Optimizing a pre-fab parapet for faster, cheaper, and better project

Cutting field install in half by designing and planning for prefabricating a mile of parapets

As a general rule, work done in the shop is safer, cheaper, and accomplished with a higher degree of tolerance than work in the field. Therefore, we seek opportunities for pre-fabrication of elements that can then be kitted, transported, and put in place in the field. Pre-fabrication frequently produces excellent labor savings.

IDENTIFY POTENTIAL PRE-FAB OPPORTUNITIES

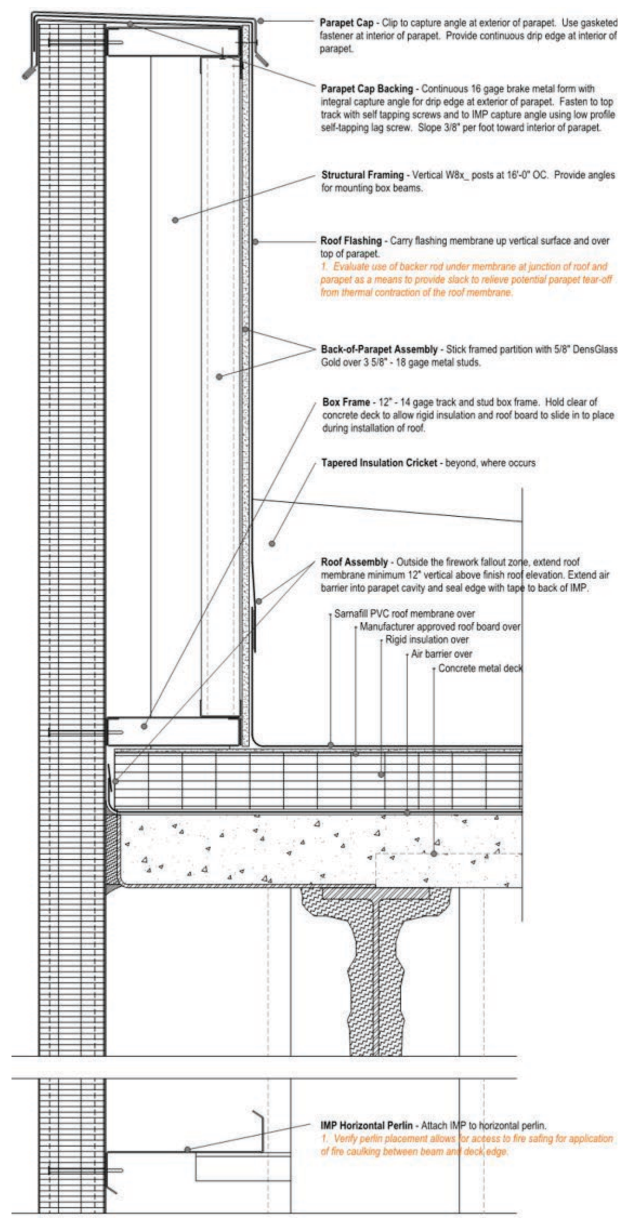
Pre-fabrication is a powerful tool, but just because an element or scope of work can be fabricated does not mean that it should be fabricated. More than the ability to fabricate off-site and transport to the field, a sound pre-fabrication strategy requires an evaluation of myriad factors, including shop v. labor rates, feasibility of site transport and installation, impact on schedule, interaction with other trades, union requirements, and inspection or regulatory constraints.

The team examined a number of opportunities for prefabricating metal stud framing. With more than 5,000 linear feet of parapet, back-of-parapet framing was identified as a rich target. Stakeholders were assembled and the work began.

DEVELOP CONFEDERATED DETAILS

Detailing a building location with pre-fabricated elements requires technical skill, knowledge of means and methods, and inspired leadership. We advocate for an integrated detail design approach with a team comprised of all work scope stakeholders. For an assembly like a parapet, stakeholders could include owner, architect, CMGC, structural engineer, framing trade partner, roofing trade partner, steel fabricator, steel erector, and waterproofing consultant.

A series of design charrettes to develop relevant details allows for the right combination of aesthetic design, building science, material usage, construction means and methods, and installation sequence.



