Total Precast Systems' Basic Building Blocks

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An architect describes some of the fundamental issues that must be addressed to maximize efficiency and aesthetics

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In the Spring 2005 issue of ASCENT, I made a case for using total-precast building systems, highlighting their structural efficiency, construction speed and design flexibility. This article describes some of the basics of how to design with those systems, introducing some fundamental issues associated with designing in architectural precast from an architect's perspective.

Total precast structures combine a building's exterior finish with its structural system. Two basic types of structural systems can be designed: load-bearing exterior wall panels and load-bearing column and beam (spandrel) panels. Both systems share certain dimensional requirements unique to total precast.

Many building materials, such as masonry units, insulated glass lites or metal panels, are smaller components that arrive at the job site in crates or on pallets and are assembled on site to form larger components. Total precast panels are different, because of their large size and weight. To fully exploit the advantages of the system, the designer must understand these limitations. The delivery to the site of the large sizes and weights of precast components is perhaps the biggest adjustment for an architect unfamiliar with these systems.

Maximum Panel Size

The maximum panel size that can be provided is impacted by local conditions, such as bridge clearances, overhead utilities, site access, and regulatory agencies such as State and Federal Departments of Transportation. Whenever designing in total precast, the architect must engage a local precast producer familiar with the region's unique transportation issues. However, in general, a panel up to 12 feet tall and 30 feet long is a manageable size. In Denver, we have fabricated and delivered panels 45 feet in length. We also have transported panels 16 feet tall using "low boy" trailers equipped with tilt frames.

Maximum Panel Weight

Most flat bed trailers can handle a payload of 40,000 pounds. Equipment in the precast producer's yard varies, but most travel cranes have a handling capacity of 50,000 pounds. The heaviest precast panel I've designed was 22 inches in thickness at maximum projection and tipped the scales at 58,000 pounds.

The panel's location on the building also affects its maximum weight. Panels at the face of a building close to the crane pad can weigh close to the crane's full capacity. However, a panel set back on a roof, such as a mechanical-equipment screen, for example, can

NBSC Headquarters building (opposite page) in Greenville, S.C., was converted to a total precast structure from its original design of structural steel with a brick veneer. The load-bearing precast panels (above) have cast-in brick units and sandblasted precast sills and headers around the precast openings.

be problematic. As the crane's stick lays down to reach over a parapet, its capacity quickly decreases.

Minimum Panel Thicknesses

Precast panels have minimum dimensional requirements as well. The right side of the wall section, or exterior face, is cast down in the form, producing the best possible finish. A minimum 6-inch bearing pocket is required, along with a minimum of 2 inches of cover from the back of the pocket to the finished face of the panel. This minimum coverage allows for proper flow and consolidation of the facing mix under the pocket as the concrete is placed. If any less coverage is used, the pockets might become visible on the outside of the panel. Additional architectural features, such as belt courses or projecting bull noses, may then be added to these minimums, as long as overall weight restrictions are observed.

Thinner panels are possible above and below the pockets. On the spandrel panel, the thickness was reduced to just 6 inches to further accentuate the dramatic fin.

Panel Joints And Location

Large precast panels require significant joints between panels, from ¾ to 1 inch wide. This may seem large, but when compared to the ⅜-inch joint required for masonry construction or the tolerances required for window openings, ¾ inch for a 30-foot-long precast panel is actually relatively small. When considering where to place joints and subdivide the wall surface, consideration must be given to logistics of fabrication, transportation and erection. The designer should engage the precaster early in the process so a strategy for panel joint locations and panelization can be worked out together, avoiding the later need to slice through a highly visible or detailed area at an inopportune location.

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Window Frame Location

Special consideration should be given to the relationship between window frames and architectural features, such as reveals and projecting elements on a precast panel. For example, window installers discourage attempts to align the frame's exterior with a series of reveals. A more successful design features window returns that create a smooth surface against which the installer can set and plumb the frames. More accurate opening sizes are produced by panels incorporating punched openings rather than ribbon windows created by a column and spandrel system. This can be an important factor if the glass units are preordered on the job.

Repetition Advantages

Economy is a key benefit for total precast systems, and repetition helps create that economy. Panel designs that can be repeated many times allow the investment made in fabricating a complex wall or column form to be amortized over a greater number of pieces. Occasionally, due to schedule issues, a precaster may be forced to construct multiple forms to produce the required number of panels within a certain time period. As a designer, such a necessity can often be turned into a benefit, allowing for the creation of a completely different form that adds variety to a façade without the additional cost of another form.

