PCI Precast/Prestressed Concrete Institute

Architectural Precasters' Design Assist Role

PCI designer's notebook

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Architectural Precasters' Design Assist Role

Design Assist is the procurement method by which, prior to completion of design, a construction contract may be awarded on a best value basis pursuant to which a contractor/subcontractor provides design assistance to the design team and ultimately the owner.

In recent years, a trend toward early integration of the design/build process has developed into what is now called design assist. This process was first used when implementing environmental goals into project planning where the design team, contractors, and owner collaborated early in design. It was quickly established that the benefit of this process is the ability to respond to escalating demands of the clients for faster, more environmentally friendly, and unified delivery of projects with less risk of price escalation. All of these demands require early and intense collaboration of the building team to be successful. Application of this process for architectural precast concrete is the subject of this notebook.

In this process, the architectural precast concrete producer is selected based on qualifications for executing the demands of the specific project, PCI Certification, and the capability for technical expertise to assist the design and construction team in the development of the project. A contract is then awarded and should, at a minimum, include compensation for the design assistance. Significant benefits can be achieved if the contract also includes the supply and installation of the final products.

Benefits of design assist include development of concrete mixtures and finishes during the development process rather than going through a sample approval process after bid and award. Requests for information (RFI) are eliminated with the precast supplier as a participating member of the design team. Precast erection drawings are prepared as design development nears completion leading to a much smoother shop drawing review process. The structural design of the precast panel connections are completed in collaboration with the Engineer of Record to assure coordination with the design of the supporting and bracing structural system. The construction schedule is coordinated with the precast production schedule to assure timely delivery and installation. Any activity that normally occurs after award in a typical bid/build arrangement would be coordinated much earlier when the total precast contract is executed shortly after the design and construction team is assembled.

Precasters can offer detailed expertise that allows for expedited development of the design with engineering innovations and scheduling improvements while enhancing aesthetics and controlling budgets from conceptual design to project completion. Each element can be made as cost-effective as possible, taking advantage of the inherent performance characteristics of precast concrete. The precaster will be able to contribute design and detailing suggestions to ensure that maximum efficiency is achieved at the lowest erected cost. The result should be a functionally efficient and aesthetically pleasing enclosure that meets or exceeds the expectations for the project.

To maximize the potential of architectural precast concrete construction, the following elements should be considered:

- Color and finish selection
- Mold fabrication
- Casting and finishing techniques
- Handling methods in plant and at site
- Connection concepts
- Locations of connections to structure
- Material costs
- Construction sequencing

The following discussion on the design assist process is broken into the traditional design phases of schematic design, design development, construction documents, and construction administration. While the topics are somewhat arbitrarily assigned to a particular phase, specific project demands may require some activities be done at different times, as design assist is a continuous process. The precaster will inform the project design team when particular precast-related design decisions are best made so that unnecessary costs of major changes being made late in the design process can be avoided.

Finally, the precaster should be considered as a partner on the design team. This will impose a responsibility on the precaster to understand related construction materials that must interface with the precast concrete so details appropriate to all the materials can be developed.

Schematic Design (SD)

The precast technical representative must be given enough information to understand the design intent regarding aesthetics and functionality. Schedule, budget limitations, and other design and delivery requirements influencing the façade materials and design should be provided. Significant design information that would influence subsequent decisions might include special fire rating requirements, seismic design requirements, and any requirements for blast resistance.

An issue of particular significance that should be addressed early in the process is the finish desired for the architectural precast panels. The precast concrete supplier can provide a multitude of options for both color and texture, including multiple colors and textures within a single panel. Veneers of clay or concrete thin brick, ceramic or porcelain tile, terra cotta, or natural stone may be included in the finish options. The process should be started early and initial samples should be prepared.

Based on a review of preliminary design concepts, whether in the form of renderings, models, or 2D-3D views, the precaster can help determine the massing of volumes and the elements being considered for architectural precast concrete. The precaster would then be in a position to present the key precast options and communicate benefits that would have a significant effect upon the appearance, function, and cost of the project. In this phase the precaster can present options for loadbearing or cladding elements. Either of these may also be supported by the structure or stacked to the foundation. These are options that have unique considerations for each project and are part of the decision-making process for selection of a structural framing, which may include structural steel, cast-in-place concrete, and precast concrete. Another consideration is whether the panels should be non-insulated (solid) or insulated precast panels. Insulated precast concrete panels maximize the energy conservation benefit of thermal mass while providing an interior surface that can serve as the final inside finish.

