Prefabrication within the Electrical Construction Industry – a Survey of Electrical Contractors

Lonny Simonian[1] and Thomas Korman[2]

Abstract

Prefabrication has been defined as "a manufacturing process that generally takes place at a specialized facility, where materials are joined to form a component part of a final installation" (Construction Industry Institute). Also, Preassembly may be defined as "a process where 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" (Construction Industry Institute). The use of prefabrication and preassembly have the potential to significantly reduce project duration, improve productivity, reduce labor needs and costs, and improve safety (National Electrical Contractors Association 2009). Projects with prefabricated assemblies also may result in cleaner construction sites due to the fact that many MEP systems are prefabricated offsite and brought on the site in assemblies, resulting in less fabrication equipment needed onsite (Khanzode 2008).

This paper presents the results of a survey of electrical contractors on their use of prefabricated electrical assemblies. The survey topics include: how the use of Building Information Modeling (BIM) enhances the prefabrication approach, systems and assemblies that are candidates for prefabrication, cost and/or time savings associated with prefabrication, scheduling improvements achieved through prefabrication, coordination of prefabricated assembly installation with other contractors, and size, type, and composite crew utilized for prefabrication. The results are correlated to the size of the construction company, size and cost of projects, types of construction market sectors, and type of project delivery.

Keywords: Building Information Modeling (BIM), Prefabrication, Preassembly

1. INTRODUCTION

This paper presents the results of a survey to determine the best management practices (BMP's) and outlining the benefits of using prefabrication for Electrical Contractors. The project had the following objectives:

- Increase awareness of technology available for use by Electrical Contractors in MEP coordination, pre-fabrication, and pre-planning processes

[1] Associate Professor, Construction Management Department, California Polytechnic State University, 1 Grand Avenue, San Luis Obispo, California, 93407; lsimonia@calpoly.edu.
[2] Associate Professor, Construction Management Department, California Polytechnic State University, 1 Grand Avenue, San Luis Obispo, California, 93407; lsimonia@calpoly.edu.

- Provide recommendations for Electrical Contractors when performing MEP coordination that will incorporate pre-fabrication, field assembly methods, and pre-planning.

- Guidelines for MEP coordination, which incorporate standard field installation methods and encourage pre-fabrication practices

2. METHODOLOGY

Survey questions were formed with input from ELECTRI-International (EI) council members; EI is the research foundation for the National Electrical Contractors Association. The survey was designed in two parts; the first obtained information regarding individual company background while the second focused upon the use of Prefabrication.

2.1 Company Background

1. What is the dollar value of your company's business?

2. What is the range of your projects, in square footage?

3. What is the range of your projects in constructed cost?

4. What is the percentage of each of your company's market sectors?

5. What is the percentage (of your company's total) for each type of project delivery?

2.2 Prefabrication

1. How has the use of BIM enhanced your prefabrication approach?

2. Does your company utilize any prefabricated assemblies?

3. Do you prefabricate the assemblies yourself?

4. How has the use of BIM enhanced your prefabrication approach?

5. What are your most frequently used prefabricated assemblies?

6. What other systems/assemblies are you considering for prefabrication?

7. What time savings do you attribute to using prefabricated assemblies?

8. What cost savings do you attribute to using prefabricated assemblies?

9. Does prefabrication allow you to perform work out-of-sequence (earlier) than conventional fab-in-place?

10. When/How do you coordinate the prefab installation schedule with the General Contractor (GC) and Mech. Contractor (MC)?

11. How large is your prefabrication shop? (e.g., number of workers, square-footage, etc.)

12. What special equipment/tools do you use in your prefab shop?

13. What is the difference between your composite crew rate for field fabrication and shop prefabrication?

3. SURVEY RESPONSES

Initially, one hundred and fifty (150) companies were selected for the survey. Selection was based on National Electrical Contractors Association (NECA) membership and geographic location. In order to be able to obtain a representative sample, companies were selected from NECA member lists from chapters located throughout the United States. The companies were selected based on annual dollar volume of work completed during the last year. Three ranges were selected: small, medium, and large. Small companies included companies with an annual dollar volume of less than $100M USD per year. Medium companies included companies with an annual dollar volume of between $100M and $250M USD per year. Large companies included companies with an annual dollar volume greater than $250M USD per year. Following the initial survey, an additional one hundred and fifty (150) companies were added in order to gain more responses. For the second round of companies, the selection process focused on companies located in major metropolitan areas throughout the United States where there has been historically a high volume of electrical construction. In total, 259 electrical contractors were contacted, 147 had the survey emailed to them, 100 were contacted by phone, and 55 returned a completed survey. A flow diagram is shown in Figure 1 for clarity.

