COVER FEATURE

Loadbearing Architectural Precast Panels Provide Solution for Performing Arts Center Theater Expansion

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A $32 million renovation and expansion of the Times-Union Performing Arts Center in Jacksonville, Florida, was made possible by using loadbearing architectural precast concrete panels for the interior walls of the new theater addition. The massive panels were cast with flat exterior sides and curving, smooth interior faces to act as the acoustical walls for the theater. Erecting the huge panels required a two-stage lift involving two cranes positioned inside the theater. Another key aspect of the project came in adding two post-tensioned concrete balconies. The solid slabs were cantilevered over the ground-floor seating and supported from the precast concrete rear wall of the theater. The use of precast components saved time and labor costs and helped keep the fast-track project on schedule.

The new Times-Union Performing Arts Center in Jacksonville, Florida, has arisen, like the mythological Phoenix, from the deteriorating Civic Auditorium. The $32 million renovation and addition project, which opened in February 1997, updated a variety of spaces and added a $10.6 million Concert Hall into the middle of the facility (see Figs. 1 and 2). Originally designed to be a cast-in-place structure, the design team decided that the significant structural, aesthetic and acoustical challenges would be better met using architectural precast concrete panels.

Fig. 1. The new $32 million Times-Union Center for the Performing Arts in Jacksonville, Florida, includes a $10.6 million concert hall (foreground) consisting of an all-precast concrete structure, including loadbearing acoustical walls for the theater.

Fig. 2. Aerial view showing how the new theater (foreground) attaches to the existing two other theater sections in the building. The rear wall was removed and extended to accommodate the new three-level theater.

These massive panels not only provided structural supports but their interior surfaces were curved and finished with such a high degree of quality that no additional treatments for acoustics or aesthetics were required (see Figs. 3 and 4). But there were major challenges involved in designing and erecting these panels and the other precast concrete components that make the new three-theater complex such a success.

Initially, community leaders had proposed demolishing the existing facility in order to build an entirely new complex. But after lengthy deliberations, they decided instead to upgrade the two existing theaters and add a new 37,000 sq ft (3437 m^2) concert hall with seating for 1848 on three levels. The new plan called for a wedge-shaped section to be removed from the end of the structure and the new concert hall added there, reconnecting to the offices and existing stages on either side of this space (see Figs. 5 and 6).

This new portion of the facility has attracted the most attention and, indeed, has been the focal point for a variety of awards the center has received. The entire structure, with the exception of the roof and foundation, was built with precast concrete structural components. These include curved wall panels in heights up to 78 ft (23.8 m) and varying in thickness from 8 to 16 in. (203 to 406 mm).

Table 1 provides a summary of the type, number and dimensional details of the precast concrete components used on this project.

Fig. 3. The new Jacoby Symphony Hall features precast concrete walls that provide a curved and completely smooth interior surface that offers excellent acoustics. Only a low-powered public address system is used for lectures, with no enhancements needed for performances.

Fig. 4. Designing the precast wall panels that provide the loadbearing and acoustical needs for the Jacoby Hall was complicated by the step-down format that places the stage at the lowest point. The wide panels featured a similar step-down style that had zero tolerance for erection.

