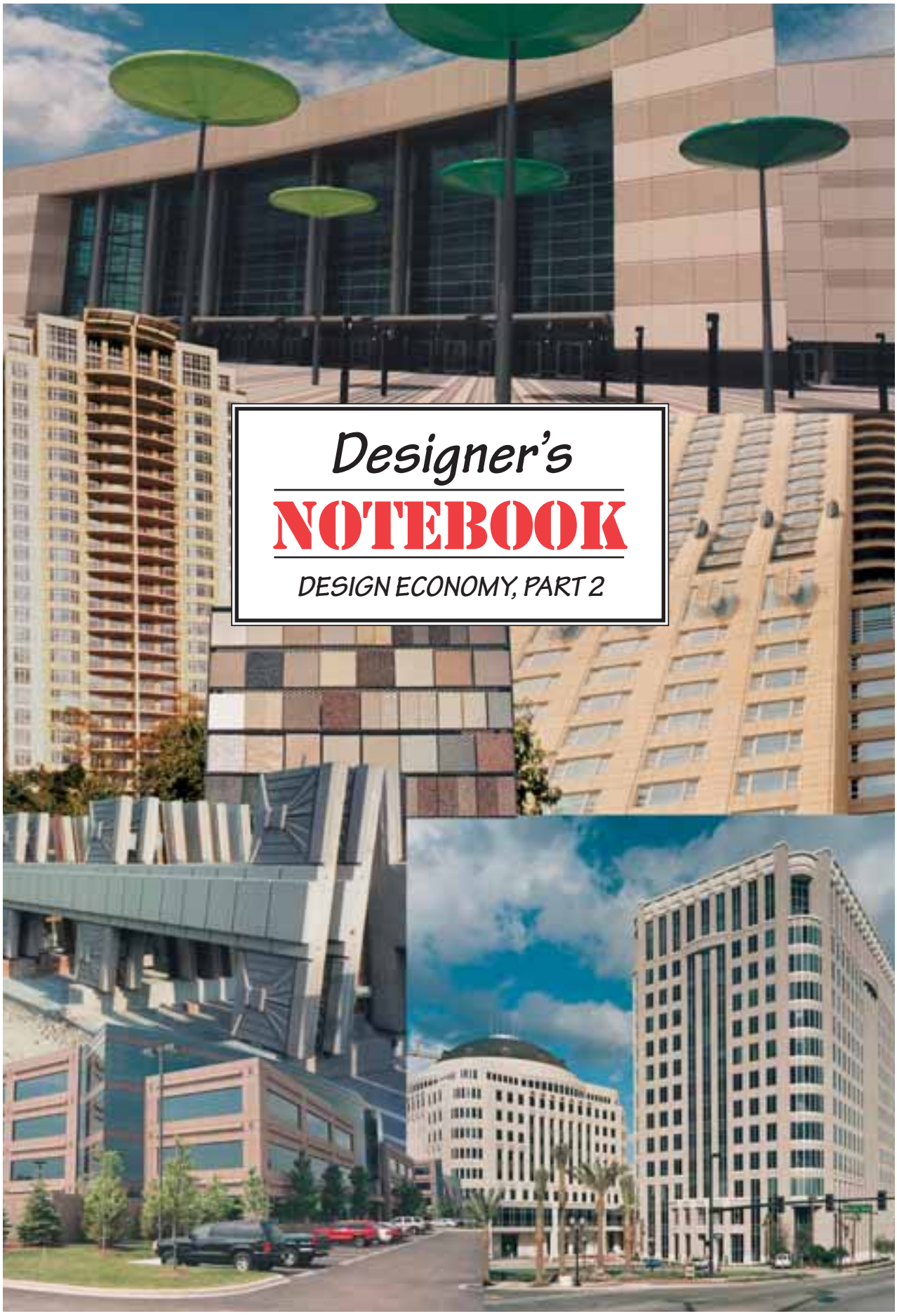


Designer's NOTEBOOK

DESIGN ECONOMY, PART 2

Design Economy – Article XII (Part 2)

PCI's Architectural Precast Concrete Services Committee offers insight on the architectural precast manufacturing process to help achieve design goals and control costs

With architectural perspective by Kevin Cantley, President and CEO, Cooper Carry

Panel Size

Precast pricing is determined primarily by the size of the pieces and piece repetition. Also, precast pricing is more dependent upon large pieces than upon a large project. For example, a 100-piece project of large panels can be less expensive per square foot than a 1,000-piece project of much smaller panels.

