of reinforcement required by the engineer to provide adequate strength and ductility leads to congestion. Trial batches are a great way to determine the acceptability of the mixture. These trial batches should be



Figure 3: The mock-up process allowed for a successful installation process, the formwork, concrete mix and construction procedures were resolved. Concrete contractor Baker Concrete Construction, Inc.



Figure 5: The Bungholes in the concrete caused by non-escaping air bubbles on the horizontal portion of the form where used to enhance the architectural concrete



Figure 4: Close-up of bungholes

done prior to the mock-up, and then improved during the mock-up phase. This is the opportunity to adjust the mix and try new materials and admixtures, such as self compacting concrete. The contractor and their crafts people, along with the Ready Mix producer, are usually the best people to propose a concrete mixture that will provide the desired results.

In conjunction with all of the above, developing an early positive relationship with the concrete contractor will help the architect and engineer establishes a cost effective and constructible Architectural CIP project. See Figure 3.

A final thought: concrete is a non-perfect material, so consider enhancing the imperfections in lieu of creating the absolute perfect concrete. See Figures 4 and 5. ■

Dan Dorfmueller is the Sales Manager for Patterned Concrete of Cincinnati, an Architectural concrete flatwork company. He is a consultant/educator for clients around the United States. He is Chairman of ACI 303 Architectural Cast-in-Place Concrete and works on many other ACI national committees. He graduated from the Department of Architecture at the University of Cincinnati in 1977.