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Determining the Feasibility of Using Abandoned Big Box Stores as Modular Construction Factories

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DETERMINING THE FEASIBILITY OF USING ABANDONED BIG BOX STORES AS MODULAR CONSTRUCTION FACTORIES

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ABSTRACT

Modular Construction is the process of prefabricating construction parts, sections of buildings, and entire modular housing units in factory-controlled environments off the construction site location. Modular construction is a process to improve quality control, decrease project schedule, decrease project costs, and a reduction in onsite safety risks. Research conducted in this thesis looks into the feasibility of developing a new space for modular construction factories inside abandoned big box stores. Big box stores house multiple amenities perfect for manufacturing purposes including: large total square footage, office spaces, multiple bathrooms, and multiple locations spread out across the country to decrease possible shipping costs and allow future rapid expansion. The aim of this research through case study investigation was to understand the feasibility of using abandoned big box stores for modular construction to compare and contrast the variables between them. Although certain store formats contain the amenities for housing certain modular factories, the adaptability for modular factories depends on the format, size, and location of the abandoned store. Research into providing space for modular construction factories may help alleviate the construction workforce challenges by bringing workers into a climate-controlled environment; where weather is no longer a schedule delay factor, safety risks are minimized, and quality control can be completed on a more frequent basis.

DEDICATION

I would like to dedicate my paper to the countless hours given to me from colleagues, professors, and construction professionals for providing me with information to complete my research. To Dr. Piper, thank you for your guidance, inspiration, and motivation to complete my thesis. To Dr. Lucas and Dr. Anderson, thank you for your devoted assistance. To my parents Nancy and Ronald, thank you for pushing and supporting my quest for education and unconditional love. To my missed brother Matthew, thank you for your love and shaping me into the man I am today. To all who molded my life and education, I personally thank you for your wisdom and encouragement.

"The roots of education are bitter, but the fruit is sweet." – Aristotle

Sincerely,

Andrew Douglas Burson

TABLE OF CONTENTS

Page

Table of Contents (Continued)

Page

Table of Contents (Continued)

Page

LIST OF TABLES

List of Tables (Continued)

Table Page

LIST OF FIGURES

List of Figures (Continued)

CHAPTER ONE

Introduction

Construction has been a rather stagnant industry where the means and methods of construction have rarely evolved to more efficient ways for completing construction projects. The use of new building material has resulted in changes in work output due to the introduction of new technology driving better construction processes. The typical stick and brick construction methods have not changed greatly due to the known ability of the industry to complete the existing work. Specialty contractors have developed certain types of work approaches to become more efficient and productive at one (1) type of work rather than engage in multiple trades. Modular construction could mark a milestone in the timeline evolution for construction's future. History has shown modular construction can be used as an effective means to completing a quality product quicker in a more cost effective manner.

Modular construction dates back to the Great Pyramids of Giza, which were built using principles of modular construction. The Great Pyramids were constructed over 80 years using 20,000-30,000 workers to build these massive symbols. The primary building system for the pyramids involved quarrying standard modular stone blocks offsite and then transporting the blocks by slave labor to the site (Berger, 2013). These principles are similar to today's modular constructions procedures of producing offsite building components designed for transportation for final assembly/construction on a construction project site. Modular construction now has the ability to develop offsite modules using

advanced building materials and better transportation systems. Modular construction practices have been increasing rapidly because it allows owners to have a completed building constructed; quicker, more cost effective, and without any loss in construction quality.

As modular construction increases in the United States, warehouse facilities and operations become an essential element in the success of modular construction. The warehouse or factory component is critical to the development of the product on time and on budget. The factories usually consist of large open floor plans consisting of columns and open steel web joists as a post and lintel structure. Large open floor areas are necessary for enough production space to produce a high volume of modules quickly. The research in this thesis will demonstrate that developing a preexisting structure with the right space and amenities could greatly advance the future of the modular construction industry. The retrofit of abandoned big box stores for modular construction would facilitate the growth of offsite construction factories located closer to more construction sites, resulting in lower transportation costs and increase employment opportunities.

CHAPTER TWO

The Construction Industry

The construction industry is considered a high-risk industry with respect to both the actual construction work and onsite management of daily tasks. Construction workers face difficult and hazardous on-site tasks as they construct complex building systems, structures, and architectural finishes from start to finish. Construction management consists of planning, coordination, scheduling, budgeting, and onsite supervision of subcontractors, vendors/suppliers, and other onsite labor. The construction industry makes up around 9% of the global Gross Domestic Product (GDP) and accounts for almost 7% of the total employment globally (Horta, Camanho, Johnes, & Johnes, 2013). The United States construction industry has a fatality injury rate of 9.9 compared to the industry standard of 3.4 fatal injuries per 100,000 full time workers (Bureau of Labor Statistics, 2014). The top 225 contractors worldwide reported a combined international revenue of $383.66 billion in 2010 (Reina & Tulacz, 2011). The construction industry covers a broad market consisting of firms ranging from small size companies to tremendously large companies.

The construction industry is a highly volatile and fragmented industry due to an influx of small to medium size firms who are increasing in numbers while large firms are decreasing in both size and number of employees. Fragmentation in the construction industry also occurs due to several reasons including skilled labor, multiple professions, knowledgeable experts and several suppliers (Alashwal, Rahman, & Beksin, 2011). The

actual construction work is completed through either self-performing or subcontracting the work. Subcontracting work means construction management firms contract the work to multiple subcontractors who have hired skilled craft laborers to perform work for a certain trade. Subcontractor companies range in various trades including carpentry, steel work, mechanical, electrical and plumbing services and are hired by construction management firms to complement their own expertise of a certain skill/job for the overall project. Self-performed work means the construction management (CM) organization contracts actual craft workers to complete portions of the project as well as keep certain trade work performed by the CM. The difference with self-performed work versus subcontracting work is the CM is in direct contract with craft laborers to perform certain tasks while subcontracting involves hiring a business with craft workers on the payroll (Nassar, 2003). Subcontractors are usually needed even if a contractor undertakes a scope of work that a contractor's skilled labor force cannot accomplish.

The construction industry has several qualities that can be enhanced through the use of modular construction. Schedule, cost, safety, and quality can all be enhanced through modular construction applications. Using the right application of modular construction yield major favorable results to construction projects. The modular construction industry has been around for a long time in different forms ranging from prefabricated offsite materials to whole modular sections of buildings. New warehouse facilities to house the modular industry could result in major growth for the modular industry.

The Modular Construction Industry

Modular construction is the process of manufacturing offsite factory prefabricated building components and systems, which are transported and assembled onsite at the construction site. Modular construction makes up only around 3 – 5% of the construction industry. Modular construction can also be referred to as prefabricated construction and potentially used for multiple industries including commercial, residential, industrial, and healthcare buildings that change in volume and design. Benefits from using modular construction include controlled factory construction of components, shorter construction schedules, and possibly a decrease in overall cost. Modular buildings are built offsite and 60-90% are built inside controlled factories and then transported for assembly or installation onsite (Smith, 2015). Modular construction is a process that has been used in the construction industry since the mid-1800s as evidenced by the construction of the Renkioi Hospital in Turkey. Prefabricated parts were developed in England and shipped to Renkioi for onsite installation (Verderber, 2003). Modular construction has numerous applications for various construction types and would be able to modernize traditional construction methods.

Two main types of modular construction are Permanent Modular Construction (PMC) and Relocatable Buildings (RB). Permanent modular construction refers to offsite prefabricated building components and systems built in controlled environment factory settings, which are then transported for assembly into a permanent building. Relocatable buildings are offsite prefabricated building components and systems transported for assembly into a building, but are deconstructed into building fragments and re-

transported to a new site for another erection (Smith, 2015). Prefabricated components are building components and systems prefabricated or built offsite which were transported to the site ready for assembly or installation (Schoenborn, 2012). Modular prefabricated building components can range from entire systems to replicated building parts. Common prefabricated building components are certain staircases and building façade parts that, when built offsite, can reduce waste onsite and improve onsite production. Other possible prefabricated parts include concrete, masonry block, tile, drywall, formwork and many other construction materials built or assembled offsite (Tam, Tam, Zeng, & Ng, 2007).

Modules can also be built for 2 different structural purposes. The first is load-bearing modules where side walls bear the weight of the floor above and transfer the load throughout the exterior walls. The other structural form of modular pods consists of corner-supported modules where the load transfers through beams located in the corners of the module (Lawson, Ogden, & Bergin, 2011). The structural integrity of modular building parts are based on the design of the overall building to counteract the possible loads or stresses modules might endure to maintain a complete structural integrity for the modular design.

Designing modular buildings can provide multiple challenges that can occur during the site preparation and factory construction process. The preliminary design considerations for modular construction include an analysis of the site as well as producing an Environmental Impact Statement (EIS). The next step involves assessing the site conditions and how the foundations will support the modules along with other

control aspects around the site such as vehicular egress and storm water management. Once the site is assessed, design choices can be made involving the foundation, building design, shipping of the modules, and finally onsite installation and finishes. During the design phase, certain building codes must be followed for all buildings to provide high quality, health and safety for occupants or visitors to a building. Building codes are developed by the International Code Council (ICC) and pertain to all occupancies. The ICC has set several standard building and occupational codes to promote safe and durable buildings, which include minimum standards for building performance and capacity, certain materials used in buildings, along with other restrictions and limitations pertaining to buildings and structures. Building codes for modular construction are found in the International Existing Building Codes (IEBC) Chapter 13 concerning "Relocated or Moved Buildings." Building codes are enforced by building code officials who inspect and enforce ICC codes by reading construction documents, interpreting local code, and any other important building information (Modular Building Institute, 2015a). Building codes are developed as its primary purpose for protecting and promoting the safety of citizens and maintaining the health of the population. Modular construction methods and techniques must abide by International Building Codes which are acceptable to all buildings and structures and for all types of building construction.

Modular construction factories are the backbone of building prefabricated buildings and components. The success of modular construction is due to the fabrication of materials and components in the factory at the same time as the development of the site and construction of the foundation occurs (Modular Building Institute, 2015a).

Numerous major construction companies including Gilbane Building Company, Clayton Building Solutions, and others have been using modular construction for several years for various applications ranging from entire modularized buildings to prefabricated fragments (Modular Building Institute, 2015b). Modular construction has multiple advantages over typical construction methods along with some possible disadvantages.

Some advantages of modular construction include a reduction in schedule, improved quality of workmanship through a more controlled work environment, and a permanent group of expert skilled workers. Modular construction produces additional advantages through a controlled factory site environment, better material storage, more efficient use of construction materials, and trained skilled labor with established work shifts. Modular construction factory conditions can reduce delays caused by weather, improve schedule efficiency by completing onsite preparation and module construction simultaneously, and improve sustainability though reduced onsite environmental impact, construction waste, and onsite vehicular emissions.

Modular construction can include several disadvantages that outweigh the advantages if not addressed by proper planning. A major disadvantage of modular construction can result from choosing modular construction with the wrong building applications. Buildings without repeating spaces defeat the benefits of modular construction because a unique space dimension may be needed to complete the construction instead of a standard sized space. Other disadvantages of prefabricated construction include an inefficient schedule if not planned properly, local code restrictions, zoning restrictions against the use of modular construction and its facilities,

and the distance of transportation from factory to site resulting in higher cost and increased time (Modular Building Institute, 2015a). Modular construction has a distinct advantage over typical construction methods when there is proper design decisions and planning conducted by the construction management team as to when and where best to use modular construction methods.

The benefits of modular construction consist of reducing cost and schedule delays, and improving quality, safety, and sustainability. Modular construction is beneficial in reducing construction site waste, normally 10-15%, to only 5% in a controlled factory setting; reducing the number of vehicles visiting the site by up to 70% which reduces the environmental site impact; and decreasing noise and disruption to the area surrounding the site. Economically, prefabrication increases material and processes efficiency, promotes cost saving with a reduced schedule, and results in a reduction in onsite supervision and infrastructure (Lawson & Richards, 2010). A benefit from modular construction could also be safer site conditions during the construction phase, which could contribute to reducing injury and fatalities in the construction industry.

Safety in the Construction Industry

Safety is important to maintaining a healthy and productive working environment in an industry with a high level of hazardous work. Safety is important for maintaining high employee morale and stable productivity rates. The Occupational Safety and Health Act of 1970 was passed by Congress to develop a Safety and Health Administration to oversee the protection and health of the workers in the workplace (Friend & Kohn, 2014).

Multiple minimum requirements are applicable to employers to provide for their worker safety to prevent fatalities or injuries. Examples include Personal Protective Equipment (PPE) such as safety goggles and steel-toed work boots; Personal Fall Arrest Systems (P.F.A.S.), a harness attached to an anchorage system to protect against falls, and multiple other safety checks and equipment for daily protection (Modular Building Institute, 2015a).

The construction industry is well-known for consistently poor safety records. From 2008 to 2009, even with a 17% reduction in overall construction hours, the fatality rate remained constant at around 9.7 per 100,000 full-time workers (Buckley & Ichniowski, 2010). In 2014, the private construction industry accounted for 19% of all fatal work injuries in the private sector of all industry. Fatal workplace injuries totaled 874 in the private construction sector which resulted in 9.5 fatal work injury rates per 100,000 full-time equivalent workers in 2014. Of the 874 deaths, 349 were falls, slips, and trips which could possibly have been prevented or reduced with modular construction methods requiring fewer workers needed on site and more laborers performing modular activities in dry, climate controlled regulated factories. Construction roofers reported one of the highest fatal work injury rates at 46.2 fatalities per 100,000 full-time equivalent workers which resulted in 81 fatalities in 2014 (U.S. Bureau of Labor Statistics, 2014). Onsite conditions represent a major factor in maintaining high productivity rates and a safe environment for workers. Unsafe conditions can occur for laborers before an activity starts or can result once work begins without proper planning and safety precautions. Unsafe conditions can occur due to: management's action/inactions, unsafe acts by

laborers, non-worker related occurrences, and unsafe conditions resulting from any natural danger associated with construction sites (Abdelhamid & Everett, 2000). Unsafe site conditions can lead to higher incidences of absent workers and reduced productivity resulting from falls along with possible fatalities.

Modular construction could possibly reduce onsite fatalities and deaths by providing safer controlled factory conditions for craft workers. Safety could also be improved due to a reduction in scheduled onsite activities. Accident rates for modular construction are not currently tracked by the Department of Labor. A survey conducted by McGraw-Hill Construction of construction professionals reported that 34% of responders stated modular construction improved site safety as compared to 10% of responders who indicated that it actually decreased onsite safety. Fifty six percent (56%) of the responders felt that modular construction had no impact or little effect on onsite construction safety (McGraw-Hill Construction, 2011). Reasons for modular construction improved safety rates include multiple precaution and preventative measures taken during the factory construction phase. Modular construction can implement better safety processes by creating the construction in a horizontal build instead of a vertical build. This limits vertical heights; prevents exposure to weather; and reduces noise, dirt, and dust as compared to typical construction methods. Other considerations in the factory environment include a decrease in the use of large, more dangerous equipment, fewer workers needed as compared to typical construction methods, and the presence of better fall protection systems in place (Modular Building Institute, 2015a). Modular construction could be the key to reducing fatality rates in an industry known for them.

