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THE GIFT OF SAFE ACCESS

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ON THE COVER

THE GIFT OF SAFE ACCESS

THE GIFT OF A 100-METRIC-TON STRUCTURE REQUIRED CREATIVE SHORING SOLUTIONS THAT SAFELY TURNED ART INTO REALITY.

BY ROBIN J. KO, P.E., WITH BRUCE SCHENA

Photo by Drone Genius

The annual Burning Man event draws tens of thousands of people to Nevada's Black Rock Desert to create Black Rock City, described by the event's website as "a temporary metropolis dedicated to community, art, self-expression, and self-reliance." Every year, a custom-designed "temple," a spiritual but not specifically religious structure, is designed and built by a group of volunteers, all with donated money, time, and effort.

Black Rock Desert is an ancient dry lakebed and considered one of the most remote and inhospitable places in the United States. Winds frequently exceed 80 mph, sometimes peaking in excess of 100 mph. These winds, combined with the ultra-fine dust from the lakebed, often create sustained, white-out conditions during the construction of this temporary city, home of Burning Man.

Temple Galaxia, a hollow, spiral mountain-like structure roughly 195 feet (60 meters) in diameter and 65 feet (20 meters) tall and weighing approximately 100 metric tons, was the centerpiece of the 2018 event. The temple was the vision of Arthur Mamou-Mani of London-based Mamou-Mani Architects and shaped from twenty triangular timber trusses converging as a spiral towards an open oculus. The structural engineering was done by Format Engineers, Ltd. to be self-supporting – but only once fully constructed.

The Galaxia scaffolding team worked for months to develop the complex construction sequencing plan and design but needed highly specialized scaffold engineering knowledge and experience to ensure the safety of the build team and structural integrity of the shoring design. To help make this vision a reality, Layher, Inc. and D.H. Charles Engineering, Inc. were brought in as integral members of the larger Galaxia team to provide expert advice, detailed engineering review, and creative problem solving to enable the construction of the massive and unique temple structure.

The scaffolding system was the very first thing that had to be built and was the last thing to come down before the crew could "gift" the temple to the 75,000 citizens of Black Rock City. Three massive scaffolds were constructed, one to support the Upper Crown pre-build, one to support the

Lower Crown pre-build, and the largest (called "S1") to support the final structure consisting of Upper and Lower Crown sections that were craned into place. S1 was then surrounded by 20 lower "petal" structures installed one-by-one around the perimeter to support and complete the entire Galaxia. S1 also interfaced to the geometrically complex Galaxia structure via a double ring of massive timbers and a custom-engineered system of support "cradles."

Layher provided the initial shoring concepts using their Allround Scaffolding system and was contracted to supply all the scaffold materials for the project with a very strict delivery and pickup window. In addition, they provided much needed field support that would be crucial to the success and safety of the enthusiastic but inexperienced volunteer crew who would

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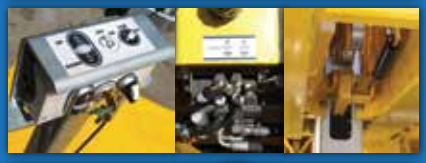

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be constructing the scaffold systems, after some basic training and under supervision of experienced workers.

D.H. Charles' scope of work was to review, design, and approve the cylindrical shoring system, roughly 53 feet in diameter and 26 feet tall, that was the primary support system for all the vertical and lateral loads from the phased construction of the Galaxia structure until it was fully constructed. D.H. Charles specified all the bracing and anchoring requirements and designed the timber interface system that would be used to transmit the loads imposed by the Galaxia structure to the scaffold/shoring system. Format engineers provided all the loads that would be imposed upon the shoring for the design, and representatives

for Mamou-Mani Architects dictated construction procedures that the shoring would need to support.

Designed for Worst-Case Conditions

A strict deadline to complete the shoring design process by the end of July was set, as the whole construction process was limited to an inflexible construction time-window in August. One of the project challenges was obtaining all the information that was pivotal to the design. Because no one was allowed on site until the actual construction window, there wasn't any time to perform any initial site visits or testing to verify field conditions or soil anchor capacities. In addition, with the Galaxia design team spread across nine time zones, many in London, with the shoring design team centered in California, timely delivery of information and quick decision-making were constant challenges.

