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MODULAR MINDSET

Using modular construction for industrial and power projects has its advantages, but there are several things to consider first.

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IN RECENT YEARS, large industrial or power projects have been embracing the concepts of modular construction to meet increasingly aggressive construction schedules.

These efforts have typically fallen under the umbrella of "PPMOF," which has been defined by the Construction Industry Institute (in Document IR171-2) as:

Prefabrication: A manufacturing process, generally taking place at a specialized facility, in which various materials are joined to form a component part of a final installation. Prefabricated components often involve the work of a single craft.

Preassembly: A process by which various materials, prefabricated components and/or equipment are joined together at a remote location for subsequent installation as a sub-unit; generally focused on a system.

Module: A major section of a plant, resulting from a series of remote assembly operations, which may include portions of many systems—usually the largest transportable unit or component of an assembly.

Offsite **F**abrication: The practice of preassembly or fabrication of components both off-site and on-site at a location other than the point of final installation.

Nearly any large industrial or energy project can benefit from PPMOF. However, these benefits are by no means guaranteed nor are they the same for every project. Every project, and project team, is different and the strategies deployed for one project may not be commercially justified or viable from a construction perspective for another. Consequently, analysis should be performed at the outset of the project to consider the extent of each component of PPMOF.

Determining Factors

There are eight general areas that should be considered to determine if PPMOF will have a positive impact:

- Schedule
- Cost
- Labor
- Safety
- Site attributes
- Mechanical systems
- Transport and erection
- Projects and contracts

Schedule. Perhaps the most significant question is: Will PPMOF shorten the critical path of the project schedule in a "meaningfully beneficial" way? Simply shortening a portion of the construction schedule may not always be an advantage. Doing so may not reduce the critical path or may disrupt the timing of other project elements, such as the scheduled removal of an expensive large ringer crane. It also may interfere with other associated schedule activities—e.g., a shorter schedule may only be viable with a premature shutdown of related industrial equipment, thereby complicating existing plant operations. By the same token, the nature of some projects can be such that even relatively small reductions in schedule can have outsized benefits due to early market entry, avoiding contractual penalties and achieving schedule bonuses. Shorter may be better, but one cannot simply assume so without a thorough schedule evaluation.

Cost. Setting aside the direct cost impact of schedule changes due to incentives/penalties, one should also consider other consequences, such as the impact on project cash flow. For example, use of prefabrication and modularization may require unusually large expenditures in the beginning of the project and corresponding changes to the project financing model.

Labor. Generally speaking, labor productivity increases when work is performed at ground level in an enclosed or protected environment, instead of at the final and elevated location. This is often considered to be a major advantage of PPMOF. Nevertheless, there are other ways a project can benefit from PPMOF, such as by shifting work from a labor-sparse location like a remote site to more labor-dense locations or a large preassembly yard. Similarly, specific skills may not be evenly distributed in the labor pool, so PPMOF can be used to move special tasks to areas where better skills are available. Related considerations include existing labor agreements, possible jurisdictional issues and political considerations in both the area surrounding the project site and the site(s) of PPMOF.

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Safety. PPMOF tends to be performed at or near ground level, while traditional work is often performed at height, with corresponding fall hazards. Some advantages of PPMOF include a reduction in worksite craft density, reduced exposure to site-specific hazards like weather events, reduced task risk and finances—e.g., potential reduction of insurance fees. Additional areas of consideration include the possibility of heavier but less frequent crane lifts (by isolating erection-related tasks into fewer but more significant operations).

Site attributes. When considering whether to use prefabrication, consider the differences between the project site and the site(s) where prefabrication will be performed. Which location has better weather? Are there political issues in certain regions that don't apply elsewhere? Are there environmental restrictions or infrastructure concerns in specific areas?

Mechanical systems. Not surprisingly, the more densely packed equipment is, the easier it will be to modularize. Take care, however, to think about how the equipment will be maintained after installation; it can be perilously easy to arrange mechanical systems for optimum density and shipping convenience, only to discover later that critical maintenance tasks cannot be reasonably completed due to interference from elements that were field-installed. This is not a new concern, but prefabrication can move coordination issues to new places/teams within the project lifecycle, potentially creating problems.

Transport and erection. The obvious question is: What load sizes can be reasonably transported to the project site? But there is also a corollary question: Does sufficient transport capacity exist—i.e., can you get a sufficient number of suitable transporters, and will they be permitted to operate in accordance with your schedule, or will it be necessary to limit their hours or sequence of operation?

Additionally, note that prefabrication techniques generally mean that any given transport load will contain more "value" than with traditional construction methods. This is one of the goals of prefabrication, but it has a flip side: If each load is more valuable, will you need additional transportation insurance or other forms of warranty against damage? Have you looked at backup transport and logistics contingencies? With extensive prefabrication, it is possible that a single delayed truck will mean that you cannot erect a key unit and will end up stalling the entire project.

Once the units have arrived on-site, does sufficient lift capacity exist, or will it be necessary to store units for some length of time before they can be moved to their final position? If they must be stored, can they be stored safely or should some form of foundation be provided for them during the storage period?

