



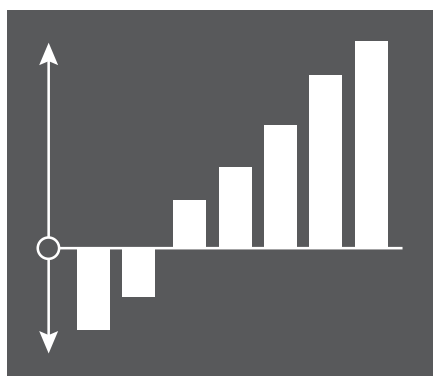
NEW DAY, NEW MINDSET

RETHINKING OFFSITE CONSTRUCTION

2018 FMI/CURT/CII Owner Survey



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OFFSITE CONSTRUCTION: A SNAPSHOT IN TIME

61%

of respondents think today's offsite construction environment is different than in 2014.

39%

78%



PREASSEMBLY

43%



OFFSITE MULTITRADE FABRICATION

78%



MODULARIZATION

91%



PREFABRICATION

PREFABRICATION

is the most popular offsite construction method among owners.

TOP-THREE REASONS FOR CHANGE IN TODAY'S OFFSITE CONSTRUCTION ENVIRONMENT:

1

Skilled labor shortage at the job site

2

Pressure on project costs

3

Pressure on project schedules

BIGGEST CHALLENGES

to the adoption of offsite construction methods are people-related.

- Lack of knowledge and experience
- Fear of taking new risks
- Reluctance to change



OFFSITE CONSTRUCTION: THE BIG CULTURE OBSTACLE

62%

of respondents are still on the fence about offsite construction.



Reducing time to project completion



Reducing construction costs (total install cost)

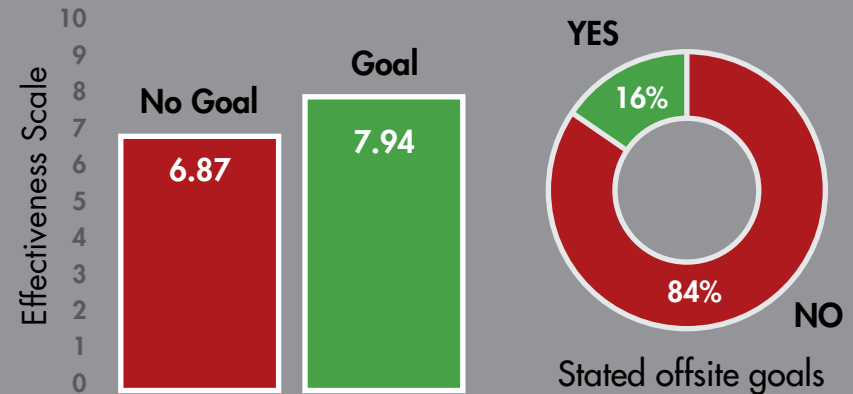


Improvements in worker safety

TOP-THREE
BENEFITS OF
OFFSITE
CONSTRUCTION:

BETTER RESULTS

Owners who plan strategically for offsite construction projects see better results compared to those lacking stated, offsite construction goals.



BUSINESS-DRIVEN

THE BIG DISCONNECT

Many of today's capital projects are business-driven, not execution-driven.

EXECUTION-DRIVEN



Executive Summary

Today's worldwide capital projects are getting ever more complex and larger in scope, with many of these projects facing chronic cost overruns and schedule delays. In fact, as an industry, we have almost accepted the fact that nothing ever gets built on time or on budget.

These conditions, combined with the ongoing exodus of industry knowledge due to retiring baby boomers, have led industry stakeholders around the world to take a step back and re-examine the status quo. It is within this context that FMI partnered with the Construction Users Roundtable (CURT) and the Construction Industry Institute (CII) to take a high-level snapshot of today's U.S. offsite construction environment, and to see how owner organizations perceive and use offsite construction for their projects.

While offsite construction – including prefabrication, modularization, preassembly or offsite multitrade fabrication—has been around for decades, it is emerging as a critical method for delivering projects faster, in a safer and cheaper manner in today's labor-constrained engineering and construction (E&C) environment. **The concepts and philosophies of offsite construction have proven themselves across a broad range of projects, market sectors and geographies, but there remains an underlying reluctance among many U.S. owner organizations to fully embrace this project delivery approach.**

The following study, which was conducted in the fall and winter of 2017, sheds light on the current state of offsite construction in the U.S., explores owner organizations' perceptions around benefits and impediments to offsite construction and associated organizational implications, and highlights industry success stories.



If you don't like change, you're going to like irrelevance even less.

– General Eric Shinseki
U.S. Army



Some key study findings include:

- **Two-thirds of the survey participants stated that today's offsite construction environment is different than it was just three years ago.**
- Top reasons for changes in the offsite construction environment include **labor shortages and increasing cost and schedule pressures.**
- **Only 38% of respondents** have a high acceptance level of offsite construction.
- **Owners who plan strategically for offsite construction projects see better results** compared to those who don't have stated, offsite construction goals.
- **Almost 50% of owners still go with the traditional design-bid-build approach**, which does not allow for optimal project planning of offsite construction.

The study's insights paint a mixed picture and reveal that although most owners perceive high levels of effectiveness for their offsite construction projects, participants use these manufacturing methods on less than 50% of their capital projects. Furthermore, only 16% of respondents plan strategically and set goals for offsite construction.

However, our study also found that **several very innovative owner organizations are pushing offsite construction aggressively across all projects and achieving great results through more collaborative and transparent delivery mechanisms.**

In the future, we will continue to promote a productive offsite construction dialogue with industry stakeholders to help further the conversation around **entirely** rethinking project delivery and moving the industry forward. Offsite construction is just one part of the bigger picture—but it's key in setting the stage for a transition to “true” manufacturing of the built environment.

As with many new concepts or changes, success breeds success. Offsite construction is no different and therefore all industry players must alter their mindsets and educate themselves – and each other – on the benefits and challenges of this construction manufacturing approach. Everyone will need to be open to new ways of designing, manufacturing, sequencing and putting construction projects in place. Rather than viewing offsite construction as a threat or disruption, owner organizations that embrace it will be best-positioned to win in the built environment of today and tomorrow.



Key Findings

The following key findings are based on contributions from more than 100 owner members of CURT and CII who are involved in offsite construction both nationally and around the globe. The data was collected during the summer and fall of 2017 via an online survey and through phone interviews that delved deeper into key topics identified in the survey.

Almost 50% of participants' firms have annual capital construction budgets of \$1 billion or more and conduct business on a global scale, primarily in the oil and gas (46%), petrochemical (44%), power generation (27%) and manufacturing (21%) sectors (see Appendix for more details). While the results are skewed toward the industrial sector, many of the comments and insights apply to the broader E&C industry as well.

Study findings are organized around the following four main themes:

- 1. The perfect storm:**
Why offsite construction is more critical than ever.
- 2. Rethinking project execution:**
The need for a paradigm shift.
- 3. The big culture obstacle:**
It's all about leading innovation and driving change effectively.
- 4. Success breeds success:**
Changing the conversation and spreading the word.

THEME 1. THE PERFECT STORM

Why offsite construction is more critical than ever.

Key Finding 1:

Today's offsite construction environment is different than it was three years ago, and it is changing rapidly.

Two-thirds of the survey participants stated that today's offsite construction environment is different than it was just three years ago (Exhibit 1). While offsite construction has ebbed and flowed for decades, there has been an unprecedented surge in recent years. Participants listed the following top reasons for this (Exhibit 2):

- The shortage of skilled labor at the job site.
- Increased pressure on project costs.
- Increased pressure on project schedules.

While these industry challenges continue to intensify, few firms are taking steps to **fundamentally** solve these issues. As one large oil and gas owner stated, "We need to move away from Einstein's definition of insanity: doing the same thing over and over again and expecting different results."

In other words, "The decades-old stage gate 'operating system' (i.e., OS 1.0) is obsolete. 'Plan the work, work the plan' simply does not work," confirmed Peter Dumont, CURT president and vice president of global strategic projects at Pentair Thermal Management.¹

EXHIBIT 1. IS TODAY'S OFFSITE CONSTRUCTION ENVIRONMENT DIFFERENT COMPARED TO THREE YEARS AGO?



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

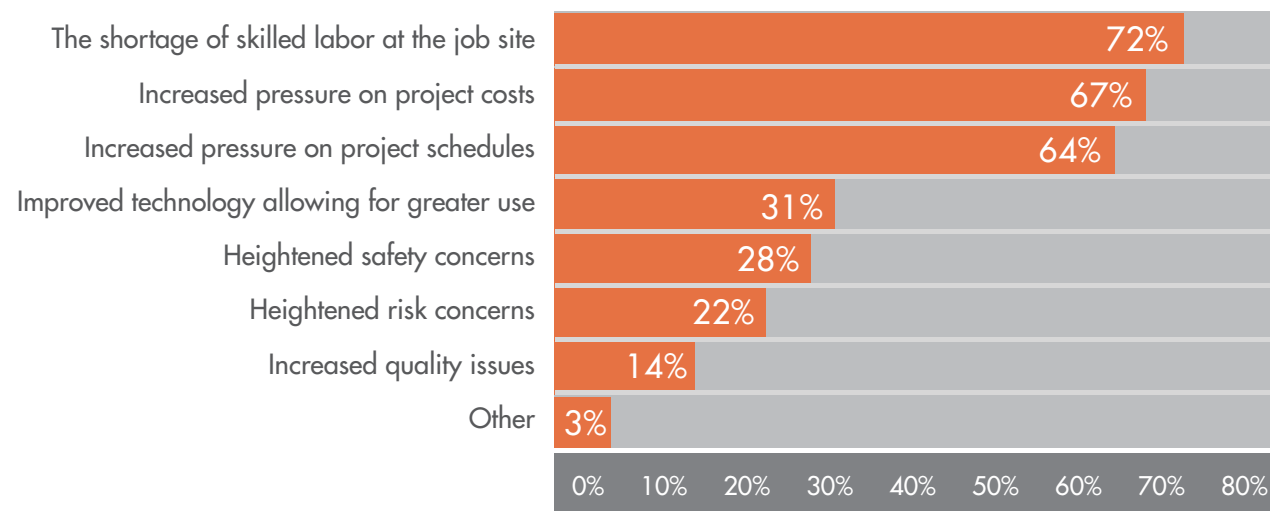
¹ The Voice. CURT Magazine. Fall 2017.

