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Scaffold Industry

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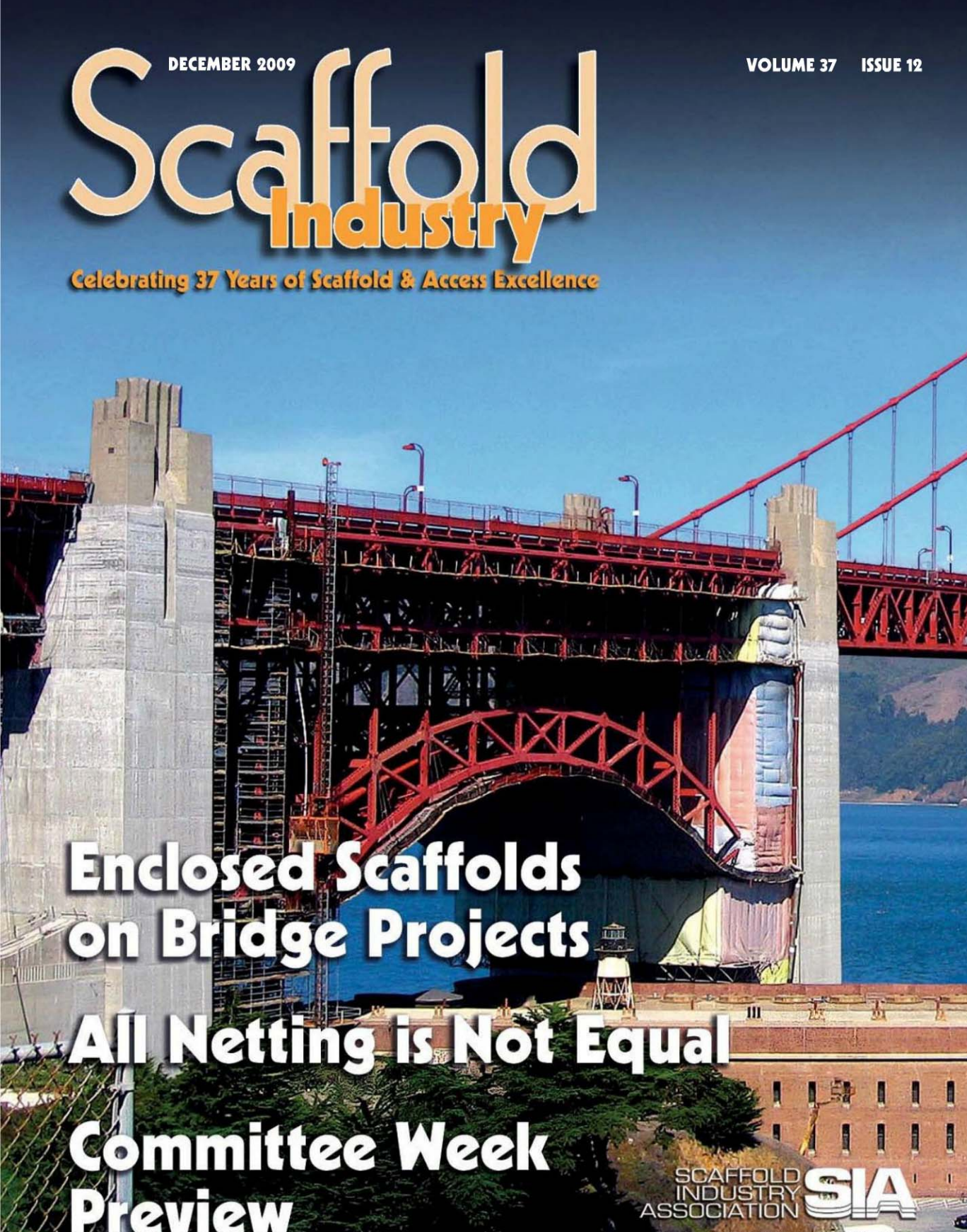


Enclosed Scaffolds on Bridge Projects

All Netting is Not Equal

Committee Week Preview

SCAFFOLD INDUSTRY ASSOCIATION SIA

Engineering Solutions to Enclosed Scaffold on High Profile Bridge Structures

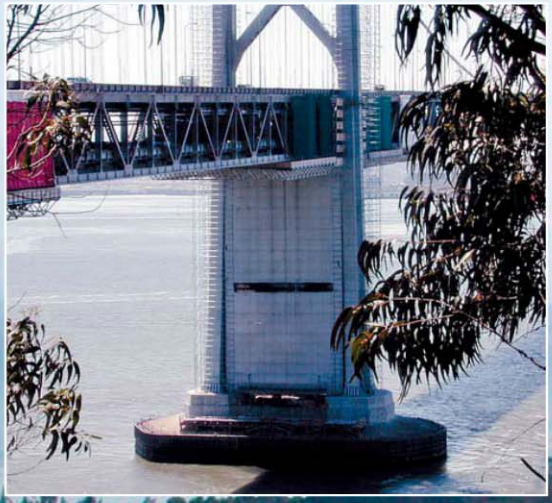
Tailoring the solution to the specific job conditions results in successful completion of complex projects

By Jasper Calcara, P.E.