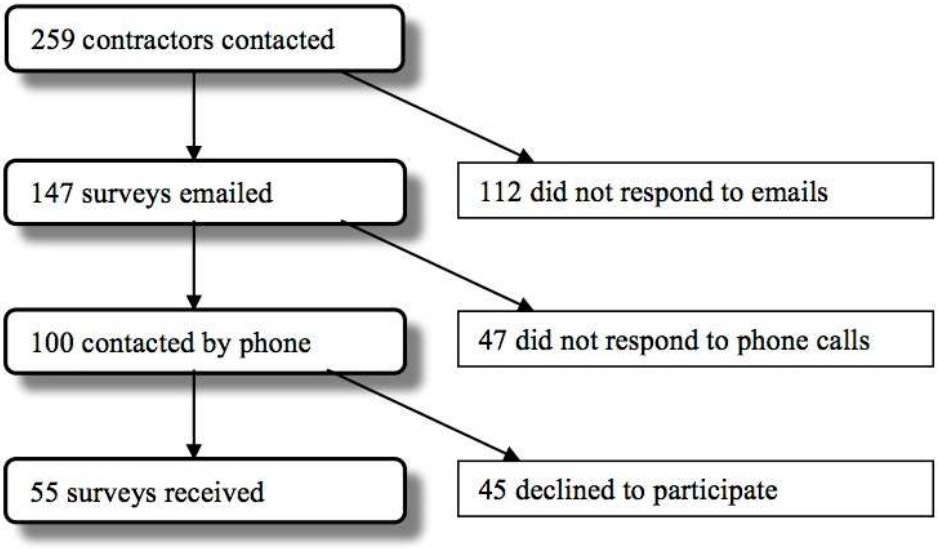

Figure 1 – Flow Diagram of Survey Solicitations

4. SURVEY RESULTS

4.1 Company Background Responses

4.1.1 What was the $ USD volume of your company's work last year?

Responses ranged from $8 USD to $455M USD. The median was $116M USD.

4.1.2 What is the range of your projects, in square footage?

Responses ranged from less than 1,000 square feet (93 square meters) up to 3 million square feet (278,710 square meters).

4.1.3 What is the range of your projects in constructed cost?

Responses ranged from less than $1,000 USD up to $350M USD.

4.1.4 What is the percentage of each of your company's market sectors?

Market Sector	Low (%)	High (%)	Median (%)
Residential	0	100	5
Commercial	0	90	39
Institutional	0	80	20
Industrial	0	100	21
Process	0	55	5

A composite breakdown of all market sectors is shown in Figure 2.

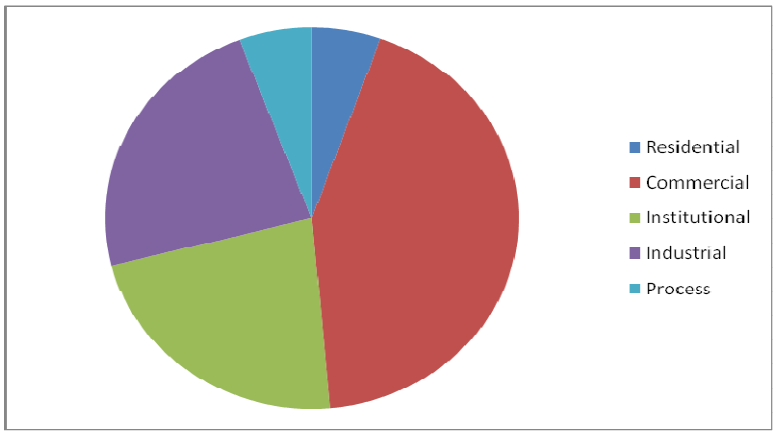

Figure 2 – Composite breakdown of company market sectors

4.1.5 What is the percentage (of your company's total) for each type of project delivery?

Project Delivery Method	Low (%)	High (%)	Median (%)
Design Only	0	80	5
Design-Bid-Build	0	100	14
Pure Design-Build	0	70	40
DB w/Bridging*	0	70	13

* Also referred to as DB assist

A composite breakdown of all project delivery methods is shown in Figure 3.