So what will it take to truly transform the industry? How can owners take charge and work with industry stakeholders to reinvent new business models, leverage innovative construction/manufacturing techniques, integrate emerging technologies and redefine project partnerships? To achieve substantial change, owner organizations and firms in engineering, construction, manufacturing and building products must all work together to rethink how projects are conceived and executed from start to finish.

As part of this effort, project delivery, people and technology must all be factored into a firm's strategic business model. Today these three elements aren't truly integrated effectively across teams and within projects; furthermore, outdated procurement practices and decision-making models hinder many owner organizations from breaking out of antiquated processes and related behaviors.

While offsite construction is not the only solution to the bigger "systems problem," it does play an important role in helping stakeholders think through the overall project delivery strategy and drive higher levels of coordination, collaboration and project team

EXHIBIT 2. REASONS FOR CHANGES IN THE OFFSITE CONSTRUCTION ENVIRONMENT OVER THE PAST THREE YEARS



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

alignment. Today dozens of innovative companies – on both the owner and design/construction/manufacturing/building product side – are reshaping and transforming outdated business models, and we expect this movement to gain traction in the coming years.

In his latest book, **“Theory of Management of Large Complex Projects,”** Robert Prieto, a former Fluor Corp. senior vice president and Parsons Brinckerhoff chairman, states, “Projects’ strategic business outcomes must be articulated and agreed upon, not just assumed. People change on long-duration projects, so desired outcomes must be continu-

ously and consistently telegraphed. Framework processes for decision-making must be strengthened and streamlined, gaining resilience through common cultures and behaviors in a transparent, communication-driven environment.”

These attitudes are often inherent to successful offsite construction projects, so why don't we see and hear more about these success stories? Why aren't owners dictating these innovative approaches on all their projects, given the benefits in schedule, cost and risk reduction, for example? For starters, not all projects lend themselves to offsite construction. Therefore, before jumping into the world of offsite construction, owner organizations must learn industry best practices and start thinking about some key questions, including:

- What is the purpose of this capital construction project, and how does that shape our project execution strategy? And how does offsite construction fit within this broader project execution strategy?

- Do the project execution strategy, project delivery method and contract type allow for proper early participation of project partners and enable adequate information flow and team collaboration to support offsite construction?
- What type of scope and trades are best-suited for offsite construction?
- How does offsite construction differ from traditional delivery methods? And what are the implications for our standard owner project management processes in planning, design and construction?
- What new skills and competencies are needed? How do we prepare our workforce to adapt to these changes? What are the cultural implications?

Al Schwarzkopf, associate director with Merck and Co., Inc., stated, “**In order for us to have a radical change in productivity as an industry, we've got to revolutionize the way we deliver projects. And modularization is probably one of the key components in**

being able to take that first step. Just like the assembly line, with modularization you're shifting the paradigm from 'the worker goes to the work' to 'the work goes to the worker.' And that allows you to work more safely and quickly and with higher quality and be more cost-effective.”

Over time, we believe the E&C industry can move beyond fabricated/offsite construction toward true manufacturing of the built environment. However, the industry at large is still stuck in its old ways today and will need to overcome some significant obstacles to truly evolve and transform in the coming years.

The following sections provide important insights into how capital projects must be strategically designed and executed, and we also discuss associated organizational and cultural implications as well as success stories and future opportunities.

THEME 2. RETHINKING PROJECT EXECUTION

The need for a paradigm shift.

Key Finding 2:

While most owners perceive high levels of effectiveness for their offsite construction projects, participants use these manufacturing methods on less than 50% of their capital projects.

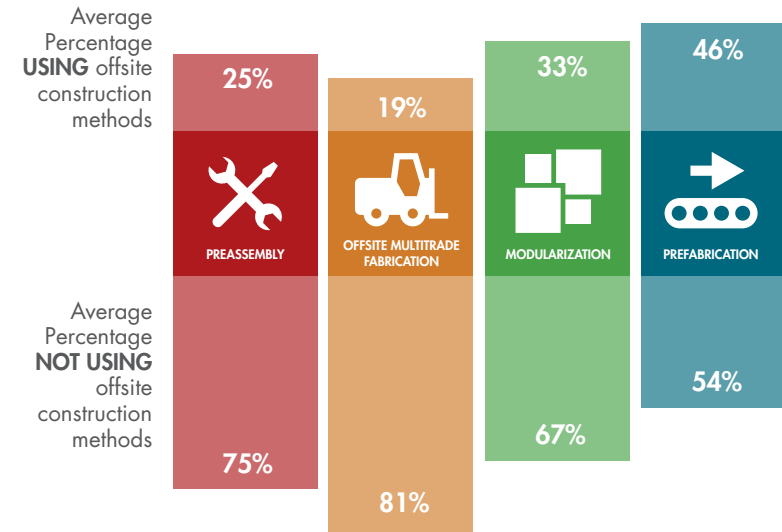
Exhibit 3 reveals the average rate of effectiveness for different types of offsite construction methods as rated by study participants. These levels (ranging from 6.7 to 7.6 on a scale of 10) are relatively high and reinforce the fact that offsite construction concepts do work when done right.

On the flip side, offsite construction methods are used less frequently than one would hope or expect. For example, participants report that only 46% of capital projects use prefabrication methods and only 33% use modularization. For preassembly and offsite multitrade fabrication, the numbers are even lower (Exhibit 4).

EXHIBIT 3. AVERAGE EFFECTIVENESS RATE BY TYPE OF OFFSITE CONSTRUCTION METHOD



EXHIBIT 4. USE OF OFFSITE CONSTRUCTION METHODS ON ASSOCIATED CAPITAL PROJECTS WORK



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

There are several possible explanations for why offsite construction isn't applied more often on capital projects, including the lack of awareness of the various offsite construction methods and a misunderstanding about what it takes to truly maximize these manufacturing techniques. Too often, decision-making related to project procurement and delivery occurs at the owner organization's executive level, while project execution occurs at the project management level. In many cases, executives don't consider project delivery methods, construction industry pressures, drivers or bottlenecks and what it takes to effectively execute a capital project.

As one study participant explained, **“In many cases, owners don't have enough project professionals engaged in the early planning phase. It's all business-driven. Wall Street is driving these projects.”**

In some cases, the owner procurement teams (e.g., purchasing departments) drive cost decisions without considering the overall project complexity, work sequence, total cost and team coordination efforts. As such, offsite construction isn't evaluated in the context of a broader project execution strategy. Consequently, con-

tracts don't allow for early involvement of key stakeholders, such as equipment vendors, fabricators and construction service providers, which further impedes project success.

As one owner participant stated, “Oftentimes, the procurement groups are not experts in engineering and construction. They're experts in how to buy pencils for 5 cents cheaper, to use an example based in hyperbole. They're not necessarily project execution specialists. The core concept that they are missing is that you almost never optimize the whole project by suboptimizing the procurement of each component at the lowest possible price. Reverse auctions are a great example of what might have been a well-intended procurement practice that went awry. They are one of the worst things that has happened to our industry in years.”

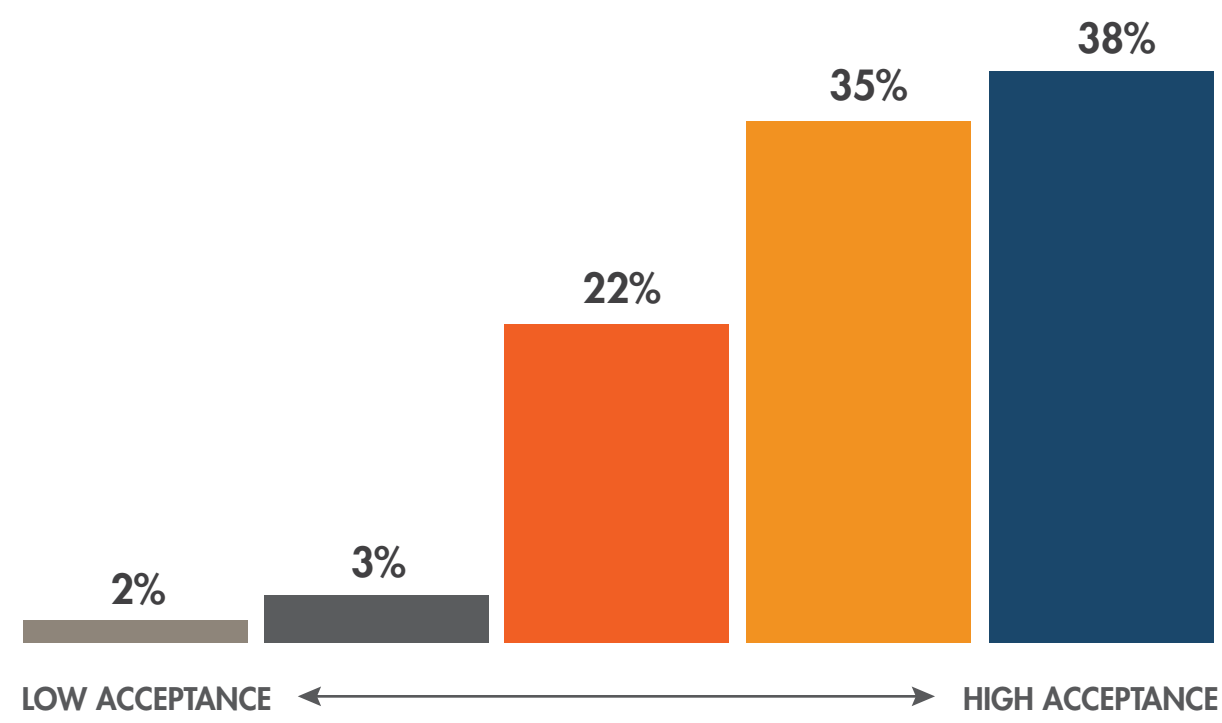
Another way of thinking about this issue is to view offsite construction as a delivery method – in the same way that owners would select design-bid-build, design-negotiated-build or design-build delivery strategies, for example. An early and deliberate decision is vital with offsite construction, since the planning, design and construction phases of such projects differ

from those of the other three traditional project delivery methods. For example, for offsite construction, project planning must include (but is not limited to):

- Firms available to the owner with expertise in prefabrication that can be considered for the project.
- Offsite resources (e.g., real estate) for fabrication and staging.
- Logistics/shipping and delivery of large prefabricated assemblies to the job site.
- Specific skills and equipment associated with offsite construction activities.

