lessons learned

Supporting Precast Panels

Understanding Facade Support Requirements

By Thomas McCluskey, S.E.

Precast concrete panels are a façade choice that competes well with the cost of other materials, can be quickly erected, and provides architects with a rich pallet of color, texture, and shape for unlimited creative expression. Too often, however, the structures that must support the façade are designed without adequate understanding of the precast panelization or consideration of the loads to the structure.

Typically, the design of precast concrete panels and their connections are performed by the precast manufacturer. Often the final panel sizes and connections are not determined prior to the bidding phase, and many times not until precast shop drawings are submitted after the start of construction. The author's company has designed the precast panel connections for numerous projects that have required revisions to the structure, the precast panelization, or interior finish dimensions because the precast panelization and support requirements were not well understood by the design team prior to bidding or were not well documented on the contract drawings. A better understanding of the façade support requirements during the design phase can mitigate changes during the construction phase.

Precast Panelization

Maximum economy for architectural precast concrete panels is generally achieved by minimizing the number of panels to be erected, which is to say maximizing panel size. In addition to lower erection costs, larger panels result in fewer panels to be handled in the precast plant, as well as on and off-loaded during shipping.

There are practical limits on panel size based on crane capacities (both at the plant and in the field), site restrictions, and trucking constraints (e.g. weight restrictions and bridge or power line clearances). While larger panels have been shipped and erected, suggested maximum panel sizes are 40 feet long by 12 feet wide and 40,000 pounds. If a project lends itself to panels larger than this, a local precast manufacturer should be consulted. Smaller panels may be required where crane reach is extensive.

Failure to establish an optimized precast panelization scheme and define support requirements in the design stage will typically result in contract language that restricts panelization, often resulting in a loss of economy. There is a balance between maximizing potential economy of the façade elements and maintaining the economy of the supporting structural system. The key is to recognize where localized loads will occur. Often the added cost of local reinforcing that may be required to accommodate larger precast panels will be more than offset by savings that result from erecting fewer panels.

Panel Connections

Typical panel connections are shown in *Figure 1* and generally consist of two load supports and four lateral (or tie-back) connections. Load support and lateral connections are sometimes combined. In addition to connections that attach the panel to the building, mid-span connections (or mid-height for vertically oriented panels) may be utilized to stiffen the panel for lateral loads resulting in thinner, lighter, and more economical panels.

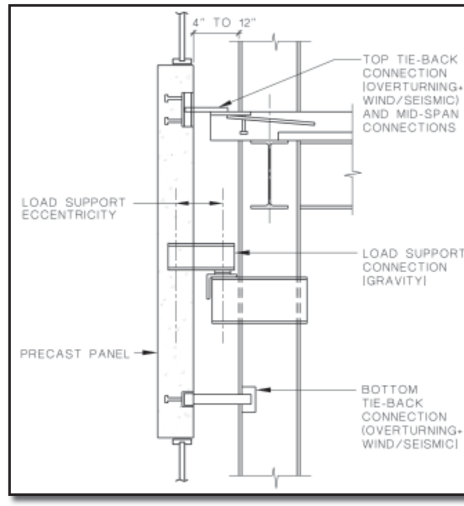

Figure 1: Typical Precast Panel Connections

Precast panels are relatively stiff and typically should be supported vertically at only two points. This comment is not intended for load-bearing precast panels continuously supported by a grout bed on the foundation system, provided the erection limitations are clearly understood (discussed below). *Figure 2* demonstrates how floor slab deflections can change the intended load path for precast support.