The proposed bay spacing and floor to floor heights need to be established in order to determine the optimum panel size and panelization scheme. Panel widths usually are dictated by either architectural considerations or the structural grid of the building frame. The panel cross-section (panel geometry or profile) is generally chosen for architectural or aesthetic reasons and needs to be discussed during this phase to determine the practical aspects of casting of the profiles. Configurations of precast corner units and joint details need to be determined as part of the panelization process.

With regard to panelization, the smaller the precast unit, the greater the number of pieces required for the enclosure. More pieces usually means more handling, more joints to be sealed, more connection points, and higher erection costs. Handling and erecting costs can constitute more than 30 percent of the total precast concrete expense. Therefore, large units are preferable unless they lack adequate repetition or incur significant cost premiums for transportation or erection. The cost difference in handling and erecting a large unit compared to a small unit is generally insignificant considering the increased square footage installed with a large unit.

Repetition should also be considered during the schematic design phase. Repetition has more to do with how intricate features are repeated from piece to piece than with consistent panel sizes. The face features will determine the complexity of the mold used for casting. Maintaining consistent feature patterns and dimensions allows the minimum number of molds to be constructed, but still may allow changes in overall panel dimensions. The precast producer can provide valuable input to the design team to control the costs of mold fabrication.

There is a balance between maximizing potential economy of the façade elements and maintaining the economy of the supporting structural system. The key is coordination of the proposed connection locations and loads imposed on the support system with the Engineer of Record. For example, there will be less impact on the support structure when panel gravity reactions are located at columns rather than on perimeter beams or slabs. Panel connection reactions will often be eccentric from framing centerlines and panel centerlines. Early coordination allows consideration of the impact of such eccentricities on both the panels and on the structure so a final solution can be mutually beneficial to both systems.

Site geometry and topography should be reviewed early. Delivery vehicles and erection cranes will require access around the building perimeter and close to the building perimeter. Close access is a prime requirement of an economical precast solution so the reach required of the crane is minimized. If a tower crane becomes a project strategy, the allowable precast panel weight is likely to be reduced due to generally lower capacities and longer reaches experienced with tower cranes as compared to standard ground cranes. The issues to be considered become even more complex when a tower crane is not located in the center of the building footprint. Because of varying lengths of reach, each elevation will have a different limitation on panel weight. This has a significant influence on panelization and needs early resolution to complete the concept of the architectural design.

Discussion should further consider the challenges, and therefore the costs, associated with installing panels that will be set back from the face of a building under overhanging structure. Such panels may require temporary floor openings, double handling, or special equipment to enable panel installation.

A preliminary budget with appropriate contingencies can be generated during the schematic design phase to confirm that the early decisions are in keeping with the project budget.

In summary, the schematic design phase should be used to evaluate options available to the design and construction team to best leverage the benefits of architectural precast concrete in an aesthetically appropriate, functional, and cost-effective manner. The design assist process becomes more technical in nature, more time intensive, and critically important to achieving the project goals as the team moves into the design development phase.

Design Development (DD)

Based on the options presented and preliminary decisions made in the schematic design phase, further refinement can be accomplished in the design development phase. The following list is both a summary of issues to be addressed and a guide to completion of design development activities relative to the architectural precast concrete.

1. At this point, the preliminary selections of color and texture for the exterior aesthetics can be evaluated for cost effectiveness. Since color can be achieved with various combinations of cement, pigments, and fine and coarse aggregates, cost adjustments can be made to achieve the intent within the budget. There may be several options for adjusting the surface texture should cost adjustments be required. Consideration may be given to using higher cost colors and textures in areas most accessible to the public while using lower cost options that would only be viewed from a distance. The precaster will be of assistance in evaluating the cost impact of these options.

   To assist in establishing the general color and texture, additional samples should be made. Samples at least 4 in. x 4 in. can be used to finalize the color and texture selections. Once the small samples are within an acceptable range, larger samples approximately 3 ft x 5 ft and full thickness should be made to confirm that the mixture proportions, vibration, and finishing techniques necessary to make production-sized units can duplicate the aesthetic qualities of the small sample pieces.