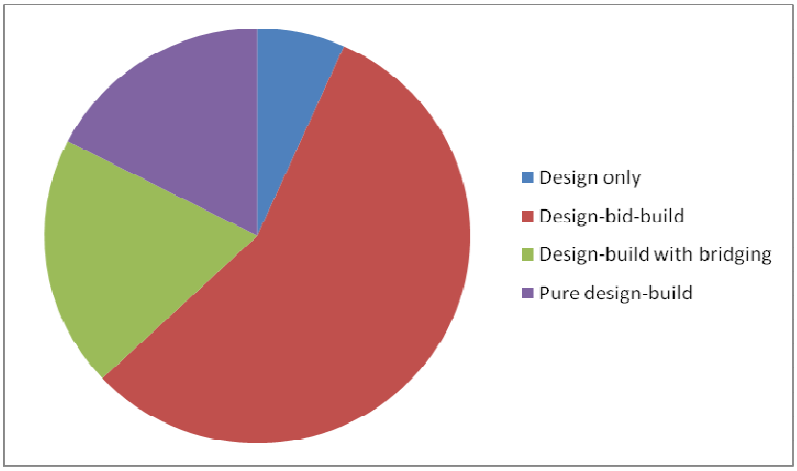

Figure 3 – Composite breakdown of project delivery methods

4.2 Prefabrication Responses

4.2.1. How has the use of BIM enhanced your prefabrication approach?

All survey respondents indicated that the use of BIM has enhanced their ability to prefabricate electrical assemblies for installation. Most survey respondents indicated that the greatest value from the BIM model was the ability to visualize the system in 3-D. Using the visualization capabilities of the BIM model allows detailers to group electrical components and determine appropriate assemblies for prefabrication. This process is more beneficial than using traditional hand or 2-D CAD drawings because when using the BIM model in the selection process, systems of the other specialty contractors can be taken into consideration due to BIM's visualization capabilities. In addition, using the electronic BIM model documents dimensions that can be validated much easier and results in increased confidence and accuracy, allowing for more prefabrication than in the past.

4.2.2. Does your company utilize any prefabricated assemblies?

The vast majority (44) of the respondents use prefabricated assemblies, as shown in Figure 4. All contractors with a volume of work greater than $90M USD reported that they used prefabrication on their projects. Thus, there is a 100% correlation between the use of prefabrication and the contractors whose volume of work exceeded $90M USD. 23 contractors reported that they use BIM to construct their projects; of these, 14 report that they prefabricate assemblies. There also is a good (61%) correlation amongst those contractors who both use BIM and prefabricate their assemblies.

Only eight of the 55 responders reported that they did not use prefabricated assemblies. This pool consisted of those contractors whose volume of work ranged from $7.0M USD to $90M USD; the median for this group was $32M USD. All eight contractors in this group reported that they did not use BIM for construction. Thus there is a 100% correlation between those contractors who do not prefabricate assemblies and who do not also use BIM.

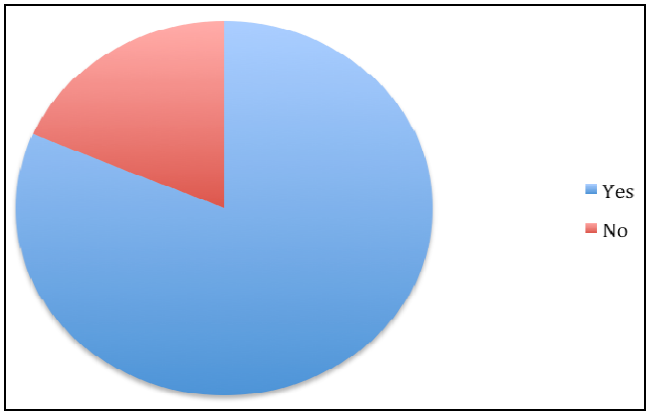

Figure 4 – Use of prefabricated assemblies

4.2.3. Do you prefabricate the assemblies yourself?

More than one half (30) of electrical contractors prefabricate their own assemblies, as shown in Figure 5.