Multiple Finishes

Precast finishes offer wide variety and flexibility. By manipulating color, aggregates, form liners and finishes such as acid-etching, exposed aggregate or sandblasting, virtually any look can be achieved. Thin-brick veneer can also simulate traditional masonry construction, or a combination of two or more types of finish or textures can be created within the same panel. The reader is advised to consult PCI's Designers' Knowledge Bank for more information on this topic.

Samples And Mockups

Various samples, ranging in size and complexity, can help designers, precasters and owners better understand the final product. The first sample prepared is usually a 1-foot square used to explore face mix designs and finishes. After a mix design is approved, six or seven range samples, usually 5 feet square, are prepared at the precast yard and finished using different levels of finish, such as a light acid etch on one end of the scale and a very heavy etch on the other end. From these, three samples are selected: a target representing the optimum depth of etch, as well two representing acceptable higher and lower depths of finish. These panels remain in the finishing yard to help workers gauge the depth of finish for the final panels.

Producing partial or full-scale mockup panels can be a helpful technique. These mockups allow the precaster and designer to explore a series of options for particularly challenging details prior to full-scale production. If approved, a full-scale mockup panel may be reused later in the form of an actual wall panel.

Structural Depth

One of the disadvantages of a total-precast system compared to a steel structure is the larger structural depth required for a given span and the resulting increase in floor-to-floor height. Taller floors increase the amount of exterior wall area required to enclose a given floor plate, which translates directly into increased construction costs for a structure's skin. However, an understanding by the designer of the scope of such increases and strategies to minimize their impact through efficient floor plate design can mitigate this perceived disadvantage.

A typical floor-to-floor dimension for a 45-foot, clear-span steel structure with an 18-inch-wide flange beam averages about 13'4". This distance accounts for a 9-foot finished ceiling height and the required clearances for fireproofing, lighting and ductwork. For a similar span in a total precast system using 24-inch-deep double tees, the required floor to floor dimension is 14'0".

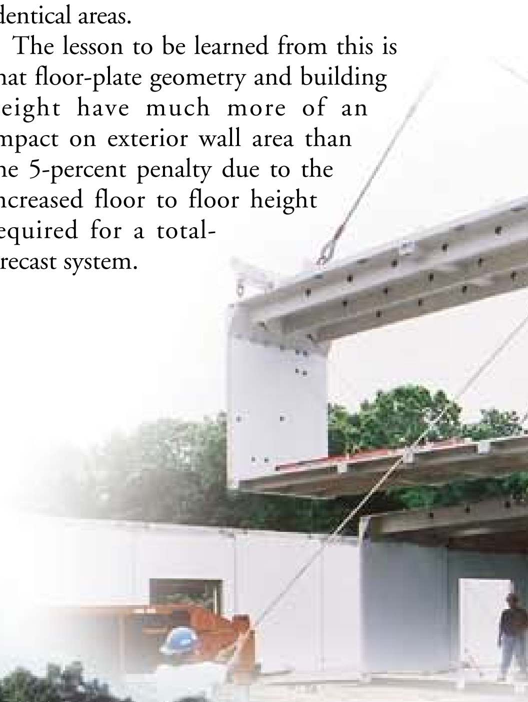
The extra 8 inches of exterior wall required for a mid- to high-rise structure can represent a significant cost increase for additional exterior wall. Overall, it accounts for a 5-percent increase in area over the total-precast system. But that increase must be put into perspective with other aspects of the design, especially floor-plate geometry.