Scheduling Construction Projects

Construction schedules dictate the necessary workers and material to be onsite to begin their scope of work (section of work to complete in total building construction) and the amount of time allotted to complete the work by construction managers. Scheduling construction projects is necessary for understanding the risk factors of the project and tracking the onsite work for substantial completion of the project. Scheduling is conducted as a result of attempting to contest project uncertainty that could possibly occur during the different phases of construction. A survey in 1992 of the top 40 U.S. Construction Managers and Owners indicated a 65% uncertainty rate with respect to the scope and design objectives (Callahan, Quackenbush, & Rowings, 1992). A construction project delivery system increasing design uncertainty is consequence from the implementation of project fast tracking through the reduction of time for planned site activities. The definition of fast tracking a construction project is an effort to reduce a project schedule by beginning the construction phase of a building before all building designs and project scopes are completed. Fast tracking construction projects creates additional risks and project uncertainty due to beginning construction early before the design is complete (Kasim, Anumba, & Dainty, 2005). Risk accompanying fast tracking projects includes the possibility of increased delays due to rework or design problems; increased expense for engineering and architectural fees due to quicker drawing schedule; and improper planning and time allocation for certain scope activities, and other risks (Abdul Rashid et al., 2006).

Modular construction projects also attempt to reduce overall project schedule delays. Modular construction reduces project schedule through starting the fabrication of building modules or parts at the same time the preparation of the site and building foundations are poured (Modular Building Institute, 2015a). Response to the survey *Prefabrication and Modularization: Increasing productivity in the construction industry* conducted in 2011 by McGraw- Hill Construction reported 66% of construction professionals responded that project schedule time was decreased. Of these professionals, 35% reported a schedule reduction of 4 weeks or more, 10% reported a reduction of 3 weeks or more, and 21% reported a reduction in schedule of 2 weeks or less (McGraw-Hill Construction, 2011). The success in reducing a schedule by using modular construction allows multiple modules to be constructed concurrently under multiple concurrent schedule paths. Transportation of modules should fall under Just-In-Time (JIT) scheduling or the delivery of modules to the site for immediate installation to avoid delay, eliminate waste, or placement in storage (Mohammad Asri, Mohammad Azwanie Naim, Mohd Nawi, Nadarajan, Osman, & Harun, 2016). Modular construction techniques reduce project schedule time though the development of beginning multiple phases including pre-construction activities and onsite site work to commence concurrently.

Construction Costs

Reducing the cost of a construction project is the goal of all industry professionals in order to increase profit margins and stay within the established budget. The cost of a project is the combination of several variables including labor, material, preconstruction

planning, and the design process. The typical construction method occurs costs throughout the project, but once the design is completed and materials procured, significant changes to onsite construction are difficult. Prefabricated modules rather than traditional construction methods incorporate design changes easier throughout the entire manufacturing process. Modular construction does require a larger upfront cost than typical construction in order to begin the design process and procure materials for initial module construction (Hairstans, 2015). Although greater upfront financing is necessary, modular construction is expected to save as much as 30% in overall costs through decreased schedule time, reduced change orders, and other costs of typical construction methods such as jobsite and general overhead costs (Mawdsley, Long, Brankovic, Connolly, & Leiper, 2001).

The Construction Labor Force

The labor force for the construction industry is a necessary element for completing any job on time and under budget. A *2015 Worker Shortage Survey* Analysis by the AGC of America reported that 86% of construction firms were having trouble filling multiple available positions for both salary and hourly wage workers. The survey also stated that 36% percent of construction firms were losing hourly workers (laborers, carpenters, etc.) to other local construction firms and 13% to other nonlocal firms. In an attempt to keep workers from relocating to other construction companies, the survey reported 56% of companies raising hourly wages and 48% were increasing salary paid employees (AGC of America, 2015). There is a clear need for more workers in the United States construction business as demand is growing for a set workforce.

Modular construction factories could be an answer for reducing construction labor shortages by bringing unemployed site laborers into the modular factory workforce. Workers typically perform this move from construction jobs to manufacturing occupations for higher pay and better working conditions. Factory conditions would be dry and prevent exposure to moisture (rain), wind, sun, and other harsh onsite conditions (Modular Building Institute, 2015a). The modular construction worker also need to understand multi-skilled training or understand and advance at multiple trades instead of in typical construction methods excel at one single trade. Examples for multi-skill familiarity are sheet metal workers who learn how to install piping or H.V.A.C. installation. Modular construction factories mimic the production of automobiles in producing an assembly line layout for production (McGuinness & Bennett, 2006). Craft laborers would also have set work shifts in a factory setting. Modular production systems (MPS) consist of manufacturing lines which combine modular components into complete modules ready for onsite installation (Shaik, Rao, & Rao, 2015). The providing of new skills for construction workers can efficiently improve the construction process in modular construction which could increase demand for more qualified craft laborers to train in modular construction applications.

Maintaining Quality of a Construction Project

Quality is an important part of construction for a client's acceptance of the building and receiving a certificate of occupancy. Emphasis on quality during the initial planning and design phase will lead to a reduction of redoing work onsite. Quality is defined as, "meeting or exceeding the requirement of client/owners and aligned with the

conformity of what the specifications have defined for the project." (The Constructors, 2015). Quality for building construction usually trends to the aesthetical look and building code compliance, but must also be defined by other onsite variables such as quality of management, time sensitivity, and assured correct original work. Managing quality is an important factor that must be proactively and constantly assessed throughout the entire project.

Modular construction quality is delivered through numerous inspections and quality control aspects during the factory construction process. Supply chain management is a form of quality control through several steps of production. The supply chain begins with a need for modular building which translates into sales of the product, planning logistics, and design in a modular format. Once the contract for the building construction is finalized, the purchasing of raw materials from suppliers can commence. Production then begins once the raw material is checked for quality. Production occurs in the modular factory setting and once construction is completed, another inspection of quality is completed for the modules to be transported to the site. For transportation, modules are carefully packaged and wrapped to protect them from damage during transportation to the site (Modular Building Institute, 2015a). An additional benefit for modular construction is the waste saving abilities of producing an accurate and precise final product with decreasing labor requirements and increasing productivity output. The modular construction process has multiple quality assurance and quality control aspects to maintain high quality work to meet job quality conditions.

Leasing/Total Construction Costs for Big Box Stores

Information on leasing or construction costs for most of the big box stores interviewed was to be kept confidential unless the store planned to close. Due to multiple big box stores which are already closed, leasing information could be found for similarly formatted buildings with similar total square footage as disclosed by previous corporate owners. A recently closed Wal-Mart Supercenter in Winnsboro, South Carolina, advertised leasing information asking $3.50/sf for 109,630 sq. ft. along with 565 parking spots at $5.15/sf (Collett, 2016). Another closed Supercenter in Durham, North Carolina is asking $54.74/sf for 109,591 sq. ft. on a 12.88 acre parcel (Walmart Realty, 2016a). An additional closed store in Morgantown, North Carolina with 88,140 sq. ft. is asking $24.11/sf or $2,125,000 as a purchase price for the 7.94 acre parcel and building (Walmart Realty, 2016b). Research for Costco located a warehouse and parking lot parcel in Bellingham, Washington for sale at $7,000,000 for 9.35 acres that includes 8.05 acres of Costco owned land and 1.31 acres of land leased to Costco (Leibsohn Company, 2016). Due to different locations, which determines pricing, information for exact pricing for purchasing or leasing building space could not be easily determined or estimated without pricing quotes provided by corporate big box storeowners. Information for other big box stores is not easily obtained for leasing or total construction cost without actual business inquiries or the stores do not have readily available entire building leasing formats.

Summary of the Literature Search

The literature search conducted for this study developed an in-depth investigation into the modular and construction industry. The literature search helped identify possible potential areas of study; a thorough comprehension of the topic; and understand existing research conducted on the topic. Valuable information was learned to set a foundation for conducting the following research. While research on modular construction is still limited currently, future research into the topic might produce additional beneficial information.

CHAPTER THREE

Research Methodology

This chapter explains the steps and procedures undertaken to gather the data of modular construction companies' factories and big box stores nominal dimensions in order to conclude if it is viable for modular construction companies to house operations in abandoned big box stores. Case studies were chosen to collect and analyze data on modular construction factories for possible adaptation to big box retail stores. Case studies allow the exploration into the differences and similarities between each modular construction company. Modular construction companies are unique in the fact that each have different operation methods and different end products. Gathering a large sample of information from multiple firms gave better insight and feasibility for calculated decisions.

The case studies were chosen in order to investigate and understand the characteristics of modular construction factories and the variables that must be considered for a successful retrofit into big box stores. Modular construction companies are dependent on multiple factors to complete work on time with high quality and to meet exact designs to fit into place onsite. Modular construction currently only consists of 3-5% of the construction industry in the United States, but offsite construction could be the answer to reducing scheduled time onsite, attracting and retaining the construction work force, and decrease onsite construction costs (Smith, 2015). Research is needed to

develop guidelines for a successfully growing the number of modular factories that could result in an increase in modular construction throughout the United States.

Information on modular construction is very limited due to the minimal use of modular construction technologies and little research into the subject. Providing construction industry information through case studies will lead to improvement and growth in the modular construction industry. The following research methodology is a detailed plan into developing the research and procedure for collecting data and information. The following objectives are necessary to capture and analyze the data to support this thesis. The initial step for conducting research began with finding information already available on the topic of modular construction though a literature review.

The objective of the literature research as well as understanding and providing a comprehension of the construction and modular industry, was to determine the feasibility of developing a modular construction factory located inside abandoned big box stores such as Wal-Mart or Costco. In order to determine the viability of producing a modular construction factory in such spaces, the following points were considered for the research:

1. Investigate existing modular construction factories and determine what makes them successful in terms of the efficient utilization of building space, yard storage, and other essential production elements of the factories.

2. Determine the size and amenities located in abandoned big box stores necessary for supporting craft workers and management who are working in modular construction facilities.

3. Identify necessary space requirements in both modular construction factories and big box stores.

4. Determine the feasibility of using abandoned big box stores in terms of cost factors, required space, and other components required to support successful modular construction factories.

Multiple literature sources were reviewed including previously published scholarly papers with similar topics, websites, books, and other sources to collect information to support the research. Print and online materials consistent with modular construction were studied to determine the materials and methods used in modular construction with insight to exposing the spaces and amenities necessary for modular construction factories. Understanding established sizes and features common in big box stores could allow the rehabilitation of an existing structure for retrofit as a modular factory.

The following objectives enabled the collection of empirical data for analysis and comparison through the investigative steps:

1. The next step after the literature review was an investigation into big box stores. The interviews of managers of big box stores shed light into big box store variables including amenities, total square footage, offices and other

factors essential to operations. Understanding dimensions and amenities of big box stores gave important information necessary to understand the value of using big box stores for modular construction manufacturing purposes.

2. Next, a personal interview is conducted for several modular construction factories to understand operation and procedures of modular factories. Through information from "*Case study research: design and methods*," found on page 47 in the book stated using the replication method for conducting case studies should include 6 to 10 case studies conducted under similar circumstances to make the information statistically viable (Yin, 2003).
3. Next, Personal interviews with construction management of modular construction factories give factory information necessary to compare variables of modular factories and big box store variables. Terms for comparable data include total square footage, assembly line/modular construction configuration, office space, amenities, and other factors. All interview questions can be found in Appendix B.
4. Another step in the research methodology was to understand the variables regarding modular construction factories and big box stores for proper assessment of feasibility. Variables necessary to determine feasibility includes square footage, office space, number of bathrooms, and other factors will be considered.
5. The last step was to compare the information from both modular construction factories and big box stores. This step includes developing a baseline of

essential information important for the conversion of big box stores to modular factories in order to determine the feasibility of developing a warehouse environment in abandoned big box stores.

Assumptions and Limitations

Assumptions

Assumptions include information that is not statistically analyzed, but information based on comparable similarities. Feasibility is assessed by researchers and supported through fact. Case studies provide the information on modular factories as compared to big box stores for the possibility of using big box stores for housing modular operations. It is assumed that each participant provided information that was both truthful and knowledgeable to make the data viable to produce practical results.

Limitations

Limitations for research include the following:

1. The research in this thesis was conducted with modular construction companies solely for increasing production spaces for large modular or pod purposes. The data does not include developing spaces for prefabricated materials closely related to certain subcontractor's scopes of work such as mechanical contractor's prefabricated piping, sheet metal, and other off-site work.

2. Certain issues like zoning, noise levels, and other inhibitors could result in the difficulty of converting big box stores, even if the stores could support a conversion to modular factories.
3. Estimated values and costs for retrofitting big box stores is beyond the scope of this research and could possibly be conducted as future research.

CHAPTER FOUR

Data Collection

Research for understanding the feasibility of modular construction companies using abandoned big box store relies on a compelling support and evidence to reinforce the achievability of this study. Initial investigation was conducted for big box stores to understand the amenities and variables surrounding them before perceiving modular factories variables. As stated in the research methodology, initial questions would be asked to store managers and revised to understand a better scope of what variables would be important to comprehend for comparing/contrasting reasons in big box stores. The following paragraphs discuss the parameters around big box stores and the data collection before moving into interviews of modular factories for the following case studies.

Big Box Stores

Big box stores generally refer to large supermarket/general merchandise stores that sell multiple products from groceries to home goods, electronics, clothing, etc. Big box stores now incorporate other businesses including bookstores, fitness centers, and banks due to the excessive amount of vacant space in big box stores (Walmart Corporate, 2014). General merchandise stores reported almost 15% of all retail revenue in 2007 (Basker, Klimek, & Hoang Van, 2012). Wal-Mart is the largest food retailer in the world and added 33 million square feet in retail space in 2014 (Walmart Corporate, 2014). Wal-Mart also reported an increase of $7.5 billion dollars in 2013-2014 and reported overall net sales of $473 billion dollars (Wal-Mart annual report).

Even with the reported increase in space and sales, Wal-Mart issued a press release on January 15, 2016, announcing the closure of 269 stores worldwide including 154 stores in the United States. Of the 154 stores, 102 of them were Wal-Mart Express stores, which are the smallest sized general merchandise store arrangement that Wal-Mart uses. In South Carolina, Wal-Mart stated that two (2) Wal-Mart Expresses and one (1) Supercenter would be closing during 2016 (Malcolm, 2015).

Kmart and Sears, which are both owned by Sears Holdings, announced closings of 75 total stores during 2016. Kmart planned to close 65 stores beginning in May along with 10 Sears stores to close in April. The C.E.O. of Sears explained that the Board of Directors want the retail giant to be a company with fewer retail stores (Northrup, 2016). Kmart, Sears, and Wal-Mart are only a few of the listed big box stores that also includes Home Depot, Lowes, and Kroger's as well as other retailers who plan to shutdown multiple stores across the country.