The design team attempted to account for every possible situation throughout the design process. They eliminated options like dead men blocks and heavy-duty anchorage due to time constraints. They were also limited by Bureau of Land Management (BLM) rules against any significant site excavation. Despite these challenges and constraints, the shoring design had to accommodate the full range of possible "on the fly" construction sequence changes. The three-phase Galaxia build required an unconventional top-down construction that would eventually place the full weight of the 100-ton temple on the cylindrical shoring tower, imposing multidirectional wind loads, dynamic construction loads, and unbalanced "lean loads" on the shoring throughout the process.

Primary Shoring

The primary shoring would initially need to support the roughly 20-ton weight of the upper and lower crown, which would also result in a top-heavy wind load. Then, as each of the 20 spiraling petals of the temple were installed, additional, very large, vertical, radial, and tangential loads would be introduced to the shoring system – mainly resulting from the

odd shape of the leaning trusses. Eventually, the shoring would need to support the worst-case scenario that would include the wind impact from the full profile of the Galaxia structure along with the imbalanced loading caused by the lean and twist of only half of the spiraling truss petals being in place. This resulted in a design requiring a spiraling bracing pattern to match the structure that it was supporting and extra shoring towers to prevent the individual petals from twisting during their installation.

Anchorage System

The second challenge would be developing an anchorage system capable of supporting such loads. Considering the "leave no trace" policy of the event, providing any concrete footings or dead men was out of the question. And given the remote desert location, using any heavy-duty anchorage that would require any specialized equipment would not be possible. Thus, the design was limited to low-capacity earth anchors, creating the need for 88 bracing points around the perimeter of the shoring, which would support the spider web of cable bracing required to tie down the shoring structure. To help facilitate the bracing process, an alternate option to use ratchet straps was reviewed and accepted, which proved to be greatly beneficial to the construction timeline due to the ease and speed with which they could be installed. Although the quantity of anchors seemed excessive at first, the scaffold/shoring team was thankful they were in place when high winds and dust storms strong enough to stop construction put them to the test, making the whole temporary structure hum from the vibration of the straps.

Load Transfer

The next challenge was to create an interface between the Galaxia structure and the shoring that could

adequately absorb and transfer the loading. This cradle structure would need to be custom built to fit Galaxia's unique shape, rigid enough to maintain the proper elevation for the Galaxia build and yet flexible enough to release the shoring from underneath the temple once construction was completed. Using timbers offered the flexibility to handle potential field variances and meet the unique factors involved in Galaxia's construction process. Two continuous 6-by-12 timber rings were constructed over the top of the shoring legs supporting crossing timber ledgers with reinforced notches cut specifically to align with Galaxia's spiraling truss petals. Another one of the positive field adjustments that was made during this installation process was to separate the timber ledger cradles from the rings and mount them directly to the lower crown. This allowed the lower crown to be placed on the shoring with greater flexibility and freedom of movement.

After 22 days of construction, 12-hour workdays, and over 10,000 man-hours in the extreme temperatures of the desert playa, the temple Galaxia was successfully completed to the cheers of the 140 volunteers from 19 countries who served as the construction crew. One of the most difficult parts of the process was removing the shoring, which had shouldered the brunt of Galaxia's weight amidst dust storms and the construction process. Workers speculated that the settlement of the Galaxia structure would be anywhere from one millimeter to complete and utter failure, but the whole timber cradle and shoring ring worked out as planned. Due to the forethought that was put into the scaffold/shoring design process, the erection volunteers were able to slowly and evenly lower all 44 U-head screw jacks and release the shoring from the Galaxia structure. The temple became self-supporting after settling about five inches once the shoring was removed, using only 50% of the total travel available with the screw jacks. Galaxia finally stood on its own on August 28 at 11:30 pm, no longer needing the critical, yet temporary, support of the shoring system.

The S1 shoring was manually removed at sunrise the next morning, and Galaxia was presented as a gift to the city that afternoon. The giant void left by the shoring removal became the sacred space for the citizens of Black Rock City to celebrate, mourn, and contemplate.

About the Authors

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