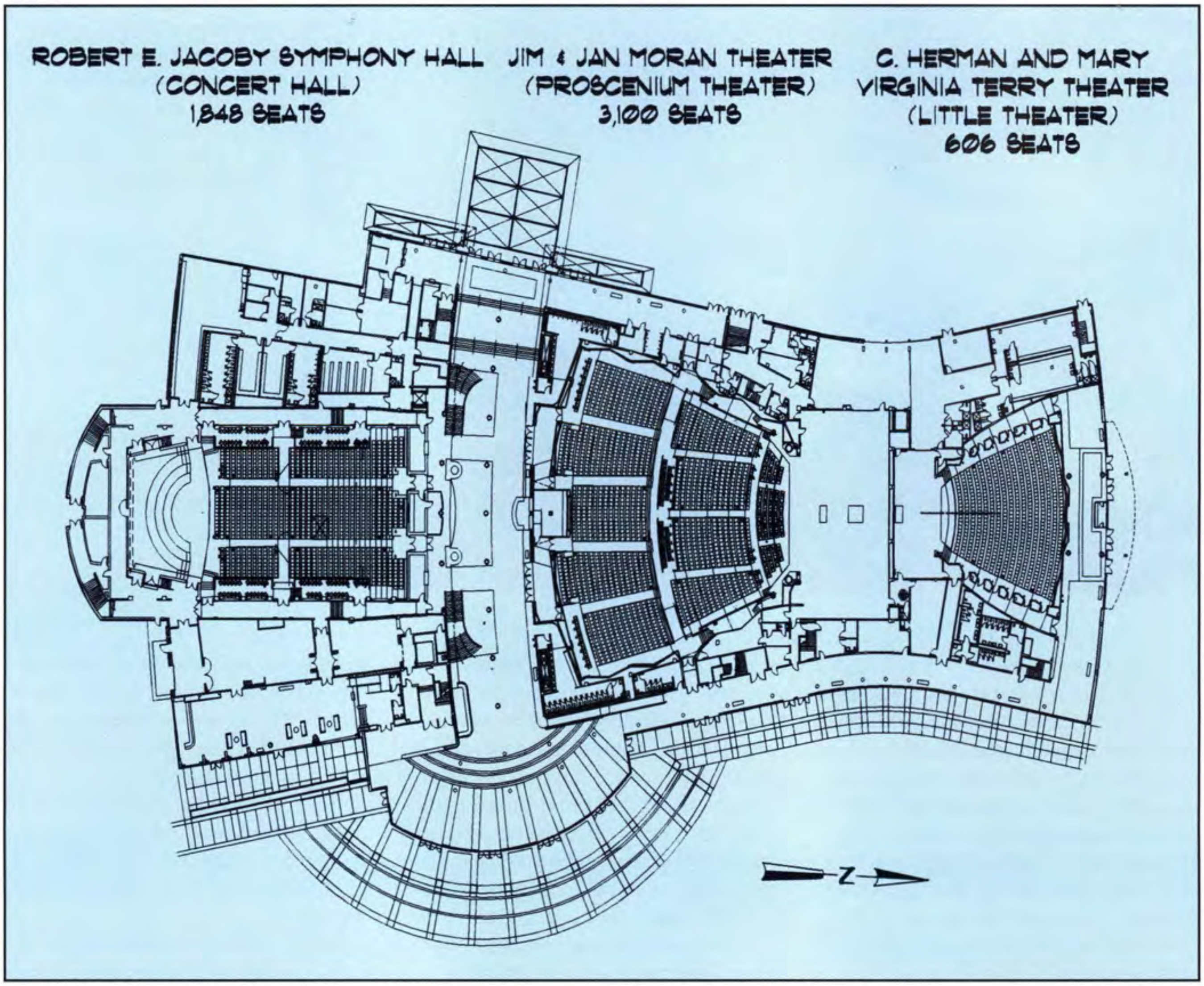


Fig. 5. Floor plan showing how the new construction (left) connects to the existing building. The structure was removed in the lobby of the Moran Theater (center) with new construction added to the left.

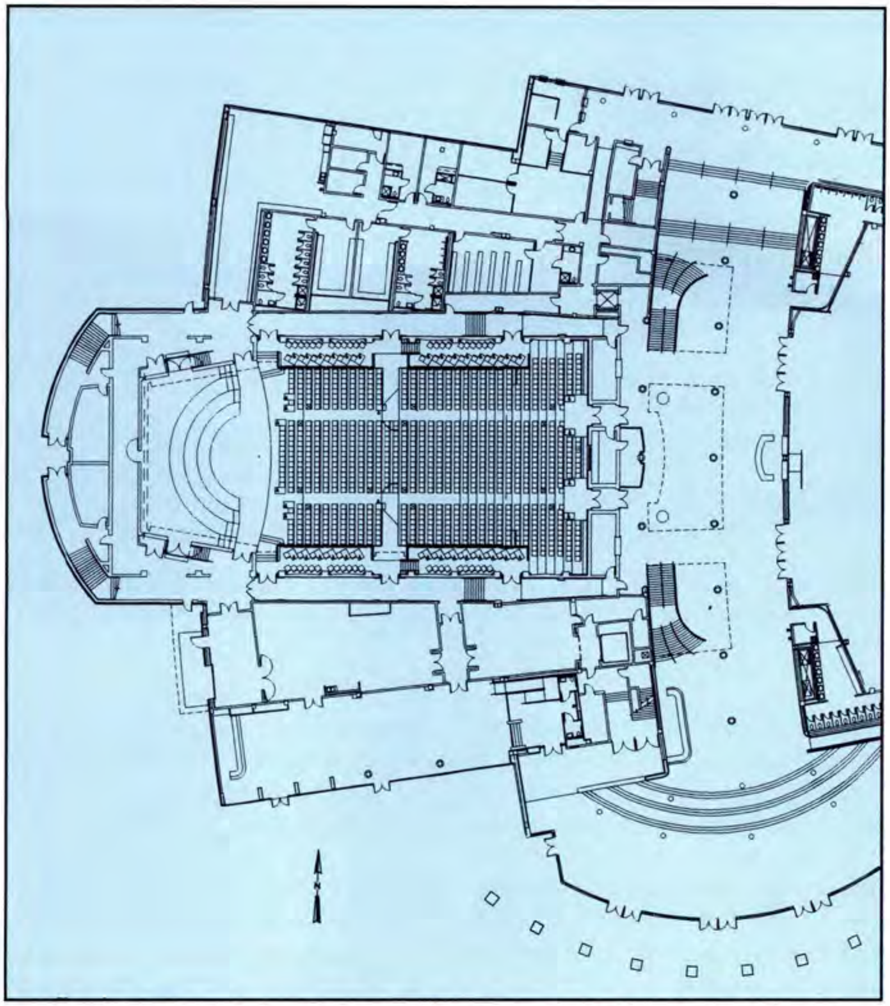


Fig. 6. The theater is designed in a long, narrow format to enhance acoustics. The new theater and office addition fits onto the original building (far right).