2. The options of nonbearing or loadbearing and supported from the structure or stacked to the foundation must be evaluated considering both architectural and structural design features. Construction scheduling may also be affected depending on the need for grouting horizontal panel joints. The factors to consider include the panel configuration, the building height, the lateral load resisting system for the building, and the gravity loads that might be supported.

   Panel configuration will affect the ability to support gravity loads. Generally, the structural design of panels includes a goal to minimize cracking. If cracking would be anticipated as a loadbearing element, the project would be better served with nonbearing panels. The panel configuration will also affect a decision to stack panels to the foundation. If no direct load path to the foundation is provided, the panels must be supported by the structure whether they are loadbearing or nonbearing. Stacking to the foundation is also influenced by the lateral load resisting system and the building height. Careful consideration must be given to the compatibility of the building drift with a stacked panel arrangement that may not easily accommodate that drift.

3. Consideration should be given to using a precast concrete structural framing system especially when the architectural precast will be used as a loadbearing system. Certain economies can be achieved when the design and installation of the two systems can be coordinated by the precast concrete supplier.

4. A decision whether to use insulated architectural precast panels should be made in the design development phase. This decision affects many of the nonstructural building systems and details. Insulated precast concrete panels can perform all the same functions that could be performed by noninsulated panels. Insulation is provided edge to edge for full continuity of the insulation envelope. Detailing at panel penetrations, such as windows and doors, must be considered to determine whether to interrupt the insulation or cover it with frames or trim. When insulated panels are used, the interior panel surface may be used as the final finished surface. When utilized, the expectation for the interior concrete finish must be understood by all parties.

5. The panelization scheme should be finalized at this point in the project design. Panelization not only expresses the architectural design theme, but also influences production, shipping, and erection strategies based on the final panel sizes. This would also be a good time to check budget constraints that are significantly affected by panel size and count.

   It is also good to start discussions on joint sizes once panelization has been completed. Unless panels are very small, a minimum ¾ in. joint should be used. Very large panels may require larger joints to accommodate tolerances and normal properties for the caulking material.

   Completion of a panelization scheme allows development of other features to be incorporated into the architectural design. Reveals offer a low cost, simple way to break up large wall masses. Reveal patterns must generally be coordinated with jointing so completion of panelization is important if reveals are to be incorporated. Reveals are required to separate multiple colors or finishes within one panel.

6. With completion of panelization and development of the desired panel features, the amount of repetition of patterns can be reviewed for consideration of mold costs. As was discussed in schematic design, minimizing the number of molds required to produce the panels improves efficiency and, therefore, cost. At this

point in the project design development, it may be the last opportunity to adjust design features to maximize repetition.

7. Discussions with the Engineer of Record (EOR) are important at this stage because the structural design scheme is being coordinated with the over-all building design. With panelization complete, final panel connection locations and preliminary connection forces can be determined by the precast engineer and shared with the EOR. The connection concepts should also be established so both parties have an understanding of the load paths and locations of volume change relief.

   Connections cannot be designed without consideration of the interior finishes. The interior drywall finish may limit both the type of connection and its location. In many cases a full-depth blockout down to the top of the supporting beam in a floor slab or recessing of a connection is sufficient to avoid conflict with interior finishes.

   For seismic applications, consideration of interstory drift should start to be discussed. The stiffness of the lateral force resisting system may have to be coordinated with panel layouts so the interstory drift can be accommodated. Using the design assist approach can aid in refining lateral stiffness and connection concepts for best efficiency in both systems.

   Another structural design issue that would be dependent on panelization is vertical stiffness of structural components supporting panels. Where panels are supported on a flexible structure, panel installation tolerances, joint tolerances, and final deflection performance will be controlled by the stiffness of the supporting structure. This is particularly important when supporting panels on a cantilevered structure. In concrete support structures, the effects of creep must be considered to avoid detrimental movements that may not show up for several years. Using the design assist approach allows all expectations to be reviewed with collaborative resolution of issues for best efficiency. Such issues are very difficult to resolve in a traditional design/bid/build arrangement.