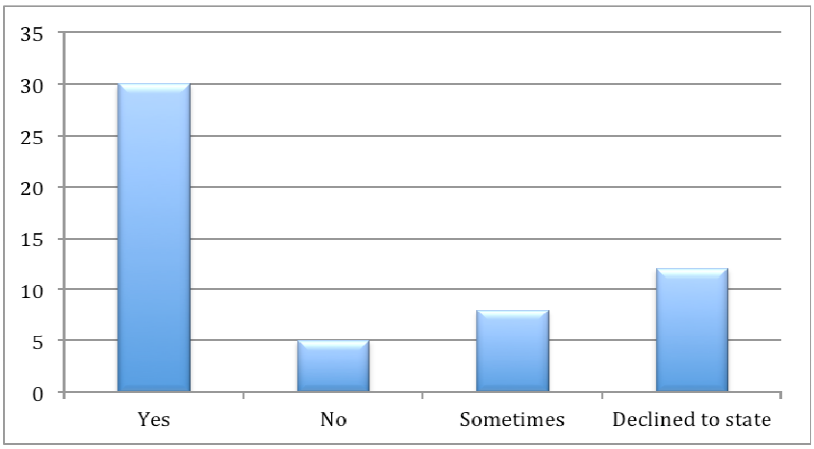

Figure 5 – Number of contractors who prefabricate their own assemblies

4.2.4. How has the use of BIM enhanced your prefabrication approach?

Several contractors reported that prefabrication was closely aligned with the use of BIM or a 3D model. Some of the most cited benefits included:

- Earlier information for prefabrication
- Fabrication directly from BIM model
- Assists and helps the installation process
- Validates dimensional concerns
- Increased accuracy allows more prefabrication opportunities

4.2.5. What are your most frequently used prefabricated assemblies?

The two most frequently prefabricated assemblies were device boxes and lighting fixture whips, as shown in Figure 6.

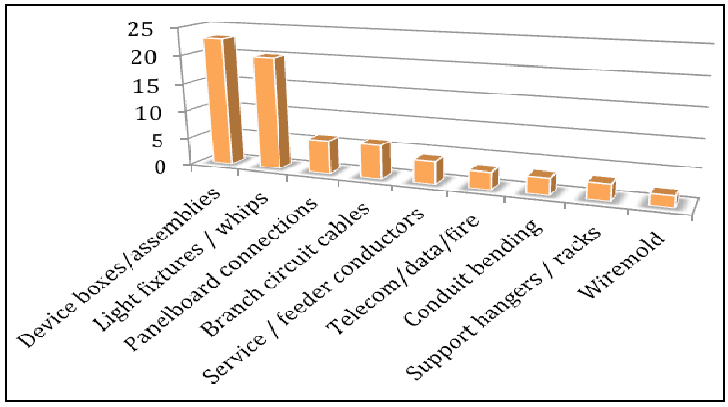

Figure 6 – Types of prefabricated assemblies (by # of contractors responding)

4.2.6. What other systems/assemblies are you considering for prefabrication?

The three most cited systems/assemblies considered for prefabrication were branch circuit cables, lighting fixture whips, and panel board connections, as shown in Figure 7. This is consistent with the results from the previous question.

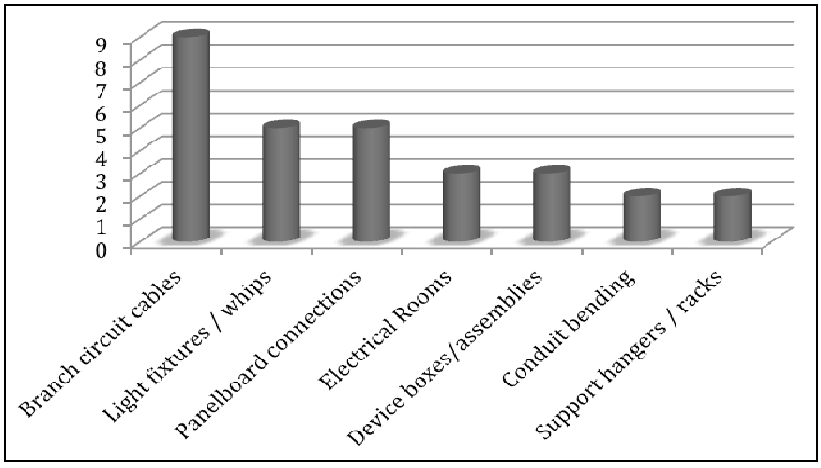

Figure 7 – Assembly candidates for prefabrication (by # of contractors responding)

