PREFABRICATION
Handbook for the Construction Industry

Agile Construction® Application through Externalizing Work®

- Design
- Site Layout
- Process
- Track
- Measure
- Forms

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Prefabrication Handbook for the Construction Industry

Agile Construction Application through Externalizing Work

by Dr. Perry Daneshgari and Dr. Heather Moore

This book is a hands-on, practical, and scalable guide to prefabrication. It applies if you are starting from ground zero, or if you are at the 3% mark and trying to get to 50%. The book is not about “benchmarking” or “best practices”; it is grounded in the reality of what other industrialized industries have passed through, which will happen in construction sooner or later. We can learn from history and the science of work (Industrial Engineering), to move faster and with fewer mistakes, rather just comparing to the status quo of “best practices” in today’s construction environment.

Maximum prefab requires a culture of prefab, by understanding the true benefits of prefab which are way beyond saving “hours”. Benefits include risk reduction, increased reliability and predictability of the outcome; reduced uncertainties from the jobsite, an opportunity to train manpower in a controlled environment. Monetarily, the benefits are best quantified as composite rate savings, which reflects a better managed crew ratio and overall productivity improvement.

The most valuable part of this book for the majority of our readers will be the Appendices, which is a set of sample and blank forms, and templates for your use, to start or add to your vision and mission of doing more prefab. We will be updating these forms and templates regularly, and have them available electronically on our www.agileprefab.com forum. Please contact us to join and always have access to the latest and greatest.
Section Topics

- **Prefabrication as a Culture:**
  In this section, we explain how to build the culture for integrating Prefab into the way the jobs are built. The benefits of prefab, centered around risk reduction, are described in addition to models for thinking about prefab beyond just “building assemblies in a shop.”

- **Designing the Process of Prefabrication:**
  This section explains the Process of Prefabrication, and its supporting elements such as: using Work Breakdown Structure (WBS) for Externalizing Work®; the process of selecting, ordering, and building prefab; how Building Information Modeling (BIM) should and should not be used; shipping and quality control.

- **Prefabrication Site Layout:**
  See samples of Prefab Site layouts, with considerations for material, work, and information flow. Examples are given for each scale of prefabrication, from a startup/small shop to a medium/production shop, to a full scale factory, as well as options for vendor support.

- **Prefabrication Forms:**
  Learn how to build the forms to support the process of prefab and how to track them. Explanations are supported with few examples for ordering, tracking, shop management, staging, shipping, and jobsite feedback. Several more examples are included in the book.

- **Prefabrication Tools and Samples:**
  This section includes a list of the tools and technology to support prefabrication. Naturally, this list is ever-evolving as the industry and its supporting suppliers and manufacturers research and develop better gadgets.

- **How to Build a Prefabrication Brochure:**
  Gain knowledge on how to build a prefab brochure to “share the successes” of prefab within the company’s culture.

- **How to Measure Prefabrication:**
  Grasp the principles for measuring prefab, and several approaches ranging from simple to comprehensive measurement.

- **Do’s and Don'ts of Prefab:**
  Here, we offer a sample list of what to do and what not to do to in order to expand successful usage of prefab in your business.

- **Appendices/Sample & Blank Forms/Catalog Samples:**
  Copy and/or build and customize your own forms.
Building On The Culture

Given the significant benefits of doing prefab already noted in this book, the next challenge in building a culture for integrating prefab into the way jobs are built is the way that your project teams think about prefab. To achieve full benefits, prefab cannot be considered separate from the jobsite. The work of a jobsite is defined by the project team, primarily the field foreman, as the licensed and technical expert tradesmen. However, this defined work does not need to be done in the constrained “time and space” of the jobsite. Once the work is defined through Work Breakdown Structure (WBS), the project team should question the following items to achieve maximum benefits listed above, for the job, project, company, and customer:

- Where is the best location for this work to be performed?
- Who is the best resource to perform the work?
- When is the best timing for the work to be done?

Figure 1 shows the “Work Cube” concept, which may help you visualize and internalize this way of thinking. Each cubelet represents a segment of work in the job, and the decision of who, where, and when can be made proactively rather than every morning at 7:00am at the job trailer. Another approach is a Plan-Prefab-Install (PPI™); a conceptual timeline of a project, comparing the typical prefab approach where planning and prefab are done up front for the entire project, with the PPI™ approach that is an ongoing cycle that supports the “main buss” of work. These ways of thinking can help project teams see that prefab is not just a location. Planning, planning, and more planning that leads to Externalized Work® is how to achieve the seven outcomes listed earlier in this section. You can’t just want and wish your way to these benefits of prefab. Realizing the benefits requires an effective “culture” bridge that must be crossed. The only way to cross this bridge and create sustainable prefab results is with a well designed and implemented prefab process. The next section provides an introduction to the process for prefab.
Designing the Process of Prefabrication

In this section, we explain the Process of Prefabrication, and its supporting elements such as: using Work Breakdown Structure (WBS) for Externalizing Work©; the process of selecting, ordering, and building prefab; how Building Information Modeling (BIM) should and should not be used; shipping and quality control.