THREE THEATERS IN ONE

The new Times-Union Center for the Performing Arts comprises three theaters. These are:

- The C. Herman & Mary Virginia Terry Theater, known as The Little Theater, which seats 606. Work in this area included acoustical improvements and interior remodeling.
- The Jim & Jan Moran Theater, called The Proscenium Theater, which is the largest theater, seating 3100. This facility was reconfigured to allow its floor, supported by piles, to provide a better view for the audience. Balconies also were added on each side, the floor was modified to add handicapped-accessible ramps and the catwalks were redesigned to accommodate new lighting and amplifiers.
- The Robert E. Jacoby Symphony Hall, known as The Concert Hall, which offers a seating capacity of 1848. This theater was added into the existing structure by removing part of the two-story exhibition hall and constructing the three-level theater.

These meticulously cast panels serve as the loadbearing and shear wall structural components as well as the architectural interior finish, meeting both the aesthetic and acoustical requirements for the performances. The hall also includes precast concrete box seats along the sides of the theater, plus two concrete balconies cantilevered and supported off the rear precast concrete walls. These structures had to be designed with post-tensioned components due to the restricted headroom (see Fig. 7).

Table 1. Precast/prestressed components used in Performing Arts Center.

Item	Average length (ft)	Average width (ft)	Average thickness (in.)	Number of pieces	Total square footage
Curved wall panels	65	15	14	22	21,000
Columns	65	4	25	22	—
Roof beams	25	2	36	14	—
Shear wall panels	41	10	14	24	9100
Radius wall panels	62	8	10	8	4200
Miscellaneous wall panels	31	9	10	25	7400
Balcony beams	10	1	24	50	—
Hollow-core slabs	—	—	6	—	9122
Hollow-core slabs	—	—	8	—	12,600
Solid slabs	16	6	6	46	4215

Note: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 sq ft = 0.09290 m^2.

CONCEPTUAL DESIGN

The hall was originally designed as a cast-in-place structure, but as the design team began mapping out details and considering their options, it became apparent that there would be tremendous obstacles to overcome in achieving the needed design requirements with cast-in-place concrete due to the size of the pour. The exacting acoustical requirements would have been difficult to achieve with cast-in-place concrete, resulting in a number of cold joints from jumping the forms, producing acoustical anomalies and adversely affecting the aesthetics of the finished walls. Because the basic design for the new hall is modeled after the concert halls of Vienna, Austria, with a narrow, linear shape, the thickness and mass of the side walls were critical.

As a result, the team contacted the precast concrete manufacturer, Gate

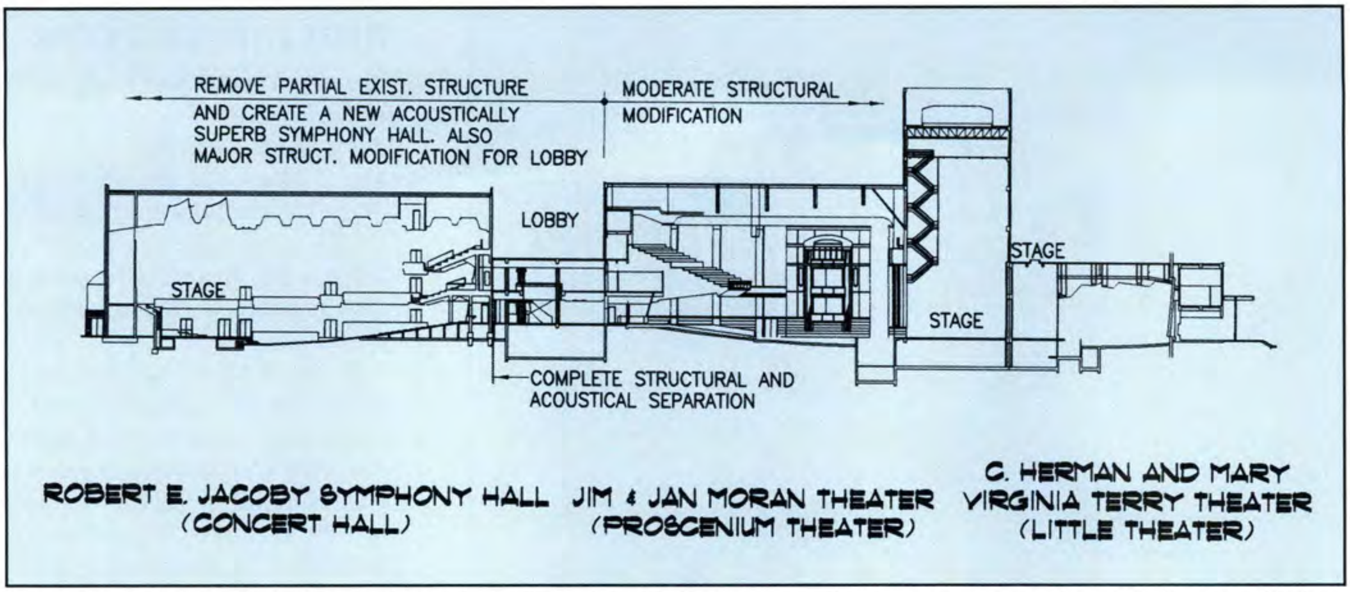


Fig. 7. Longitudinal section showing the grade levels and heights for the new and old structures. Note the two balconies added to the new section at left, which cantilever off the rear wall.