Enclosed scaffold systems on bridges can reveal some of the most complex erection and engineering challenges to face the scaffold industry today. Extreme heights, elaborate bridge profiles, severe wind speeds and other complications regularly push scaffold contractors and engineers to develop inventive solutions in order to complete work. The following three high-profile bridge projects may have faced similar design obstacles, but ultimately they each implemented unique and individually successful solutions.

Dames Point Bridge – Florida

Abhe & Svoboda, Inc. (ASI) was faced with the daunting task of providing full access and enclosure of all stay cables on the Dames Point Bridge in northern Florida. With scaffold heights pushing 300 feet, D.H. Charles



Engineering, Inc. (DHC) worked closely with ASI and bridge engineers to develop an enclosure and wind speed removal scheme, which would allow for completion of painting operations, while ensuring that scaffold and bridge components would not be overloaded. After completion of preliminary engineering, the system was eventually designed and certified to withstand 40 mph wind speeds when enclosed with shrink wrap, and 131 mph wind speeds with the enclosure material removed.

The primary complication was proving that the 7-foot wide scaffold, being secured to only the bridge suspension cables, could reach the tremendous heights without overstressing scaffold elements or exceeding the capacity of bridge stay cables. Stresses in the scaffold members were directly related to how much the framework would actually move horizontally under wind load. On most projects, the scaffold is tied uniformly to rigid support elements so that the entire scaffold exhibits minimal deflection between unyielding tie points.

In this case, the supports themselves, the stay cables, varied in length up to 700 feet and each point on each cable was able to move a different distance under the same load. Due to this complication and the non-uniform geometry of the bridge, a simplified linear design approach was ruled out. Ultimately, a complete 3D model of the entire scaffold system was developed, accounting for the different rigidity of the stay cables at each and every tie point. Vertical diagonal bracing and anchorage to the bridge were then strategically placed to finalize the design and confirm adequacy of the overall system.

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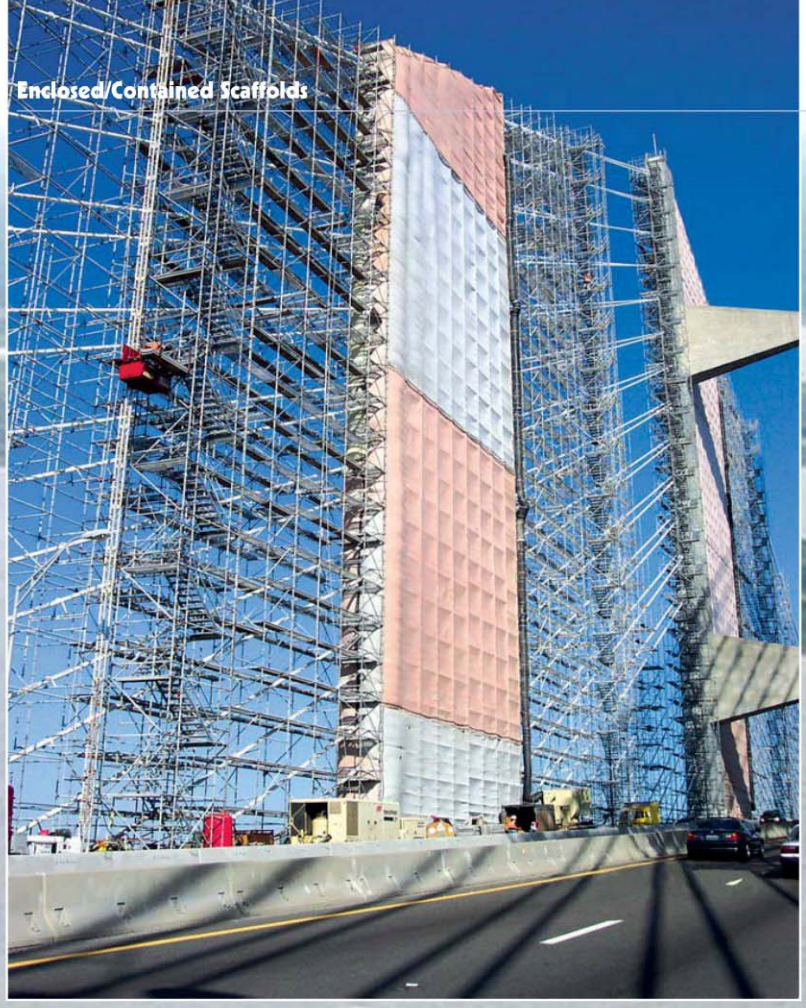