4.2.7. What time savings do you attribute to using prefabricated assemblies?

The average time savings was 11-20% as shown in Figure 8.

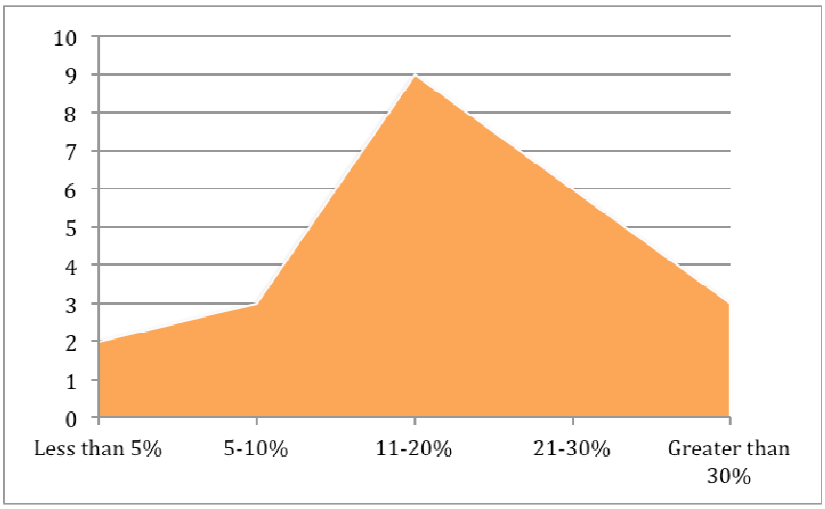

Figure 8 – Time savings using prefabricated assemblies (by contractors responding)

4.2.8. What cost savings do you attribute to using prefabricated assemblies?

The average cost savings was 21-30% as shown in Figure 9.

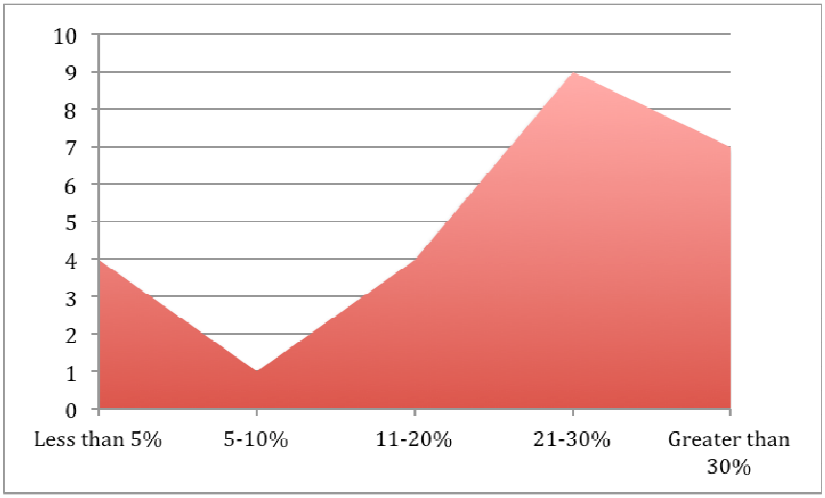

Figure 9 – Cost savings using prefabricated assemblies (by contractors responding)

4.2.9. Does prefabrication allow you to perform work out-of-sequence (earlier) than conventional fab-in-place?

One half (28) of the respondents reported that prefabrication allowed them to perform work out-of-sequence as shown in Figure 10.