The high level Process of Prefabrication that has proven effective over many years is shown in Figure 2 below. The specific elements that can be used to support this process are explained further in the book.

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**Figure 2: Process of Prefabrication**

1. **Risk Identification**
   - Plan for Externalizing Work©
   - Work Breakdown Structure
   - Identify externalizing opportunities
   - Failure Mode Effect Analysis (FMEA)

2. **Planning**
   - Product & Process Development
   - Select type of prefab per opportunity
   - Develop spec for Type 2 & 3 prefab
   - Make/buy decision
   - Design for Manufacturability (DFM) & Design for Assembly (DFA)
   - Translate project budget to prefab budget
   - High level prefab build schedule
   - Project-specific needs and requirements

3. **Execution**
   - Prefab Planning
   - Translate field spec into design spec
   - Prototype and testing plan
   - Prefab WBS
   - Schedule 3M's (manpower, money, material)
   - Integration planning at jobsite interfaces
   - Plan Quality Assurance/Quality Control process checks

4. **Step 4**
   - Prefab Production
   - Production scheduling
   - Build
   - Delivery
   - QA/QC checks
   - Adjustments to process & product based on prototypes
   - Job feedback
   - Production tracking
   - Production documentation

5. **Step 5**
   - Lessons Learned
   - Good/bad
   - Feedback to catalogue
   - Feedback to process
   - Measurements
   - Prefab
   - Project integration
   - Expected vs. actual

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1 Prefab Types:
   - Type 1 = common items (non-job related)
   - Type 2 = work specific items (job related)
   - Type 3 = build-to-order (job specific)
Work Breakdown Structure (WBS)

Once the type of work and risks are clear, the WBS is used to identify the work and evaluate the risk in more detail to determine WHAT to prefab. From here, the opportunities to externalize the work from the jobsite become plentiful. The final install or assembly is technically the only work that justifiably must be done onsite. Figures 3 shows an example of a WBS created for a power substation project. In addition to planning for the prefab up front, opportunities that occur throughout the job should be captured and planned for externalization. As the project goes from one phase to the next, the WBS can be revisited for opportunities to reduce the changing risks. The appendix shows several additional WBS’s where opportunities to Externalize Work® are identified for selection of possible prefab.
Prefab Work Flow Design

In addition to material and information flow, the prefab work space should be laid out to accommodate the flow of work which transforms raw material into output packaged assemblies and sub-assemblies ready for shipping. A few simple considerations are:

- Ergonomics
- Safety
- Tool utilization and uptime
- Flexibility of workspaces to accommodate changes in flow and mix of assemblies produced
- Spaces for job planning and review incorporating access to technology

The work flow (see Figure 4) should also be laid out segregated for the three types of prefab, as follows:

- Common among all jobs: Use catalogue/standard order forms
- Type of work-specific Prefab: common within a type of work: product configuration sheets or work packages
- Build-To-Order: sketch of the assembly

![Figure 4: Work flow in cell layout, for common production items](image-url)
## Sample Agile Construction Prefabrication Order Form

**Assembly Name:**

<table>
<thead>
<tr>
<th>Job Name:</th>
<th>Quantity Needed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Number:</td>
<td>Expected Hrs. per Assembly</td>
</tr>
<tr>
<td>Construction Drawing #:</td>
<td>Cost Code:</td>
</tr>
<tr>
<td>Location at Jobsite:</td>
<td>Ordered By:</td>
</tr>
<tr>
<td>Date Ordered:</td>
<td>Phone Number:</td>
</tr>
<tr>
<td>Date Needed at Jobsite:</td>
<td></td>
</tr>
</tbody>
</table>

**Job Address:**

**Labeling Instructions:**

**Special Instructions:**

**Sketch your assembly below**
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Over 200 pages of comprehensive explanation and examples for supporting any size and scale prefab shop.

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"By far, there is more take-home value compressed into one of Perry Daneshgari’s sessions than a full-semester in most college-level construction management courses! While others continue to look in the rear-view mirror rehash-ing same-old "best practices," Perry insightfully points us ahead to where the industry is going--and provides us with a full set of practical solutions on how to get there."

~ Fred Sargent, former CEO of Sargent Electric Company.

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