Big Box Stores Sizes

Big box stores have large size and space characteristics to support supermarket operations and amenities. Wal-Mart and Costco are two of the largest United States big box stores in terms of total store square feet (sq. ft.) and annual company profit. Each company boasts a remarkable amount of space for distribution of goods and multiple services. Costco Wholesale currently has 702 warehouses (stores) that range in size from 73,000 to 205,000 sq. ft. The average square feet for all stores internationally are 143,800 sq. ft. (Costco, 2016). Wal-Mart stores have three main store arrangements including

Wal-Mart Supercenter, Discount store, and Neighborhood Market with 4,573 stores as of February 2016 (Wal-Mart Stores, 2016). The Wal-Mart Supercenter have the largest stores with an average square footage of 179,000 SF with individual stores sizes ranging from 70,000 to 260,000 sq. ft. A Wal-Mart Discount Store ranges from 30,000 to 219,000 sq. ft. with an average of 105,000 sq. ft. The Neighborhood Market includes all other store formats that are a maximum of 66,000 sq. ft. and a store average of approximately 40,000 sq. ft. (SEC 2016). Ample space in big box stores could provide the controlled factory settings necessary for modular construction factories to occupy abandoned big box store structures.

Big Box Store Investigation

The following presents an examination and research into the general retail big box stores located in the state of South Carolina. An examination of the following research into each store along with an understanding of heights, space, and amenities will provide valuable information for determining the feasibility of using certain retail stores to house modular construction factories. Each big box store representative who was interviewed was asked specific questions in an effort to determine the available space, average amount of employees working, and how the space was used such as for bathrooms and office space. The big box store chains were interviewed in an effort to compare big box store variables with modular construction factory conditions for the purpose of determining which store conversions to modular construction purposes would be most feasible. Due to confidentiality reasons, not all questions asked were answered by the store representatives.

Big Box Store Questions

Questions for big box stores consisted of eight (8) questions in an effort to understand and collect data regarding spacing and dimensions of various spaces, the amount of amenities located in each store, and the total amount or average number of employees working in the store at one time. A ninth question was asked regarding total construction cost and annual/monthly leasing information in order to understand the dollar amounts associated with new construction of a large sized space vs. renovation of a similar sized space for an existing structure. All questions asked for big box stores can be found in Appendix A. Leasing and total construction cost questions were asked for all locations, but not always provided and this information was found using alternative sources. Most store managers who were interviewed for this information could not answer all questions. These questions were then directed to other company sources for more information.

Wal-Mart

In the state of South Carolina, Wal-Mart employs 30,828 employees at 111 total retail store locations, which include 18 neighborhood markets and 12 Sam's Clubs along with 4 distribution centers. According to Net Lease Advisor, a Wal-Mart store with an average square footage of 100,000 costs $150.00 dollars per sq. ft. (Walmart Corporate, 2016). Wal-Mart has all three-store types located in South Carolina and plans to close three of them (2 Expresses and 1 Supercenter). Store information is provided below based on an investigation of three (3) actual stores located in the state of South Carolina.

WAL-MART NEIGHBORHOOD MARKET

Interviewed: PETE SPADETTI Date: 4/15/2016

Figure 4.1 Courtesy of Wal-Mart Neighborhood Market

Big Box Store name: Wal-Mart Neighborhood Market

Location: Clemson, SC

Employees: 20-30 workers average

Factory Size: 41,000 SF

A Wal-Mart Neighborhood Market located in Clemson, SC was investigated to obtain information on logistics and size that characterizes the neighborhood market store format. The store is roughly 41,000 sq. ft. with column spacing at 50' or 57' 10" from either column to column, or column to exterior wall. The store is located on a 6.628-acre lot with an annual lease of $725,000 a year for the building, or $60,416.70 a month. The store lease is priced at $346.18/sf. Amenities in the store include 2 offices at 315 sq. ft. total, 1 break room totaling 204 sq. ft., and 2 bathrooms (1 womens and 1 mens restroom). The loading dock area of the building includes two standard loading docks

located in the rear sized at 10’ high, 8’ wide, and 66’ in length from the beginning of the truck ramp to the actual dock doors which represents typical standard dimensions for Wal-Mart. The parking lot includes 180 spaces specifically for Wal-Mart store customer parking. Employees working at the same time range from 20-30, but 30 is the maximum number of employees at any given time (Perrault, A. Phone Interview, April 18 2016, Spadetti, P. Personal Communication, April 15, 2016). Information derived from this Wal-Mart Neighborhood Market interview can be used as a general guide for determining common traits with actual modular construction factories for comparison purposes.

WAL-MART SUPERCENTER

Interviewed: GWEN ESTES Date: 4/15/2016

Figure 4.2 Courtesy of Wal-Mart Supercenter

Big Box Store: Wal-Mart Supercenter

Location: Central, SC

Employees: 152 workers maximum

Factory Size: 203,622 SF

Investigation for a Wal-Mart Supercenter was conducted at the store at Central, SC that is 203,622 sq. ft. This Wal-Mart has four (4) truck loading docks at the standard Wal-Mart size of 10' high, 8' wide, 66' in length and one (1) non-standard smaller dock used for forklifts and hand jacks to transport exterior storage items into the store. Amenities for the store include 10 office spaces, 1 break room, and 6 restrooms with 18 water closets/urinals. During the busiest times in the store, the number of workers will not exceed 152 workers (Estes, G. Personal Communication. April 15, 2016). The

supercenter retail space and amenities possibly could house more than just one modular construction firm within the confines of the building or double the production space of a preexisting modular manufacturer.

Figures 4.3 and 4.4 below shows a Wal-Mart Supercenter floor plan as well as a modular process diagram with an overlay of how the process might fit into the Wal-Mart Supercenter format. The blue line in the overlay shows the process of a modules movement throughout the modular factory format. The modular process shown below demonstrated in Figure 4.4 is a typical production format for modular construction companies. The initial process starts with structural fabrication including developing jigs to set prefabricated wall panels or welding a structural frame. Next, the module moves to mechanical, electrical, and plumbing applications or any other in-wall work needed to occur before the walls are closed up. Finish work can then begin to complete the modules with the last finishes including: painting, setting fixtures and furniture, millwork can be positioned and other work necessary to finish the module, etc. The process using the hybrid/assembly line format pushes the module through the factory from starting structural work to final finishes. Office spaces have been included over the existing big box store office locations. The overlay format is developed on attempting to develop a modular process of movement from the loading dock entrance to each scope of work before being exported back through the loading dock area.

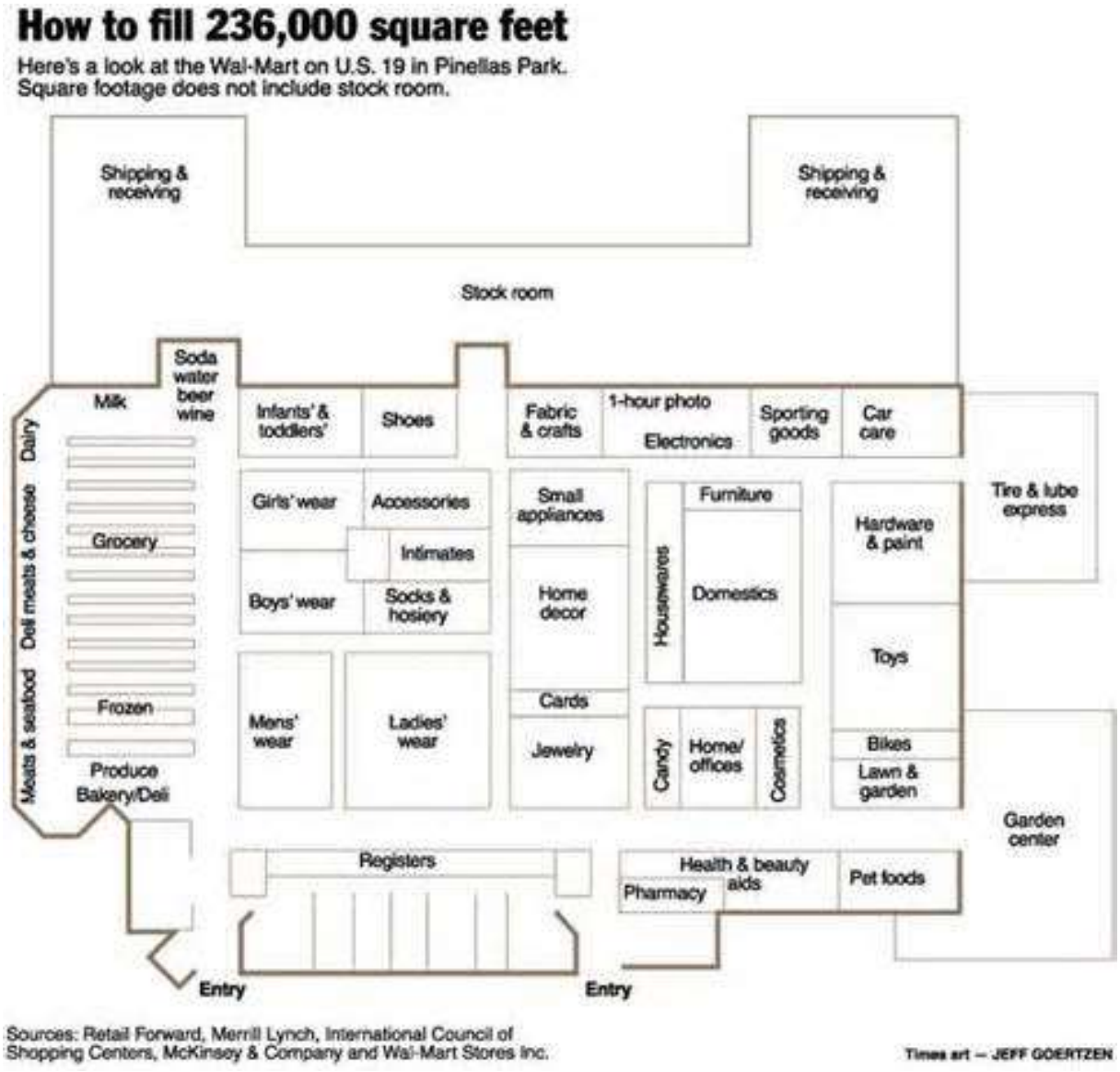

Figure 4.3 Wal-Mart Supercenter Floor Plan – 236,000 SF

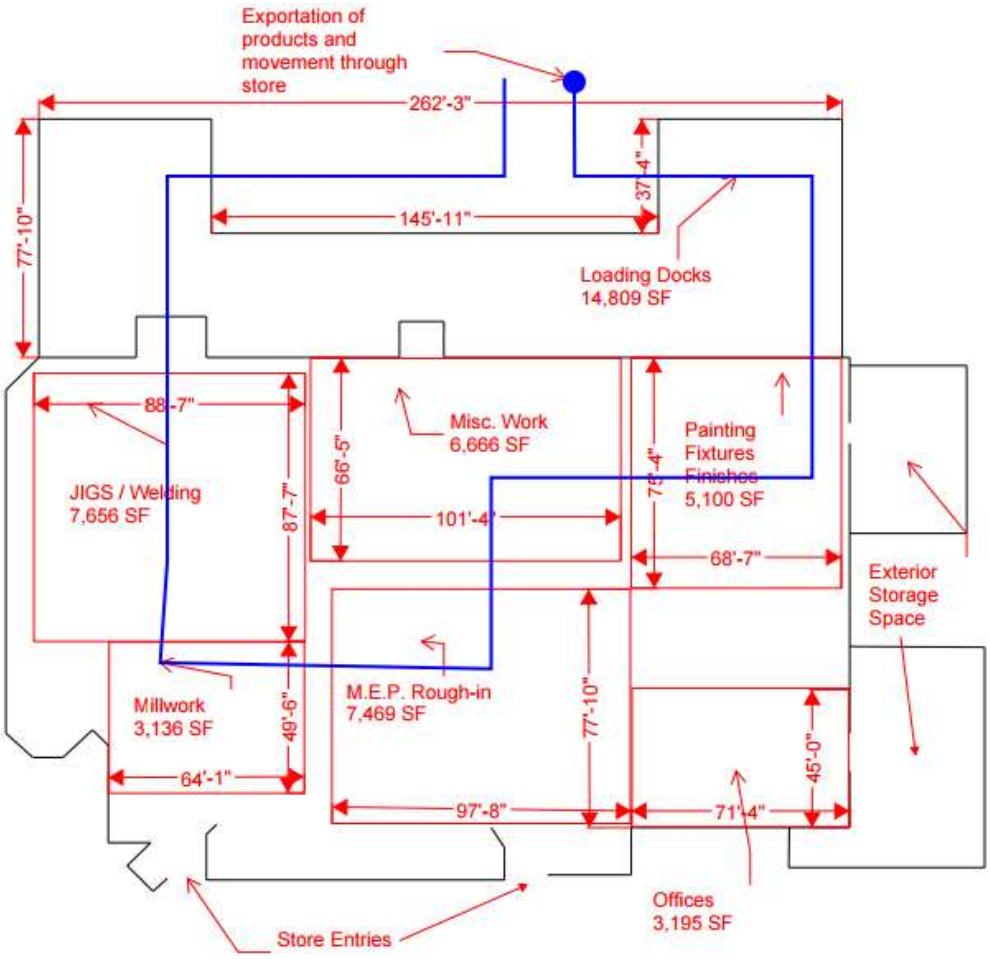

Figure 4.4 Wal-Mart Supercenter Modular Factory Modular Process Example

COSTCO

Interviewed: LISA LANZ Date: 5/28/2016

Figure 4.5 Courtesy of Costco

Big Box Store: Costco

Location: Greenville, SC

Employees: 75 workers maximum

Factory Size: 148,000 SF

Costco Wholesale represents another large general merchandise retailer that sells products in wholesale bulk with a goal to sell more for less. Costco provides approximately 4,000 stocked items per store as compared to 30,000 items on average at other supermarket formatted stores with a goal to maintain quality products at low prices (Costco, 2016). Costco as of November 2015 had 493 stores in the United States and Puerto Rico with three (3) located in South Carolina (Costco, 2015). Investigation and

research into a Costco Wholesale Warehouse operation was conducted at the store located in Greenville, SC. This Costco Warehouse store utilizes 148,000 sq. ft. with 4 standard loading docks. The Costco ceiling height is estimated to be 40+ feet. Amenities for the building included 1 office, 2 break rooms, and 3 restrooms. The average number of employees working at one time in the store was approximately 75 with 202 employees on payroll. Figures 4.6 and 4.7 below shows a typical Costco floor plan as well as an example of a modular factory overlay onto the Costco floor plan to show an example of how the modular process might be formatted in the Costco floor plan. The blue line in the overlay shows the process of a module movement throughout the modular factory format. This is a similar process explained before at the end of the Wal-Mart Supercenter data collection section (Pg. 32).