   The precaster may identify locations that may require supplemental support, such as projecting brackets, kickers, hardware, and bracing integral to the panel support frame. On steel frame structures, these secondary structural elements may be most efficiently supplied with the structural steel package or the miscellaneous steel package. First, shop fabrication is less costly than field fabrication. Second, a structure that is complete and ready to accept precast panel installation reduces the cost of precast erection. The detailing of these secondary elements would normally be up to the subcontractor engineers. Using the design assist process, this detailing can be accomplished early in the design process allowing for the most efficient material procurement with timing that best suits the project schedule.

8. Jobsite activity requirements and coordination are important to resolve during design development. Coordination meetings should consider all details of safety, loading, types of transportation, routes of ingress and egress for delivery trucks and erection cranes, site access, street use, sidewalk permits, oversized loads, lighting, or unusual working hours. The anticipated production schedule and duration; preliminary delivery schedules; erection methods (craning) and sequencing; the effects of temporary bracing on other trades; onsite storage, if any; and protection, as well as tolerances and interfacing with other envelope materials and interior finishes also should be discussed.

At the conclusion of this phase, the precaster can provide a guaranteed maximum price cost estimate and delivery schedule based on design development drawings with appropriate contingencies. If properly coordinated during this phase, the drawings essentially complete the contract drawings with the details incorporated in the shop drawings.

Other topics to be discussed during design development include:

Design options or panel enhancements to add design interest usually with minimal cost increases.

1. Incorporate more than one concrete face mix with multiple colors and finishes throughout the building façade.
2. Add a special shape.
    a. Design an appendage to an existing mold. Doing so likely will cost less than adding a full form, yet will create a unique building detail. Projections, cornices, bullnoses, formliners, sculpted panels, bottom and/or top returns, and curved panels are the most typical features added to enhance visual interest. These features can be added at a minimal cost if they are used repetitively within a unique mold family.
    b. Set windows back from the building's face at one or two column bays, or at certain levels.
    c. Add a few small ornate pieces at the entrance or as site walls. The small panels will be more expensive per square foot, but a few of them amortized over the entire project will add minimal additional cost.
3. Incorporate thin brick, ceramic or porcelain tile, terra cotta, or natural stone accents into the precast concrete.

Construction Document (CD)

As design development drawings transition into completed construction drawing documents, and as detailed specifications are finalized, the design assist process remains valuable. The precaster can confirm that the refinements of and additions to architectural elevations, sections, and dimensions are in accord with earlier decisions and cost estimates.

The precaster will still provide erection drawings and related calculations showing the loads and final forces from the connections to the structural frame and the connection load locations. These precast drawings and calculations enable the EOR to finalize the structural design of the supporting frame. In the case of a steel frame, detailing of the secondary elements for supporting and bracing the architectural precast panels can be coordinated between the precast erection drawings and structural drawings to avoid duplication of effort. In this phase, dimensional location of slab edges, clearances, specific connection details, and support locations are finalized.

The architectural drawings are completed in this phase. Using the design assist process, details specific to the precast concrete may be completed on the precast erection drawings rather than being incorporated into the architectural drawings. Interfacing details with adjacent materials such as glazing or other façade materials would still have to be included in the architectural drawings so the other trades can be informed of the intended detailing.

The precaster should point out the availability of PCI's Guide Specification for Architectural Precast Concrete on PCI's website www.pci.org. Further, the precaster should review the appropriate parts of the Guide Specification with the architect's specification writer, to help ensure an appropriate comprehensive final specification.

The precast erection drawings should still be reviewed by the contractor, architect, and engineer for conformance to the intent of the project design. In the design assist process, the goal would be to minimize the erection drawing review task since the precaster was included as a partner in the design process. Progress drawing coordination should have promoted resolution of all difficult issues as the process proceeded.

If not already completed, final color and texture selection must be done in this phase. As a last step in the sampling process, the production and approval of range samples is desirable as a visual means of establishing the range of acceptability of precast color and texture variations, uniformity of returns, frequency, size and uniformity of air-void distribution, surface blemishes, and overall appearance. The acceptability of repair techniques for chips, spalls, or other surface blemishes can also be established on these samples.

If the project size warrants, the architect and owner may want to authorize full-size mockups. The mockup, produced prior to start of production with all detail features is an ideal mechanism for coordination of all trades with abutting materials such as windows, caulking, and anchorages.