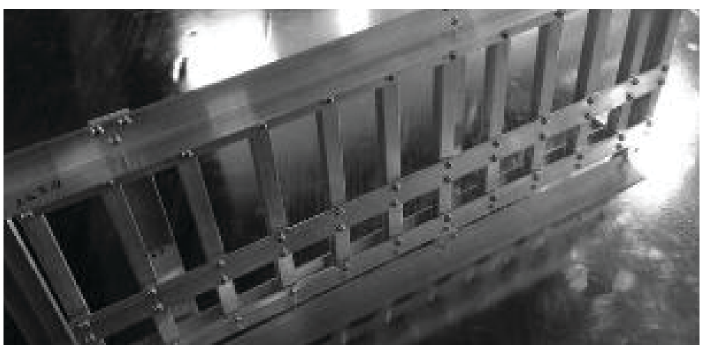
Confederated parapet detail developed with stakeholders

These charrettes should be iterative and should incorporate the assumptions, requirements, and methodologies of pre-fabricated elements as a part of the iterative process.

The team first agreed to standardize the parapet detail across most parapet conditions, meaning that the opportunity for pre-fabrication was maximized. A charrette process was used to develop a shared detail that was approved by all stakeholders. As part of the process, virtual and physical models were developed to explain concepts and build support among team for adopting a prefabrication approach.

ENGAGE IN PREFAB > PANEL > MODULE PROCESS

Pre-fabricated elements can be developed as component types with varying levels of installation efficiency. A prefabricated framing element is typically more efficient than stick framing. A modular panel element is usually more efficient than a panelized element. Consider the installation of dressed stone versus the installation of bricks. Each stone must be assessed and placed in a sequence that requires an element of artisitc skill. Brick installation is much more a function of manual skill gained in part because any brick can be used at any point and in any order. Thus, maximum efficiency suggests that prefabricated framing panels should all be sized identically to allow for optimum installation speed.



Physical model at 1" = 1'-0" scale

The team determined that a modular panel approach would allow more than 95% of the back-of-parapet to be installed using prefabricated panels. The size of the panels was determined by measuring the amount of framing material required and sizing the weight of the panel to fall within the safe lifting range for a two-person installation crew. Other parapet systems were adjusted to meet the modular spacing, including spacing of cantilevered structural posts and lighting.

STUDY FABRICATION AND INSTALLATION PROCESSES

Industrial engineering methods can be employed to study the time and motion requirements of the fabrication of panels. Simulation modeling allows for study of the fabrication method, essentially treating the panel assembly as a work cell from manufacturing. A sim model also allows for multiple fabrication scenarios to be tested and evaluated against the current working estimate. While an assessment of any assembly can be beneficial, employing more standard pre-fabricated elements and maximizing the total number of pre-fabricated elements results in the greatest potential savings.

The team worked through a number of iterations to determine an ideal sequence for fabricating a panel. Work included time/motion study of materials, placement of individual components, ergonomics of the fabricator, and benefits of multiple fabricators working simultaneously. A similar approach was used to develop a standard process for field installation of the panels, as well.

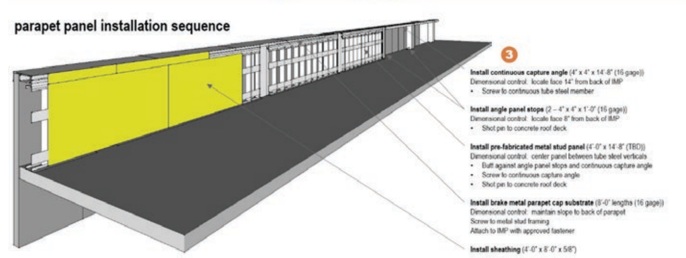
DETERMINE A LOGISTICAL APPROACH

Pre-fabrication logistics requires studying many variables, including shop or field pre-fabrication at its most fundamental level. A logistical analysis must include factors of labor rates, transportation cost, material availability, site access, sequencing of work, and impact of installation on other trades. All must be evaluated and combined to find the best value solution for installation logistics.