“

WHAT LEVEL OF ACCEPTANCE TOWARD OFFSITE CONSTRUCTION METHODS DOES YOUR ORGANIZATION CURRENTLY HAVE?



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

62% of respondents' organizations are still on the fence about offsite construction. Only 38% have high acceptance levels toward offsite construction.

”

Gregory McQueen, vice president with Pentair, confirmed, “I’ve worked and lived in offsite construction for more than 20 years, and I’ve seen it carried out under every contractual situation imaginable. And it still works. What’s key is to make sure that you’ve got it as part of your design philosophy at the very, very beginning of a project. And then ensuring that all the execution skill sets and tools are in place to be able to execute it adequately.”

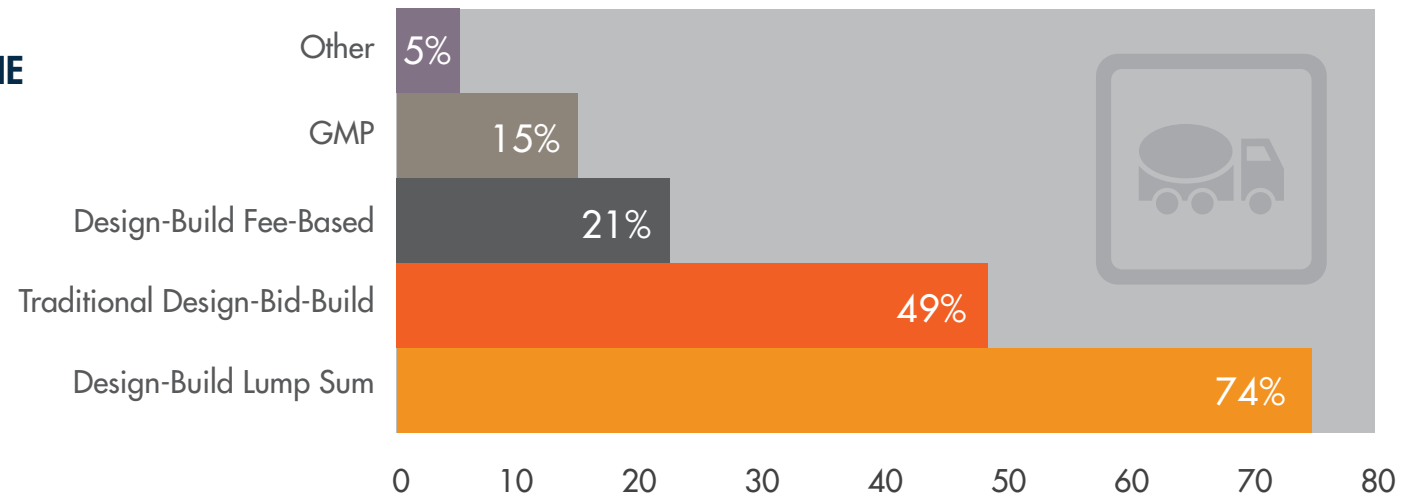
During the design phase, the offsite engineering and construction firm(s) must drive the coordination and production of archi-

tectural and engineering drawings. In fact, in the near future, with a true offsite construction project delivery approach, the construction drawings could conceivably be exclusively produced by the contractor and specialty trades with further coordination and code compliance review by the architecture or engineering firm(s). In this scenario, the construction phase also requires considerable ongoing planning and coordination, as building assets and systems move through fabrication, shipping and final assembly/connection onsite. You can quickly see how offsite construction can serve as a project delivery method that maximizes the benefits and success of this approach.

Our study findings indicate that while 74% of owners use design-build lump sum as a procurement strategy for selecting offsite construction providers, **almost 50% still go with the traditional design-bid-build approach, which does not allow for optimal project planning and execution** as described in the above scenario (Exhibit 5). This is another reminder that the industry must reform traditional procurement and delivery methods and rethink project execution entirely.

EXHIBIT 5. PROCUREMENT STRATEGIES WHEN SELECTING THE OFFSITE CONSTRUCTION FIRM

Percentage of Participating Respondents by Procurement Strategy



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

Key Finding 3:

Owners who plan strategically for offsite construction projects see better results compared to those lacking stated, offsite construction goals.

As with all important strategic initiatives, the “business of offsite construction” starts at the top, with committed leaders who communicate a clear strategy and strong vision around the company’s mission (e.g., start with the question: Why are we pursuing offsite construction?). Successful companies typically select an executive-level champion to lead the offsite construction initiative and align all teams with the company’s overall project execution vision and strategy. This approach often requires close collaboration and coordination across different business groups and ultimately helps build a better business.

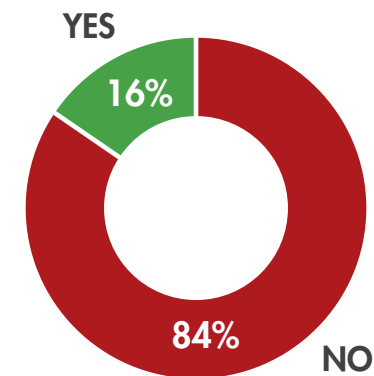
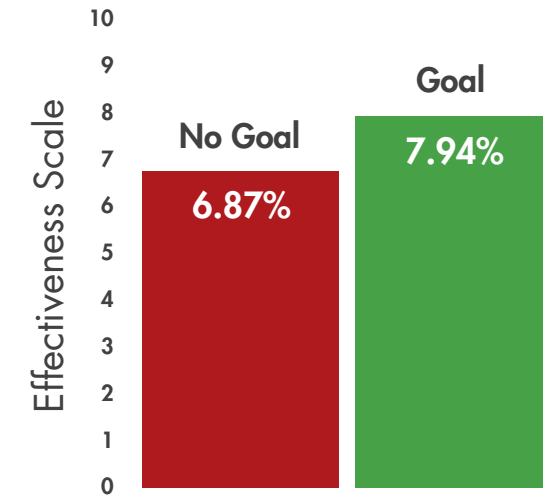
Jeffrey Johnson, manager of process energy initiatives with GM Global Facilities Engineering, stated, “First, you need someone who is willing to be a true champion for the cause. Someone who is going to apply constant, gentle but unrelenting pressure toward reaching the offsite construction goal to prevent the

system from backsliding. This is true not only in the proposal and development phase, but also after project award, because there will still be many people who will slip back into the same behaviors and methodologies that they would use on a conventional construction project.”

An interesting finding from our owner study confirms the importance of viewing project execution holistically and planning for it strategically. Exhibit 6 shows how owner organizations using formal offsite construction goals perceive such projects to be more effective compared to owners who lack strategic goals. However, only 16% of respondents have such strategic offsite construction goals in place.

In our work with contractors, we often encounter situations where a project manager or superintendent experiments with offsite construction on a project-by-project basis. But offsite construction is not something you can just dabble in and expect to see big returns from; it is an entirely different business philosophy and must be a fundamental part of the corporate strategy. Otherwise, it just ends up being a very expensive experiment.

EXHIBIT 6. DO YOU HAVE STATED OFFSITE CONSTRUCTION GOALS?



Stated offsite goals

Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

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Offsite work requires a lot of up-front planning, which needs to be completely analyzed and prepared for during FEED. It also requires many special design and material selection considerations. You just can't take stick-built designs and cut them up into modules. You have to perform modular-based design upfront and plan the myriad of material, logistical and scope-split types of issues into the process.”

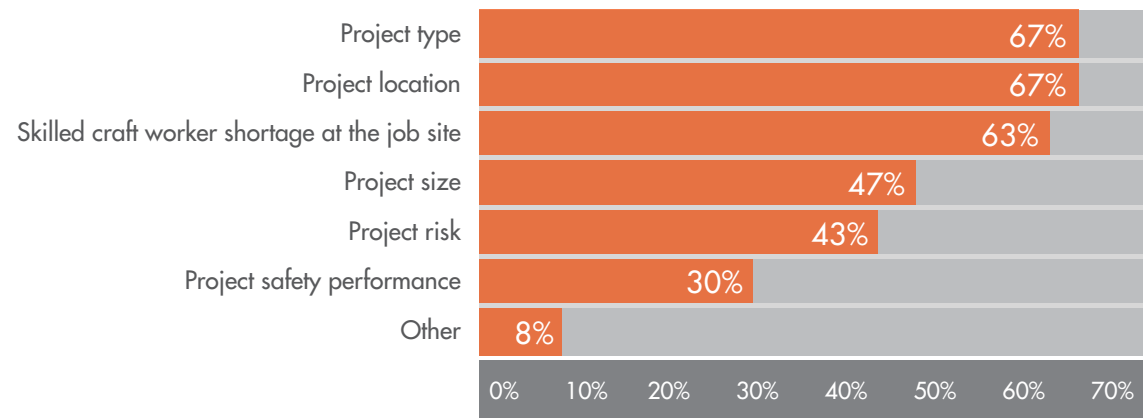
– Peter Dumont, P.E.
Vice President
Global Strategic Projects
Pentair Thermal Management

The same goes for owner organizations. Unless offsite construction is fully understood and supported at all levels—and made an integral part of a corporate project execution strategy, with measurable goals and objectives—it won't succeed.

Atul Khanzode, Ph.D., head of technology and innovation at DPR Construction, explained, “The challenge with doing prefabrication is that it's not just thinking about prefabrication. Instead, it's more about thinking of how your prefabrication strategy fits within the overall strategy of delivering a project.”