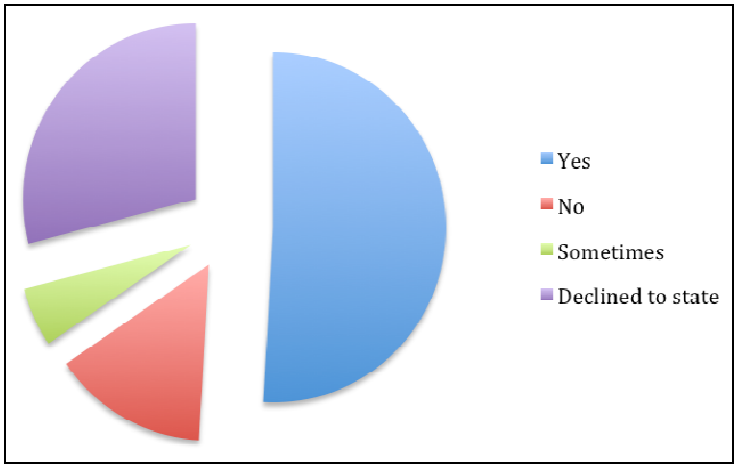

Figure 10 – Ability to perform work out-of-sequence due to prefabrication

4.2.10. When/How do you coordinate the prefab installation schedule with the General Contractor (GC) and Mechanical Contractor (MC)?

While some respondents stated that they did not coordinate prefabrication with the GC or MC, the majority of respondents coordinated their prefabrication installation as early as possible; this usually occurred at the bid and initial coordination meeting. They also coordinated their work throughout construction via BIM or 2D/3D meetings and information sharing. Some also engaged in wall mock-ups at the submittal stage.

4.2.11. How large is your prefabrication shop? (e.g., number of workers, square-footage, etc.)

Responses ranged from 2 to 10 employees and 1,000 to 50,000 square footage of shop space. The average was 4 to 6 workers in a 3,000 to 6,000 square foot shop.

4.2.12. What special equip/tools do you use in your prefab shop?

Special tools included:

- Plasma cutting machines
- Pipe cutting machines
- Computerized welding machines
- Specially equipped band saw
- Hydraulic benders
- Power cable stripper
- Power crimp tools
- MC cut/stripper machine
- Pneumatic tools
- Press Punch
- Welders
- Chop saw

4.2.13. What is the difference between your composite crew rate for field fabrication and shop prefabrication?

Respondents stated that they were able to have a consistently lower composite crew rate in their prefabrication shops due to the nature of the work and the skill level needed. This included a composite rate reduction of from 15-30% by using more apprenticed labor.

5. CONCLUSIONS AND RECOMMENDATIONS

All contractors responding to the survey who had an annual volume of work greater than $90M USD reported that they used prefabrication on their projects. Conversely, only eight of the 55 responders reported that they did not use prefabricated assemblies. Electrical contractors who use BIM indicate that an additional benefit in cost and time savings was the ability to prefabricate assemblies for direct installation.

There was a 100% correlation between those contractors who do not prefabricate assemblies and who do not also use BIM. Therefore, we concluded that if a design model was not provided, electrical contractors were not inclined to produce their own system model unless it was beneficial for their fabrication process.

6. ACKNOWLEDGEMENTS

The researchers would like to acknowledge the contributions of the ELECTRI Council members and staff who contributed to this project. The researchers wish to thank the ELECTRI Council for providing the financial support and the project Taskforce members for providing their comments.

The data collection for the preparation of this report would not have been possible without the hard work and efforts of numerous student research assistants, who obtained the data needed to complete the project.

REFERENCES

Haas, C. T., O'Connor, J. T., Tucker, R. L., Eickmann, J. A., and Fagerlund, W. R., (2000). "Prefabrication and Preassembly Trends and Effects on the Construction Workforce." Center for Construction Industry Studies, Construction Industry Institute, Report No. 14, May 2000, The University of Texas at Austin.

Khanzode, A., Fischer, M., and Reed, D., (2008). "Benefits and Lessons Learned of Implementing Building Virtual Design and Construction (VDC) Technologies for Coordination of Mechanical, Electrical, and Plumbing (MEP) Systems on a Large Healthcare Project." *ITcon Vol. 13,* June 2008, 324-342.

National Electrical Contractors Association (NECA), (2009). Best Practices: Prefabrication for Electrical Contractors.