



Customer Story

Turner Construction Brings Unique Seattle Aquarium Ocean Pavilion to Life with Trimble Technology

Trimble X7, Connect, FieldLink and Robotic Total Stations



Overview

Founded in 1902, Turner Construction Company has charged a path for advancement in construction. At the turn of the century, the company pioneered the use of steel-reinforced concrete to create safer, stronger, and more efficient buildings. In the decades since, Turner has built a reputation for undertaking large, complex projects, fostering innovation, and embracing emerging technologies.

One project that put Turner's innovative spirit to the test was the Seattle Aquarium's \$160 million Ocean Pavilion expansion. The project includes the creation of three large habitats with essentially no straight edges, including a main habitat consisting of 680 cubic yards of concrete and 355 tons of rebar. Turner Construction Company's self-perform concrete team brought this complex project to life with a powerhouse of trade partners, technology, and innovative digital fabrication techniques.



A Geometric and Logistical Challenge

The unique build presented several challenges. The Aquarium is in the heart of downtown Seattle's waterfront which has been undergoing a multi-year redevelopment including construction of an underground tunnel for highway 99, demolition of Seattle's Alaskan Way Viaduct, and major revitalization of the surface streets and pedestrian corridors.

The ongoing street revisions meant that a portion of the building's footprint on its West side would be in use for Alaskan Way before traffic could ultimately be shifted to the East side of the site. Traffic's revised path would take it underneath the new pedestrian bridge, allowing pedestrians a new unimpeded walking path between the Pike Place Market and Seattle's waterfront, and spectacular views of the Salish Sea from Ocean Pavilion's public rooftop.

Site constraints coupled with a small footprint required careful logistics planning to depict the multiple milestone phases of construction. The small footprint left little space for staging, and the geometry of the primary habitats meant that formwork coordination and prefabrication efforts would need to account for the numerous life support systems (LSS) and embedments prior to site delivery.

With its extensive tech stack, Turner Construction Company was well-positioned to overcome these challenges. Among the products used were Trimble Access with TSC7 data collector, Trimble FieldLink, Trimble Connect, Trimble RTS771, Trimble X7, SketchUp and Tekla Structures. Interoperability between Trimble solutions and other software tools contributes to the project's success.

Model-Based from Start to Finish

While the project presented several challenges, one of the issues the Turner team managed was working from a contractual 3D model provided by the designer, LMN Architects, that represented the geometry of the primary habitats. “Because of the habitat’s complex geometry, the architect provided us with a model that could be used as the basis for Turner’s self-perform concrete detailing efforts. This collaborative detailing effort combined all the formwork, rebar, embeddings, acrylic viewing windows, and mechanical systems into one model that could then be used to generate the necessary shop drawings and digitally fabricated formwork elements,” said Sean Beatty, Virtual Design and Construction (VDC) department manager at Turner Construction.

The main habitat’s structure includes a two-foot-thick curved concrete wall with 355 tons of rebar and 680 cubic yards of concrete, or four times the rebar used on a typical core. Turner Construction’s VDC team used internally developed parametric modeling scripts to generate the rebar geometry necessary to understand the congestion and the constructability of the engineers reinforcing design. This 3D representation and visualization in context with the final habitat geometry, mechanical systems and formwork enabled for revisions of the reinforcing that aided constructability while ensuring a monolithic pour of the main habitat without cold joints.

SketchUp was used throughout the process, beginning with a quality control model to understand overall project quantities through each design iteration. This included an accurate geolocated site model that combined drone imagery, adjacent buildings, underground utilities, and adjacent street revisions in SketchUp. Modeling the site from civil surveys and bringing in pre-made components from the 3D Warehouse, as well as components they developed internally gave Turner an accurate representation of the site in its current state.

With this, Turner Construction Company began planning the phased site logistics, which included excavation, fencing, trucking, formwork and public protection at all project stages. They organized the SketchUp model into layers, leveraging scenes and textures to differentiate between phases and collaborated with trade partners to determine precisely how things will be assembled and bundled for delivery. “The model was a powerful way to visualize logistics plans in 3D and convey them to the owner, the city and our trade partners,” said Beatty. “It gives us the flexibility to model things quickly, incorporate different model content and move it between platforms.”