Today most owners don't think of offsite construction as a delivery model or project execution strategy. And as such, they often can't effectively leverage technology, people and manufacturing techniques to reduce cost and project schedules. In fact, our findings show that project type and location are the top drivers for selecting offsite construction methods (Exhibit 7), not necessarily risk or safety—two strategic business areas that can be dramatically improved when offsite construction is implemented as a comprehensive project delivery model.

EXHIBIT 7. WHAT DRIVES ADOPTION OF OFFSITE CONSTRUCTION IN YOUR ORGANIZATION?



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

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THEME 3. THE BIG CULTURE OBSTACLE

It's all about leading innovation and driving change effectively.

One of the biggest barriers to change and transformation as it relates to offsite construction is not technology; it's culture. Getting people to embrace new ways of thinking and doing work differently is one of the most challenging aspects of organizational change. Introducing a manufacturing concept like offsite construction requires curious, tenacious people who are willing to learn new things, take risks and work continuously to improve outcomes. It is also particularly important to develop a culture in which employees aren't afraid to make mistakes and where everyone is open to learning from each other's mistakes.

In the industrial space, for example, firms have been using offsite construction successfully for decades. Within this realm, scores of processes, tools and methods have already proven to be highly effective. However, as one participant stated, "We just have a 'stick-built' culture."

The problem is that in many cases, a company's strategy is at odds with its very culture. When this occurs, leaders may mistakenly underestimate the direct connection between strategy and culture. And the latter trumps the former every time.

This is an area where the E&C industry must start to connect the right dots and shift behaviors. Leaders should be asking questions like:

- What new behaviors would a new cultural approach reinforce?
- Which existing behaviors would be eradicated?
- How would our relationships with industry stakeholders change and morph?
- How will employees propose new ideas and/or evaluate and collaborate with one another?
- How will employees make light of potential problems and/or react to their colleagues' actions?

Getting people to embrace new ways of thinking and doing work differently is one of the most challenging aspects of organizational change.



By emphasizing a few key behaviors, companies can motivate employees to serve as ambassadors and reinforce those behaviors. In a Harvard Business Review article,² authors explain, “As GM was emerging from bankruptcy, the company decided to spur innovation by placing a renewed emphasis on risk-taking and the open exchange of ideas. After one colleague complimented another on his performance in a meeting, their team lightheartedly began a practice of handing out ‘gold star’ stickers to recognize colleagues exhibiting strong character and candor. The practice soon began to spread. While the stickers probably would have been received skeptically as a top-down initiative, as an organic peer-to-peer custom, they helped reinforce GM’s larger cultural evolution.”

This is just a simple, yet powerful example of behavioral change, and the E&C industry is in dire need of such refreshing “movements.” **Our research shows that four of the top-six impediments currently holding owners back from adopting or driving offsite construction methods are all people-related** (Exhibit 8):

- Lack of knowledge and experience
- Fear of taking new risks (and associated job losses)
- Corporate culture that does not embrace change
- Reluctance to use different delivery methods such as design-build

EXHIBIT 8. TOP IMPEDIMENTS TO THE ADOPTION OF OFFSITE CONSTRUCTION



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

² Jon R. Katzenbach, Ilona Steffen- and Caroline Kronley. “Cultural Change That Sticks.” Harvard Business Review. July-August 2012 Issue.

Most of these challenges point to leadership and the issue of how leaders actually **lead** the business to drive innovative thinking and execution. In a **one-day workshop** hosted for three industry disruptors – Russ Becker (APi Group), Tom Scarangelo (Thornton Tomasetti) and Atul Khanzode (DPR Construction) – FMI gleaned the following insights on this topic of innovation³:

- **Spend your time, energy and resources on your organization’s people and culture.** Helping them learn and grow in their thinking, experiences and competencies now will pay dividends when you need an innovative shift later. Shortcutting people development never pays off.
- **Recognize that the power of your culture is stronger than you think.** Toxic, negative or close-minded cultures chew up new ideas and spit them out. Cultures where ideas are valued and heard provide a safe harbor for people to speak up and share different – and sometimes

radical—new ideas that could forever change the trajectory of your business.

- **Don’t expect the leader to come up with all the innovative ideas.** Every role in your business has a different perspective on how things could be done better. Provide an inclusive way for all voices to be heard – and then listen.
- **Build a culture that encourages frequent conversations around continuous improvement and better ways of doing things.** Create a safe place to talk about failures, learn from those mistakes and teach others in the future.
- **Create space for nontraditional employees to join your team.** External experiences and perspectives often bring some of the most influential shifts in our industry. Just because you don’t have a traditional role for them doesn’t mean they can’t find a place to thrive.

These perspectives are crucial in today’s owner organizations and in E&C as a whole. Unfortunately, many organizations – both on the owner and service provider side – are stuck in their old ways and reluctant to change. One study participant noted, “What does it take to get good things done in the industry these days? It seems like a lot of owners are moving more toward the older, more competitive and traditional approaches in executing jobs and shifting risks to the contractor instead of considering more advanced approaches like collaborative contracting/IPD.”

Another study participant explained, “In our industry, people tend to go stagnant with what they believe has worked historically. So they’re very resistant to change. And while a lot of progress has been made within the offsite construction or modularization world, a lot of that progress has come hesitantly... Today owners have almost been pushed into a corner where they have to re-evaluate the way they deliver their projects.”

³ Kim Morton and Ron Magnus. “Leading Innovation: Insights From Industry Executives (Part 1).” FMI Quarterly. December 2016.

Beyond overcoming antiquated habits and behaviors – all pure human challenges – the industry must also rethink existing business models and re-evaluate how capital funding is assessed and allocated. Joe Gionfriddo, consultant with Sizemore & Company Premier Resource Group, explained, “Our stage gate delivery process in the industry only looks at part of the total investment cost equation. When you only look at the capital part of the equation, offsite construction sometimes can show more cost. The key is that offsite construction accelerates project schedules, and if you’re able to go to market faster, there’s a dollar amount associated with those time savings. Therefore, you really must educate the owners, the contractors and the designers to show the total investment cost equation versus just the capital equation.”

In a key industry initiative led by CII and CURT, industry stakeholders are trying to tackle just that: the creation of a new business model, “Operating System 2.0” (OS 2.0), that will shape a project delivery ecosystem in which cost can be dramatically lowered and schedule, safety and quality will improve.

Questions that the research will address include (but are not limited to):⁴

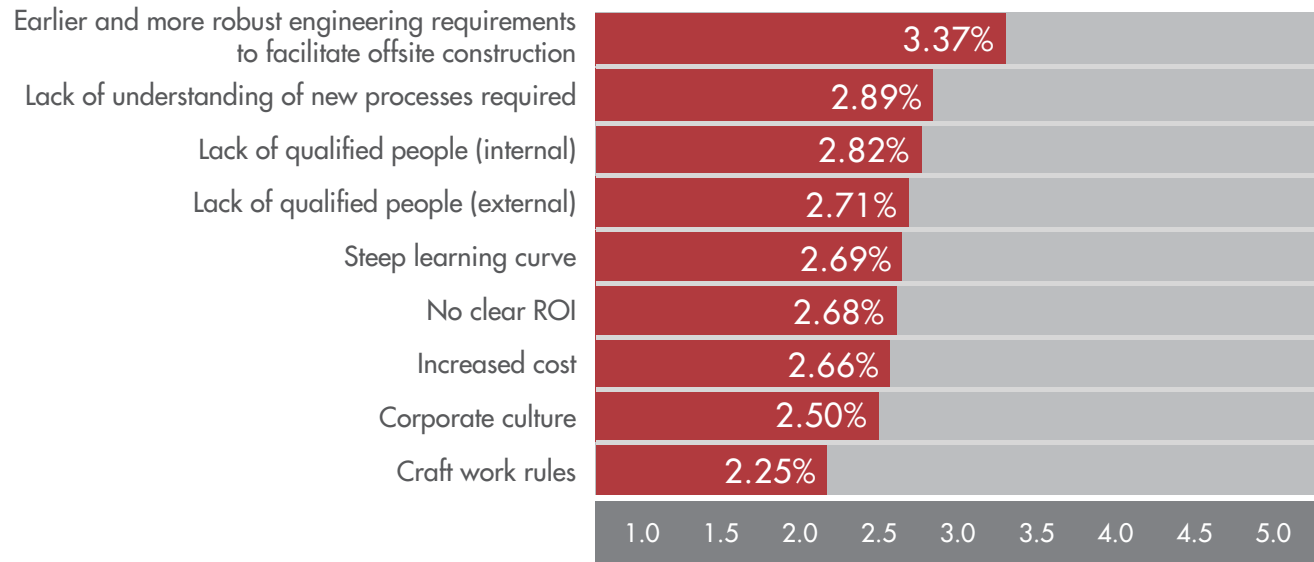
- How can we more closely integrate the business team and the project team within the owners’ organizations?
- How can we take more of an enterprise view and better conceive of and deliver projects that enhance business value?
- How can we more tightly integrate capital and operating budgets, and perhaps approach projects with completely different approaches to funding?
- In what ways might our industry create a catalyst (integrator) function within the delivery of capital assets to achieve maximum business value?

These questions call for fresh thinking and new ideas and the removal of old stigmas. Bill Lewis, senior manager, Projects Construction, Global E&PM with Sabic, explained, “It’s an education of the business. We must educate the owners and upper executives. We need to advertise our successes and maybe even share our failures. We must get out of the stigmatism that all modularizations have failed. Just because you happened to have a project that failed back in 1976 doesn’t mean that it will not work. We really need to educate the masses to understand what the possibilities and benefits are.”

