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OLD ROOF, NEW DIGS – SEATTLE'S CLIMATE PLEDGE ARENA

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OLD ROOF, NEW DIGS – SEATTLE'S CLIMATE PLEDGE ARENA

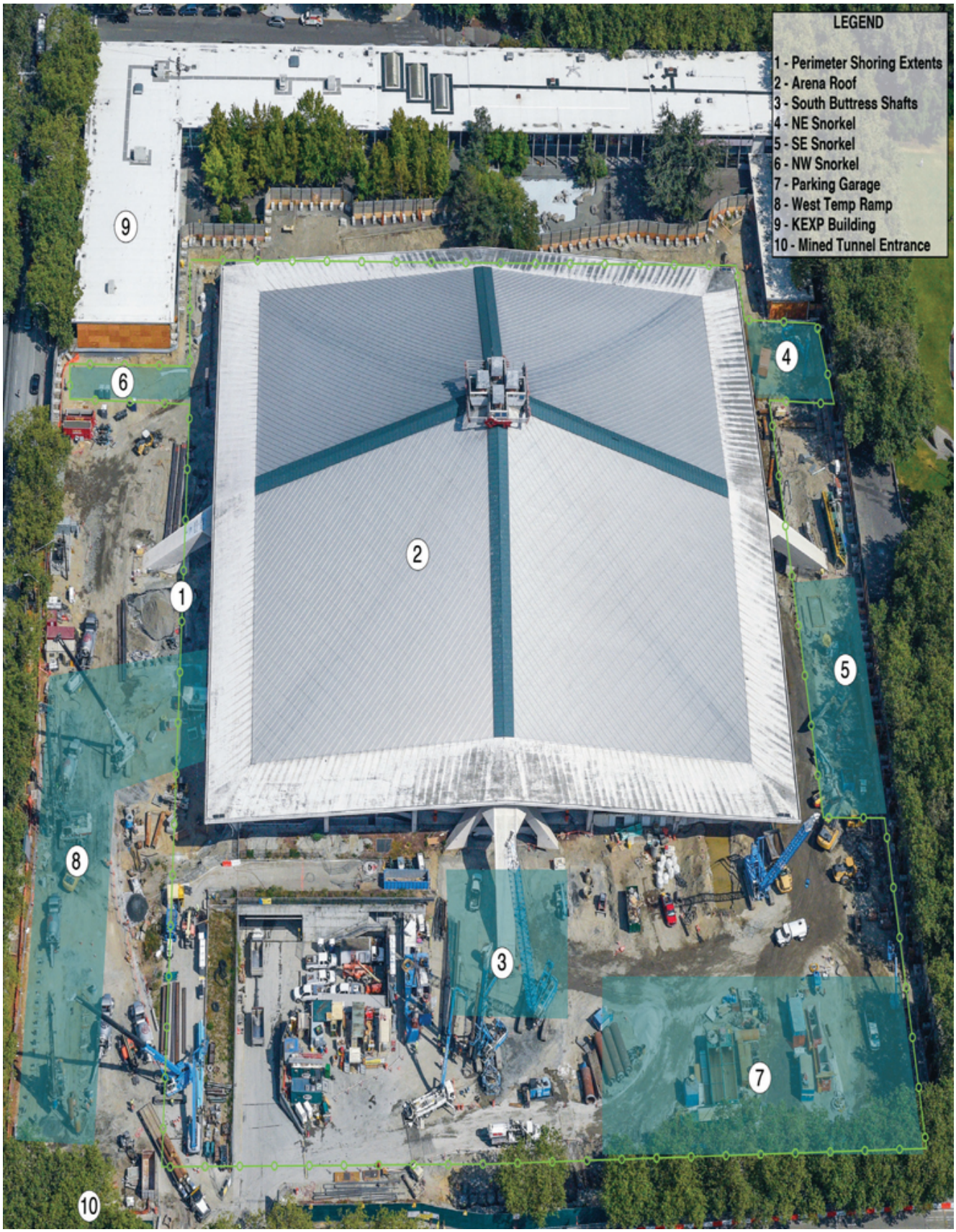
BY MIHIR BHARMAL, BRYCE NIEKAMP, ADAM RUNNING, DANIELLE SALTARELLI

AN AERIAL VIEW OF THE CPA EXPANSION

An unlikely mecca for tower crane erectors, Seattle and its construction market have continued to capture national attention despite a global pandemic and a nationwide slowdown. While you may be reminded of the Space Needle or the Amazon Spheres, it is a different landmark that is enshrined in the hearts and minds of locals across the Puget Sound: the Seattle Center Coliseum aka KeyArena, former home to the city's beloved NBA team, the Seattle SuperSonics. Originally built to host the 1962 World's Fair, this Arena has undergone several transformations over the years. In its most recent incarnation as **Climate Pledge Arena (CPA)**, it will house the city's brand new NHL team, the Seattle Kraken, as well as the WNBA's Seattle Storm. This development is led by a partnership between the City of Seattle and Oak View Group (OVG), and includes Engineer of Record Thornton Tomasetti (TT) and General Contractor M. A. Mortenson (MAM).