Concrete Products Company Inc., of Jacksonville, Florida, to discuss other options. The precaster made a number of suggestions and the designers adapted the plans to include precast concrete elements. Because design documents already had been completed for a cast-in-place structure, the contractor was given the choice of format to use and selected the precast option.

The precaster's nearby location and experience with large structural components as well as quality products were key considerations in deciding to use the redesign for the precast concrete structure. In fact, had the team initially had the option of using precast concrete and created the design with that in mind, even more benefits might have resulted.

The precast option addressed more than the structural support and acoustical needs for the new concert hall. Although material costs were slightly higher on an in-ground basis, savings accrued in several ways that more than made up for the difference.

First, because casting of the components could begin while excavation and foundation work progressed, the panels were ready for erection earlier than would have been possible with cast-in-place concrete. This proved advantageous because the amount of foundation work required

Fig. 8. Using precast concrete panels allowed the new theater to be enclosed much faster than would have been possible with other systems. It also provided the strength and thin profiles required to add two balconies into the space and reach the necessary seating requirement.

was considerable and using other options might have delayed the erection schedule.

Second, because such large panels were used, the number of picks along with connection time and related elements were reduced. Further savings also resulted from keeping forming and pouring equipment off-site and eliminating the need for a steel contractor working on-site concurrently. The final quality of the panels was also superior to what would have been achieved with any other design, especially in attaining the necessary fire rating.

Constraints at the job site itself proved challenging and required careful consideration, especially in preparation and determination of crane locations. The building is situated on an old shipping channel of the St. Johns River that is filled with approximately 70 ft (21.3 m) of silt. The rear wall of the balcony area for the theater, which would be subject to tremendous lift, was to be located in this area (see Fig. 8). To overcome this, tension piles were integrated with the precast wall panels.

In addition, one end of the concert hall extends out from the original endwall of the removed exhibit hall area. This element would interfere with the city's 12 ft wide, 7 ft deep (3.66 x 2.13 m) storm drainage culvert near the surface. To alleviate this, an array of shallow grade beams was designed to bridge the culvert to receive the massive loadbearing precast walls. Additional 26 to 90 ton (23.6 to 81.6 t) tension piles were provided in this area to balance the intermingled grade beams.

Another key concern arose in finding the best way to minimize noise from air flow during concert events. A concrete air tunnel with a large cross section was cast below grade for the low velocity/high volume HVAC system. The tunnel's interference with the existing and new pile systems also posed a problem. The new pile foundation was engineered to interact and complement the existing one. To receive the new heavier structure, substantially higher capacity piles were strategically located to supplement the existing piles.

Fig. 9. The precast structure comprises a variety of components, including loadbearing panels that were curved on the interior for proper acoustics and flat on the exterior. These exterior walls were furred out and clad with drywall to serve as the corridor outside the theater.

WALL PANELS POSED GREATEST CHALLENGE

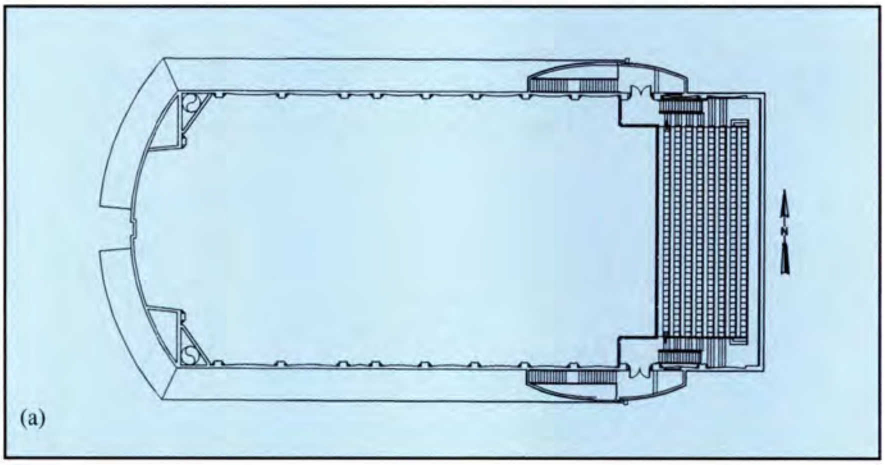
The interior loadbearing precast panels represented the greatest challenge of the project because they had to meet structural, aesthetic and acoustic requirements, with tight tolerances. The panels stood 63 to 78 ft (19.2 to 23.7 m) tall and measured 16 ft (4.88 m) wide, with weights of as much as 50 tons (45.4 t).