Turner and its trade partners produced various model content, which was imported into Tekla Structures to generate the consolidated self-perform concrete model and lift drawings. The Tekla Live Link plug-in for bi-directional data exchange ensured that any modifications made in other software could be synchronized back to Tekla Structures to maintain consistency in the geometry throughout design iterations and input from the design and trade partners. “The Tekla Live Link streamlined the design-build process and empowered us to explore complex geometries and prepare models for fabrication with enhanced precision and efficiency,” said Beatty.

“Reference models produced with a variety of software applications were continuously updated throughout the formwork and MEP coordination efforts, and this up-to-date data ensured that our final concrete geometry was accurate and could be conveyed via Trimble Connect to our field survey team for model-based layout,” he said. The integration of Trimble software and hardware made this process very efficient and accurate.

The imported geometry, facilitated by the Tekla Live Link, served as the foundation for subsequent detailing and constructability analysis. Tekla Structures provided a comprehensive suite of analysis for creating accurate concrete elements, formwork, embed, rebar and more. These tools enabled the creation of detailed installation sequence drawings specifically developed for the tank’s formwork and concrete lift drawings.

Pour breaks and planning for the installation of the habitat’s complex formwork were carried out using Tekla Structures. Additionally, formwork installation drawings for the field were created in a combination of Tekla Structures and SketchUp Layout. “To achieve the final geometry in this large monolithic self-consolidating pour without straight edges, we, along with our trade partners, created 229 custom padded formwork panels that were CNC milled, coated in fiberglass and supported by Peri formwork,” said Beatty.

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Taking the Model to the Field

With no straight lines, the complex geometry of the habitats made it difficult to lay out in the field using traditional methods. To solve this, Turner imported the 3D Tekla model directly into Trimble FieldLink and used a Robotic Total Station for their model-based layout. The technology is designed specifically for contractors and enables people of various backgrounds to achieve the highest level of accuracy without needing a surveying degree. This enabled teams in the field to select lines, surfaces, and features directly from the model and lay them out without additional processes or point management. In addition, laser scan data of the installed rebar assemblies enabled the team to ensure proper placement of all the habitats reinforcing when compared to the model content.

“With the data available in the cloud with Trimble Connect, the surveying and VDC groups can collaborate and work hand in hand,” said Gabriel Kettler, the survey department manager at Turner Construction Company. “It enables them to track and monitor changes to the design quickly and easily and implement that data in the field where it needs to be used.”

The company also used Trimble FieldLink MR, which combines the context of the Trimble XR10 with Hololens 2 with the accuracy and precision of Trimble’s layout instruments. This was a prototype for their self-perform operations (SPO) warehouse to develop training and education on robotic total stations and other construction technology.

Using Trimble Access for surveying, Kettler keeps track of surfaces created on the fly and exports reports that show deviation from the theoretical space. “This workflow is more efficient than using CAD,” he said. “The ability to manipulate how I export the data and stake surfaces and export deliverables quickly helps me collect data in the field accurately and efficiently.”

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Cloud Connection Key to Sharing Data and Ensuring Accuracy

Most of the data transfer for the project runs through Trimble Connect, and BIM 360. All interfacing between the VDC and surveying teams goes through Trimble Connect, where models and project data are uploaded to the cloud for viewing and access in real time.

Trimble Connect and the Trimble X7 3D laser scanner have been beneficial to verify installed formwork matches the model utilizing the point cloud. With the forms milled to a specific shape, Gabe Kettler can scan the formwork and rebar at various stages of placement to ensure that the location is accurate, and that enough coverage of the reinforcing bar is achieved.

“The surfaces inside survey equipment are limited to the Z-Axis, but in Trimble Connect, I can select a certain elevation and points on the interior face of the concrete model and compare that to the existing bar to quickly verify the clearance,” said Kettler. “Anyone in the industry knows how critical it is to verify the clearance, and we can do this with confidence.”



Keeping an Eye on Sustainability

In pursuit of net-zero emissions and net-positive energy for the Ocean Pavilion, Turner is analyzing embodied carbon and selecting building materials that are free of toxic chemicals and being deliberate in its construction material choices by minimizing plastics, vinyl, biocides and red-list materials. When it opens to the public in 2024, the Ocean Pavilion will feature 3,500 sustainably sourced plants and animals including sharks and rays, a variety of fish, up to 30 species of corals, anemones, sea stars, giant clams and other marine life.



BuildingPoint
OHIO VALLEY

www.buildingpointohiovalley.com

Trimble Building Construction Field Systems
10368 Westmoor Drive
Westminster CO 80021 USA
fieldtech@construction.trimble.com

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