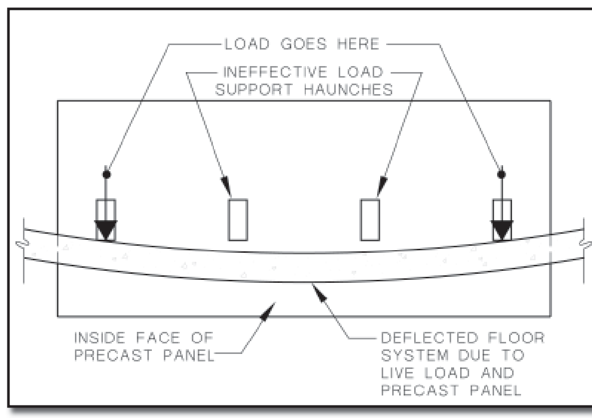

Figure 2: Impact of Floor Deflection

Precast panels are typically leveled by shims, or a similar leveling connection, and the structure must be able to accommodate these concentrated loads. *Figure 3* illustrates an instance where continuous support was assumed in the design of the beam and supporting angle. However, under a uniform load the beam will deflect much more than the stiffer panel, forcing the precast load to the ends of the panel. (Deflection of the beam under roof loads would exacerbate the condition.) For this case, the concentrated panel load at the ends of the panel exceeded the local bending capacity of the supporting angle, requiring re-design of the structural elements.

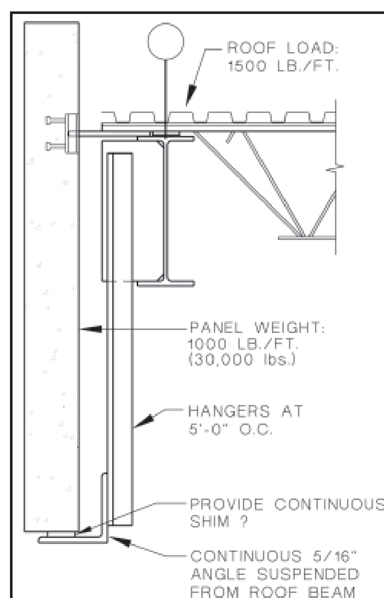

Figure 3: Inadequate Support Detail

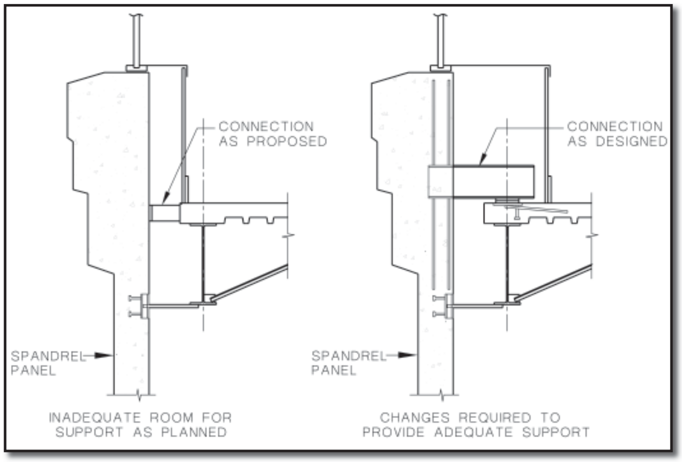

Figure 4: Inadequate Tolerance/Accessibility

Even where deflections of the structure are not a consideration, requirements for redundant support points (e.g. loading a foundation system or masonry wall in a fashion that will assure uniform loading) may be unrealistic. No system of shimming or adjustable support can provide reasonable assurance of continuous uniform support. (It should be obvious, but often isn't, that asking the contractor to shore a panel or suspend it from a crane until a grout bed is sufficiently cured to support a panel is not economical.)

Maximizing precast panel size to achieve maximum economy often results in vertical panels that span several floors. Vertical support should be provided only at one level, as it is not possible to determine the amount of the panel weight supported at each level and the loading would change as a result of panel volume changes (e.g. shrinkage and temperature changes). This may result in local loads to column brackets or floor beams larger than a uniform façade load that the structure may have been designed for. It is important for the structural engineer to recognize when this occurs, and assist in determining whether changes to the precast panelization or to the structure will minimize any adverse impact to the project budget and schedule.

Where possible, the lower two to three stories of panels should be stacked and supported directly on the foundation wall to eliminate load support connections and speed erection. Panels have been successfully stacked higher than three stories, but require special considerations regarding the impact of volume changes and lateral building drift.

Volume Change Considerations

Precast panels are subjected to volume changes due to concrete shrinkage, temperature changes and creep that differ from the structure that supports them. These differences must be accommodated in the panel connections to the building. While elaborate and expensive slide bearings are typically not required, welding long precast panels directly to the structure at both ends should be avoided. In the Midwest, a conservative estimate is to allow for about one eighth of an inch of movement per 20 feet of panel (more in colder climates and less in warmer climates).