The panels vary in thickness from 8 in. (203 mm) at their edges to 16 in. (406 mm) at their centers, producing specifically shaped forms to reflect sound while providing architectural elegance. The supporting columns, which also stand 63 to 78 ft (19.2 to 23.7 m) tall, measure 25 in. (635 mm) deep at their centers and stair-step back on each side to meet the 8 in. (203 mm) width of the panel edges.

Because the panels used in the theater structure had to be thicker and more massive than more typical architectural precast panels in any design scheme to meet the strict acoustical needs, the loadbearing design saved cost. Using this thickness to provide the structural support eliminated the need for a costly steel framing system on which to hang the panels.

This design also allowed the columns to immediately serve as a support structure for the roof. Once the columns were set, a large roof beam was placed perpendicular to the columns on top of them, helping to tie the panels to the roof truss. The panels also were welded to the foundation, creating a connected structure early in the process.

The panels required a perfectly smooth finish on the interior, radiused side, both for acoustical reasons and to provide a proper aesthetic look. Because the panels would be completed with light fixtures washing down their face, any imperfections would be magnified and made apparent to theater patrons. A number of mockups of different form finishes were furnished before a final decision was made.



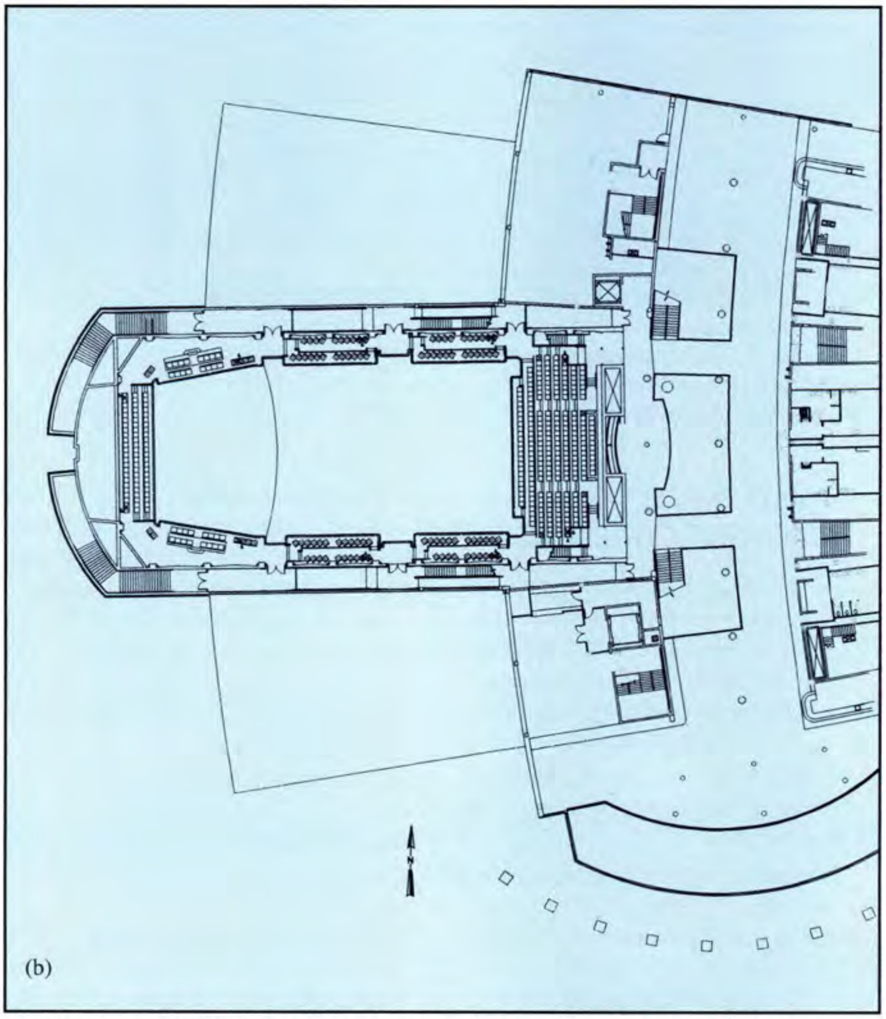


Fig. 10. These drawings show how the upper (top) and lower (bottom) balcony structures align within the theater.

The precast components were cast with custom-made steel forms and were so finely finished that they were simply painted with no other finishing touches added. In fact, the finish was so smooth that when the painters conducted adhesion "pull" tests on sample panels, they found that the paint would not adhere to the panels because of their smoothness. The painters ultimately had to give the panels a light acid-etching to allow the paint to adhere. The exterior sides of these panels were cast flat and were furred out and hung with drywall to act as the inside wall of the corridor running outside the theater area (see Fig. 9).