Construction Administration (CA)

Product fabrication, delivery, and installation will take place during this phase. The design team is invited to the production facility to view initial panels produced to assure that the desired color, texture, and quality are being achieved. Even with all the preliminary preparation and sample review, it is not uncommon to make minor changes once a full scale panel can be viewed. The impact of such changes will be minimized if done at the beginning of casting.

During the project's construction, the precaster frequently becomes an information conduit to assure smooth operations at the jobsite. The precaster will make onsite visits and attend and actively participate in project meetings. The precaster will monitor installation, and offer modifications to field conditions not anticipated. They will also coordinate handling and erecting details as well as the erection plan including the sequence of erection with the general contractor. The precaster will maintain contact with the firms responsible for both transportation and erection to ensure that the precast units are delivered in a timely manner, properly handled, and erected according to design and project specifications.

The precaster will monitor tolerance and alignment issues during installation, if any, especially at the interface between trades. To close out the project, the design team's punch list items will be addressed and completed. If desired, the precaster can suggest a simple program of inspection and maintenance.

With execution of the cooperative efforts described for the design assist process, all project complexities will have been discussed and resolved early in design and planning, eliminating expensive modifications during construction. The benefits to the owner and design team are a cost-effective design with a time- and money-saving schedule along with optimum product quality and appearance. So contact your local precaster to discuss the design assist process and the benefits design assist can bring to your project.

AIA Learning Units

The Precast/Prestressed Concrete Institute (PCI) is a Registered Provider with both the American Institute of Architects (AIA) and the National Council of Examiners for Engineers and Surveyors (NCEES). Continuing education credit is reported to both agencies.

All certificates of completion, for architects and for engineers, will be available from the Registered Continuing Education Provider (RCEP) web site at www.rcep.net. PCI reports data twice per month so you should see your credits appear (and your certificate will be ready) within 30 days of our receiving your completed quiz.

If you are new to the Registered Continuing Education Provider system, www.rcep.net will email you a welcome email when PCI uploads your data. That email will contain your account password. Your login name at www.rcep.net will be your email address, so you must include it when submitting your completed quiz.

Instructions

Review the learning objectives below.

Read the AIA Learning Units article.

Answer the 11 questions at the end of the article and submit to PCI. You will need to answer at least 80% of the questions correctly to receive the 1.0 HSW Learning Units associated with this educational program.

Learning Objectives:

1. Explain the benefits of the design assist process for precast concrete.
2. Describe when it is desirable to begin the design assist process.
3. Understand how to enhance aesthetics and control budgets from conceptual design to project completion.
4. Describe the importance of design assist for saving time and money while obtaining the desired design objectives.

Ascent 2012 – Architectural Precasters' Design Assist Role

Name (please print): ____________________

Company Name: ____________________

Address: ____________________

City: ____________________ **State:** __________ **Zip:** __________

Phone Number: __________ **Email Address:** ____________________

Title: ____________________

Background (circle one): Architect – Engineer – Business – Marketing/Sales – Finance – Other

To receive credit, please submit completed forms to:
Attn: Education Dept. - Alex Morales, Fax (312) 361-8079, Email amorales@pci.org

1. Design assist is appropriate for which of the following delivery methods:
    a. Design/Bid/Build
    b. Design Build
    c. CM-at-Risk
    d. Integrated Project Delivery
    e. All of the above

2. The number of Requests for Information (RFIs) with design assist:
    a. Increases
    b. Decreases

3. The design assist process is:
    a. Intermittent
    b. Continuous

4. Design assist is best started during which design phase:
    a. Schematic
    b. Design development
    c. Construction documents

5. Panel sizes, panelization and finishes are not important considerations:
    a. True
    b. False

6. Proposed connection locations and loads imposed on the supporting structure should be coordinated with Engineer of Record:
    a. True
    b. False

7. Design assist will improve which of the following:
    a. Cost effectiveness
    b. Schedule
    c. Quality
    d. All of the above

8. Insulated, noninsulated, loadbearing or cladding options should be determined during which design phase:
    a. Schematic
    b. Design development
    c. Construction documents

9. Panelization affects color and finish options:
   a. True
   b. False

10. Reveals are a low cost way to break up large wall masses:
    a. True
    b. False

11. The erection drawing review phase is more complex with the design assist process:
    a. True
    b. False

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