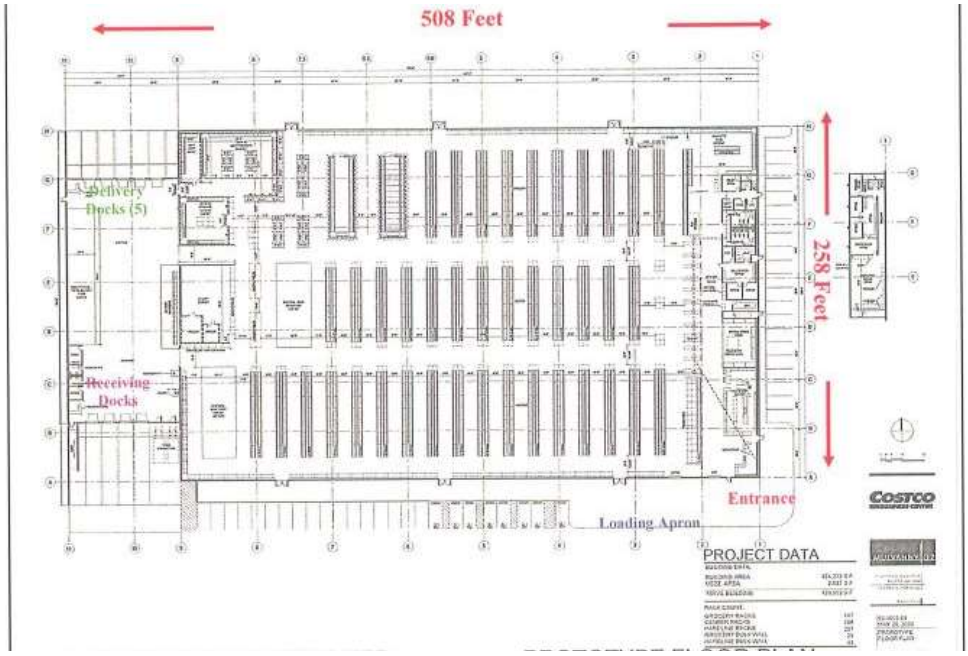

Figure 4.6 Costco Floor Plan - 141,261 SF

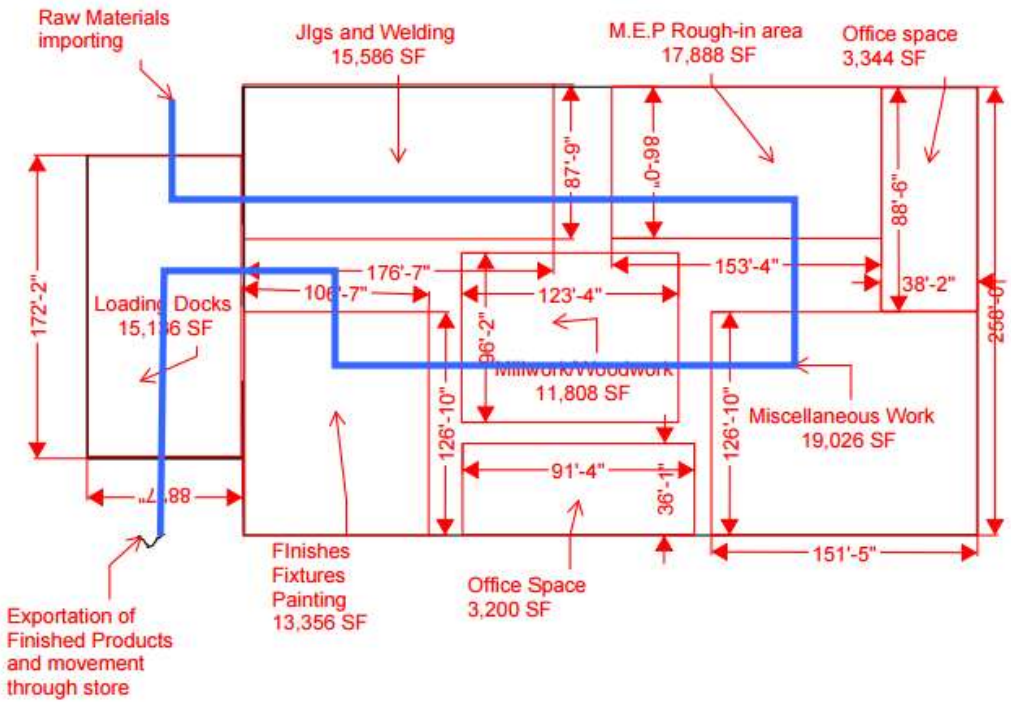

Figure 4.7 Costco Modular Factory Modular Process Example

HOME DEPOT

Interviewed: BRAD CARSON Date: 5/14/2016

Figure 4.8 Courtesy of Home Depot

Big Box Store: Home Depot

Location: Anderson, SC

Employees: 55 workers average

Factory Size: 128,000 SF

Home Depot is another large general retailer that specializes in providing home improvement goods and services. Home Depot has over 2,200 stores located in the United States and its territories with 25 located in South Carolina. Home Depot Stores typically average 105,000 sq. ft. per store with an additional 23,000 sq. ft. added for the

Garden Centers outdoor space (Home depot.2016). Investigation and research at a Home Depot retail store operation located in Anderson, SC and provided valuable store information for a typical Home Depot store. This Home Depot store was approximately 100,000 sq. ft. with approximately 28,000 sq. ft. added for the adjacent Garden Center. Column spacing of the store was approximately 36’ X 36’ with a ceiling height of 20’ in the Northeast storefront which slopes to a 16’ ceiling height in the Southwest section. The store has 4 standard 10’ high X 8’ wide loading docks. Amenities for the store include 3 offices with 2 office spaces totaling 8’ X 8’ (64 sq. ft.) and 1 office 10’ X 24’ (240 sq. ft.). There are 2 bathrooms both public and private (1 womens and 1 mens restroom), and 2 break rooms with 12’ X 30’ spaces (360 sq. ft.). The average number of employees working at one time in the store ranges from 50 – 55 with 55 being the maximum number of employees (Carson, B. (2016, May 14, 2016). Personal Communication)

LOWES

Interviewed: SARAH MCCORMICK Date: 5/14/2016

Figure 4.9 Courtesy of Lowes

Big Box Store: Lowes

Location: Anderson, SC

Employees: 75 workers maximum

Factory Size: 148,000 SF

Lowe's is a similar home improvement goods and service retailer with over 1,840 home improvement stores located in North America including other stores owned by Lowe's such as Orchard Supply Hardware Stores. Lowe's stores average 112,000 square feet of retail selling space (About lowe's.2016). Investigation and research into a Lowe's Home Improvement store was conducted at the store in Anderson, SC. Total square

footage of the building was approximately 169,000 sq. ft. with column spacing throughout the store of 36’ X 36’. The building had 3 standard 10’ high X 8’ wide loading docks. Amenities at the building included 3 bathrooms which include 2 public and 1 private, 4 offices at 10’ X 15’ (150 sq. ft.) each, and 1 break room 26’ X 26’ (376 sq. ft.). The average number of employees working is 75 with 150 employees being the maximum number at any given time (McCormick, S. (2016, May 14). Personal Communication).

BI-LO

Interviewed: WAYNE PIERCE Date: 4/29/2016

Figure 4.10 Courtesy of BI-LO

Big Box Store: BI-LO

Location: Clemson, SC

Employees: 75 workers maximum

Factory Size: 148,000 SF

BI-LO is a general merchandise grocery retailer located primarily in the Southeast with stores in North Carolina, South Carolina, and Georgia. BI-LO LLC, employs over 15,000 employees in 182 stores in the Southeast region (*About us | BI-LO.*2016). The BI-LO located in Clemson SC, provided valuable information and research in response to questions about the store. The total size of the store is 47,000 sq. ft. that includes 2 loading docks. Amenities include 3 bathrooms which are, 2 public and 1 private, 2 offices, and 1 break room for employees. The average number of workers ranges from

30– 35 with 35 being the maximum number of workers at one time (Pierce, W. (2016, May 14). Personal Communication.).

PUBLIX

Interviewed: TERRY BOYD Date: 4/29/2016

Figure 4.11 Courtesy of Publix

Big Box Store: Publix

Location: Clemson, SC

Employees: 90 workers maximum

Factory Size: 47,000 SF

Publix is the largest employee owned grocery chain in the United States with 1,114 stores located in 6 states in the Southeast. Publix has 55 stores located throughout South Carolina (Facts & figures | company overview.2016). Investigation and research was conducted at the Publix store #5539 located in Clemson, SC in order to obtain store space information. The total square footage of this Publix store is 47,000 sq. ft. with 1 loading dock located in the rear of the store. Amenities for the store include 4 offices, 1 break room,

and 5 bathrooms. The maximum number of employees working at one time approximates 90 (Boyd, T. (2016, May 14). Personal Communication). Figures 4.14 and 4.15 Show the floor plan of a typical Publix floor plan as well as an overlay and the modular process and how it could be formatted into this floor plan. The blue line in the overlay shows the process of a module movement throughout the modular factory format. This is a similar process explained before at the end of the Wal-Mart Supercenter data collection section (Pg. 32).

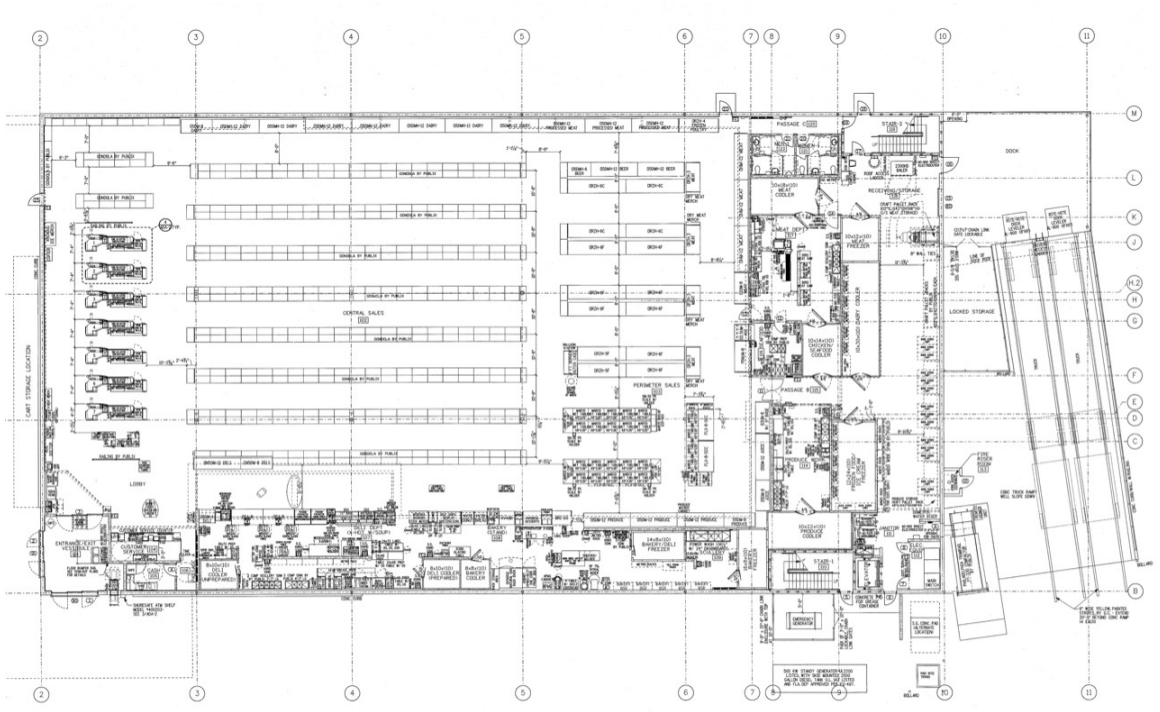

Figure 4.12 Publix Floor Plan – Approx. 47,000 SF

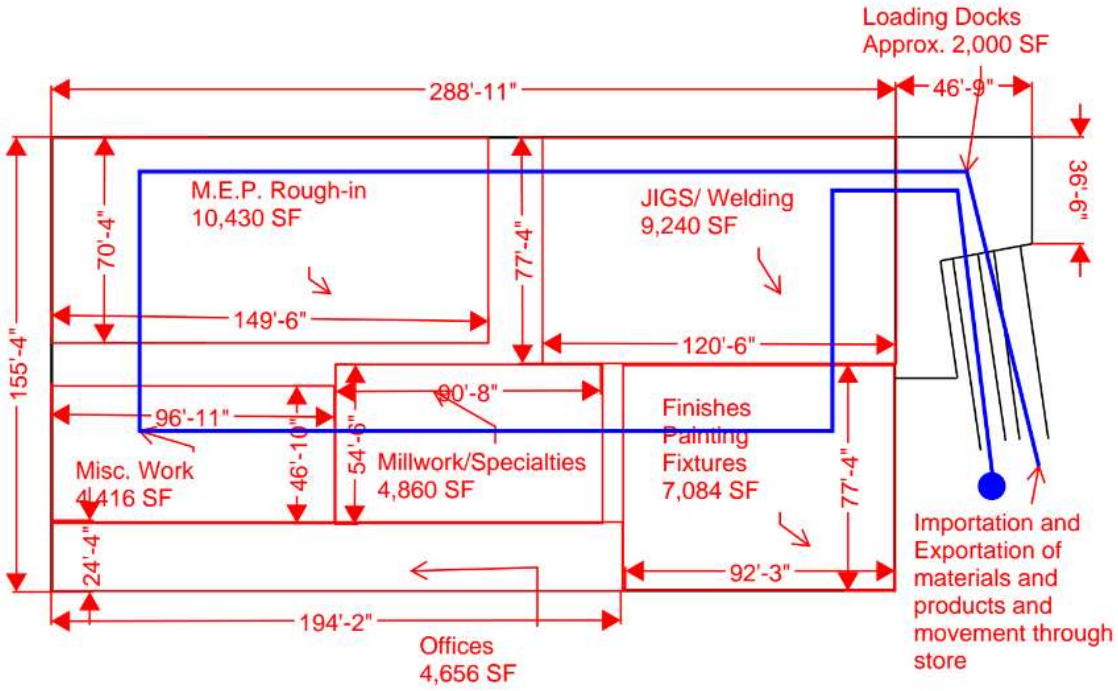

Figure 4.13 Publix Modular Factory Overlay Example

Summary of Big Box Store data collection

The data collected for big box stores presents a baseline for better understanding the amenities available inside existing big box formats with respect to how adaptable these stores are for modular manufacturers. A determination of the existing amenities will help develop an understanding for what modular manufacturers would need in the big box stores or what might need to be added/retrofitted. Investigation in the data collection for each of the modular manufacturers and their requirements necessary for a big box store conversion.

Table 4.1 is a summary of the information received on the big box stores. Data is presented as received from store managers. Certain information could not be presented specific for example square footage of office space and other variables where only numbers could be given as a representation of the multiple offices in the big box store. Parking lot size is an attempt to shop possible exterior yard storage for modular factories.

Big Box Store data								
Store	**Square Footage**	**Column Spacing**	**Loading Docks (#, Size)**	**Offices**	**Bath rooms**	**Break Rooms**	**Average number of workers**	**Parking Lot Size (Appox.)**
Wal-Mart Neighborhood Market	41,000	50' - 57' 10"	2 at 10' X 8'	2	2	1	20- 30 max	180 Spaces
Wal-Mart Supercenter	203,622	Unknown	6 at 10' X 8'	10	6	1	152 max	1100 spaces
Costco	148,000	Unknown	4 at 10' X 8'	1	3	2	75 max	500 spaces
Home Depot	128,000	36'	4 at 10' X 8'	3	2	2	55 avg.	450
Lowe's	169,200	36'	3 at 10' X 8'	4	3	1	150 max	500
BI-LO	48,000	Unknown	2 at 10' X 8'	2	5	1	30-35 max	250
Publix	47,000	Unknown	1 at 10' X 8'	4	5	1	90 max	120

Table 4.1 Big Box Store data

Case Study Pilot Case Questioning

In order to develop relevant questions for modular construction factory operations, a baseline must be developed to determine the most important information for understanding the business processes for maintaining and operating a modular factory. The most important questions to answer pertain to space requirements, required number of employees, and numerous other variables important for an efficient factory operation. An initial factory operation must be chosen to develop questions in order to determine if the chosen questions are relevant and complete, or whether they need to be changed in a final draft for additional follow up questions for additional factory operations. The

following requests an initial pilot case study for determining a base of reference for developing further research into modular construction factory operations.