Delivering such large panels proved to be challenging. The precaster had two options for delivery: barging them down the river or trucking them over surface roads. Ultimately, the precaster decided on truck delivery, which required making modifications to their existing tractor trailers. The changes included adding racks to provide flexible support for the substantial weight as it traversed the streets. Special permitting was required for many of the deliveries. Extra care was taken during loading and unloading to ensure no damage was done to the panels, as their high-profile positioning meant patches would be quite obvious and objectionable.

TWO-STAGE ERECTION PROCESS

Once at the site, the panels had to be erected with precision due to the limited work space available. The panels were erected using two cranes. A large 250 ton (227 t) crane was centered in the theater space with a smaller rig adjacent. This provided access to the erection space but limited the swing and pick accessibility, requiring a two-stage erection process.

Each panel was backed up to the large crane, with the panel's bottom and middle at about the two-thirds point, then connected to the crane. The panel's top was hooked to the smaller crane. The two cranes then lifted the panel up off the truck, which was driven out from underneath the panel. The panel was then rotated into a vertical position and its top was rehooked

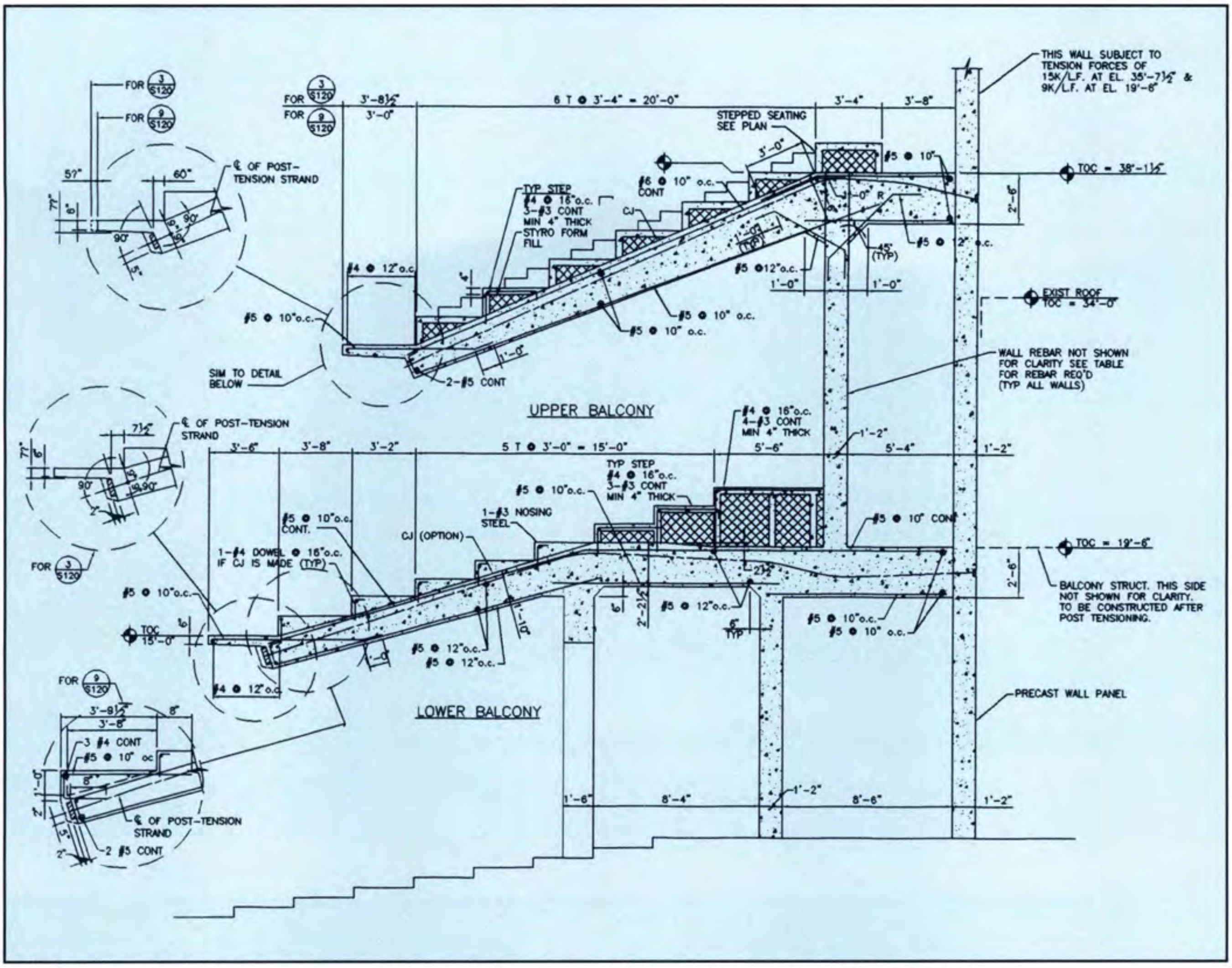


Fig. 11. Sectional drawing showing how the balconies were cantilevered off the rear wall of the theater.

to the large crane, which hoisted it into position.

