

Case Study: Innovation in Digital Fabrication Prefabricated Formwork



Combining innovative VDC (virtual design and construction) tools and workflows with in-house CNC machining capabilities, Turner Seattle's VDC team transformed the typical process by which carpenters create concrete formwork - making the work simpler, safer, and more efficient.

INNOVATE TO IMPROVE

Traditionally edge form construction for post-tensioned slabs requires that carpenters cut formwork materials to size on site and install them according to established layouts, cutting any notching or embed requirements in place. Conflicts between edges, embeds, post tensioned cable heads, and other elements are discovered and resolved in the field and considered part of the work. The traditional process also requires extensive bending and drilling at odd angles, putting craftspeople at risk for repetitive motion injuries.

Turner's Seattle VDC team developed an innovative workflow that combines BIM trade coordination, 3D parametric modeling, tool path development, and CNC routing in order to produce precise, prefabricated formwork components. The complete workflow includes process improvements developed sequentially over several years, with the successful result of each change feeding the initiation of the next.

CHANGING THE WAY WORK GETS DONE

The VDC team validated their innovative workflow by successfully prefabricating concrete slab edge formwork

for a 25 story post-tensioned, cast-in place mixed-used residential complex. Their process began by taking 3D models from the designers and trades and consolidating and coordinating them to vet slab edge locations, post-tension heads, and embeds – identifying and resolving conflicts in the model instead of in the field.

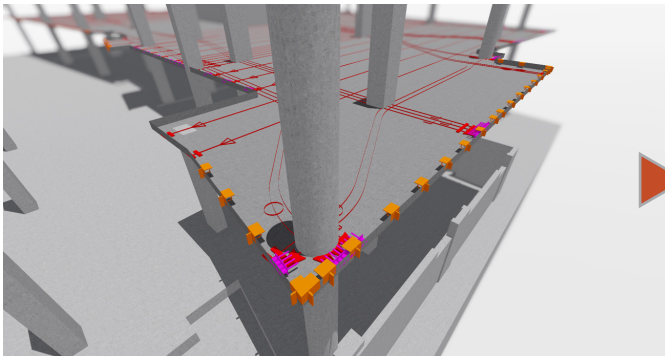
The consolidated slab edge coordination model was then used to build a parametric formwork model



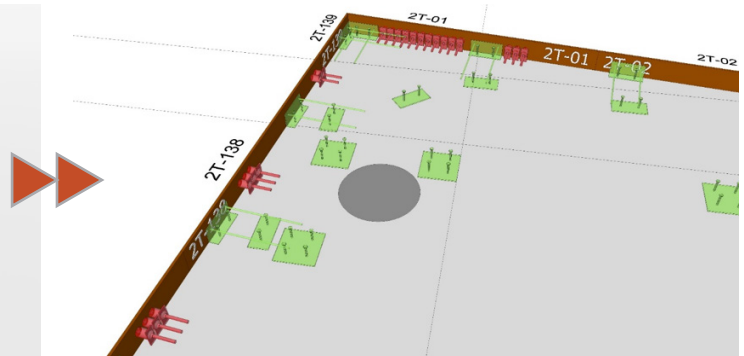
Build Washington
A W A R D S

Turner's office in Seattle was awarded the AGC Build Washington Innovation Award from the Associated General Contractors of America in recognition of their concrete edge formwork digital fabrication process. The team also earned recognition from Turner's Innovation Award program.

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A coordination model is used to vet slab edge locations, post-tension heads, and embeds.



A parametric model of the formwork is created and used to generate production drawings.



The formwork arrives on site as an easy to assemble 'kit-of-parts' that requires smaller field crews to install and simplifies the work.



The formwork is labeled, drilled, and cut to size using in-house CNC routers. The formwork is then packed and delivered to the jobsite.

which included the post-tension heads, embeds, and penetrations. From this formwork model, production drawings were generated and submitted for sign-off by appropriate stakeholders.

The VDC team then developed tool paths for the CNC router using data from the formwork model so that the router could machine the formwork precisely per the production drawings. Using a CNC router located in Turner Seattle's prefabrication shop, the forms were labeled, drilled, and cut to size. The prefabricated formwork was then packed and delivered to the jobsite 'just-in-time'

reducing waste on site and allowing the team to optimize the concrete pour cycle schedule.

This process was used to prefabricate the slab edge formwork for 29 concrete slab pours. Through rigorous testing and improvement, the team was able to prefabricate forms for an entire deck in a single week on average while reducing on-site labor and install times.

DELIVERING VALUE

This innovative workflow yields several benefits over the traditional process. For one, the use of the coordinated

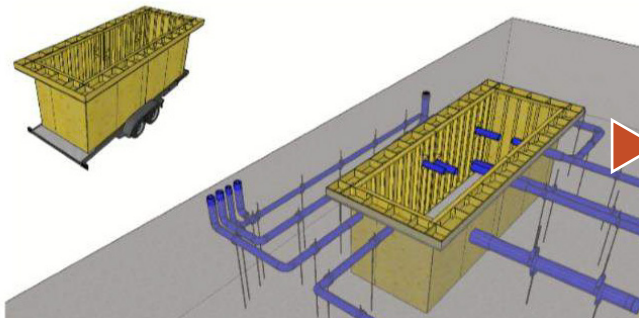
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model data eliminates the chance for human error during field layout. CNC machining is also well suited for precise, repeatable tasks and can perform them safely and more efficiently than human workers. In addition to being faster and more precise, the CNC router uses 'nesting' software which reduces waste by optimizing the amount of forms that are cut from each board.

The machined formwork arrives on site as an easy to assemble 'kit-of-parts' which not only requires smaller field crews to install but also simplifies the work of those crews – increasing labor productivity and reducing the chance for worker injury.

CONTINUOUS IMPROVEMENT

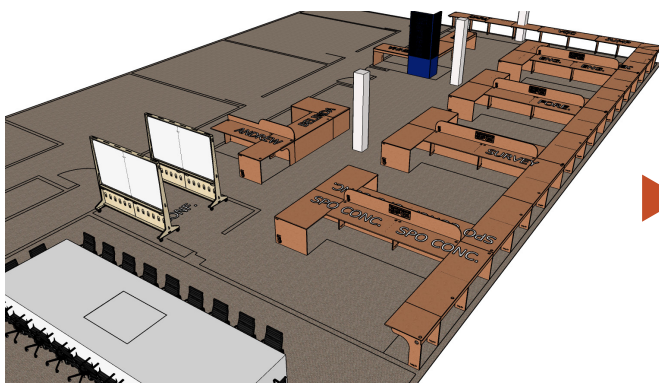
The team has since applied this innovative process to other formwork challenges – machining forms for pony walls, in-fills, sump pits, concrete planters, and other complex forms. The workflow has even been leveraged to prefabricate furniture for Turner project offices. Seizing on the prefabrication movement sweeping the construction industry, innovative workflows leveraging digital fabrication will continue to provide Turner with new opportunities to make building processes safer and more efficient.



Formwork for a concrete sump pit is modeled and then prefabricated.



The sump pit formwork is delivered to the project site 'just-in-time' for the concrete pour.



Jobsite furniture and accessories like rolling white boards are modeled in 3D and then machined using CNC routers in Turner's prefabrication shop.



The furniture 'kit-of-parts' is easily assembled in the Turner field office.