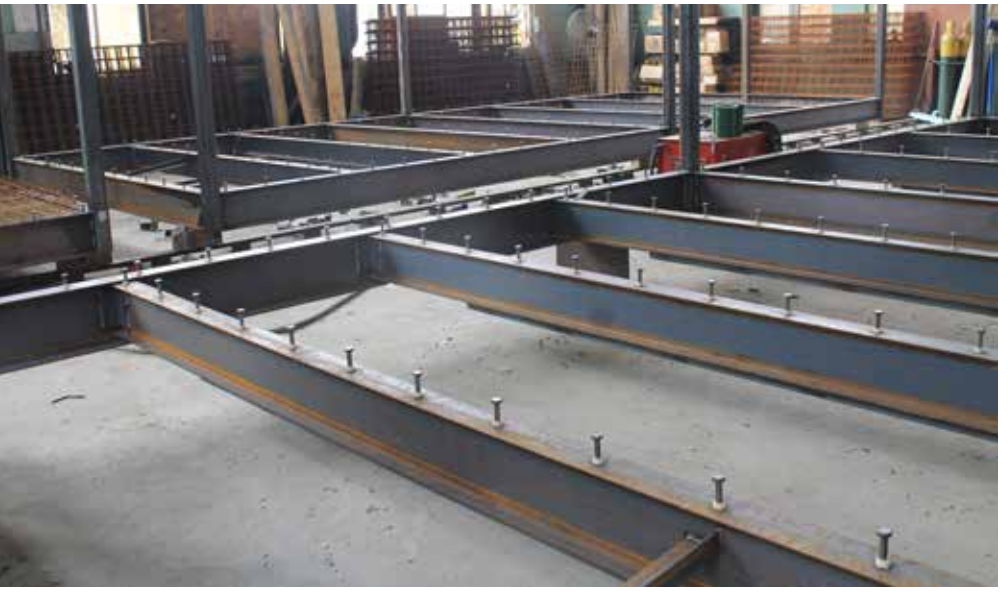
Projects and contracts. The various legal formalities and contracts required for traditional construction methods are fairly well-tested and most firms have a sense of what is reasonable in those contracts. This may not be true for projects involving significant prefabrication, so you should look at contractual arrangements in detail. For example, the question of who will carry risk can be especially fraught in projects involving multiple off-site suppliers, assembly yards and transport routes. By the same token, equitable allocation of incentives and penalties may require more than the usual degree of attention. You may also find that prefabricated elements that incorporate certain components can create special issues with equipment suppliers, such as intellectual property concerns that mandate special agreements (e.g., perhaps attention must be paid to keeping specialist installers from one supplier away from components that have been installed by their competition).

From a project-planning perspective, prefabrication/modularization will tend to produce an earlier resource peak, but will also require that project scope and design freeze must occur earlier. The sooner everyone can commit to a hard freeze, the better. Between the earlier resource peak and requirement for early design freeze, you may find that the risk profile of the project can change substantially compared to traditional approaches and can be a notable advantage.

Possible Impacts

It is likely that using extensive prefabrication/modularization on a project will result in increased efforts to develop the structural drawings, as well as additional increases in mechanical systems drawings (especially electrical and control systems). There will also be a need for greater coordination in general, which should be accounted for. The overall result, from an engineering point of view, may end up being on the order of double the engineering hours.

◀ Eight general areas should be considered to determine whether PPMOF will have a positive impact on a project: schedule, cost, labor, safety, site attributes, mechanical systems, transport and erection and projects and contracts.



Nearly any large industrial or energy project can benefit from PPMOF (prefabrication, preassembly, module and off-site fabrication).

This does not mean that prefabrication isn't worth pursuing—but it does mean that project teams should pay careful attention at the very beginning. PPMOF must begin in the preliminary design phase or you risk not having sufficient time to conduct a proper analysis. Being able to complete a full cost/benefit analysis is especially important whenever changing traditional practices in any industry, as costs are frequently underestimated. As such, analysis of new PPMOF techniques should show a substantial benefit before proceeding further.

Be absolutely sure that you understand the potential effects on key project variables and have looked at the consequences across the project team; you cannot assume that everyone will understand the impact of your prefabrication choices. There will be multiple critical paths in your project and the entire project team will be more interdependent than ever, so increased communication at all levels is a must. ■

This article is based on the session "Modular Construction Practices" from the 2013 NASCC, presented by Perry Green and Jim Ryan. You can view it at ***www.media.aisc.org/NASCC2013/N44.mp4****. For more on industrial facilities, see "Power Up" (11/2012) at* ***www.modernsteel.com****. You can also view CII IR 171-2* Prefabrication, Preassembly, Modularization, and Offsite Fabrication: Decision Framework and Tool *and CII RS 283-1* Industrial Modularization: How to Optimize; How to Maximize, *both at* ***www.construction-institute.org****.*

Prefabricated components often involve the work of a single craft.

Technical Advice

Thinking about modular construction for an industrial facility? Here are some tips:

- Include modularization in design criteria for all disciplines before starting detailed engineering.
- Develop the general arrangements for the project around modular framing.
- Use bolted field connections.
- Budget extra steel and commodity fittings.
- Question the value of preassembly; once you start down the path of increasing prefabrication, people may start thinking of everything that you could possibly preassemble, but you must always ask whether it genuinely makes sense to do so.