LOUISIANA SPORTS HALL OF FAME & NORTHWEST LOUISIANA HISTORY MUSEUM

By David L. Kufferman, P.E.

Figure 1. Cast stone entry façade. Courtesy of Timothy Hursley.

In the small Northwest Louisiana town of Natchitoches, there now stands a striking building to house both the Louisiana Sports Hall of Fame and the Northwest Louisiana History Museum. (*Figures 1* and *2*) The Hall of Fame, created in 1958, honors athletes who are either from Louisiana or have played for teams based there. Its roll of inductees includes football greats such as Y.A Tittle, Terry Bradshaw, and Archie Manning, basketball stars such as Pete Maravich and Shaquille O'Neill, and many other standouts from the sports world. The Northwest Louisiana History Museum examines how diverse groups of people, including the Caddo Indians, French and Spanish settlers, and free and enslaved Africans created the unique culture of the region. Natchitoches is the oldest municipality in the state, founded by the French in 1714.

The Sports Hall of Fame had been housed in a section of Northwestern State University's Prather Coliseum since 1971. In 2003, the Hall of Fame was accepted into the Louisiana State Museum system, which set the stage for the creation of a new museum building. The project was funded with a $12.6 million construction budget in 2007. Trahan Architects of New Orleans were ultimately selected to design the building. Construction began in 2010 and was completed in 2013.

The Hall of Fame/Museum is a two-story box-like structure enclosing about 28,000 square feet. The structural system of the building is a braced steel frame with composite concrete metal deck slabs. The ground floor is a slab-on-grade. The building is founded on auger cast piles. Lane Bishop York Delahay, Inc. (LBYD) of Atlanta, Georgia was the structural engineer for the building frame.

The most distinctive feature of the building is the expressive undulating cast stone surface which defines both its interior and exterior. The architect wanted the building to evoke the meandering rivers of

Figure 2. Cast stone atrium. Courtesy of Timothy Hursley.

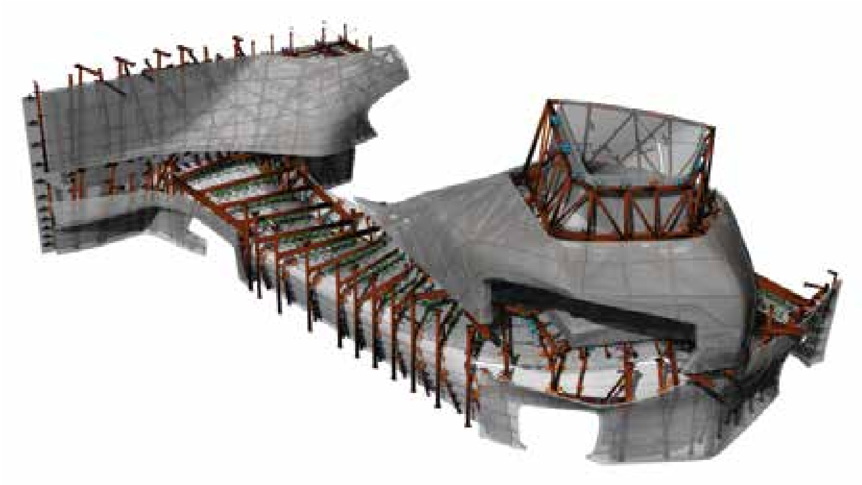

Figure 3. Complete Rhinoceros model of cast stone and SSSS. Courtesy of Method Design.

the region. David Kufferman Structural Engineers was awarded the task by Advanced Cast Stone, the cast stone fabricator, of designing the shaped surface supporting steel structure (SSSS) for the cast stone panels.