First String Inc. is a modular construction company located in Pearson, Georgia which has offered modular construction services since 2007 specializing in multiple types of construction utilizing various structural materials. First String Inc. has performed construction services for government, military, and public projects. The firm's construction projects include commercial, medical, education, disaster relief, and other types of construction projects. First String's main warehouse includes a 100,600 SF factory as well as an additional 13 acres for storage purposes. The main warehouse including the surrounding area totals 143,000 SF including 27,800 SF of exterior office space and material storage (First String Space, 2016).

NRB Inc. represents another modular construction company which operates two modular construction factories located in Grimsby, Ontario and New Holland, Pennsylvania. The two factories employ over 150 skilled laborers from administration personnel to skilled tradesmen including welders, carpenters, and other factory skilled workers. Modular construction services offered from NRB Inc. includes healthcare, industrial, education, and student housing, along with other modular construction building and design services. Both factories contain multiple factory adaptations to produce more efficient work in safer conditions which improves project quality.

NRB Inc. factories include multiple attributes in order to maintain a safe and productive factory setting. Both factories include natural lighting, energy efficient

Mechanical, Electrical, and Plumbing (M.E.P.) systems to reduce energy consumption, sprinkler systems, and large and secure material storage areas. Steel fabrication onsite includes multiple machines for welding and cutting in its own building to help assemble steel erections. The factories also incorporate overhead crane systems for easy movement of large modular pieces. Material storage yards are fully furnished with graded, gravel, and drainage systems. The material yards also include lighting and electrical services for working on large projects outside with extensive fencing for security.

The modular factory site in Grimsby, Ontario began production in 1980 and has undergone multiple renovations and additions since then. The site includes 3 modular manufacturing factories, consisting of one 15,792 SF building, and two 21,000 SF manufacturing buildings. The site also houses a 10,000 SF steel fabrication factory and a 6-acre manufacturing yard for storage and exterior work on large projects. The site also includes a 7-acre overflow yard along with a finished storage yard for completed projects ready for transportation. Office space onsite exceeds 12,000 SF for housing administrative personnel. Total square footage for the plant aggregates 95,000 SF located on a 20-acre site. The plant in New Holland, Pennsylvania was built in the winter of 2014 and completed in June 2015. The site consists of a 55,000 SF building and manufacturing dedicated space located on a 16-acre site. The newly built factory includes a 45,000 SF manufacturing site and 10,000 SF of office space. The site includes similar amenities found at the NRB Inc. plant in Grimsby (NRB Inc., 2016). Information for both modular construction factories attributes and big box store amenities provides for understanding the possibility of integrating big box stores for modular construction purposes. Below is

Table 4.2 that summarizes the data collected from the two (2) companies for the pilot case study.

Pilot Case Study					
Companies	**Factory total SF**	**Site, Acres**	**Exterior Storage, Acre**	**Office Space**	**Material Storage, Acres**
NRB (Grimsby)	15,792, 2 at 21,000	20	13	12,000 SF	6 Acres
NRB (New Holland)	45,000	16	Unknown	10,000 SF	Unknown
First String Inc.	100,600	13	0.6	27,800 SF	Unknown

Table 4.2 Pilot Case Study Data Summary

Comparing Big Box Stores and Modular Construction Attributes

A comparison of modular construction factories and big box store amenities should address whether there exists sufficient manufacturing space, office space, and other amenities to support a factory operation as well as enough workers to complete an integration process. Adequate space and amenities is needed in certain big box store formats in order to ensure the feasibility of using the abandoned store for modular construction purposes. Information from modular factories indicates existing factory sizes range from as little as 45,000 sq. ft. to 143,000 sq. ft. for manufacturing purposes. Several big box store formats would have sufficient space for housing large modular construction factories including Lowe's, Home Depot, Costco, and the Wal-Mart Supercenter. The NRB Inc. New Holland manufacturing space totals 45,000 sq. ft. which would fit into some of the smaller big box store sizes including Publix, Wal-Mart Neighborhood

Market, and BI-LO. These represent some examples of stores with square footage that would be able to accommodate other small modular factories. Space is one of several essential factors for determining the feasibility of converting big box stores for modular purposes.

The amount of yard and storage area is another essential factor for the operations of larger modular projects or multiple projects concurrently. Yard space is essential not only for storage, but also for scheduling transportation for modules and providing more room to work on large projects outside. Data obtained for the modular factories indicated the smallest yard space at 13 acres with the largest at 20 acres. Most big box stores are in tough locations to provide enough acres for exterior storage/yard space. Information for the Wal-Mart Neighborhood Market indicates a 6.628-acre site including the 41,000 sq. ft. store which is similar in size and configuration to NRB Inc. factories with a 7-acre overflow storage yard in Grimsby. The Costco Warehouse in Washington included an 8.05-acre site as well as 1.31-acres of additional land which could be used for storage purposes. There is also a large abandoned store with extensive manufacturing space. Sufficient yard storage for modular construction is necessary to accommodate multiple projects at one time along with the possibility for expansion of additional manufacturing space.

Indoor factory amenities are crucial to maintaining a productive, safe, and comfortable environment for both labor and management personnel. Bathrooms and break rooms must be adequate to ensure a comfortable environment to maintain high morale in the workplace. The number of bathrooms, offices, and break rooms in big box

stores was dependent on the number of workers and customers. Information for the modular factories indicates significant office space. 10,000 sq. ft. of office space was provided at both NRB Inc. factories and 27, 800 sq. ft. of exterior office space was provided at the First String Inc. site. All big box stores do not necessarily provide enough office space to meet these demands, but additional office space can be added when surplus interior office space is needed through modular additions. Bathrooms represent another space issue easily convertible with a modular construction factory, which needs more space. Many big box stores provide 3 bathrooms or more to accommodate at least 30 employees or more plus numerous customers. NRB Inc. which typically employs 150 employees considers 3 bathrooms to be sufficient as bathrooms in the big box stores contain at least 2 toilets or more. Interior bathrooms can also be renovated in existing structures to accommodate more personnel. Big box stores have multiple positive factors and attributes suitable to convert to modular factories and there are several aspects that are easily changeable to meet mandatory necessities for modular factory operations.

Modular construction factories have multiple variables that can be altered or adapted to assist in using big box stores for construction space. Adequate interior space is available with multiple store formats to provide adequate office space and amenities for personnel. Research into existing modular factories indicates that the minimum space requirement must be around 40,000 sq. ft. The amount of manufacturing space needed also depends on the number of workers needed daily in the factory. Office space requirements for management personnel indicated a minimum need of at least 10,000 sq. ft. depending on the size and space needed for the modular operation. Amenities cannot

be easily determined without an initial understanding of the needs of the factory employees to determine acceptable and suitable space for such purposes. Developing a baseline for these requirements can provide guidelines for the types and size of modular factories that can be opened in abandoned big box store factories. The research collected above will provide empirical information for the comparison of big box stores and modular construction factory requirements.

CASE STUDIES

CASE STUDY: PIVOTEK

Interviewed: LARRY HODSEN Date: 7/11/2016

Figure 4.14 Courtesy of Pivotek

Modular construction factory: Pivotek

Location: Cincinnati, Ohio

Employees: 25-30 workers per shift, 12 office personnel

Factory Size: 50,000 SF

Company Background: Pivotek is a modular construction company which started about 5 years ago specializing in developing offsite modular bathrooms and kitchen pods which serve the hospitality, healthcare and housing construction projects (PIVOTEK, 2016). Pivotek's area of operation is not limited and work has been completed for clients located

as far away as the Grand Cayman Islands, Fargo, North Dakota, and the City of Vancouver, B.C. Pivotek currently is located in a 50,000 SF warehouse for factory production, but is looking for increasing production space to 100,000 SF total by converting an abandoned Kmart store nearby as their new warehouse. Pivotek develops modules similar to an automobile manufacturer assembly line to develop a quick and efficient method of developing their product. For a complete summary of Pivotek's factory variables refer to Table 4.3 Pivotek Factory Summary on page 58.

Factory: The current 50,000 SF factory for Pivotek has ceiling heights of 30', exterior yard storage of 20,000 SF, and a separate parking lot large enough to house 30 cars for employees. The offices for Pivotek are located in an attached building to the warehouse with 9 full offices totaling 200 SF, including mens and womens bathrooms, 4 cubicles, and 1 conference room for company and client meetings. Amenities for the factory include 1 break room large enough for 50 people which includes a sink, vending machine, and microwave. The factory also contains both womens and mens bathrooms with multiple stalls, multiple 3 tiered 25' high racks and cages for material or tool storage, and 5 loading docks for material export and import. Finish material is stored inside the factory, but metal studs used for wall construction are stored outdoors. No special loading dock sizes are needed, but one loading dock must have a full ramp down to ground level for movement of pods down to side load on to trucks.

Assembly Line/Work Force: Pivotek's workforce includes 25-30 construction laborers along with 12 office personnel per shift. Pivotek operates one shift a day from 6:30 AM to 2:30 PM to finish work. Modules are built in a hybrid assembly line where both

workers and pods move down the line towards completion. Bays for the line are 20’ X 20’ with up to 30 pods able to be in production at one time on the line. During production, one worker or trade is dedicated to one module and their scope of work is completed before the modules move to a new station. The first station in the line begins with jigs, a plate, box, or open frame for holding work as well as guiding a machine tool to the work. The location is the start point for all other work to conform and follow the set guides (Kipfer & Chapman, 2007). Then other work stations add to the pod until modular completion including walls, electrical work, mechanical work, and other tasks etc. Specific training for new workers includes ongoing training at a local high school for both existing and new hires and specific job training for new hires. Each trade has a cell leader or experienced foremen for onsite training and help.

Transportation: Pivotek uses Landstar as a third party transportation contractor for moving pods, material, and modules to site. Certain finish and trim material is also necessary for construction onsite to finish pods and connect them with the existing building or structure. The farthest transportation point for the pods is always dependent on the final project destination for each pod, and increased distance results in additional cost.

Summary: Pivotek is currently looking to double their factory facilities to 100,000 SF in order to increase module production space. Big box stores would represent a good option for space with various amenities to foster a new Pivotek production line with minor modifications. Alterations required to make the transition would include electrical drops at each station for power tool use, and compressed air drops at certain stations for

pneumatic nailers. Pivotek is interested in using an abandoned Kmart located close to their existing factory as a new location for operations with a less costly price per square foot. This possible move into a big box store could be a reaffirming statement supporting the research and conclusions of this thesis regarding the feasibility of retrofitting big box stores for modular construction purposes.

Pivotek	
Company Background	
Location	Cincinnati, OH
Type of Work	Bathroom Pods
Area Served	United States
Factory	
Total Factory Sq Ft.	50,000
Ceiling Height, feet	30
Assembly/Yard Storage, acre	0.45
Parking lot size*	30 cars
Number of Offices*	9 full offices, 4 cubicles
Bathrooms	2
Breakrooms	1
Loading Docks	5
Number of modules to be worked on at a single time	30 pods
Work Force	
Number of workers	25-30
Number of management personnel	12
Production style	Hybrid Assembly Line
Multiple Shifts	No
Future Expansion?	Yes
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.3 Pivotek Factory Summary

CASE STUDY: FALCON STRUCTURES

Interviewed: TORI SMILEY Date: 10/14/2016

Figure 4.15 Courtesy of Falcon Structures

Modular construction factory: Falcon Structures

Location: Manor, Texas

Employees: 50 workers per shift, 35 factory personnel, 15 office employees

Factory Size: 3 large factories approx. 216,000 SF, 1 small dome approx. 12,000 SF

Company Background: Falcon Structures was started in 2002 in Manor, Texas as a modular manufacturing company using shipping containers as the primary housing and support modular unit. Falcon Structures develops full turnkey shipping containers for multiple housing purposes including industrial and residential living spaces along with custom built containers. The company has completed work for BP, Chevron, GE,

Marathon, Shell, and the United States Army. The Falcon Structures area of operation includes all of the United States, but the company does not ship over 1,000 miles in order to maintain lower competitive prices. Falcon Structures already achieves competitive low prices due to an efficient factory operation which produces a quality product. For a complete summary of Falcon Structures factory variables refer to Table 4.4 Falcon Structures Factory Summary on page 65.

Figure 4.16 Courtesy of Google Maps. Image of the Falcon site and one warehouse located in the left of the picture.

Factory and Operations: The Falcon Structures site covers over 51 acres with only 5 acres set aside for production space which leaves room for future expansion and material yard storage. Falcon Structures uses 4 different warehouses for production space including 3 large warehouses and 1 small factory. The warehouses are half circle barrel vaults with overhead fluorescent lighting. The three large domes measure approximately 60’ X 60’ X 60’ and the small warehouse is about 60’ X 10’ X 20’ which totals approximately 660,000 SF for manufacturing purposes. Each factory is divided into multiple sections to facilitate a sequence for completing work in assembly line fashion. Each bay has adequate space for work completed on the containers which range from 8’W X 40’L to 8’W X 20’L. Six (6) containers can be worked on any given time inside

the large warehouse along with outside work on containers to meet production goals. The factories are configured for an assembly line production method where modules are moved through a sequence from start to completion. Material storage is very simple due to dry interior space inside the containers. Steel products such as metal studs are stored inside the containers and excess material is ordered for just in time delivery to complete new orders. Multiple containers are stored onsite and are stacked no more than 5 containers high. Each warehouse has one large bay door for the transportation of modules in and out of the warehouses using forklifts.

Falcon Structures includes multiple amenities and offices for operations management and workers. The offices for Falcon Structures were built in the manufacturing warehouse and consist of 8 connected shipping containers as well as 2 smaller separate offices made from 1 container each for total office space approximating 100,000 SF. Amenities for the factory include 3 bathrooms with multiple stalls, 1 break room totaling 3200 SF, 2 kitchen areas including a refrigerator and microwave, and an exterior overhead covered picnic area 20’ X 40’ (800 sf). Falcon Structures factories utilize skilled craftsmen in multiple disciplines to produce a quality product.

Work Force: Skilled workers are the backbone for any manufacturing facility to complete and manage the on time completion of work. Falcon Structures employs approximately 50 workers consisting of 15 office personnel and 35 task specific craftsmen. The company uses 2 assembly lines for producing multiple finished containers at one time. Workers include welders, framers, painters, millworkers, along with other trades. Only 1 shift per day is employed now due to past issues with multiple shift

production. New shift workers did not understand completely the finished work status of the earlier shift and where to resume and complete work. One shift a day makes it easier for workers to resume work where they left off from their previous shift. Workers are assigned 2 per zone or trade with usually 2 workers working on a single module until their scope of work was completed. Other workers float and provide assistance to each zone as needed. The workers are local non-union workers with previous experience in their trade. Before each worker is hired, they are required to pass a test for their specific trade and then begin working with the lead worker in their trade. Workers also are given OSHA training to maintain and promote safe work practices.