The last round of renovations in 1994 lowered the arena floor by 38 feet; this most recent overhaul takes the floor down another 15 feet while expanding the footprint to the perimeter of the property. This endeavor required approximately 178,000 sq. ft. of permanent shoring extending 60 to 70 feet below street grade. While this was challenging enough on its own, the entire project had to be constructed while supporting the iconic 44-million pound arena roof in place, given its status as a historic landmark. The system devised to support the roof during construction involved a Temporary Roof Support (TRS) bracing system supported on a network of drilled shafts around the perimeter of the roof. In its final condition, over 160 drilled shafts were installed from the new foundation grade to provide permanent support for the roof as well as other building elements.

"The entire project had to be constructed while supporting the iconic 44-million pound arena roof in place, given its status as a historic landmark"



SCHEMATIC SHOWING VARIOUS WORK AREAS ONSITE

A unique challenge required a unique team: ADSC Members **DBM Contractors and Malcolm Drilling Company** teamed up as a Joint Venture (Malcolm/DBM) to install the shoring and drilled shafts. A dewatering system consisting of deep wells around the excavation and an eductor well system around the mined tunnel also

was installed to lower the groundwater table encountered roughly 30-35 feet below grade. The soil profile consisted of three major units – fill material made up of very loose to dense silty sands underlain by poorly graded, coarse grained sandy silts with gravels over very stiff to hard, fine-grained silts and sands.