The reason piece size is so important is because most every labor function performed by an architectural precaster and erector is required because of the existence of a piece. The more pieces the project has, the more labor hours it will take to engineer, cast, strip, finish, load, deliver and install the panels. Therefore, it is more economical to cover a larger portion of the building's exterior with fewer precast panels.

The Lazarus Department Store Pittsburgh, Pa.

The Lazarus Department Store in downtown Pittsburgh, Pa., was designed to complement its urban surroundings and the city's rich architectural history. Precast concrete panels are a very economical way to cover broad areas, and architectural precast concrete is a durable material that will weather well. The use of architectural precast concrete and glass created a distinctive, urban look which is associated with traditional downtown retailing. — Kevin Cantley, Cooper Carry

Therefore, for economy, it is best to make precast units as large as possible within normal manufacturing and shipping limitations. Handling/erection of precast components constitutes a significant portion of the total precast expense. The cost difference in handling and erecting a large unit versus a small unit is insignificant compared to the increased square footage of a large unit, see Table 3. To be economical a project's average piece size should be at least 100 to 125 square feet and ideally larger than that.

Table 3
Effect of Panel Size on Erection Cost per sq. ft.*

Panel Size, sq. ft	Erection Cost per Piece, $/sq. ft			
	$300	$600	$900	$1800**
50	6.00	12.00	18.00	36.00
100	3.00	6.00	9.00	18.00
150	2.00	4.00	6.00	12.00
200	1.50	3.00	4.50	9.00
250	1.20	2.40	3.60	7.20
300	1.00	2.00	3.00	6.00

* Based on a minimum one month of erection time.

** New York City

Sq. Ft. per piece	Cost per piece	Cost per sq. ft.
100	$3000	$30.00
150	$3500	$23.22
200	$4000	$20.00

Table 4
Lump Sum Price Versus Piece Size

Table 4 gives examples of how, even though a panel's lump sum price increases, as the panel size increases, the square-foot price decreases rapidly. One method of lowering a project's square-foot price is to add square footage without adding pieces.

There is no exact optimum size. Usually the optimum panel size is dictated by size and weight limitations imposed by transport and site cranage capacity. To determine the optimum size of architectural panels, a close collaboration between the designer and a local precaster is required during the early stages of building design. The designer should be familiar with highway legal load limitations, or ask a local precaster. Piece sizes that require highway permits for over height, width, length or weight generally should be avoided. The common tractor/trailer payload in many areas is 20 to 22 tons with a product size restriction of 8 ft. in width, 8 ft. in height, and 45 ft. in length. If a unit will fit within these confines, it can be hauled on a standard flatbed trailer without requiring permits. By use of lowboy or drop deck (step deck) trailers, the height can generally be increased to about 10- to 12-ft. without incurring special permit load costs. Panels up to 15'8" can be transported only on specially built tilt frame trailers but with certain restrictions. However, the shorter bed length of lowboys, drop decks or special trailers may restrict the length of the piece. Most precasters do not have a large fleet of these special trailers, so it is necessary to consult a local precaster to determine what sizes are economically feasible.

For a particular project, designing larger panels, even though they may carry a hauling premium, may be most cost efficient. For example, an office building with 30- by 30-foot column spacing require fewer columns, fewer precast panels and yield a more wide open interior than the same building with 20- or 25-foot column spacing. The cost premium (if any) to haul two 30-foot long panels versus three 20-foot long panels usually can be more than overcome by cost savings in other engineering, production and installation. The typical parking structure may have 60-foot plus perimeter panels that run parallel with the 60-foot long double tee floor system. The double tees can not carry the perimeter panel weight alone. A structural beam would have to be added to support a 60-foot long perimeter panel. Therefore, the added cost to haul a 60-foot long panel is overcome by the beam's omission.

In addition to providing cost savings during erection, larger panels provide secondary benefits by shortening a project's schedule, reducing the amount of sealant needed, and requiring fewer connections. Thus, large units are preferable unless they create significant cost premiums for transporting and erecting.

If a design requires the appearance of smaller units, the inclusion of false joints (rustications or reveals) cast into the face of larger elements can give the illusion of smaller elements. These false joints can be caulked to increase the illusion of small panels.