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The work was completed successfully, but not before the entire system and engineering was put to the test by Mother Nature. In August 2008, Tropical Storm Fay was projected to completely miss the project site. However, a last minute shift in direction brought the storm to the scaffold before ASI could completely remove the enclosure material as directed by the design plans. Scaffold workers rushed to make large X-cuts throughout the shrink wrap to increase wind flow through the enclosure and reduce impact on the scaffold. Although the enclosure material completely disintegrated due to wind speeds in excess of 80 mph, there was essentially no damage to the scaffold itself, and the project was completed on schedule.

San Francisco-Oakland Bay Bridge – California

Although construction is currently underway on the high profile east span replacement, the west suspension span of the Bay Bridge recently underwent a significant seismic retrofit. To complete a portion of this work, the roughly 460-feet tall main bridge towers were enclosed with an access scaffold and containment system over their entire height, in two phases. Unlike the Dames Point Bridge, this system was designed for maximum anticipated wind speeds, with no plans to remove the enclosure material. Although dealing with very high leg loads and other design issues proved difficult, it was the containment and geometry of the bridge tower legs that resulted in most of the complications during the design phase.

The diamond shaped voids between the tower bracing resulted in horizontal and vertical gaps of up to 60 feet between available tie points. The independent scaffold walkways did not prove adequate to allow the scaffold to free span these gaps. Therefore, plan bracing and horizontal ties were used so that the entire scaffold cross section could be analyzed as a giant truss with

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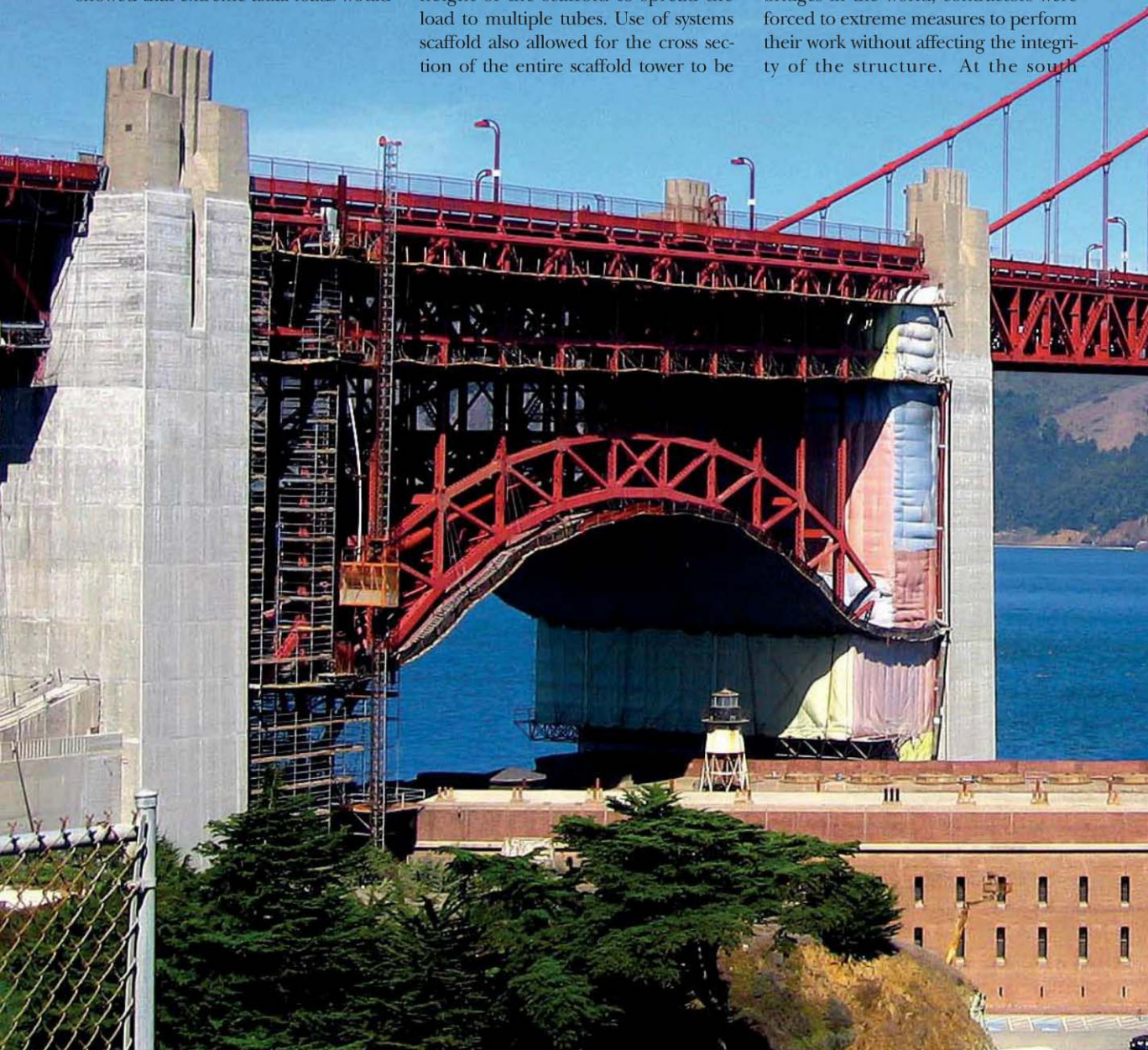
each walkway acting as either the tension or compression chord, depending on wind direction.