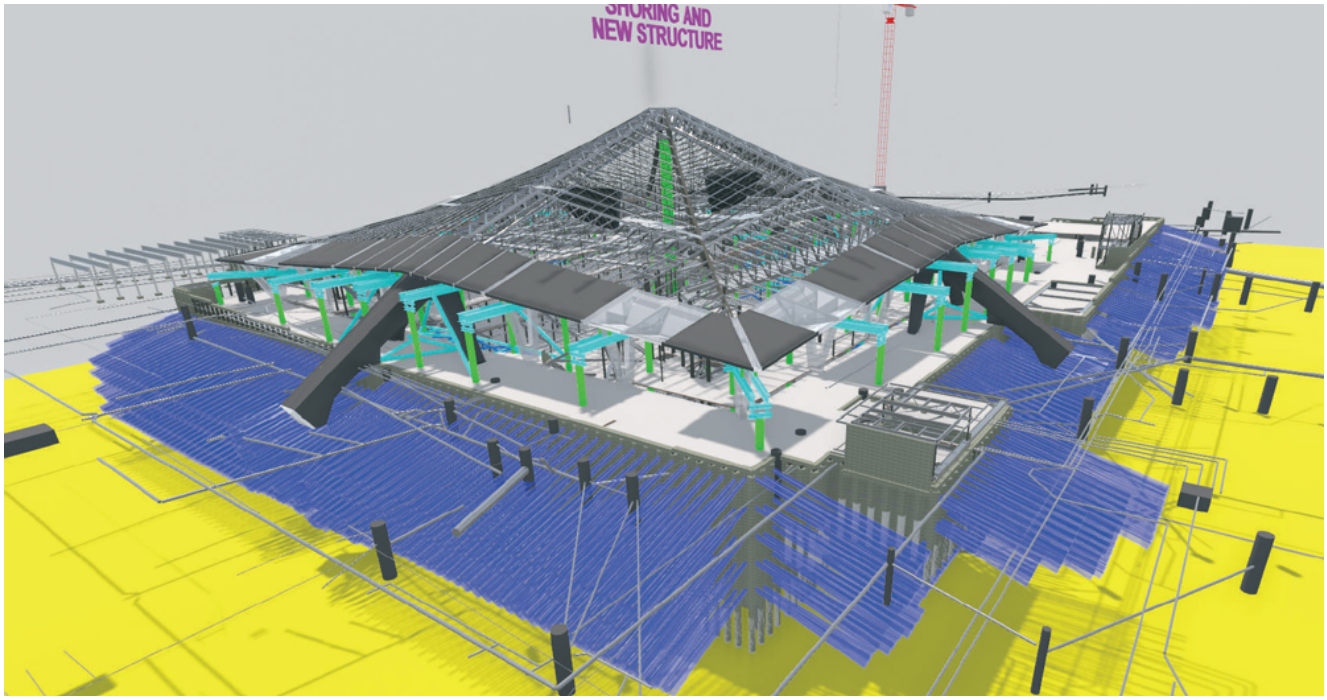
From the outset, the project team was faced with a number of challenges, driven primarily by the fixed opening date of the arena in time for the 2021 NHL season. The project schedule intensified every challenge including sequencing, access, constructability and a constantly evolving design required to respond to these challenges in real time. Extensive overlap of work activities was required to meet the schedule, which was planned and managed by dividing the project site into six zones. As a result, multiple drill crews were required to work on different headings. Each zone required continuous coordination between five to 10 different contractors performing, in order: shoring, demolition, temporary roof support shaft and column installation, excavation and finally, permanent foundation installation. Mortenson led this effort by deploying a sophisticated 4D CAD model along with holding daily schedule meetings with the project team, which balanced the work flow for each zone and the overall project schedule.

Supporting the historic roof was a complicated task, as it required a system which could fully support the roof prior to excavating below the existing footings. This system needed to provide roof support while soil was excavated around the supports approximately 60 feet deep. In addition, this temporary system had to be designed to function for an extended duration through construction of the perimeter shoring walls, permanent roof support elements and the building structure. The system relied on temporary drilled shafts to transfer the roof loads below the future arena subgrade. These shafts had to be installed in a low overhead condition either under the roof line or just outside it and utilized 3-ft diameter spiral weld pipe with mechanically bolted connections.

MALCOLM/DBM PARTNERED AS A JOINT VENTURE ON THIS PROJECT

CPA BOWL EXCAVATION WITH THE TEMPORARY ROOF SUPPORT SYSTEM IN PLACE

These casings were sequentially installed, many in very tight quarters, against existing roof foundation elements. Following the temporary support shaft install, these casings were extended up to the roof, braced and jacked to take over the load of the roof that was previously supported on footings.



A SNAPSHOT FROM THE VR MODEL SHOWING VARIOUS SHORING AND ROOF SUPPORT ELEMENTS

The permanent shoring system for the project consisted primarily of soldier piles, with five to six rows of permanent double corrosion protected tieback anchors providing lateral support. The need to maintain the roof structure, including both existing and new foundation support elements, impacted the design and installation of the shoring system. Exposed buttresses on the north, west and east sides of the roof provided lateral and vertical support of the structure. At each of these buttress footings, a complex array of splayed and crisscrossing tieback anchors was required, accompanied by horizontal bracing to span across the footings.