Transportation: Shipping containers were developed for shipping cargo containers long distances which makes transportation of them easier. Finished containers are forklifted to an exterior designated shipping site for loading onto trucks. Falcon Structures uses three trucker broker agencies in order to find the lowest fare for trucking containers to their destination. Falcon Structures has trucked containers all over the continental United States including long distances to Maine and Washington. Trucking shipping containers is relatively simple due to the configuration of flatbed trucks to accommodate shipping containers. Falcon Structures typically produces 20’ to 40’ shipping containers for passage. The 20’ containers weigh around 4500 lbs. empty and 9,000 lbs. full while the 40’ containers fully loaded weigh around 14,000 lbs. eliminating the need for overweight shipping permits. Freight Management and Operations designate shipments under 80,000 lbs. gross vehicle weight to be acceptable without an overweight permit. Containers are also only 8’ wide and thus under the 102” or 8’ 6” over width rule which requires a

special permits that includes manufactured homes (United States DOT, 2016). When the company does ship wide loads, the largest is 12' wide when they cut in half containers for shipping and reassembly onsite. Falcon Structures has never shipped double wide containers, but has shipped 1.5 wide shipping loads. The company has also completed jobs in Hawaii where the containers were transported on freight ships. Jobs like Hawaii are not completed often due to the expensive shipping costs totaling $12,000 per container which reduces the cost effectiveness of using this method of transport.

Summary: Falcon Structures is an efficient modular shipping container company that prides itself in producing quality and cost effective modular shipping containers for both spec and custom built jobs. Falcon Structures, due to a recent increase in business, is planning company growth by adding additional 3 large domes for doubling the production space and completing more orders. The total of 51 acres will aid in strategically completing this expansion with possibly even more expansions in the future. Due to Falcon Structures location outside of the town of Manor, they do not have issues with zoning or noise from manufacturing processes as compared to using strip mall big box stores as a primary production space. Other issues with using big box stores for Falcon Structures include material storage for containers due to the preset module and stacking storage application. Another issue is the type of paint used by Falcon Structures which is an enamel based paint requiring Environmental Protection Agency (E.P.A.) permits and special ventilation which would involve a large retrofit to a big box store. If renovation and the right site for material storage were available, Falcon Structures would

make a change and utilize abandoned big box stores for its operations under the right conditions.

Falcon Structures	
Company Background	
Location	Manor, TX
Type of Work	Shipping Containers
Area Served	United States
Factory	
Total Factory Sq Ft.	660,000
Ceiling Height, feet	60
Assembly/Yard Storage, acre	51
Parking lot size*	Dirt area
Number of Offices*	5
Bathrooms	3
Breakrooms	1
Loading Docks	0
Number of modules to be worked on at a single time	6 inside, additional outside
Work Force	
Number of workers	35
Number of management personnel	15
Production style	Hybrid Assembly Line
Multiple Shifts	No
Future Expansion?	Yes
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.4 Falcon Structures Factory Summary

CASE STUDY: BOXMAN STUDIOS

Interviewed: JASON MURRAY Date: 10/17/2016

Figure 4.17 Courtesy of Boxman Studios

Modular construction factory: Boxman Studios

Location: Charlotte, North Carolina

Employees: 52 workers per shift, 30 factory personnel, 22 office employees

Factory Size: 65,000 SF

Company Background: Boxman Studios started in 2009 producing and shipping container built modules, which were adapted for multiple uses. The modules were developed for both leasing and purchasing purposes to meet a client's need for housing mobile operations and for marketing purposes for large events. Applications of Boxman Studios modules include using them for mobile food and beverage operations, mobile marketing purposes, and other purposes for displaying and generating interest in a client's products. A client will specify custom uses for modules which Boxman Studio will design and provide the appropriate module to suit specified requirements. Clients for Boxman Studios include BMW, Adidas, Canalside, Chipotle, and Delta Airlines. The company geographical area of operations is global and the company is willing to ship internationally for clients. Boxman Studios domestically has shipped to California, Wisconsin, and multiple other states. For a complete summary of Boxman Studio's factory variables refer to Table 4.5 Boxman Studios Factory Summary on page 71.

Factory and Operations: A safe and functional factory and operation space starts with the production line from where modular construction factories produce their product. Boxman Studios is located in an industrial business park with a 65,000 SF warehouse dedicated to production operations. The site includes a large parking lot split in half which is used for employee parking (around 40 spots for vehicles) with the other half utilized for completed exterior module storage. The production floor of the factory consists of approximately 40' spaced columns creating 4 bays in width and 5 bays in length. The factory also includes a 4 bay wide by 2 bay long storage space for completed modules not in use, but the modules could be used in the future for clients. The ceiling

height of the factory is 48’ high with factory lighting for the warehouse consisting of 4 bulbs 4’ fluorescent lights. The production space has specific areas dedicated for welding, painting, millwork, miscellaneous metals, and other trades. Materials are stored inside on a stacked racking system close to each trade production area. The factory has 5 loading docks, but mainly uses 2 for exporting modules and importing material. One of the loading docks is approximately 11’ 6” for easy exportation of larger finished containers exportation forklifts. The maximum number of containers that can be assembled at one time is 20 to meet production needs, but the normal average is 5-6 modules. The factory produces finished modules using a hybrid assembly line in which both the modules and workers move along the assembly line to complete the work. Forklifts make the movement of containers easy and eliminate the need for overhead craning and hoisting equipment.

Additional space in the Boxman Studio warehouse includes office space, employee amenities, an employee dining area, and a workout area. Offices for Boxman Studios include multiple offices, cubicles, and a conference room for client meetings. Each office is approximately 90 SF as well as an additional renovated design office constructed from 2 conjoined containers. The production area includes an extra office consisting of 2 shipping containers for the factory managers. Since Boxman Studios is a full turnkey module manufacturer, the company also houses departments for design, estimating, accounting, and business development. Additional amenities for the factory also include 3 bathrooms consisting of, 2 mens and 1 woman’s restroom, a kitchen, and

employee break room. Boxman Studio provides multiple amenities and support for its employees to provide a healthy, safe, and productive working environment.

Work Force: Boxman Studios has 52 full time workers consisting of 30 craftsman and 22 office personnel. The office personnel include: 3 project managers, 5 business developers, 1 controller, 1 estimator, 2 engineers, 2 marketing managers, 2 sketch up/designers, 1 C.F.O., 2 front desk receptionists, 2 logistic managers, and 1 C.E.O. Factory workers includes multiple specifically trained employees for trade specific tasks. Workers are typically assigned 2 to a module on average with the maximum number being 15-20 workers assigned to one module to finish projects. Boxman Studios maintains a 40 hour/1 shift per day manufacturing process, but the company will schedule multiple shifts to finish projects if required. All workers are local non-union workers with no specific training required. Multiple trades require certificates for craftsmen such as welders, but other workers are hired based on experience and judgment.

Transportation: Boxman Studios is unique in the fact that they have their own transportation logistics division to oversee the shipping of modules. When Boxman Studios doesn't have the logistics to complete the transportation of an order, they outsource the transportation to a company called Over the Road Trucking which is a trucking broker agency. Boxman Studio has transported a module in the United States as far away as Texas, California, Florida, Wisconsin, and multiple other states. The largest modules shipped are 11' 6" which requires special permits for wide and heavy loads with lead and follow vehicles. Boxman Studios is located conveniently near Interstate I-85 for truck shipping, but is also located near a Union Pacific railroad. The company has not

used railroads for transportation before, but for a certain client may consider the railroads in the future if it were cost effective for a certain client. Boxman Studios has multiple options for shipping in order to determine the best choice for their clients.

Summary: Boxman Studios has developed a custom product to meet and exceed their client's needs with exceptional quality, a unique product, and competitive pricing. Boxman Studios has been increasing business on the west coast for clients such as Facebook which is driving a decision to develop another factory on the west coast to reduce shipping costs and pass the cost savings on to their customers. Boxman Studios is a tax exempt company which also provides an incentive to develop another factory. Boxman Studios would consider the retrofit of big box stores into a production factory for a new operation. Factors to consider for a retrofit to a big box store would include a paint booth setup with an improved ventilation system, additional office space, and yard storage. Other potential issues include noise concerns and zoning issues due to the location of a big box store. Boxman Studios believes that under the right conditions, an abandoned big box store could provide the right amount of space and environment to house a new manufacturing operation.

Boxman Studios	
Company Background	
Location	Charlotte, NC
Type of Work	Shipping Containers
Area Served	International
Factory	
Total Factory SF	65,000
Ceiling Height, feet	48
Assembly/Yard Storage, acre	0.25
Parking lot size*	50 Cars
Number of Offices*	Over 12 + Cubicles
Bathrooms	3
Breakrooms	1
Loading Docks	5
Number of modules to be worked on at a single time	20 Containers
Work Force	
Number of workers	30
Number of management personnel	22
Production style	Hybrid Assembly Line
Multiple Shifts	If needed
Future Expansion?	Yes
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.5 Boxman Studios Factory Summary

CASE STUDY: INSULSTEEL

Interviewed: STEVE BOSTIC Date: 11/11/2016

Figure 4.18 Courtesy of Insulsteel

Modular construction factory: Insulsteel

Location: Charleston, South Carolina

Employees: 300 workers

Factory Size: 60,000 SF, 50,000 SF production space, 10,000 SF state of the art virtual reality floor plan showroom

Company Background: Insulsteel is a unique modular fabrication/energy innovation company that produces an intelAwall or an insulated injection molded composite wall

panel system for developing an Ecoshell Building envelope. The injection molded composite panel includes up to thermal insulation ratings of R-40 to R-58. The panel is able to withstand gale force winds up to 200 M.P.H., complete two-hour fire rated walls, and result in L.E.E.D. platinum homes. The Ecoshell wall system can be assembled onsite to dry in a building's exterior and includes the home's mechanical system. A 2500 SF house can be erected in 3 days using the system. The homes are also produced at 50% less cost than traditional onsite residential construction methods. Insulsteel has developed a superior product in order to make the competition irrelevant through an efficient and effective production method. For a complete summary of Insulsteel's factory variables refer to Table 4.6 Insulsteel Factory Summary on page 77.

Factory and operations: Insulsteel is in the design and planning process of building its own factory in Charleston, SC. Currently the company uses a west coast company to manufacture their designed product, but the company wants to develop the product in-house for the South Carolina and some of the North Carolina construction market. The design of the factory will include 50,000 SF of production space, and a 10,000 SF virtual reality showroom to display residential home designs for clients to choose their own home and custom floor plans. Material handling and storage in the factory will be 10,000 SF inside of the 50,000 Sf production area. The warehouse will be unique as the first zero energy factory in the United States. The factory will use an energy efficient system as well as the Ecoshell system for the building exterior walls and will provide a visual representation of the product to possible clients. The factory ceiling height will be 24' high with a low energy lighting system. The factory will have 2 production assembly

lines for molding the steel shell which will inject the panels with insulation. The lines will be able to produce 4’ X 12’ to 10’ X 24’ panels every 6 minutes. Four (4) houses will be in production concurrently in the factory with a 2-day turnover rate for each house from factory production start to finish. Each panel will include penetrations for M.E.P. (Mechanical, Electrical, and Plumbing) passage, openings for door and windows, and made ready for bolted onsite construction finishing. The factory will also have multiple other work stations for other trades including: painting, millwork, and electrical and mechanical work. The final product will be transported with an overhead craning system to move panels down the assembly lines directly onto the transportation trucks. The factory will be a revolutionary manufacturing facility using revolutionary energy efficient systems with multiple innovative employee amenities.

Amenities for the factory will include bathrooms, offices, and revolutionary spaces different than other factory operations. Offices will be included in the 10,000 SF showroom for marketing and sales, distribution and logistics, and other divisions of the factory’s management. Office space will be included as well on the factory floor, but will mainly consist of work stations for all to use. The factory will also include 2 bathrooms consisting of, 1 mens and 1 womens for employee comfort. Another unusual amenity designed into Insulsteel’s site planning is the development of an enterprise K-12 grade school onsite for employee children’s education. The school is an effort to change the environment of the company by producing a friendly and different working environment. The institute will also be an attempt to education children about the company’s history and culture, and perhaps contribute to a future factory work force.

Work Force: Insulsteel has a detailed management plan for hiring workers for all trades and management positions. The plan projects that over 300 workers will be hired over the next 3-4 years. By the year 2020, the company plans to have hired for the following trades: 90 onsite assembly crewmembers, 24 mechanical technicians, 36 electrical and plumbing workers, 40 millworkers, and 30 painters as craft laborers. Upper management jobs created will include: 13-26 architecture/design workers, 20 engineers including factory production engineers, 20 distribution and logistics employees, 22 marketing and sales personnel, and 17 management employees for a total workforce of 336 full time employees. The workers will complete one shift per day and will undergo specific training for each trade to increase manufacturing quality and job assignment flexibility.

Transportation: Insulsteel will provide its own in-house logistics to reduce transportation costs. Transportation for modules can be as high as 20% of the total cost of the modules but Insulsteel hopes to reduce that cost to 5% for shipping. Distribution and logistics plans to use low bed trucks to ship as many panels as possible per load. Wide load and heavy load permits will not be necessary due to the placement of the panels on the trucks. The largest panel 10 X 24' will be placed with the 10' vertically and 24' long to eliminate the need for special permitting for transportation. Initially the company is looking to ship throughout South Carolina and as well as 200-300 miles north into North Carolina. In the future, the company will look to ship their product as far as economically possible for clients, but will not attempt to complete the field assembly work onsite.

Summary: Insulsteel, by using precision planning, dedication to details, and developing an outstanding product, has created a modular building system with exceptional qualities.

The company is planning to begin construction of a factory by the end of 2016. Once the factory is operational, Insulsteel has multiple plans for more growth and expansion for producing and distributing their product. The company will provide a 20-year warranty for the Ecoshell building system which will demonstrate the quality of the product and its ability to perform well. The panels will represent an effort by Insulsteel to improve the quality of building structures in our industry. Although Insulsteel is in the design stage of developing a modular production factory, abandoned big box stores are not planned to be retrofitted by the company for several reasons. The main reason is the exterior of the factory being completed with the Ecoshell building system needs to be displayed in order to visually show the quality of the product. The company also wants the factory to be zero energy efficient to demonstrate the quality of the energy efficient building systems inside the factory, which is not found in big box stores. Mr. Bostic stated that only 1 out of 9 people plan to build a new home due to the long and painful construction process involved in a new residential home construction project. Insulsteel hopes to bring back the other 8 out of 9 people not eager for new home construction through courteous service and by offering a superior product.