Material and Labor Costs and Uniformity of Appearance

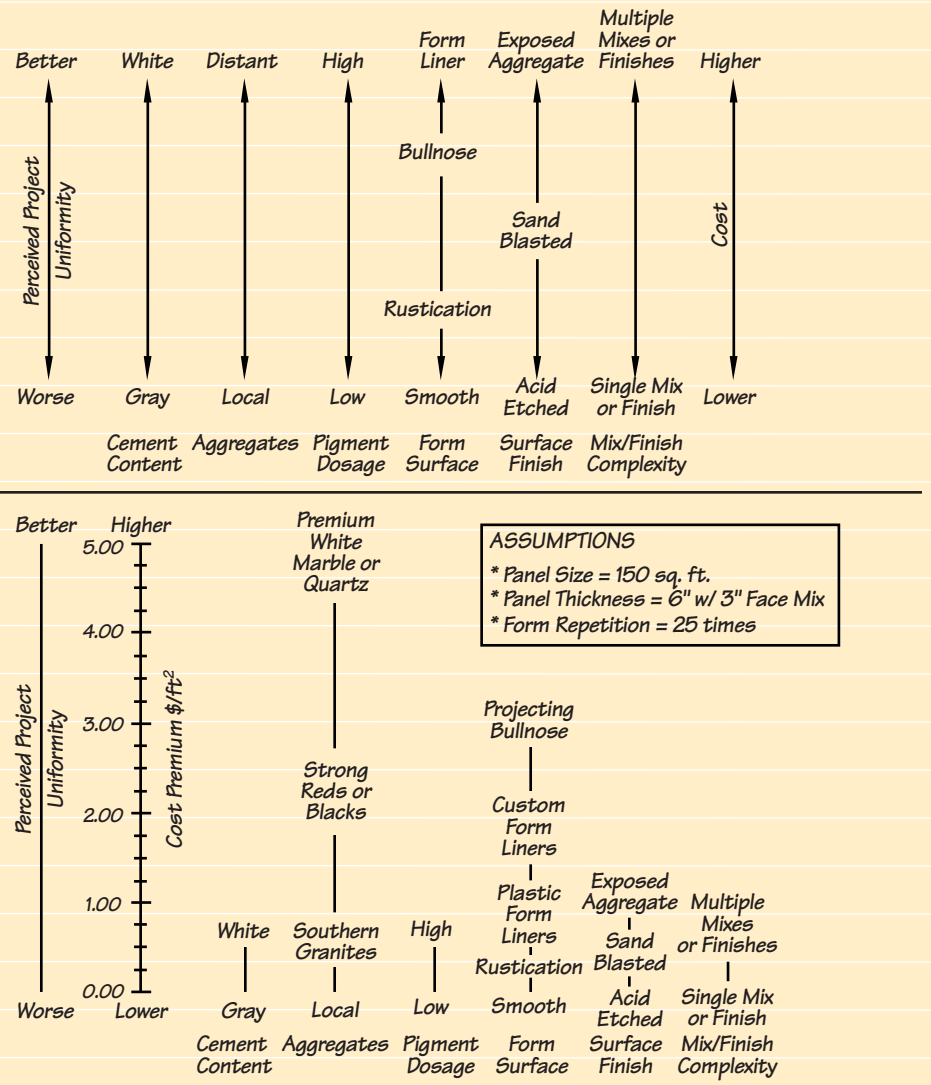
Panel manufacturing costs (materials plus labor) are other major factors in finished precast unit costs. Material factors and labor processes that cost more but at the same time increase visual uniformity are shown in Figure 1. (Assumptions and general comments for this figure are shown in Table 5.) This data is based on the cost structure of a typical Midwest plant. Good product color and textural uniformity at moderate cost can be obtained by the designer by selecting an optimum combination of items shown in Figure 1.

It is difficult to provide extremely accurate cost figures for different precast surface finishes, since individual plants may price them somewhat differently. Some plants, for instance, consider acid-etched surfaces an expensive finish. Some precasters discourage its use, while others may prefer its use to sandblasted or retarded (exposed aggregate) finishes.

Table 5. Factors Related to Cost & Perceived Color Uniformity: Assumptions and Comments