The cast stone surface can be described as a 1,051 piece three-dimensional jigsaw puzzle that weighs about 700 tons, with each piece separately made according to its own unique, digitally created pattern, therefore having a different size and shape from any other piece. At the beginning of the design process, it was realized that the puzzle could only be properly assembled if all the pieces were nearly perfectly made. Otherwise, the pieces would not fit together correctly. The task was further complicated by the fact that this massive three-dimensional jigsaw puzzle had to be supported by a steel space frame. In turn, the frame had to be supported either by the ground floor slab-on-grade, which is essentially rigid, or by the second-floor framing, which would deflect under load, thereby causing a change in the puzzle's geometry as load is applied or removed. Again, if some panels moved too much, while others moved little if at all, the pieces of the puzzle would no longer fit properly. A brittle material like cast stone cannot tolerate much movement without the risk of cracking.

Early in the design process, it was hoped that the great compressive strength of the cast stone might be exploited through shell action, but the overall surface was far too irregular to allow for this kind of behavior to happen. This was only possible in cases where panels could be stacked into a wall that was more or less vertical, though they still had to be tied back to the steel framing to keep them stable. Far more often than not, the panels had to be fully supported by the steel framing hidden behind them. Indeed, movement connections were required in nearly all panels, specifically to *prevent* shell action, since accumulating forces flowing from panel to panel through their anchor bolts would have failed these bolts had the panels been fully restrained. Ceiling panels that were close to horizontal could only be supported by hanging them from the steel frame. Most other panels were somewhere between these two conditions and had to be bolted directly to the steel frame using connections with a large degree of adjustability to allow for the ever varying geometry. In some cases, connections were easily accessible for welding, but in other cases, the erection sequence would have made access to some connections impossible, so 'blind' connections had to be developed. In areas exposed to the weather, it was feared that hot fragments from field welding might damage the waterproofing below the connection, which necessitated fully bolted and galvanized connections with six degrees of adjustability, and often 'blind' as well. In the end, over two dozen 'typical' panel connection types had to be developed, depending on 1) whether the panels were stacked, bolted up, hung, or some kind of hybrid thereof, 2) whether the panel was interior or exterior, and 3) whether the connection was accessible or 'blind'. Still, many completely unique connections had to be developed on a case by case basis.

As the original digital surface in the Trahan model was 'panelized' in five sequences by CASE Inc., the project's Building Information Model (BIM) consultants, using CATIA CAD/CAM software, the Shaped Surface Support Steel (SSSS) design team took over. The 'SSSS' design team consisted of David Kufferman Structural Engineers working jointly with Method Design, the cast stone support steel geometry consultants, Craft Engineering Studio, the structural analysis consultants, and Total Global Steel Detailing, the steel shop drawing detailers. Kufferman worked with Method Design to develop the structural geometry of the supporting steel frame in digital space. Using the appropriate panel connections developed by Kufferman, Method Design developed a digital model in Rhinoceros three-dimensional modeling software by creating automated steel framing geometry definitions using Grasshopper, a graphic algorithmic editor that is tightly integrated with Rhinoceros. Such algorithms were developed based on preliminary framing element shapes and their location parameters, as specified by Kufferman. Panel anchor type and locations were fully defined, and this information was passed back to CASE so that final panel shop tickets could be generated for cast stone panel production. Kufferman and Method Design worked together to vary such parameters until an acceptable frame geometry was obtained that would minimize the number of complex mitered butt welded 'kinks', but without allowing steel framing elements to either get too close or too far from the back surface of the cast stone panels. Every single connective element specified by Kufferman was defined in the Building Information Model by Method Design. Over 2,150 separate panel connections were needed for the project, with each connection providing support to any number of panels, ranging from one to four (*Figure 3*).

The resulting 'SSSS' frame was then analyzed under load using Robot, a three-dimensional structural analysis program. Method Design used yet another plug-in program called Geometry Gym to convert the Rhinoceros model into a Robot input file. Kufferman, in collaboration with structural analysis consultants Craft Engineering Studio in New York City, refined the Robot models, modifying support and connective conditions so as to best simulate what was to be expected in reality. After over-stressed or excessively flexible elements in the model were beefed up, and under-stressed elements were lightened to reduce steel weight, the structure was reanalyzed. Once an acceptable SSSS was fully developed, the Rhinoceros model was updated, and converted into SDS/2, a steel detailing program, so that shop drawings could be generated.