Using the geometry of the tower legs to our advantage, we were able to brace the scaffold chords tight to the tower steel in multiple directions, and transmit the high loads over long spans with a light and very efficient framework of scaffold. Preliminary analysis showed that extreme axial loads would develop in horizontal tubes of the compression chord and overload many of the members. However, the flexibility of modular scaffold allowed for multiple options to resolve this problem.

One solution included placing truss ledgers at locations of maximum load to increase strength of the individual framing, while another was to simply install ledgers at every cup along the height of the scaffold to spread the load to multiple tubes. Use of systems scaffold also allowed for the cross section of the entire scaffold tower to be easily tapered as the tower reduced in size over its height. This scaffold was ultimately erected at multiple locations throughout the scope of the project and performed exceptionally well.

Golden Gate Bridge – California

When performing a state of the art retrofit on one of the most beloved bridges in the world, contractors were forced to extreme measures to perform their work without affecting the integrity of the structure. At the south



approach of the Golden Gate Bridge, a roughly 300-feet arch gracefully bows over the Civil War fort below. This popular tourist destination was built in the 1850s and was to remain open to the public during the extensive work above.

Suspended platforms, complex scaffold and extensive containment systems were widely used to allow for work throughout the arch. The most complicated of the many systems designed for Shimmick Obayshi, included a 200-feet tall Cuplok scaffold system, partially supported by a suspended Beeche Space Frame, and completely enclosed with shrink wrap over the entire height.

The bridge district required that every structural element of the existing arch be checked for the loads to be imposed upon it from the scaffold system, in conjunction with original bridge design loading. Therefore, DHC had to demonstrate that elements originally exposed to wind pressures across their 2-feet width could now support wind from a 36-feet wide sail. Normally, a very dense scaffold system, or possibly an external bracing scheme, would be implemented to help relieve the structure from the increased loads. However, due to restrictions from the

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fort below, and limited access in general, a very minimal framework of scaffold would be allowed. Therefore, an intricate hybrid system of cables, scaffold and suspended platforms was ultimately developed to satisfy the bridge's enclosure needs

Numerous 7 feet by 10 feet systems scaffold towers were erected around the main arch columns, which free spanned up to 70 feet vertically and were spaced as far apart as 42 feet 6 inches on center. This scaffold was either directly supported from the ground, or set on an independently suspended work platform. These individual scaffold bays were then tied together with a matrix of cables, which acted as the supporting skeleton of the shrink wrap. These cables were installed with very specific sags between the support points at each scaffold tower to control the high-tension loads that would develop and attempt to pull the opposing scaffold together.

The cabling proved to be the backbone of the entire scheme, allowing for a light and efficient overall system while providing the vast enclosure required for the worksite. Although the cabling was efficient from an installation point of view, it proved to be challenging on the engineering, as the cables developed extreme tension loads, which were passed to the highly taxed bridge elements. Eventually, by simultaneously manipulating the cable sizes, spacing, sag, scaffold assembly and wind speeds, a system was chosen which met everyone's needs and gained approval from the bridge district.

With the overwhelming magnitude of the project, elaborate site restrictions and endless field changes, it was truly impressive that a scaffold implementing so many complex support, bracing and reinforcing schemes could work in harmony to meet the demands of this world-class bridge.

Year in and year out, our nation's most historic and important bridges require extensive repair, maintenance and retrofit work. The scaffold industry has played a vital role in allowing this work to be completed efficiently and safely while being exposed to some of the most hazardous conditions in the construction world today. Pushing the engineering and erection envelope has allowed scaffold contractors to stay at the forefront of this industry and leaves us excited to see what the future brings. ■

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