The team studied a number of alternatives for pre-fabrication logistics. One alternative involved setting up a fabrication station on-site. A variation of the on-site method examined the potential of making an assembly jig on wheels that could be located on the roof, allowing the fabricators to fabricate panels just-in-time, leading the installers along the perimeter of the roof. Ultimately, the team decided to fabricate at the framing trade partner's shop and to transport the completed panels to the site.

FABRICATION

Pre-Fab CALIFORNIA	Walk to	Select	Walk from	Place	TOTAL	Assumption: 2 workers working on a vertical jig with staged materials
Wall Panels						
Place bottom track	2.0	3.0	2.0	3.0	10.0	Worker 2 stages track
Clamp bottom track	0.0	0.0	0.0	2.0	2.0	
Place top track	2.0	3.0	2.0	3.0	10.0	Worker 2 stages track
Clamp top track	0.0	0.0	0.0	4.0	4.0	
Place studs	2.0	10.0	2.0	60.0	74.0	Worker 2 counts and stages studs
Screw studs front side	0.0	0.0	0.0	120.0	120.0	Worker 1 - work simultaneous on front and back
Screw studs back side	0.0	0.0	0.0	0.0	0.0	Worker 2 - work simultaneous on front and back - time included above
Place lower backing	2.0	1.0	2.0	3.0	8.0	Worker 1 - work cascade on top and bottom
Screw lower backing	0.0	0.0	0.0	48.0	48.0	Worker 1 - work cascade on top and bottom
Place upper backing	0.0	0.0	0.0	3.0	3.0	Worker 2 - work cascade on top and bottom - time included above
Screw upper backing	0.0	0.0	0.0	16.0	16.0	Worker 2 - work cascade on top and bottom - time included above
Attach temporary clamp stops	0.0	0.0	0.0	20.0	20.0	
Demount panel	0.0	0.0	0.0	10.0	10.0	
Reset jig	0.0	0.0	0.0	0.0	0.0	
					325.0	**6.2 minutes per panel to fabricate in place**
			PFD	15%	373.8	



Fabrication and installation study with time / motion analysis

PLAN FOR SCATTER AND STAGING

In order to maximize the impact of the pre-fabrication approach, individual elements must be treated as material goods in a supply chain. To leverage savings, materials must be staged appropriately to allow workers to arrive on site, put work in place efficiently and safely, and install elements at the design speed developed in the time / motion analysis. Consideration should be given not only to locating elements where they will be installed, but also placing them in such a way as to minimize movement in installation, including orienting in the direction of installation and staging in a way that minimizes risk to the installer. The installer is the customer of the stager and should be treated as such.

The team received delivery of the panels and staged and scattered them on the roof using the crane on site. Attention was given to orienting the panels for correct installation.

CONDUCT A FIRST RUN STUDY

Key to leveraging a modular panel pre-fabrication strategy is the speed to efficiency of installation. As each panel is identical and installed in the same way, a time/motion study will reveal the best way to approach installation and allow the crew to develop standard work. Some of the standard work can be developed based on past experience, but the best results come from installing work in the actual field conditions using a first run study. Video of the first run study can be used in a manner akin to sports game tape, allowing the installers to see their work and seek opportunities for improvement.

The team selected an area of the parapet for a first run study. The correct number of panels were fabricated, delivered to site, lifted by crane to the roof, and scattered along the parapet for installation. The installation crew swept through and quickly installed the panels. Each panel fit in place perfectly.

EXECUTE INSTALLATION PLAN

A sound installation plan relies on first developing standard installation work and then leveraging standard work to maximize efficiency and savings. In the same manner in which a manufacturer refines and improves work in a cell, each installed panel should build on the lessons of the previous installation. Workers on the crew should remain on the crew, leveraging the benefit of learning through repetitive motion.

The team found that the potential maximum pace of modular panel installation far exceeded the pace of accompanying trades, speaking to the importance of examining all connected trades. Therefore, installation was broken into phases that aligned with the overall pace of work. The team did realize savings for the reduction in labor required to frame the parapets, though the overall project duration remained the same.

REFLECT FOR IMPROVEMENT

The exercise of pre-fabrication, transport, and installation should be examined not only for its own sake, but also as a catalyst for finding other ways to pre-fabricate and optimize installation on the current project and on future projects.

Panel successfully installed on site