Setting the panels onto the grade-beam system was complicated by the panels' stair-step bottom profile. This design required taking many field dimensions and ensuring all pieces aligned properly between the cast-in-place foundation and the concrete walls.

Two connection systems were used. Panels acting as shear walls were designed using NMB Splice Sleeves, a connection using a steel bar inserted into a matching sleeve that is then pumped full of high strength grout. The panels not accepting the shear load were set on shims and welded to the base.

The entire exterior structural system was designed to tie together as one unit, completely isolated from the adjacent structure by a 1 in. (25.4 mm) sound isolator to abate external vibration and sound transfer. This meant

Fig. 12. Post-tensioning tendons and mild steel reinforcement for balconies.

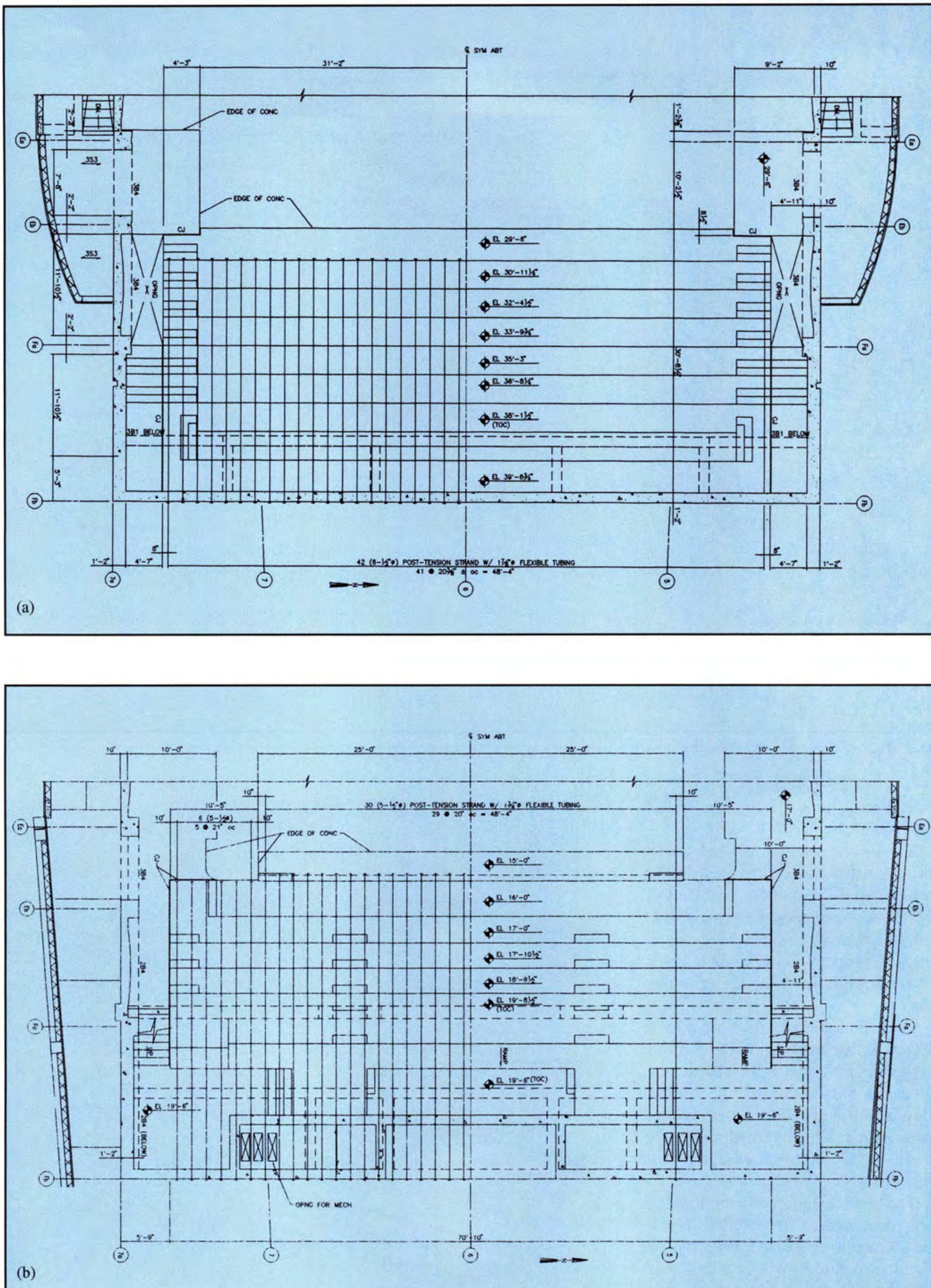


Fig. 13. Post-tensioned strand plans for the upper (top) and lower (bottom) balconies in the new theater.

that until the roof was poured and the system was completed, the structure was exposed to wind loads and required temporary bracing.