	Assumptions	Comments
General	1. Panel Size = 150 sq. ft.	Costs will generally decrease as panel sizes increase. The most cost effective panels are generally larger than 100 to 125 sq. ft.
	2. Panel Thickness =6" w/ 3" of face mix	Flat panels w/o recessed windows can use less face mix. Panels w/recessed windows, shape, or returns require more face mix.
	3. Form repetition = 25 times	Form costs must be amortized over the number of castings that are made within the form. Always attempt to use the "master mold" concept.
	4. Includes labor, overhead, and profit	
Cement Content		Gray cement is sold for structural applications. The cement manufacturers do not attempt to control the color of gray cements. They do actively try to control white cement color and brightness. Gray and white cements can easily be blended to achieve reasonable uniformity at lower cost. Uniformity normally increases as the percentage of white cement increases.
Aggregates		More expensive and less expensive aggregates sometimes are blended to reduce costs.
Pigment Dosage		Lower dosages of pigments often are used to create subtle shades, but very low dosages will not yield good color consistency. High dosages are used to create strong colors. Often white cement must also be used to increase pigment effectiveness and thus color consistency.
Form Surface	1. Liner covers the entire form surface. 2. Bullnose/cornice assumes a projection of 12" – 18" with some steel forming of the shape.	1. Often partial bands of liner are used to create texture differences within a panel. This is generally less expensive than covering the entire form surface. Remember that liner is a manufactured product and often has size and module limitations that must be considered during design. 2. Smaller, less complex projections will greatly reduce the cost.
Surface Finish		1. Acid-etched surfaces should normally be created by using a white cement base for color uniformity. 2. Because of the fine, flat surface resulting from an acid-etched finish, the panel surface should be broken up with details or rustications to break up the surface mass. Doing so will result in a more uniform color appearance.
Mix/Finish Complexity		Details must be provided at mix/finish changes in order to provide a termination line for a mix/finish change.

Fig. 1
Factors Related to Cost and Perceived Project Uniformity



For reasons of appearance and cost, aggregate choice is an important factor. Aggregate cost is determined primarily by the distance of the quarry to the manufacturing plant. Most aggregates cost the same to remove from the earth and to crush to the appropriate size. The trucking cost from the quarry to the plant is the principal cost variable. In order to minimize mix cost, a designer should discuss aesthetic requirements with a local precaster. Ask the precaster for aggregate color options and their associated cost. The lump-sum cost should be presented on the basis of both per-cubic-yard and per-square-foot.

A particular aggregate's cost should be calculated only for the amount of face mix used. If a gray back-up mix is used, do not calculate this material cost for pricing comparisons. Most precast panels are produced with ½ thickness of face mix (usually 2 to 3 inches) and ½ back mix. Panels with large projections and returns will increase the face mix quantity required. Window setbacks may dictate the thickness of the face mix. As the set back increases so does the amount of the more costly face mix. If the panel configuration is such that little or no back-up concrete can be used, then the cost of the facing aggregate can have a significant effect on the cost of the panel.

Precasters can modify mix ingredients depending on the selected finish in order to lower material costs. For example, some acid-etched finishes will expose only the coarse aggregate tips. Thus, expensive coarse aggregates can be minimized or eliminated since they will not be seen. Since sandblasting dulls the coarse aggregates, less expensive aggregates may be used. Local, less expensive aggregates may look very close to expensive aggregates after they are sandblasted. A bushhammered finish will give a similar appearance to sandblasting without dulling the aggregates. Exposed aggregate or retarded finishes expose the coarse aggregate to reveal their natural beauty. So these mixes require colorful coarse aggregates and thus tend to be more expensive.

By incorporating demarcation features, multiple mixes can be incorporated in a single panel. A designer can also achieve different colors and textures from a single precast mix simply by varying the finish treatment. This multiple-finish technique offers an economical yet effective way to heighten aesthetic interest.

It is desirable to develop the mix design before the project goes out for final pricing. Most precast manufacturers are eager to assist the architect in developing a control sample as early as possible. The best method in selecting a sample is to visit the precast plant to view a multitude of samples and finished panels stored in the yard. Alternatively, a designer can refer the precaster to an existing example and give them a piece of natural stone (or other material) to match.

It is common for a designer to create a new, one of a kind concrete mix. When visiting a plant, the designer can select the cement color, aggregate type and size, and surface finish method/depth. Asking a precaster to make several different samples is common and is encouraged. Once a project's 12- by 12-inch sample for each color and texture has been finalized, the designer should make the sample available to all interested precasters to view and photograph. In some cases, multiple samples are made so that each precaster can have a sample. Listing the exact mix ingredients in the specification is not necessary.

The cost of reinforcement is typically not significant in architectural precast concrete. An exception is the choice of finish of the connection hardware and reinforcement. The cost of galvanized or epoxy-coated reinforcement is substantial, and is not normally required. Additionally, it is not a substitute for adequate concrete cover or concrete quality. Connection hardware cost is governed mainly by structural load requirements, including special structural functions and possible earthquake considerations. Hardware cost may be minimized by making the precast concrete units as large as is consistent with the size limitations discussed earlier in this article. Four lateral and two gravity connections are the minimum required for most precast concrete units regardless of size. The labor cost of producing and handling small individual pieces of hardware normally exceeds the material costs, thus increasing the relative cost of hardware for small units.

- Next: Part 3 of Design Economy