Insulsteel	
Company Background	
Location	Charleston, SC
Type of Work	ExteriorWall Panels
Area Served	SC and southern NC
Factory	
Total Factory SF	60,000
Ceiling Height, feet	24
Assembly/Yard Storage, acre	0.22
Parking lot size*	Unkown
Number of Offices*	10,000 SF, Work stations
Bathrooms	2
Breakrooms	1
Loading Docks	2
Number of modules to be worked on at a single time	2 panels every 6 minutes
Work Force	
Number of workers	336
Number of management personnel	17
Production style	Assembly Line
Multiple Shifts	No
Future Expansion?	Yes
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.6 Insulsteel Factory Summary

CASE STUDY: OLDCASTLE SUREPODS

Interviewed: PAUL REIBEL Date: 11/14/2016

Figure 4.19 Courtesy of Oldcastle Surepods

Modular construction factory: Oldcastle Surepods

Location: Orlando, Florida / Madera, California

Employees: 70-120 factory workers, 20 management personnel

Factory Size: Approximately 100,000 SF

Company Background: Oldcastle Surepods is a lean bathroom pod manufacturer which produces quality modules in a controlled factory environment. Oldcastle Surepods has been in operation since 2005 and has produced over 20,000 units for multiple clients in the commercial construction market. Clients for Oldcastle Surepods include Marriott, Hilton, University of Tampa and the company has completed large-scale projects for many other clients. Oldcastle Surepods area of operations stretches across the United

States except where limited by high shipping costs which can result in decreasing the cost effective option of using modular bathroom pods. For a complete summary of Oldcastle Surepod's factory variables refer to Table 4.7 Oldcastle Surepods Factory Summary on page 83.

Factory and operations: The Oldcastle Surepods factory is located in Orlando, Florida and has approximately 100,000 SF of production space for the manufacture of single use bathroom pods. The factory is located in an industrial park which will allow for a significant amount of exterior yard storage if needed for finished pods. Material handling and storage is not needed for the lean production method employed by Oldcastle Surepods. Oldcastle Surepods utilizes Just in Time delivery (J.I.T.) to develop a lean and effective production operation and reduce the need for storage of surplus material in the factory. The factory has fluorescent overhead lighting sufficient to light the large factory. 5 production lines are able to be used to complete projects and catch up on schedules if needed. The production lines utilize state of the art methods as they have been designed with rollers for bathroom pods to easily move down the assembly line for work completed by different trades. Computer Numerical Control (CNC) routing machines are used for custom fabrication of structural components for the pods. Eight (8) loading docks are used in the factory and have custom dimensions for the exportation of finished pods using hydraulic lifts, gantry lifts, and overhead craning equipment for transportation purposes. Although the factory uses multiple specialty hoisting equipment, CNC machinery, large overhead fans, and multiple trades and workers, noise levels of the

factory are relatively quiet and manageable. An Oldcastle Surepods factory employs multiple other factors in order to maintain a productive and relaxed space.

The factory includes multiple amenities for employee comfort which helps to maintain high productivity on the production floor. Amenities include a cafeteria, break room, conference room, and locker room. Bathrooms for the facility include 1 womens and 1 mens in the office and 1 unisex bathroom on the production floor. 12 offices are located throughout the factory for management personnel which include cubicles. Amenities for Oldcastle Surepods are provided for the benefits of the workers who represent the most important part for an efficient production of the company products.

Work force: Oldcastle Surepods employs a large skilled and proficient labor force to maintain efficient production for all five production lines. Oldcastle Surepods has a workforce of 70 – 120 skilled craftsmen to meet the demand and schedule needed for multiple projects. The company employs 20 management personnel to track schedules, costs, and develop more projects for the company. Trades for the factory include plumbers, tile, electricians, general laborers and other trades to complete the finish work of the bathroom pods. The company can support multiple shifts depending on the current production demands of the factory and scope of projects. The workers are non-union and receive cross training through work experience in different trades to improve factory efficiency and maintain Oldcastle's lean principles. Transportation is a key factor which contributes to the success of Oldcastle Surepods to produce a product at an effective and competitive cost.

Transportation: Oldcastle Surepods uses multiple third party transportation contractors to ship their finished pods. Oldcastle Surepods business strategy led to the development of two factories, with one on the west coast in California and one on the east coast in Florida for cost effective shipping of pods. The company has shipped throughout the United States to multiple states. The company attempts to ship as many pods as possible using box or panel trucks which is less expensive than semi-trucks. The company does not use the railroads due to high costs for shipping, and the Orlando factory is also located near the multiple lane Martin Anderson Beachline Expressway toll road. Wide and heavy loads are not necessary for shipping the single use bathroom pods. Oldcastle Surepod's superior product and cost effective production methods allow them to be competitive as a state of the art modular bathroom pod manufacturer.

Summary: Oldcastle Surepods is a successful modular single use bathroom manufacturer utilizing lean manufacturing principles which provides cost savings for its clients. The Oldcastle Surepods business strategy has allowed them to pursue multiple projects across the country. The company also is looking to expand production and develop another factory located in the center of the United States in order to further decrease shipping costs. The feasibility of using an abandoned big box store to house their new operation is unlikely due to the design aspects for the factory equipment and overhead hoisting equipment. These essential factory modifications would represent costly retrofits to an existing production site. However, if the company would modify operations and use gantry lifts as the primary moving equipment for the pods, an abandoned big box store

could have similar attributes after a retrofit to their current factory operations and could be feasible as a new production site for Oldcastle Surepods.

Oldcastle Surepods	
Company Background	
Location	Orlando, FL
Type of Work	Bathroom Pods
Area Served	USA
Factory	
Total Factory SF	100,000
Ceiling Height, feet	Unkown
Assembly/Yard Storage, acre	Unkown
Parking lot size*	Unkown
Number of Offices*	12
Bathrooms	3
Breakrooms	1
Loading Docks	8
Number of modules to be worked on at a single time	Fluctuates
Work Force	
Number of workers	70-120
Number of management personnel	20
Production style	Assembly Line
Multiple Shifts	Yes
Future Expansion?	Yes
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.7 Oldcastle Surepods Factory Summary

CASE STUDY: INDICOM BUILDING, INC.

Interviewed: DEVIN DUVAK Date: 2/1/2017

Figure 4.20 Courtesy of Indicom Building, Inc.

Modular construction factory: Indicom Building, Inc.

Location: Burleson, TX

Employees: 85-120 manuals laborers and 15-20 management personnel

Factory Size: 75,000 SF

Company Background: Indicom Building, Inc. is a wholesale modular manufacturing company located in Burleson, Texas. The company was started in 1986 and has been since bought in 2007 by Sunbelt Modular. The company constructs and delivers modules

to distribution companies for delivery to its final occupant. Notable distribution companies Indicom Building, Inc. have worked with include William Scotsman, Vanguard, and other known modular distributors who have supplied the finished modules for multiple large corporations such as Toyota, Facebook, and several others. Indicom Building, Inc. has completed several types of projects including medical buildings, education, and labs ranging in both permanent and relocatable building styles. Due to Indicom Building, Inc.'s business model, the company only operates in around a 600-mile radius in which modular distribution companies like Vanguard will purchase the wholesale modules for further shipment nationwide. This eliminates the need for transportation or logistics for Indicom Building, Inc. and allows distribution companies to handle the work and cost of shipping the modules. For a complete summary of Indicom Building, Inc.'s factory variables refer to Table 4.8 Indicom Building, Inc. Factory Summary on page 88.

Factory and operations: Indicom Building, Inc. factory sits on 14 acres for possible future expansion based on Sunbelt Modular decisions for Indicom. The factory is 75,000 SF with 4,000 Sf of interior bay space for material storage. Adjacent to the factory is an approximately 100-car asphalt parking lot for employees and sometimes used for modules storage ready for pick up. The factory ceiling height is about 30' with fluorescent strip lighting hung 5' off the structural joists of the ceiling. The factory can hold up to 24 different modules for completion through the different stages of Indicom's hybrid assembly line in which both modules and personnel move. The warehouse uses 18' X 20' overhead rolling factory doors for importation of raw material and exportation

of finished modules. Modules are moved through the assembly line with forklifts and a tractor is used for the final modules movement out of the warehouse. Once outside of the warehouse, a standalone crane is used for loading products directly onto trucks for shipment. The factory maintains a high noise level due to the large moving equipment and work required loud tasks like miter saws and nail guns. Indicom's factory includes multiple amenities for employees to be comfortable and safe during work hours.

Amenities of the factory include employee break rooms/kitchen area, offices, and bathrooms. Office space for the factory totals around 4,200 SF where as 2,000 SF is permanent office space attached to the factory for visitors, and 2,200 SF is modular built office space in the warehouse. Four bathrooms are located in the factory and two located in the offices approximately 800 SF total. An interior break room is provided for the employees equipped with kitchen equipment like a fridge, sink, and microwave. An outside assembly meeting area is established for team meetings like updated safety training. Production in the factory is not possible without the proper supervision and work force.

Work Force: Indicom Building, Inc. hires employees based on the production expectation and amount of work in the factory at the time. The workforce is usually between 85-120 labor workers in multiple trades from welding to painting. Management for Indicom is between 15-20, but hires on additional supervision for larger projects or when the company has a lot of work requiring multiple trades. The company does not use multiple shifts and attempts to use extra workers to pick up the additional work. Workers can range from 2 to up to 15 local non-union employees on one module at a time depending

on what work that the module still needs for completion. Indicom requires in-house/OSHA safety for all employees, but most work training occurs through experience and on the job training.

Transportation: Indicom Building, Inc. does not offer transportation or logistics for their clients. They offer the product wholesale only and require a client to figure out the 3rd party arrangement for transporting the modules.

Summary: Indicom Building, Inc. produces versatile modules for clients with permanent or relocatable needs with outstanding quality. Since Indicom is a part of the Sunbelt Modular team, Indicom is not looking for expanding the business, but Sunbelt is always looking for expanding or purchasing new companies to expand the brand. Challenges presented by the interviewee to make a retrofit of a big box store as a possible production facility are ceiling heights, exterior craning retrofit, sufficient loading docks or warehouse doors for input and export of materials, zoning considerations and location. Indicom Building, Inc. wholesale modular factory is very efficient and produces a quality product ready for M.E.P. connections and occupant ready spaces. Under the right retrofit of a big box store and location, Indicom Building, Inc. would consider a big box store for their manufacturing purpose if expansion for the company is a future decision.

Indicom Building, Inc.	
Company Background	
Location	Burleson, TX
Type of Work	Building Modules
Area Served	600 Mile radius
Factory	
Total Factory SF	75,000
Ceiling Height, feet	30
Assembly/Yard Storage, acre	14 acres
Parking lot size*	100 cars
Number of Offices*	4,200 SF, 20 offices
Bathrooms	6
Breakrooms	1
Loading Docks	18X 24 warehouse doors
Number of modules to be worked on at a single time	24
Work Force	
Number of workers	85-120
Number of management personnel	15-20
Production style	Hybrid Assembly Line
Multiple Shifts	No
Future Expansion?	No
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.8 Indicom Building, Inc. Factory Summary

CASE STUDY: SUTTOR MODULAR HOMES

Interviewed: JUSTIN VALLEY Date: 2/9/2017

Figure 4.21 Courtesy of Suttor Modular Homes

Modular construction factory: Suttor Modular Homes

Location: Charlotte, North Carolina / Headquarters: Pittsburgh, Pennsylvania

Employees: 1st shift – 120 laborers, 4 Management, 2 Supervisors

2nd shift – 15 laborers, 2 supervisors, 1 crew leader

Factory Size: 120,000 SF

Company Background: Suttor Modular Homes is a well-established residential homebuilder that has been constructing residential homes since 1948. The company's main headquarters is located in Pittsburgh, Pennsylvania as well as subsidiary offices located in 14 other states including New York, Virginia, Ohio and multiple other East coast states. The research gathered for this case study was for the factory located near Charlotte, North Carolina. The company's geographical area of operations is primarily

large metropolitan areas where the company can shorten shipping distances and set up factories near large cities instead of shipping to them. For a complete summary of Suttor Modular Home's factory variables refer to Table 4.9 Suttor Modular Homes Factory Summary on page 93.

Factory and Operations: Suttor Modular Homes factory develops both modular residential site ready homes as well as modular building products to finish both typical construction residential homes and the modular homes onsite finishes when necessary. The factory sits on a 5-acre site including about 3-acre 180-car parking lot with the factory totaling 120,000 SF. The factory is divided into 3 main sections for material storage, operations and labor bays, and management offices and purposes. The factory also allocates around 1.5 acres of exterior space for material storage and finish product ready for transportation. The ceiling height of the factory is approximately 30' with T5 overhead fluorescent strip lighting. The factory has standard sized loading docks including 4 for importation of raw material and 4 for exporting finished modules and products. The factory also includes two "pits" which are recessed areas for easy loading of modules onto semi-trucks or lowboy type trailers. The factory can work on 4-5 full sized modules in the factory at one time. Two hybrid type assembly lines are configured in the factory lined up to finish at loading docks for exportation. Modules are moved in the factory with 10 forklifts and 3 crane-hoisting systems attached to the overhead joist structural system. Modules outside the building are moved with a truss lifted with a special concrete pad to support the large piece of equipment. The noise level of the factory is medium to loud due to power tools like nail guns and miter saws. Suttor

Modular Homes develops a quality product due to a comfortable and provided for workforce.

Amenities for the workers in Suttor Modular Homes Includes a break room, kitchen area, outside designated smoking areas and more facilities for convenience and comfortability for workers. Offices for the factory are located towards the front to greet visitors and totals 8 offices approximately 4,000 SF. The offices includes 2 small bathrooms for management as well as 2 bathrooms located in the factory for both men and women. Other amenities for the factory include a break room with a kitchen area and exterior designated smoking areas.

Work Force: Suttor Modular Homes uses two shifts for completing work to ensure quality and schedule. 1st shift includes 120 workers, 4 managers, and 2 superintendents. 2nd shift uses 15 workers, 2 superintendents, and 1 crew leader to manage the work and employees. Thirty (30) different modules can be worked on at one time in the factory and evolve down the assembly to substantial completion before they can become stationary and workers only move. The workers are local non-union laborers that received on the job training and in-house OSHA safety to prevent accidents on the factory floor.

Transportation: Suttor Modular Homes uses both 3rd party transportation consultants and in-house shipping logistics for certain modular loads. Suttor Modular Homes distance for transporting modules is a 300-350 mile radius from the Charlotte factory. The company's in-house logistics have all special permits for all types of modules transported including wide loads, heavy loads, and escort loads. Multiple lane highways are located near the

factory for easy shipments of modules to the site. Transportation is a key component for delivering the final product for Suttor Modular Homes.

Summary: Suttor Modular Homes mark in the residential modular industry is well known as a quality manufacturer and J.I.T. (Just in Time) delivery expert for customers. Suttor Modular Homes provides quality service to reduce the schedule of residential construction with the beneficial cost savings of prefabricated homes and building components. The company is currently in the process of expanding and had not thought of renovating a big box store for a new manufacturing site. Items to consider for using a big box store to suit Suttor Modular Homes would be multiple loading docks or exterior warehouse doors at minimum of 10 for exportation and importation of materials to maintain a lean philosophy and diminish storage space. Another key factor for feasibility for Suttor Modular homes would be enough space for the long assembly lines and large amount of work to occur inside for multiple modular homes. The right location, size, and logistics in a big box store might be the right home for another Suttor Modular Homes manufacturing facility.