Floor To Exterior Wall Ratio

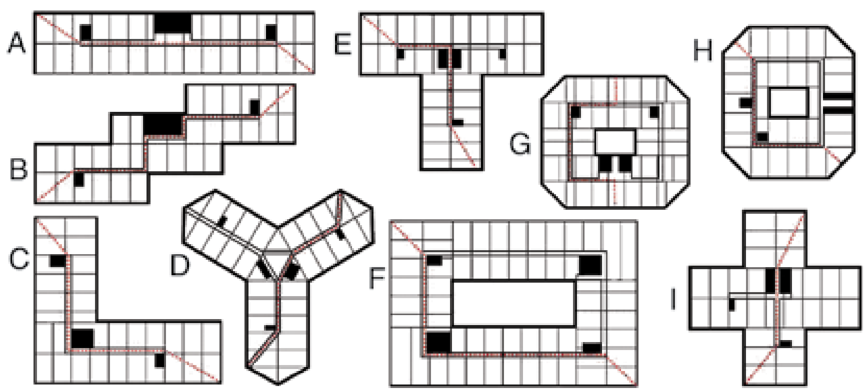
An important consideration when determining the efficiency of a particular structure is the ratio of exterior wall to floor area. The lower this ratio, the more efficiently a particular floor plan shape encloses interior space and reduces the required amount of exterior wall.

As we know, the circle provides the most efficient perimeter defining a given area. Floor-plan shapes that most closely resemble a circle (such as a square as opposed to long, thin rectangles, tees, or ells) offer better floor-to-wall area ratios. Also, buildings that have fewer floors have better ratios than those that have more floors. The difference between these building shapes with varying numbers of floors for a program of 140,000 square feet is shown on the accompanying chart (right), and it amounts to a 29-percent swing in the wall area required to enclose identical areas.

The lesson to be learned from this is that floor-plate geometry and building height have much more of an impact on exterior wall area than the 5-percent penalty due to the increased floor to floor height required for a total-precast system.



Building	Numbers of Floors	Floor Plate Area	Perimeter Wall / Floor Area	Gross Area	Net Area	Net Area / Gross Area	Corridor Area	Walking Distance	
								Corner to Core	Diagonal
A	4	40,000	0.32	160,000	150,200	93.40%	5,900	225	430
B	4	41,300	0.34	165,400	165,400	94.00%	7,200	255	510
C	4	40,100	0.32	160,600	160,600	95.00%	5,700	235	455
D	4	39,300	0.33	159,200	159,200	95.00%	7,200	175	330
E	4	40,000	0.32	160,000	154,300	96.00%	5,700	180	330
F	2	80,500	0.27	161,000	155,300	96.50%	7,900	330	620
G	3	52,100	0.29	156,400	149,000	95.50%	9,000	250	400
H	4	40,000	0.31	160,100	152,500	95.30%	9,200	270	315
I	4	39,900	0.33	156,800	147,700	94.20%	5,100	170	240



Notches And Setbacks

Devising a floor plan that includes notches or recesses is relatively easy in a total-precast system, as long as the load paths from the structure's upper floors are maintained through the lower levels of the structure and into the foundation. However, the designer should be aware that total precast does have limitations when creating setbacks on upper floors or mechanical roof screens in the mid-span of a precast structure.

In a steel structure, a beam can be deepened as required to increase its capacity to transfer a point load to a different path. However, in a total-precast structure with hollowcore plank or double tees, there is a need to provide additional structure, such as an inverted tee or rectangular beam. However, lightweight-steel stud framing for vertical screen walls or sloped mansard mechanical screens can be added over precast roof structure with minimal impact.

Retrofitting Existing Structures

Occasionally, a client will request higher floor load areas on an existing floor plate for file or storage uses. In general, it is easier to increase the floor-load capacity of an existing steel structure than that of a total precast structure, by simply supplementing with additional members. Carbon-fiber technology can increase the capacity of precast structures, but it tends to be costly and not necessarily approved by local building departments. A better idea is to simply add additional prestressing strands to structural members during fabrication, an economical way to increase load capacity and ensure floor plan flexibility.

It is also fairly common for clients to request the connection of two or more floors within a single office suite with a stairway. Again, precast concrete is more difficult to modify in this manner than steel construction. Removing all or part of a double tee or a hollowcore plank in an existing structure is an expensive and time-consuming process. It is possible to squeeze a stair run between the vertical legs of a double tee, requiring the demolition of portions of the tee flanges only.

Only A Start

These building blocks serve only as a starting point. As designers become more familiar with these guidelines and develop working relationships with their local precasters, specific requirement unique to their local conditions will emerge. From an architect's perspective, total precast is an easy medium in which to work that offers an unlimited potential for creativity. ■

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To learn more about **total precast systems**, visit the Designer's Knowledge Bank by clicking on the DKB icon at **www.pci.org** or at your local precaster's Web site. (Adobe Acrobat version 5 or greater required.)