3D ADJUSTABLE FORMING SYSTEM FOR ARCHITECTURAL PRECAST CONCRETE PANEL PRODUCTION

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ABSTRACT

Forming & molding production process complex shape buildings & water wall for the Salt Lake City Library.

•Why 3D forming? We believe the way we addressed the production of highly difficult and varied shapes of Architectural Precast Concrete panels, in a very tight period of time for three different buildings with exterior & interior panels stated a challenge for typical production forming practices.

•Problem to solve: To cast 2,124 panels, where 1,306 for Crescent Building within had 296 different warps & twists according to the different size panels. Those 296 casts required5 to 8 panels a day, with daily changes of the warping forms. This required one panel per mold and296 different molds.

•Approach: Flat or two return panels with acid etch finish were manufactured in regular wood casting beds, Water wall panels used mold rubber liner because of the particular shapes required, but the Crescent Building panels needed a special forming system to cover for each slope & twist required so 296 different molds were needed. For this Crescent Building, we had to design a very unique & special 3D adjustable form in order to easily adjust to the slopes with our everyday casting, suitable for all curved panels.

•Conclusions: This presentation will show the final result where one adjustable 3D form was used for all different shapes & warps in the architectural precast panels required for The Library, avoiding the fabrication of 296 wood forms. This represented sustainable savings of time and money.

Keywords: Aesthetics and finishes, Innovative solutions, Sustainability.

INTRODUCTION

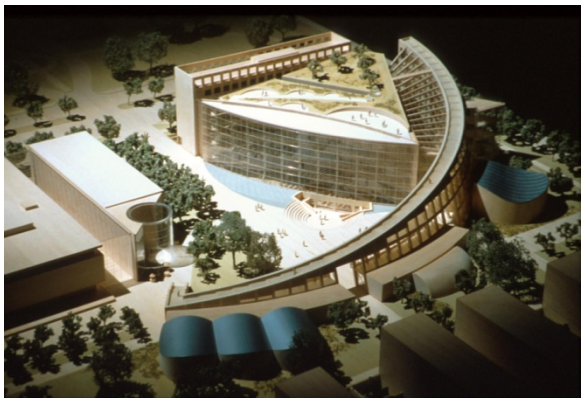
Salt Lake City is the capital and the most populous city in the state of Utah. It is surrounded by mountains about 10,000 feet high (3,500m) that became the framing background for the unique color and shapes of this project, giving a very rich visual sensation that inspired the architects for the design of the Library. With these beautiful surroundings the complex was built in the heart of the city with an area of 240,000 square feet.

The Library complex is basically composed by three buildings five stories high.

The Triangle building, with the most complete collection of more than 500,000 books, subscriptions to over 60 newspapers and magazines, and 163 internet linked computers, becoming one of the largest, if not the largest, graphic novel collection in a public library with several special areas like a kid friendly reading zone.

The Bar building; where the management and administration offices are located.

The Crescent building that shelters many reading areas, coffee shops, stores, and a wide staircase that elevates into a terrace, from where you can appreciate the splendor of the Wasatch Mountains. As general information, the structure includes 44,960 cubic yards of concrete (34,370m3) and 176,368 square feet of glass. (34,370m2)



THE PROJECT

In April of 2001, Architectural Precast Concrete panels were selected for the facade solution and landscaping areas and the contract was finally assigned to a precast producer.

For the owner and architects, this final decision considered the following elements:

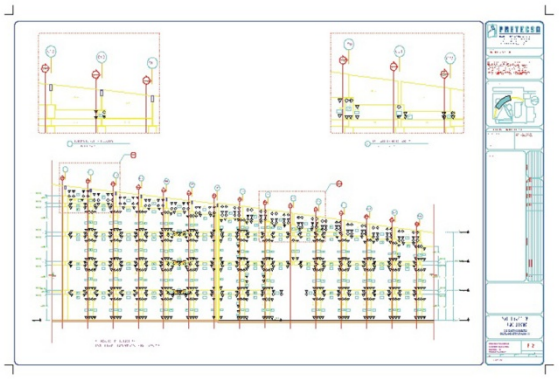
- Experience & Technical qualifications
- Installed Capacity
- Quality control system according to PCI guidelines.
- Price

Real size mockups were made special for the Crescent building in order to check the geometry, right color, texture, dimensional measures, with “0” tolerance allowed.

Only the Bar building and the Crescent building required architectural precast concrete panels and the Triangle building was covered with glass.

The main characteristics are the following:

- Architectural precast concrete panels 4” width with no insulation.
- Color matching the surrounding elements, old buildings and mountains.
- Light to medium acid etched.
- Gap graded mix design with 6 different size aggregates, 5,000 psi with 6% air content. Additives and admixtures, Air entrainment agent, plasticizer, high range water reducer, and micro refined pozzolan instead of silica fume because of its white color.



The final quantity numbers were:

- Bar building, 618 panels / 27,161.73 square feet (1,261,241 lbs)
- Crescent building, 1,306 panels / 54,292.18 square feet (2,318.505 lbs)

- Landscaping: 98 panels / 2,205.95 square feet (138,940 lbs)

Adding to a total amount of 2,124 panels and 87,489.19 square feet with a total weight of 3,994,710.54 lbs.

8,284 engineering and drafting hours were used for the production and erection drawings, and the shop tickets had to show the measures in imperial and metric system.