Tolerance and Accessibility

The structural system should provide adequate tolerance to allow precast panels to be installed and adjusted to required line, grade and elevation, and have adequate accessibility to make connections. Typically one to one-and-one-half inches should be provided between precast panels and structural elements for steel structures, and one-and-one-half to two inches for cast-in-place concrete structures.

Where panels are sized for maximum economy (large panels), load support connections must be sized to handle significant loads and adequate room must be provided to accommodate the connection hardware. *Figure 4* illustrates a project that required changes in the location of the finish materials and sill extensions to accommodate the panel load support connection. In this instance, no connection information was shown on the contract structural drawings, and the architectural drawings suggested that a 35,000-pound panel be fastened to the light gage pour stop.

In addition to adequate room for connection hardware, space must be provided to complete the connections. Access must be provided to install shims or apply a wrench to adjustable connections, and for welding and weld inspection. Additionally, it is difficult (though not impossible) to tie back to a floor slab where the panel edge is at the floor level. A much better connection will result where the top of a panel is four to six inches above the floor line. *Figure 5* illustrates various conditions that inhibit connection accessibility.

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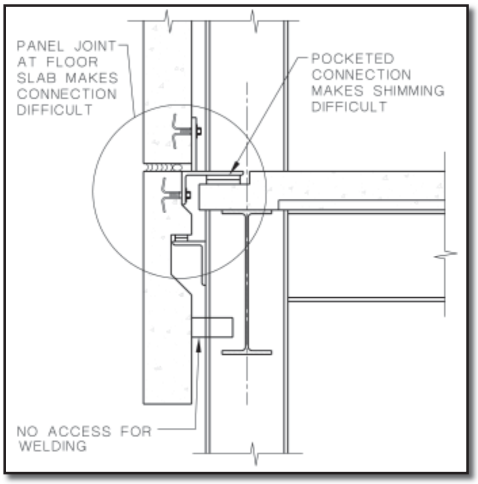

Figure 5: Accessibilty Issue

Temporary Loads during Erection

While "Means and Methods" of construction are typically the responsibility of the contractor, there are some loading conditions that occur during panel erection that should be recognized and accommodated during the design phase.

Load-bearing wall panels on a grout bed can transfer building floor and roof loads uniformly to the foundations, but the foundations should be able to safely support the dead load of panels at local shim stacks. This may require an increase in footing thickness or transverse and longitudinal reinforcing.

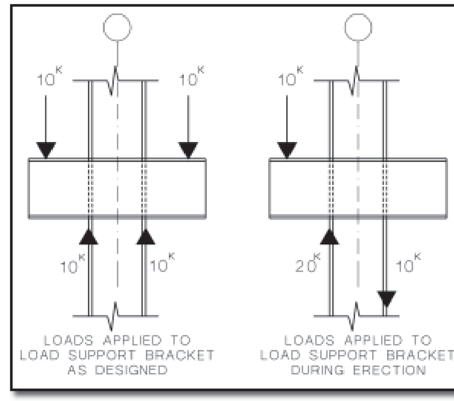

Figure 6: Erection Sequence Loads

Figure 6 illustrates how erection sequence may have dramatic effects on local elements due to unbalanced loading conditions. In most instances, the cost of local reinforcing of the structure will be less than the cost of temporary shoring.

Summary

Structural engineers should become familiar with proposed precast panelization and the magnitude of loads to the structure during the design phase to minimize revisions during construction. Keep the following suggestions in mind:

- Provide for only two points of vertical support
- Allow for volume changes in the precast elements
- Provide adequate tolerance and room for accessibility to connections
- Consider temporary loading increases due to erection sequence where appropriate

There are numerous resources available to the design team. These include the following publications of the Pecast/Prestressed Concrete Institute:

- *PCI Design Handbook* (5th Edition)
- *Architectural Precast Concrete* (2nd Edition)
- *Connections for Precast and Prestressed Concrete* (2nd Edition)

The best source of information is a local precast manufacturer who can provide guidance on panelization, panel thickness and weight, connections, manufacturing economies, crane lim-itations as well as available shapes and finishes.▪

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