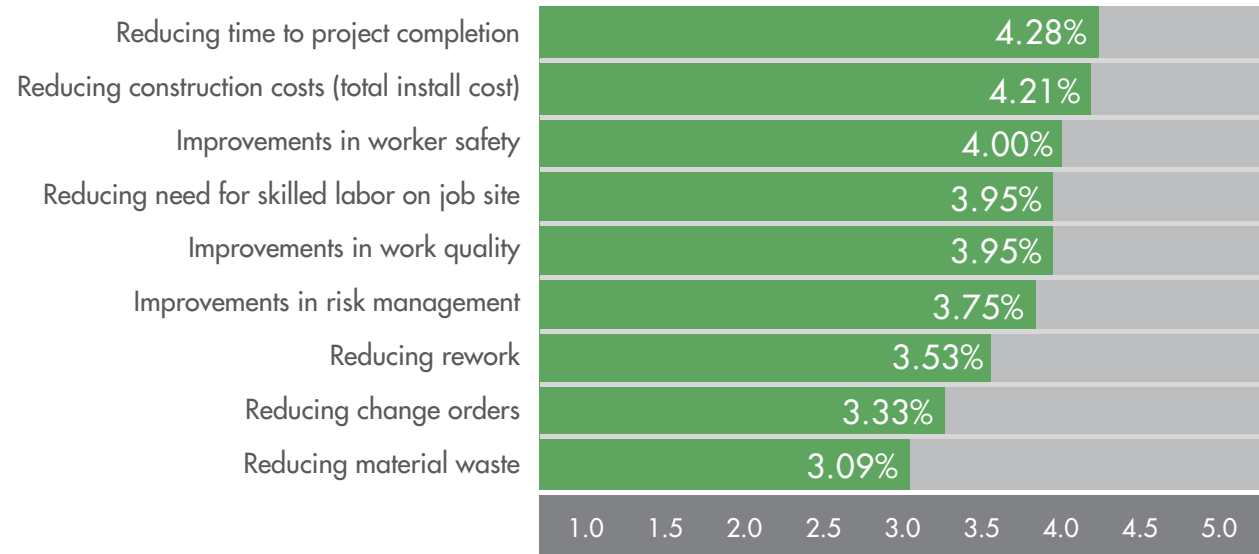
As new business models emerge in the coming years, offsite construction is expected to play an increasingly important role in the evolution from stick-built to manufacturing to automation to integrated automation models in which more standardization and miniaturization could lead to scalable, Lego-like design, manufacturing and assembly. **In the meantime, owners and service providers must keep an open mind to doing things differently, collaborate more openly with one another, and let go of some of the “tried-and-true” project/business models that no longer work in today’s E&C environment.**

⁴ Peter Dumont. The Voice. CURT Magazine. Fall 2017.

RANKING OF OFFSITE CONSTRUCTION IMPEDIMENTS THAT ARE MOST IMPORTANT TO PROJECT SUCCESS



RANKING OF OFFSITE CONSTRUCTION BENEFITS THAT ARE MOST IMPORTANT TO PROJECT SUCCESS



Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey

THEME 4. SUCCESS BREEDS SUCCESS

Changing the conversation and spreading the word.

In a recent **Turner & Townsend international construction survey**, 23 of the 43 markets surveyed were dealing with labor shortages – an increase from 20 in 2016. Four regions reported a surplus: Muscat, Perth, Santiago and São Paulo. And in the World Economic Forum’s recent “**Shaping the Future of Construction**” report, the U.S. construction industry’s productivity has reportedly fallen 19% since 1964.

Despite these rather gloomy statistics, there is hope, and there are many great companies doing great things to combat these industry challenges. A look around the E&C industry reveals a number of success stories already being told by the firms that are using offsite construction strategies.

In the alternative energy space, for example, Roeslein Alternative Energy helped Smithfield Foods transform a bankrupt 221,000-sow complex into a successful hog development complex. For this project, Roeslein Alternative Energy focused on an approach in its goal to

convert 112,000 tons/year of swine manure to pipeline-quality renewable natural gas (RNG). The turnkey modular design provided the design and fabrication of flare, compressor and membrane skids as well as the offsite design and fabrication of all electrical, instrumentation and programming controls required for each of those sections. Due to the remote location of the project, a modular design-build approach allowed fabrication to take place at Roeslein & Associates’ 400,000-square-foot fabrication facility out of Red Bud, Illinois.

The project will yield up to 2.2 billion cubic feet of pipeline-quality RNG, or the equivalent of up to 17 million gallons of diesel fuel annually. The modular component of this alternative fuel solution allows it to be economically replicated worldwide with a lower cost, quicker startup and more simplified operations and provides final project scalability based on client needs.

Joining Roeslein in its quest to best leverage prefabrication and offsite construction are large firms like General Motors, Proctor & Gamble, Sutter Health and other notable organizations. To build its new Sutter Van Ness Medical Office Building, for instance, Sutter

Health is manufacturing and constructing seven of the building’s nine floors (equaling approximately 158,000 square feet of space) entirely of DIRTT, a proprietary 3-D software to design, manufacture and install fully customized, prefabricated interiors. “Part of the reason we chose to go with DIRTT is we believe its approach can collapse our schedule by three to four months on the job site,” Michael Shanahan, a Sutter Health senior project manager stated **in a company press release**. “That alone means approximately half a million dollars in savings.”

At General Motors, new programs required major utility upgrades at five different plants. Working with a short design time and a process design that was significantly trailing the building engineering side of the project, GM opted to use a packaged build process to meet its aggressive schedule for HVAC and process water utility completion. This minimized field work allowed the company to use a packaged provider’s solutions and incorporated all of GM’s mechanical, electrical and control standards. The offsite fabrication removed utilities from the critical path on sites with skilled labor shortages, and the engineering team’s workload was reduced (with the burden placed on the package supplier).

Located just north of Edmonton, Alberta, Canada, the North West Redwater Sturgeon Refinery is the region's newest stand-alone refinery and the first to be built in more than 30 years. For the project, which incorporated numerous prefabrication and modularization techniques, Pentair engineered, fabricated and supplied the complete electric heat tracing system. Pentair also designed, supplied and installed a proprietary insulation system (called Trac-Loc™) on insulated storage tanks. This standing-seam insulation system, which used prefabricated panels that were made in a factory off-site, was installed without the use of any scaffolding, resulting in a dramatic reduction in fieldwork hours and improved worker safety.

Pentair handled work in multiple module and laydown yards, spanning from Alberta to China. Most of the project's tall vessels were predressed (e.g., ladders and platforms attached, heat tracing and insulation applied) in the horizontal position. "They were then transported to their foundations and set in place vertically," says Peter Dumont, Pentair's VP of global strategic projects. "That precluded the need to erect what otherwise would have been significant quantities of vertical scaffolding around those vessels."

Also, all the electrical buildings were prefabricated and assembled in Calgary and then shipped to the job site.

The project's implementation of prefabrication, predress and modularization played a major role in the overall execution strategy and helped decrease costly sitework hours while increasing productivity. Also, it allowed the builders to keep their total peak site workforce numbers to approximately 7,500 workers—a number that would have been substantially higher had the offsite construction strategies not been implemented.

Keeping with this theme across the globe, **LHC Modular Buildings Framework** is a program under the U.K. government that establishes procurement vehicles for public sector clients to purchase buildings constructed offsite and assembled through modular construction. This program is available for nonresidential construction such as schools, hospitals and office buildings. In 2017 LHC programmed \$1 billion GBP for offsite construction projects.

These examples articulate a growing understanding of offsite construction's benefits, and not just in one particular market or geography and/or complementary to specific building codes. The international adoption of offsite construction will not only continue to gain momentum, but also is already starting to be standard consideration for worldwide design and construction projects. In fact, modularization is expected to rise 6% globally by 2022, with some countries like Sweden, China and Japan already leading the offsite construction charge. Here at FMI, we expect this momentum to continue as more E&C firms adopt offsite construction techniques and as more owners are introduced to – and recognize – the value that such delivery methods can provide.

“

In our company, we're pushing to do more with lean construction and are piloting projects with shared risk and reward multiparty agreements. Offsite construction is an important element of how we do things and helps remove waste out of the system by improving safety, quality, cost and schedule.”

– Michael Mayra
Construction Group
Manager, General Motors

”

TOP CRITERIA IN SPEEDING UP THE ADOPTION OF OFFSITE CONSTRUCTION



1 Clear understanding of the potential cost benefit



2 Clear understanding of the potential schedule benefit



3 Clear understanding of the potential safety improvements

- 4 Knowledge and availability of experienced offsite construction providers
- 5 Continued lack of available skilled labor
- 6 Overall interest in improving construction productivity
- 7 Acceptance and use of design-build
- 8 Corporate culture that accepts and embraces/will invest in “change”
- 9 Setting of corporate goals related to percent of project labor hours offsite
- 10 Continued improvement and implementation of CAD and BIM
- 11 Well-planned and written business case approved by senior management

Source: 2018 FMI/CURT/CII Offsite Construction Owner Survey



Looking Ahead

Offsite construction has been very successfully used and practiced for decades. It is now experiencing an unprecedented surge due to a combination of unique trends that are taking place in today's E&C industry: a severe, chronic skilled labor shortage; a mass exodus of industry experience and knowledge; increasing project complexity and size; emerging integrated technologies; and the convergence of design and construction disciplines.

While design and construction functions are becoming increasingly complex and require evermore specialization, the disciplines' segregated silos are crumbling, creating space for integrated, cross-disciplinary thinking; new project execution strategies; and innovative, all-inclusive business approaches. The ongoing evolution of design and construction functions; the widespread adoption of high-grade digital modeling; and technological trends like cloud computing, big data, robotics, virtual reality/artificial intelligence, business intelligence dashboards, etc., are just a few of the most visible examples of this transformation. **On the service provider side, the modern-day “master builder” is emerging and will likely evolve into a “construction manufacturer” over time.**

For owners, these trends offer new challenges and great opportunities. Now is the time to rethink how capital projects should be planned and executed. Questions to consider include:

- How can we integrate **business** teams and **project** teams more effectively across the entire organization?
- How can we plan for projects in a more interdisciplinary way that allows for systems thinking and integrated design?
- How can we work with suppliers and service providers to quantify the value that offsite construction offers, looking beyond just the project level or initial capital costs to the whole asset life cycle costs?
- What skills and capabilities (internally and externally) will we need in the future to plan for and execute capital projects?
- How can we adapt contracting methods to accommodate more collaborative partnerships and investments in offsite construction projects?
- How do we connect people, technology and business value more effectively?