PROBLEM TO SOLVE

So far everything was normal for a project of this nature.

The Bar building was a conventional structure that contained flat panels, several with window openings, and returns at the top, but the Crescent building presented a very different challenge.

The Crescent building was a complex structure located next to the Triangle building. Begins at the south at plaza level and increases its height towards the north while it varies its inclination, making an angle of 74 degrees west and recovering its verticality at the end of the building at a height of 5 levels.

A total of 1,306 panels were required for in the Crescent building, 154 different panels at the outer crescent and 142 panels for the inner crescent elevation, with a total of 296 different panels with 24 different radiuses (concave, convex and warped) and several other vertical panels of the building as column covers.

In a regular production system, the decision would be to use wood molds, where some simple adjustments solved a typical low repetition, however the shop tickets indicated that each panel was different. To manufacture molds with 296 different variations for a single piece use would be totally ineffective.

The simple idea was terrifying, just thinking of the work hours in carpentry and molds; they would be Titanic, expensive and impossible to meet the required shipping schedule.

In the majority of cases, the difference between curves and twists in each panel because of the varying angle of the building was very small, however based on the architect directive that each panel had to be dimensionally supervised to meet the desire effect over the façade design, we needed to find a new approach.

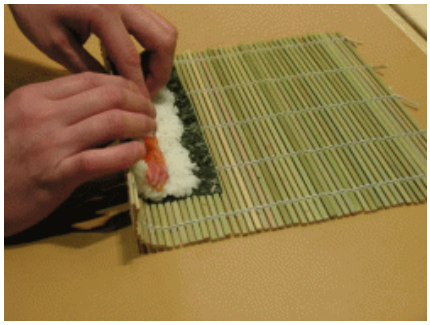
The main problem was trying to avoid at all cost the manufacture of molds for single-use due to the amount of materials, the work man hours and such a short time in schedule delivery. The primary responsibility for the areas involved in the production team was to work in search of a solution to the problem proposed.

We had to seek the way to manufacture “disposable” inexpensive molds that did not require so much time to manufacture or to design a master molding system that we could adjust to the given requirements: one mold for all.

FINAL APROACH AND SOLUTION PROPOSED

With this problem in our minds, we were inspired in a sushi restaurant where a “flat” surface was magically twisted to the required shapes. We were attracted by the principle of individual linear pieces that together formed a flat pane. If this linear element were adjusted at their edges - like the image of a graphic equalizer- the elements combined would result in a 3 dimensional surface.

The idea was that by moving those axes we could obtain all the form adjustments needed for the necessary shapes in a single surface that what would be receiving the architectural concrete.



Apparently with this basic solution as our first step, we found ourselves with the fixed idea of achieving this unique form. Now the second issue was to find a surface that could be bent without breaking, with daily adjustments that could recover its deformation to correct its curvature without damage.

We made several tests with different materials. We thought of a metallic surface made with a thin steel sheet, plastic or rubber surfaces that regained its deformation and not be affected by the release agents or the high temperatures of the concrete when curing. Finally, we found special plywood with excellent characteristics for elastic recovery. With the help of a self-leveling epoxy form coating that made a hard smooth surface on both sides of the plywood, we produced a sandwich effect that gave elasticity and recovery to the wood without damage.

The combination of a linear axle surface with some adjustment in its height and the ideal cover that accepted the required shapes depending on the form adjustment, the 3D form resulted in a adjustable casting bed with unique features for the project: it gave us the possibility to adjust shapes in much less time instead of producing a new mold with impressive cost and time savings.

THE FORM

The final form resulted was a steel structure with “L” shape angles 3”x3” x 5/16”, a 2½” x 2½” steel stud frame base, 5/8” bolts as the “equalizer” adjustment device, and a cover made with plywood with epoxy coating on both sides of the wood, as simple as that.

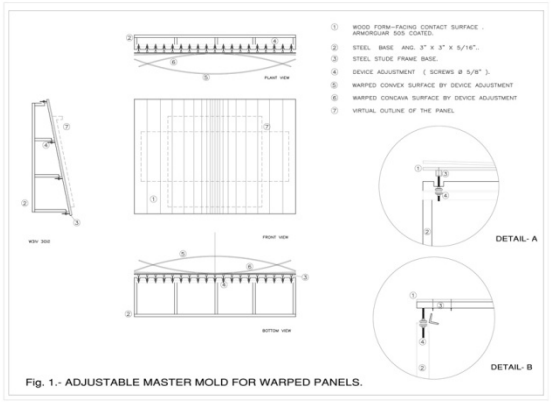


Fig. 1.- ADJUSTABLE MASTER MOLD FOR WARPED PANELS.

LEARNING LESSONS

- Forming:
    - Traditional forms: The first forms for the Crescent building mockup were made with GFRC because of the tight manufacturing schedule, but we quickly changed to the needed adjustable system to solve the required 296 different forms.
    - Adjustable forms: 8 steel & wood 3D adjustable forms were made with the needed wood casting kits (sides, liners, blockouts, etc.) for the entire project.
- Environmental Care:
    - Wood usage: With the use of our 3D adjustable forms instead 296 different shape forms, the amount of wood considered was reduced by 97%, plus equivalent savings in wood resin, polymers and epoxy coatings.
    - Electric tooling time: With many man hours saved without the typical wood forms, power usage represented savings as well.

Project date of completion: January 31, 2003