A tremendous amount of engineering work was required to design this temporary bracing system, which remained in place for two months during the hurricane season while the "wedge" of the stage construction was inserted into the existing building. To adequately support this system, holes were cut into the original building adjacent to the new structure and W14 beams and other elements were installed to hold the loads temporarily and provide resistance to the wind load until the new roof diaphragm could be cast-in-place.

One panel was left out of the erection sequence to give the crane an exit space. Once the crane was removed, this final panel was erected from the exterior. This leave-out space also allowed the temporary structural framing to be pulled out once the roof was cast. If cast-in-place concrete had been used for the walls, it would have taken far longer to prepare for the castings of the roof. Similarly, the use of the panels made it easier to attach catwalks, acoustical banners and other necessary elements to the theater walls.

CANTILEVERED BALCONIES

Another key challenge came in adding the two balconies required to meet the desired seat count (see Figs. 10a and 10b). Due to the limited headroom, designers used cantilevered post-tensioned concrete solid slabs to provide the 25 ft (7.62 m) long balconies (see Fig. 11). These slabs were supported with high tension tendons through precast columns and beams (Figs. 12, 13 and 14). The post-tensioning tendons were cast into the cantilever beams and threaded through sleeves in the precast columns and tensioned from the back side of the column prior to placement of the flooring units.

These slabs varied in thickness from 18 in. (457 mm) at the free end to 30 in. (762 mm) at their fixed point. Due to the long overhang and the short anchoring distance from both balconies, the back wall at the north end of the concert hall was subject to tremendous uplift forces. To accommodate such high masses, thirty-four 90 ton (81.6 t) tension piles were added.

Fig. 14. The balcony slabs were cantilevered and connected to the back wall of the theater, which was also made of precast concrete.

Tying the finished theater to the existing building was fairly routine. The only concern came in tying the upper edges of the new precast panels to the existing structure and adding increased bracing to take the wind loads required by the newly revised building code. Other structural work completed on the facility included modifying existing rooms to accommodate new elevator openings and new equipment loading.

Because the project architect had designed the original theater, matching the exteriors was simplified. The existing structure featured a yellow-brick exterior that the designers decided to complement rather than attempt to match. This was accomplished with an exterior finish painted in the same buff color as the original building. The combination of two finishes in the same color proved to be a success in matching the two different structures (see Fig. 15).

To help direct visitors to the proper location in the three-theater complex, the exterior marquees on each building façade also were redesigned. At the south marquee, the existing concrete canopy was replaced with a 9000 sq ft (836 m^2), 35 ft (10.7 m) high addition to the existing lobby leading to the riverfront garden. Two marble Greek columns, each weighing 15 tons (13.6 t), adorn the lobby. The columns were hauled in and placed on the basement's slab. Supporting the columns was made more difficult because installing an additional pile was not possible.

At the north marquee, the existing concrete canopy was replaced with a 3600 sq ft (334 m^2) skylighted drive-through canopy. A row of compatible canopies were also erected for the ground and transportation waiting area on this side. On the east side, the existing concrete canopy was replaced by a new version in a crescent shape. Two new pedestrian bridges with elegant, curved staircases were constructed to connect the new Concert Hall with the Proscenium Hall, the largest of the three theaters.

CONCLUDING REMARKS

The result of this close attention to detail is a theater complex that has received high acclaim from the city, concert-goers and design peers. Acoustics consultants have been pleased with the

Fig. 15. Large glass areas set into the precast concrete structure of the new theater section in the center offer a dramatic and eye-catching view at night time.

design and responsiveness, which always remains an unknown until it can be tested after completion. When they verified the attainable levels against the design requirements, they were very pleased with what was achieved. Amplifiers are not required to reach the furthest reaches of the concert hall and only a low-powered public address system was installed for announcements and lectures.

The city administrators were pleased as well. The $32 million project was completed on time and under budget, exceeding expectations. Carl Cannon, publisher of the *Florida Times-Union* and a community leader, compared the project to "an $80, $90 or $100 million facility when one counts land, location and three different halls."

Design professionals have also shown their admiration. The project has received a variety of awards, including being named a Finalist in the Engineering Excellence Program sponsored by the American Consulting Engineers Council. It also was given a State Award by the Consulting Engineers Council of Georgia in its Engineering Excellence Awards Program, an Eagle Award for Excellence in Construction by the Associated Builders & Contractors Inc., and Project of the Year Award by the First Coast Chapter of the Associated Builders & Contractors Inc.

Precast concrete played an integral role in creating a first class structure and in getting this project finished on time and within budget. Since opening 2 years ago, the new theater complex has fulfilled its promise. The theater-going public is very happy with the facility. Indeed, the new facility has become a popular meeting place and a much admired landmark.

CREDITS

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Precast/Prestressed Concrete Form Manufacturers:

- Hamilton Form Co., Fort Worth, Texas (curved panel forms)
- Bonnybrook Custom Steel Forms Inc., Calgary, Alberta, Canada (column forms)