PROXIMITY TO EXISTING ROOF SUPPORT ELEMENTS WAS A CONSTANT CHALLENGE DURING TEMPORARY ROOF SUPPORT SHAFT INSTALLATION

In addition to the buttresses, the roof support system included an extensive system of steel pipe support and braced frame systems. As these systems needed to be installed concurrently with mass excavation, the installation of tieback anchors had to be coordinated to fit in and around the bracing steel. This required design solutions such as shifting and redesigning tieback anchors to internally mounted channel walers where they fell directly in line with roof support structures; Malcolm/DBM also deployed alternate drilling equipment which could be configured around the roof support structures and sequenced this work to allow the installation of tiebacks to proceed concurrently with the steel bracing.

ONCE THE TEMPORARY ROOF SUPPORT SYSTEM WAS INSTALLED, THE ORIGINAL ROOF SUPPORT COLUMNS WERE SEPARATED FROM THEIR FOOTINGS

MALCOLM/DBM EQUIPMENT CONFIGURED TO INSTALL TIEBACK ANCHORS AROUND TEMPORARY ROOF SUPPORT COLUMNS

INSTALLING SHAFTS AROUND THE PREVIOUSLY INSTALLED TEMPORARY ROOF SYSTEM BRACING

A unique sequencing challenge arose in the form of “snorkels” around the perimeter of the shoring system. These were small, tiered bump-outs in the primary shoring wall which were required to route air-handling and ducting equipment as well as egress stairs from the interior of the Arena. According to Seth Knihtila P.E., Project Engineer from Thornton Tomasetti, “The complex configuration of the snorkels presented a design and construction challenge for both temporary and permanent (excavation) support. Due to the extensive quantity and congestion of the permanent tiebacks, an intricate temporary internal bracing system was selected for the snorkels. This non-conventional design solution required a contractor who could bring their A-game.” Since the critical path was driven by the primary perimeter shoring work, the snorkel shoring and excavation were isolated from the main shoring and performed later. “This very specific installation sequence required close coordination between all parties involved, including day-to-day coordination with Malcom/DBM and MAM to avoid re-work or delays”, he said. Specialized drilling equipment was flown in and out of the snorkels using cranes sitting either above or below the work area. Thus, Malcolm/DBM was able to provide key constructability and design inputs to the project team which allowed the snorkel shoring design to be modified without impacting critical path work.

"Specialized drilling equipment was flown in and out of the snorkels using cranes sitting either above or below the work area"

INTERNALLY BRACED SE SNORKEL INCORPORATED INTO PERIMETER SHORING SYSTEM

Upon completion of the permanent shoring, shaft crews started working on the 117 permanent shafts to support the 59-year-old roof and new building foundations. A series of 1-meter diameter shafts in groups of two to three per footing were installed directly underneath the previously demolished footings. This put them directly in between the previously installed temporary support shafts, which restricted the working area vertically with head room and side to side between the TRS columns. Due to the proximity of these new shafts to the existing TRS shafts, the design required the use of temporary and permanent casing for these permanent shafts to prevent destabilizing the temporary support shafts, adding more equipment to an already congested jobsite.

INTERNALLY BRACED SW SNORKEL

THE ROOF IS RECONNECTED TO NEW COLUMNS SUPPORTED BY PERMANENT ROOF SUPPORT SHAFTS INSTALLED BY MALCOLM/DBM

INSTALLING THE SOUTH BUTTRESS SHAFTS NEAR EXISTING ROOF SUPPORT ELEMENTS

Shaft lengths extended up to 113 feet, forcing the use of custom fabricated Kelly bar extensions to be able to achieve these depths in low head room conditions.

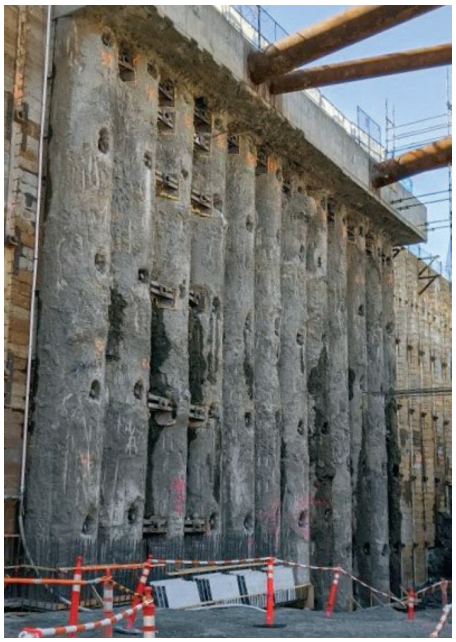
Rebar cages were installed at each shaft and Thermal Integrity Profile testing was conducted on 50% of these shafts.