As mentioned earlier, these are just few of many questions that all call for fresh thinking, new ideas and the removal of old stigmas.

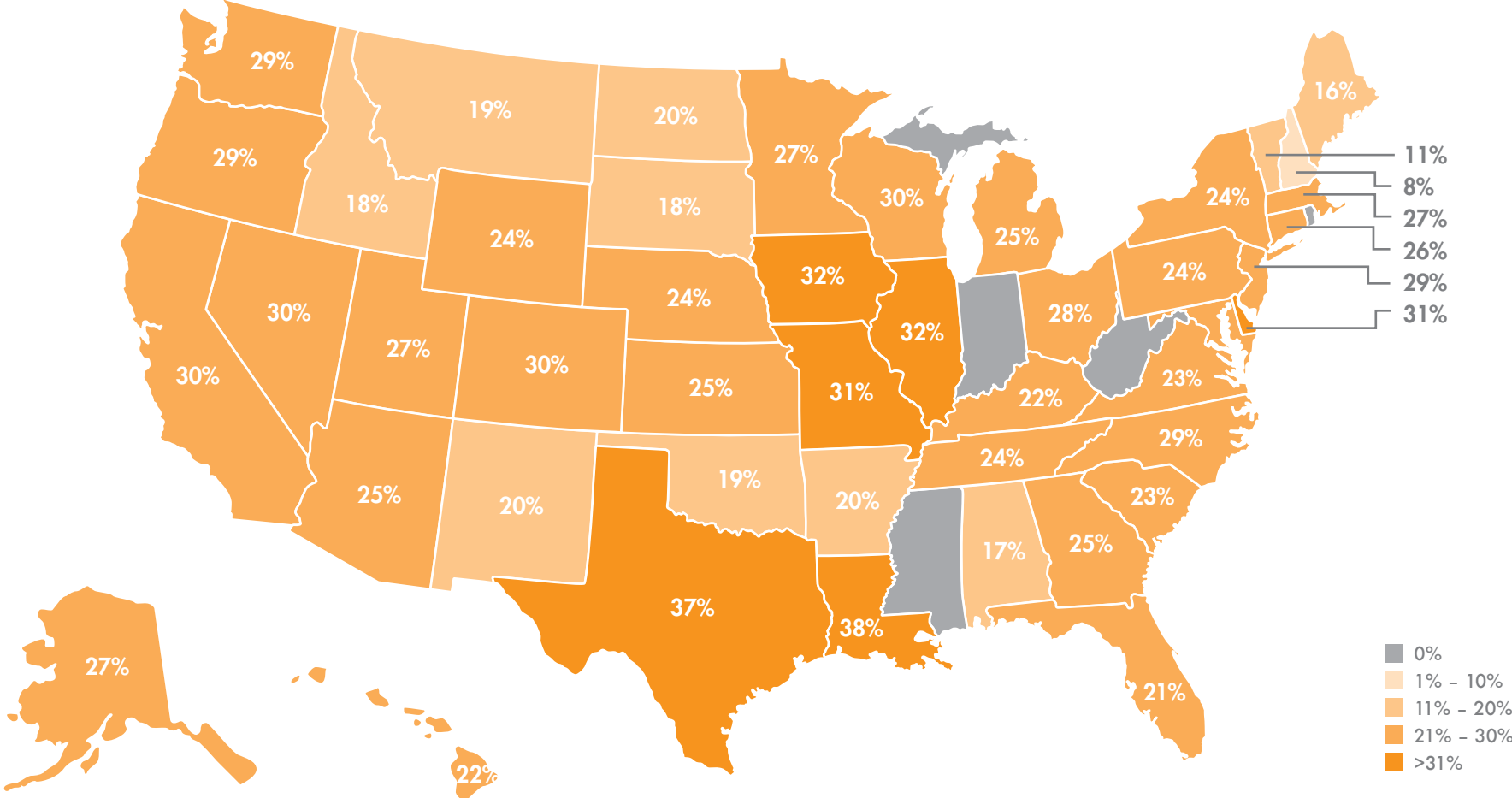
The time is also ripe for organizations to leverage fresh thinking of younger people who are entering – or who have already begun their careers in – the E&C industry. Not unlike other generations that enter the workplace, millennials and Gen Z have new perspectives to share, new ideas about getting things done, and new ways of tackling problems. They were born with technology at their fingertips and see it as a critical part of the workplaces and their interactions with others. This new perspective is critical because it can push all of us forward (whether we want to be pushed or not).

Finally, offsite construction and related systems thinking and integrated design are key milestones in moving the industry forward to a more efficient, predictable business environment. This will require innovative thinking and patience and will likely involve multiple failures, which are a hallmark of a true breakthrough and systemic change. Now is the time to take charge.