Steel was fabricated and erected by Champion Steel of Louisiana and Commercial Metals Company (CMC) of South Carolina. A total station theodolite, that was digitally referenced to the BIM, was used to locate steel during erection such that any point on the steel had to be within one-half inch of the specified location. The same system was used to precisely locate the cast stone panels as they were erected by the installer, Masonry Arts.

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Figure 4. Exterior steel showing galvanized channel section 'blind' cast stone panel connectors. Light gauge metal framing of weather wall not yet installed. Courtesy of VCC.

Figure 5. Atrium steel framing with one of two pre-deflection ballast tubs in the foreground. Courtesy of VCC.

The precise specification, fabrication and erection of the SSSS became especially critical during the second sequence, which included all of the exterior cast stone panels. Since the panels were considered to act as a rain screen rather than a waterproof barrier, the steel elements had to be installed prior to the waterproofing system, which had to occupy the space between the cast stone and the SSSS. The panels could only be installed after the waterproofing was complete. This meant that the galvanized connection elements, to which the cast stone panels had to be bolted, as well as the galvanized stand-off tubes that penetrated the waterproofing, had to be precisely shop-welded to the SSSS frame, with no possible provision for field-modification afterward. Galvanized clips with long slotted holes and galvanized A325 slip-critical bolts had to be used to accommodate all tolerances. Open slotted holes were used for 'blind' connections (*Figure 4*).

In the case of the final sequence, which was the cast stone surface defining the atrium and the monumental stair, concern was raised about deflections due to the fact that the SSSS that provided support for the 165 tons of cast stone in this area was completely carried by the second-floor framing. The Robot analysis of this sequence included the floor beams so that an accurate estimate of the deflections could best be achieved. It was indeed found that the overall flexibility of the system would lead to panel fitment problems if no compensating action was taken during panel installation, despite the fact that code mandated deflection criteria was easily satisfied. A structure that does not deflect under load is, quite simply, a physical impossibility. Theoretically, the only way to get the geometry perfect would be to pre-deflect the SSSS frame using ballast equal to the cast stone panels in both weight and distribution. Because of the practical problems surrounding the procurement and installation of 165 tons of ballast over about 500 connections, an alternative approximate means of pre-deflection was devised using two concentrated loads totaling 24 tons, hung from temporary frames. As panels were erected, panel positions were continuously monitored so that the pre-deflection loads could be reduced appropriately. This procedure successfully minimized the racking and distortion problems that were anticipated, while using ballast equal to only 15% of the final panel weight (*Figure 5*).

The Louisiana Sports Hall of Fame opened to the public on June 28, 2013, at a gala to celebrate both the astonishing new building as well as the induction of basketball legend Shaquille O'Neill and tennis star Chandra Rubin, among several other outstanding athletes. Since then, the project has won numerous major design awards, including the 2015 American Institute of Architects (AIA) National Interior Architecture Honor Award, the 2014 Chicago Athenaeum American Architecture Award, the 2013 *Architect* magazine Honor Award, and the 2013 *Interior Design* magazine Best of Year Award. In 2013, *Azure* magazine named it the Top Project in the World. Not too bad for a small town museum in west Louisiana.▪

Project Credits

Client: State of Louisiana, Office of Facility, Planning & Control
Structural Engineer: LBYD
Cast Stone Support Steel Engineer: David Kufferman, P.E. w/ Craft Engineering, NYC
Architect: Trahan Architects, New Orleans
Interior Designer: Lauren Bombet Interiors
M/E/P/FP Engineer: Associated Design Group
Civil Engineer: CSRS
Geotechnical Engineer: GeoConsultants
General Contractor: VCC
Landscape Architect: Reed Hilderbrand Associates
BIM Manager and Technology Consultant: CASE
Cast Stone Support Steel Geometry: Method Design
Acoustics: SH Acoustics
Waterproofing: Water Management Consultants & Testing

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