On the south end of the project, the buttress footing for the roof support conflicted with the new arena structure and had to be removed without compromising the support of the roof. To achieve this, the design team utilized a large steel collar and steel pipes to transfer the large lateral and vertical loads into the south perimeter shoring wall. To resist these large concentrated loads on the south end, the soldier pile and lagging system was replaced with 6-foot diameter tangent shafts, connected by a cap beam and two large pipe supports that transferred the load of the south pylon to the tangent wall. These shafts included full-length rebar cages with blockouts for tieback anchors. During the early planning stages of the project, Malcolm/DBM worked closely with the project team to evaluate other options for this section, including a slurry wall. The tangent wall was ultimately selected as it could be installed faster with a much smaller equipment and staging footprint, an important consideration on this congested site. To maintain the required tolerances for these shafts, Malcolm/Malcolm/DBM mobilized a separate drilling operation including an oscillator, BG 40 drill rig, and service crane to install and extract the full depth temporary casing. This work was performed concurrently with the installation of the perimeter shoring.

PERMANENT FOUNDATION SHAFTS BEING INSTALLED ADJACENT TO AND UNDERNEATH TEMPORARY ROOF SUPPORT BRACING

MALCOLM/DBM INSTALLED A TANGENT WALL TO FACILITATE ROOF LATERAL LOAD TRANSFER

Another challenging area was the new parking garage and loading dock where a new footings were required. The new footings utilized 16 2.0-meter shafts, both temporary and permanent cased and installed underneath the newly constructed south temporary supports. Each 2.0-meter permanent shaft had a full length rebar cage extending 85 feet below bottom of excavation. However, due to the temporary roof support directly above, some rebar cages had to be split into four pieces and spliced together over the hole for installation.



THE SOUTH "KICKSTAND" BRACING TRANSFERRED THE LATERAL ROOF LOAD INTO TANGENT SHORING WALL INSTALLED BY MALCOLM/DBM


MALCOLM
Link-Belt

A MALCOLM/DBM PILEBUCK WELDS THE WEST TEMP RAMP BRACING ELEMENTS ON SITE

THE WEST TEMP RAMP ALLOWED CONTINUOUS ACCESS INTO THE BOWL WHILE THE MINED TUNNEL WAS BEING COMPLETED

Concurrent to these operations on the main project site, a site approximately one block south of the Arena had been selected as the access point for the future loading dock tunnel. JW Fowler had been contracted to install a mined tunnel across Thomas Street to provide direct access from street grade to the Bowl, or the floor of the Arena, roughly 60-70 feet below. This tunnel was intended to serve as construction access for equipment and materials, and required a braced secant shaft wall at both ends. However, as the tunnel was not scheduled for completion until well into the project, a temporary ramp had to be designed and installed behind the West shoring wall to support construction access. Dubbed the west Temp Ramp (WTR), it was excavated in three stages with a complex cross-lot, pipe bracing system used to shore the ramp at each stage. To provide sufficient

access, the pipes were spliced together into roughly 125-ft-long pieces supported on temporary piles and welded to a network of walers at the perimeter. The design of the bracing allowed for continuous construction access throughout the mass excavation, but required further coordination, design input and a large volume of in situ fabrication welding by the Malcolm/DBM team.

special thanks

A once-in-a-lifetime experience, the success of the project relied on the collective knowledge base of the DBM Contractors and Malcolm Drilling teams. Climate Pledge Arena is scheduled to open in October 2021. Special thanks to Seth Knithtila (TT), Greg Huber (MAM), Elliot Veazey (CAA Icon) and the entire Project Team, including but not limited to Ryan Pruitt, John Matyasovszky, James Turpin, Matthew Smart and Caleb Hancock.