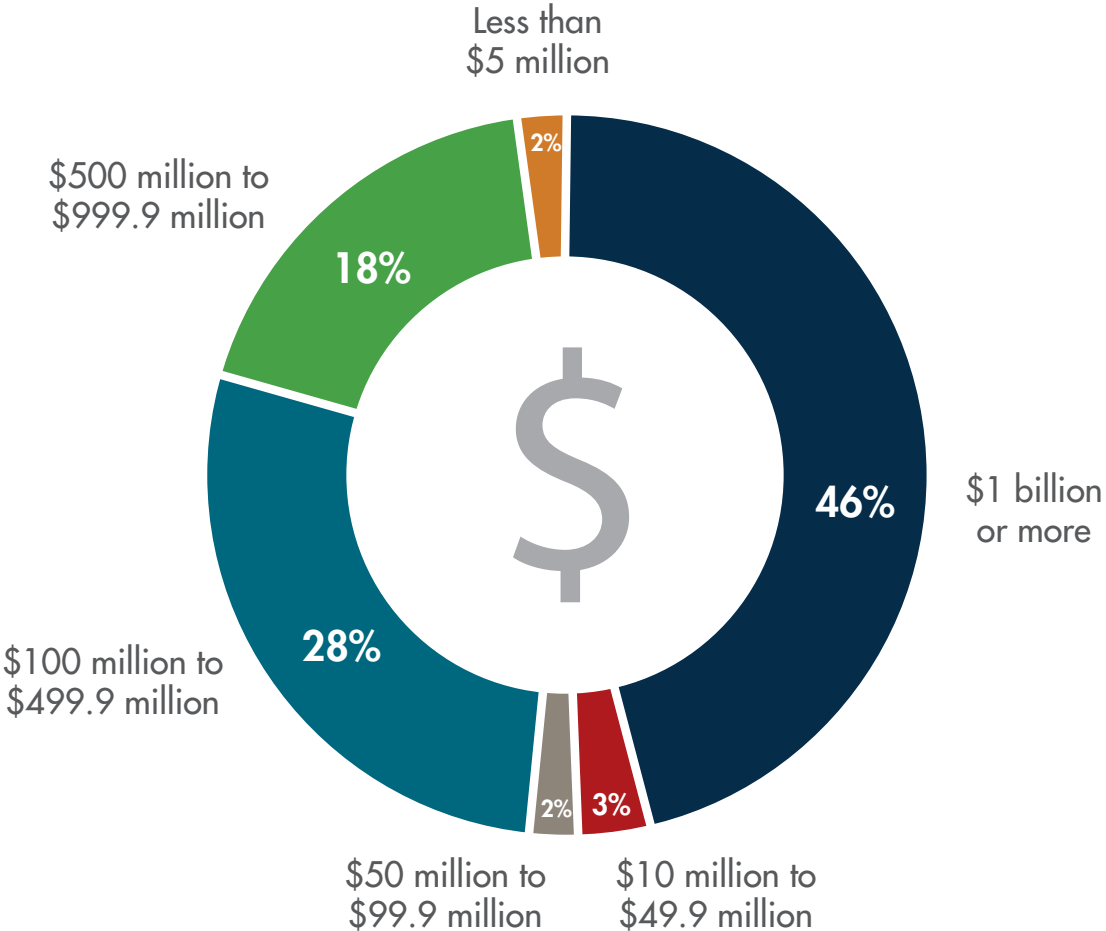


Appendix

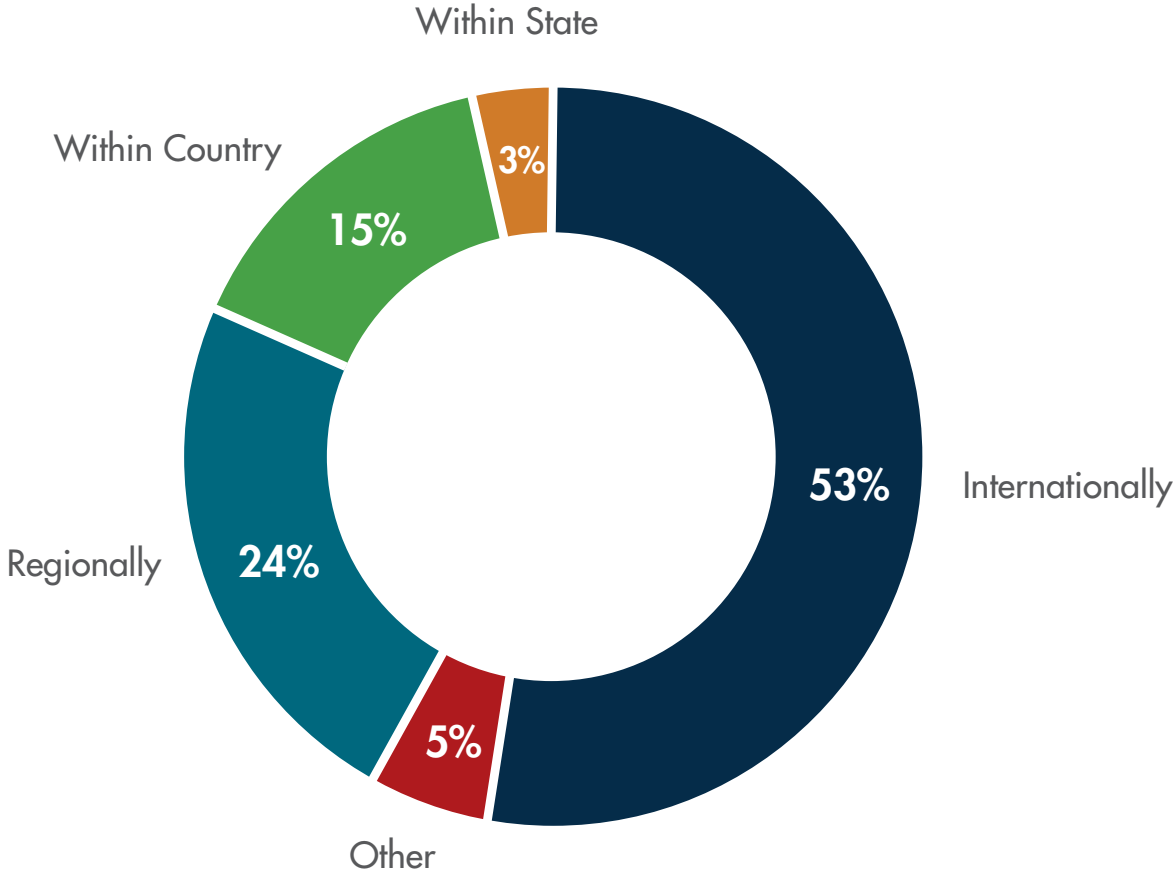
ESTIMATED USE OF OFFSITE CONSTRUCTION BY STATE



CAPITAL PROJECTS CONSTRUCTION BUDGET BREAKDOWN



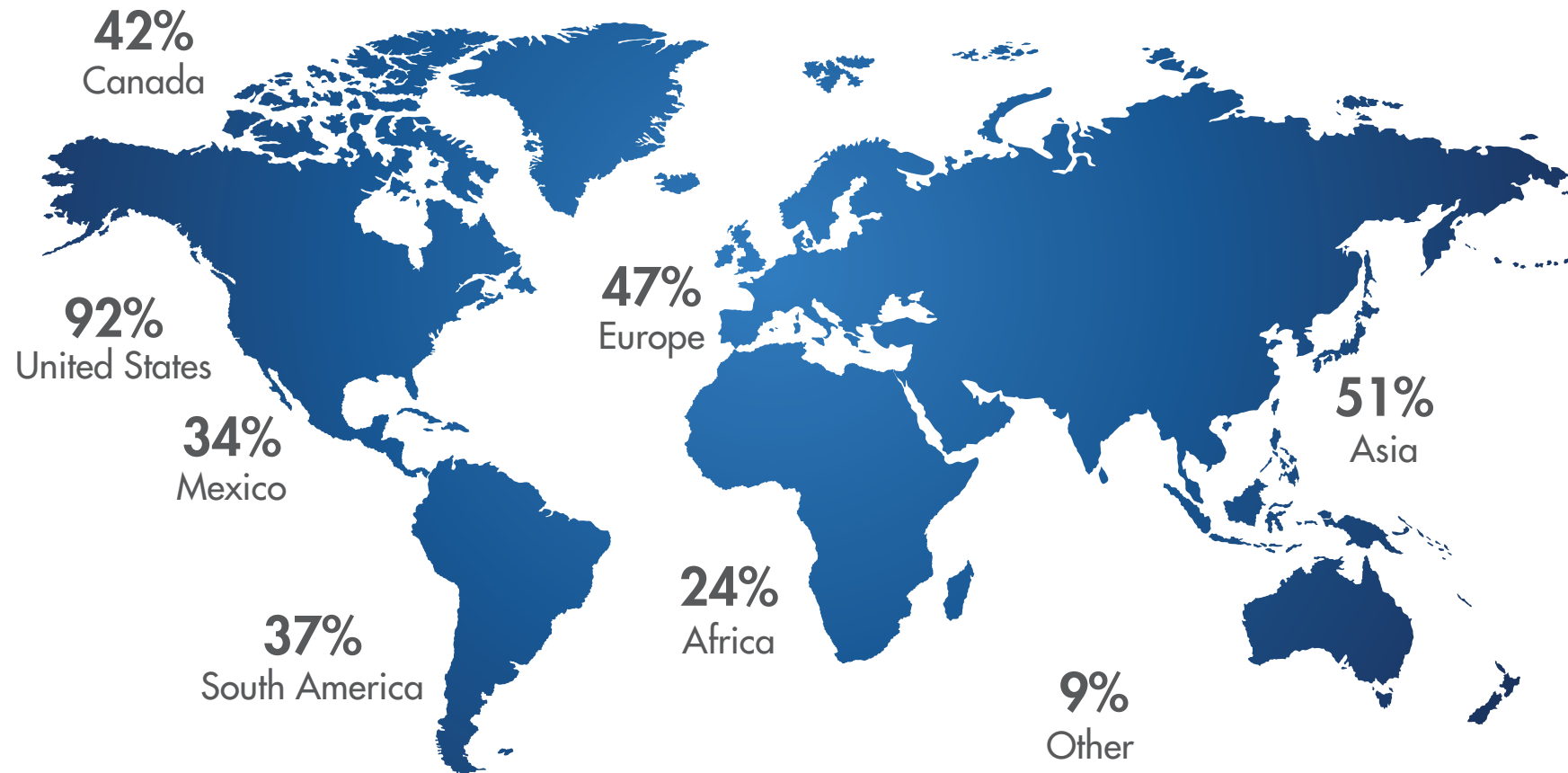
OFFSITE CONSTRUCTION RANGE BREAKDOWN



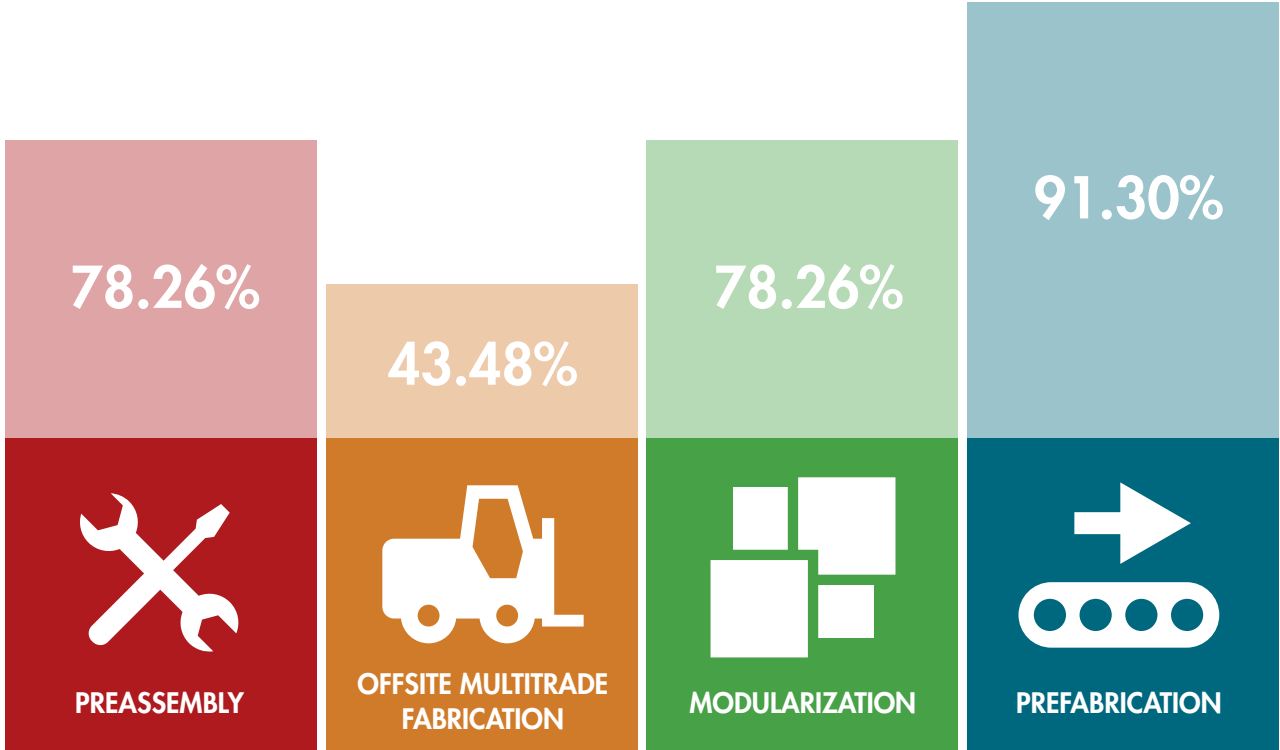
ROLE LEVEL BREAKDOWN



REGIONS IN WHICH STUDY PARTICIPANTS CONDUCT BUSINESS

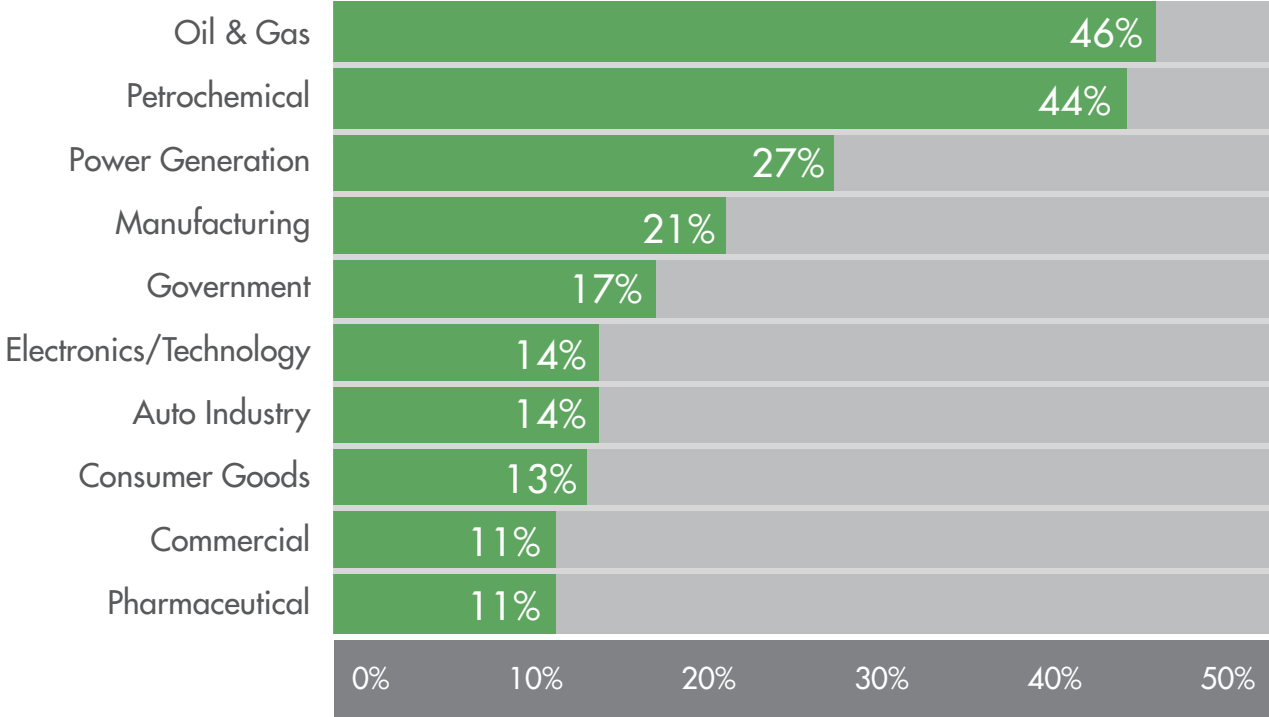


OFFSITE CONSTRUCTION METHOD BREAKDOWN



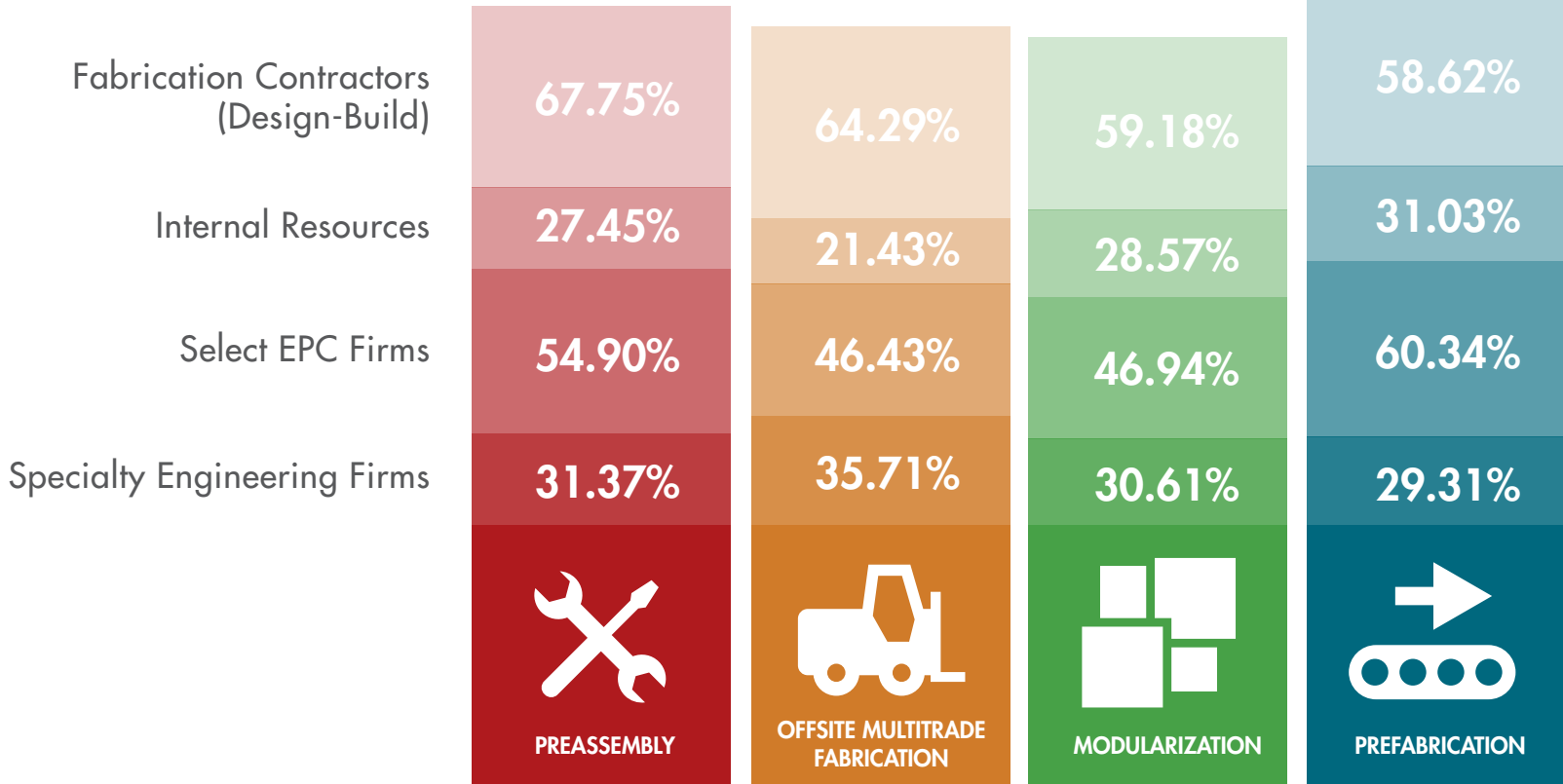
* 3.26% of respondents do not currently use any offsite construction methods.

INDUSTRY BREAKDOWN



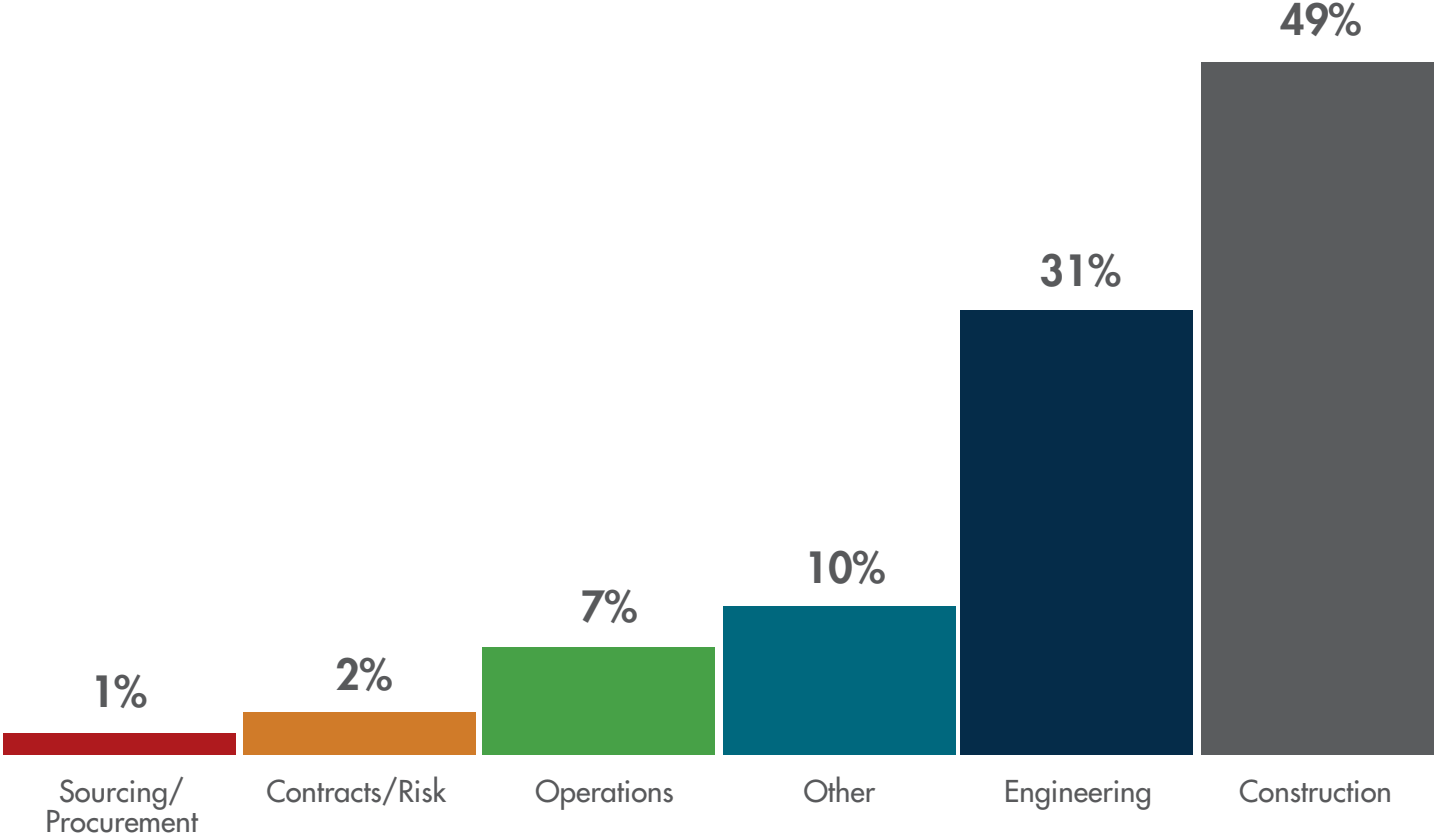
- <10%**
- Health Care 9%
 - Food & Beverage 8%
 - Office 8%
 - Education 5%
 - Other 5%
 - Public Safety 4%
 - Communication 3%
 - Amusement & Recreation 2%
 - Civil/Transportation 9%
 - Lodging 3%

DETAILED ENGINEERING WORK PREFERENCES BY OFFSITE CONSTRUCTION METHOD



BUSINESS GROUP BREAKDOWN

Percentage of Participating Respondents by Business Group





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About FMI

For over 65 years, FMI has been the leading **management consulting and investment banking** firm dedicated exclusively to **engineering and construction, infrastructure and the built environment**.

FMI serves all sectors of the industry as a trusted advisor. More than six decades of context, connections and insights lead to transformational outcomes for our clients and the industry.

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