Suttor Modular Homes	
Company Background	
Location	Charlotte, NC
Type of Work	Residential Modules
Area Served	Charlotte Area
Factory	
Total Factory SF	120,000
Ceiling Height, feet	30
Assembly/Yard Storage, acre	0.91
Parking lot size*	180 cars
Number of Offices*	8 full offices
Bathrooms	4
Breakrooms	1
Loading Docks	8
Number of modules to be worked on at a single time	4-5 homes
Work Force	
Number of workers	144
Number of management personnel	9
Production style	Hybrid Assembly Line
Multiple Shifts	Yes
Future Expansion?	Yes
Notes	Parking lot avaliable only in car parking spaces
	Offices data explained in both SF and number of offices

Table 4.9 Suttor Modular Homes Factory Summary

Summary of Modular Factories data collection

Data collected for this study includes the investigation into the characteristics of big box stores and the requirements of each modular manufacturer's factory. The goal of collecting data on both big box stores and modular factories is to establish the requirements of the modular factories and the current available amenities in big box stores. An understanding of the big box stores amenities will allow for a determination to be made of the requirements needed to be added/retrofitted into the big box stores. Modular factories requirements must be met in order for big box stores to feasibly house production operations. The data collected will assist in developing the findings for which big bog box store will provide the best framework for meeting each individual modular manufacturer's requirements.

Table 4.10 on the next page is a summary of all the data obtained from the modular construction factory data collection process. The investigation provided valuable information into determining the variables between big box stores and modular construction factories. Table 4.10 summarizes the amenities and available spaces for the modular factories interviewed in order to show the similarities and contrasts between each factory. The table's horizontal axis presents each company interviewed while the vertical axis lists out the variables measured for each company. Data for each company's factories are provided below each company's name. An example for reading the graph would be for Boxman Studios and the number of workers is 30 workers. First the company name (Boxman Studios) must be located on the table and then vertically moved down to the category (number of workers) identified in the vertical row to the left to find

the correlating company factory characteristic with the amenity subject. Another example would be Suttor Modular Home's Total Factory SF is 120,000 SF.

Modular Construction Factories Summary Data							
	Pivotek	**Falcon Structures**	**Boxman Studios**	**Insulsteel**	**Oldcastle Surepods**	**Indicom Building, Inc.**	**Suttor Modular Homes**
Company Background							
Location	Cincinnati, OH	Manor, TX	Charlotte, NC	Charleston, SC	Orlando, FL	Burleson, TX	Charlotte, NC
Type of Work	Bathroom Pods	Shipping Containers	Shipping Containers	ExteriorWall Panels	Bathroom Pods	Building Modules	Residential Modules
Area Served	USA	USA	International	SC and southern NC	USA	600 Mile radius	Charlotte Area
Factory							
Total Factory SF	50,000	660,000	65,000	60,000	100,000	75,000	120,000
Ceiling Height, feet	30	60	48	24	Unkown	30	30
Assembly/Yard Storage, acre	0.46	51 acres	0.25	0.22	Unkown	14 acres	0.91
Parking lot size*A	30 cars	Dirt area	50 Cars	Unkown	Unkown	100 cars	180 cars
Number of Offices*B	9 full 4 cubicles	5	Over 12 + Cubicles	10,000 SF, Work stations	12	4,200 SF, 20 offices	8 full offices
Bathrooms	2	3	3	2	3	6	4
Breakrooms	1	1	1	1	1	1	1
Loading Docks	5	0	5	2	8	18X 24 warehouse doors	8
Number of modules to be worked on at a single time	30 pods	6 inside, additional outside	20 Containers	2 panels every 6 minutes	Fluctuates	24	4-5 homes
Work Force							
Number of workers	25-30	35	30	336	70-120	85-120	144
Number of management personnel	12	15	22	17	20	15-20	9
Production style	Hybrid Assembly Line	Hybrid Assembly Line	Hybrid Assembly Line	Assembly Line	Assembly Line	Hybrid Assembly Line	Hybrid Assembly Line
Multiple Shifts	No	No	If needed	No	Yes	No	Yes
Future Expansion?	Yes	Yes	Yes	Yes	Yes	No	Yes
***Notes**							
***A**	Parking lot avaliable only in car parking spaces						
***B**	Offices data explained in both SF and number of offices						

Table 4.10 Modular Construction Factories Summary Data

CHAPTER FIVE

Findings

For the retrofitting of abandoned big box stores to be viable for modular construction factories, several key parameters including sufficient square footage, ideal office space amenities, and site logistics must be present at these existing locations. The expansive open space, high ceilings, widespread column spacing, and existing restrooms provide a favorable framework for abandoned big box stores to be reconfigured for a factory work environment. In lieu of constructing a brand new facility, modular manufacturers can take advantage of these ideal conditions through leasing or purchasing existing abandoned stores.

The manufacturers interviewed for this study were separated into three different types of groups: Pods, Modules, and Containers. These groups were classified based on the size of the final modular product fabricated by each company. Tables 5.1-5.7 presented in the following sections for each company indicates the feasibility of each big box store location to match the key variables required by the modular manufacturer for their operations. Color association utilized in the tables clearly designates the suitability of each variable as green denotes “acceptable”, yellow represents “plausible applications”, and red indicates that “the big box store variable is unsuitable,” for the modular company’s existing factory operation method/requirements. The following paragraphs provide a more in-depth analysis into the multiple groups of modular

manufacturers and how suitable manufacturer's operation methods align with certain store formats.

Findings for the Pod group

Pods consist of a group of smaller modular manufacturers categorized from the multiple factories interviewed and grouped together based on the final product size itself. The pod manufacturer's grouping selection was not contingent to the actual factory size. The manufacturers that fall in this category are Pivotek, Insulsteel, and Oldcastle Surepods. These manufacturers produce a smaller product. Therefore a smaller abandoned big box store could provide sufficient space to match the assembly line size and amenities required for the factory as well as accommodate an adequate work force size. The largest Pod manufacturer total square footage is Oldcastle Surepods at 100,000 SF, the next largest was Insulsteel at 60,000 SF, and the smallest being Pivotek at 50,000 SF. The first step for analyzing the basic need for each individual factory is defining the space requirement for each operation. This variable immediately eliminated the Wal-Mart Neighborhood Market (41,000 SF) as a possible retrofit for any modular manufactures in the pod category primarily due to the small total square footage of the average Wal-Mart Neighborhood Market store format.

Subsequently, the analysis reviewed each big box amenity by means of utilizing a color guideline by means of green for "acceptable," yellow for "possible or plausible," and red for "not possible," for determining if the big box store amenities would meet the "Pod" manufacturer's category requirements. Based on the variables and needs for each

manufacturer, conclusions were derived as to which big box store formats would provide suitable arrangements for each pod operation.

In order to understand which store format would be capable for housing a new operation, the study evaluated the similar qualities between each pod company. Oldcastle Surepods and Pivotek both construct bathroom pods and have comparable processes, while Insulsteel develops an intelAwall-insulated injection molded composite wall panel system. Similar qualities observed for pod manufacturers include the following:

- Smaller factory operations ranging from 50,000 SF to 100,000 SF
- Large office space requirements with both large square footages and multiple office/cubicle needs.
- Small assembly/yard storage needs
- Multiple loading dock requirements
- Consistent number of breakrooms and bathroom necessities

Equivalent amenities and requirements for Pod manufacturers demonstrate the wide feasibility of reusing multiple big box store formats. However, the retrofits for each company will differ based on the specifics of each pod company's individual needs. Figures 5.1 and 5.2 display a plausible modular process and overlay of the process in a typical Publix floor plan. This is a similar process explained before at the end of the Wal-Mart Supercenter data collection section (Pg. 32).

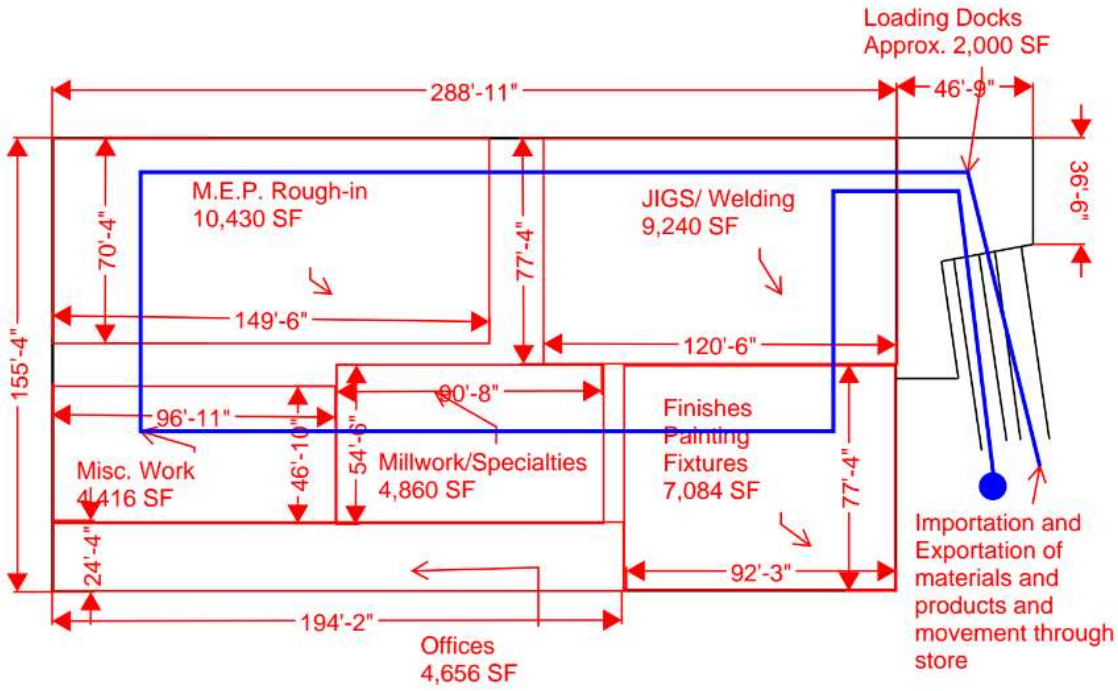

Figure 5.1 Publix Modular Factory Overlay Example

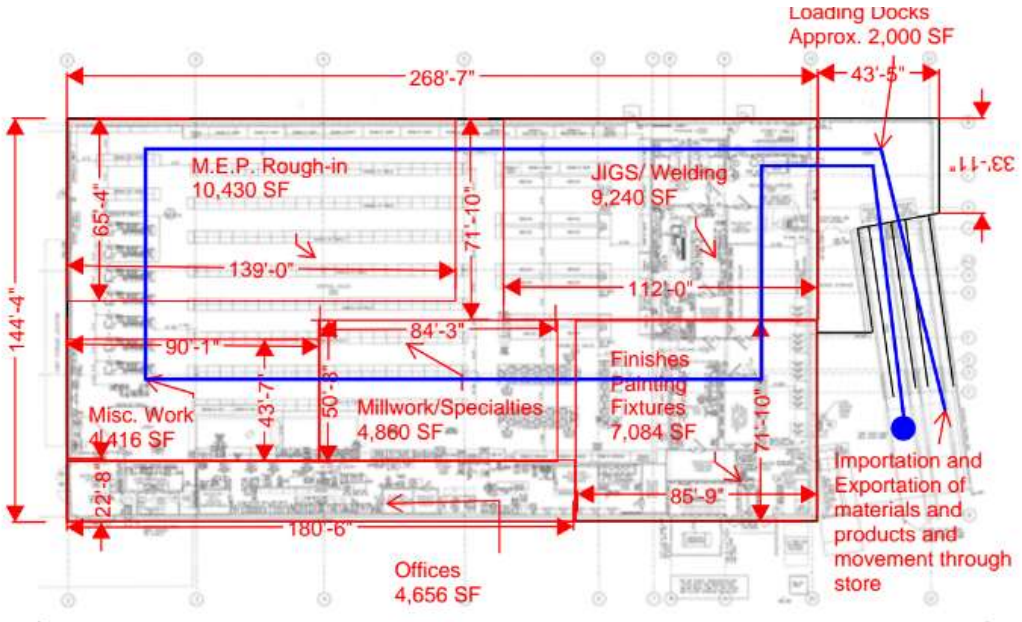

Figure 5.2 Publix Overlay/Publix Floor plan Example

Pivotek

Pivotek's current operations have multiple requirements such as a minimum of 50,000 SF, five (5) loading docks, and two (2) bathrooms. Retrofits for abandoned big box stores need to account for Pivotek's individual characteristics to fit into the big box store format. Pivotek's construction of bathroom pods allows the company to produce a smaller product and requires less production space. Initial space requirements for Pivotek (50,000 SF) would be satisfied by all big box store formats except the Wal-Mart-Neighborhood Market's (41,000 SF) store format. BI-LO and Publix square footages are feasible store arrangements for Pivotek, but might prove to be small if Pivotek continues to expand and pursue a larger factory operation. The required number of loading docks would be the first retrofit requirement for Pivotek's conversion. Pivotek's current operation uses five (5) loading docks, which only a few store formats could plausibly handle or meet the requirement currently. Home Depot and Costco have four (4) loading docks, which plausibly could meet the needs for the number of Pivotek loading docks required with minimal renovations to increase the needed number of loading docks to five (5). Wal-Mart Supercenter has six (6) loading docks that exceeds Pivotek's required number of loading docks. The last addition/retrofit necessary for Pivotek would require an addition to each existing big box store location for new office space. Pivotek currently has nine (9) full offices and four (4) cubicles that multiple big box stores do not currently possess. The office space variable is indicated as plausible in Table 5.1 for most big box stores since the office space data obtained in interviews with modular factories and big box stores was estimated and not exact square footage. Table 5.1 Pivotek Plausibility

Summary below summarizes and compares the plausibility of Pivotek's requirements compared to the big box store amenities.

Pods #1						
Pivotek	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Pivotek Requirements	50,000	5	9, 4 cubicles	2	1	25-30
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				

Table 5.1 Pivotek Plausibility Summary

Insulsteel

An Insulsteel modular factory would require slight retrofit options for the suitable big box store formats in order to successfully convert an abandoned big box store for Insulsteel's purpose. Insulsteel's intelAwall-insulated injection molded composite wall panel system is also a small-sized product requiring less space for manufacturing applications. The BI-LO (48,000 SF), Publix (47,000 SF), and Wal-Mart Neighborhood Market (41,000 SF) formats provide an insufficient amount of overall square footage for Insulsteel's (60,000 SF) spatial requirements. The other four (4) stores consisting of Wal-Mart Supercenter, Costco, Home Depot, and Lowes all exceed the square footage needs for Insulsteel's operation. The only possible or necessary retrofit for the four (4) big box

stores adequate for Insulsteel would be the addition of office space. Insulsteel's current operation design requires 10,000 SF for office space. Big box store data was obtained in nominal amounts for offices, and might not support Insulsteel's overall office space requirement. Retrofitting additional office space might be necessary for the adaptation of a big box store format for Insulsteel. Breakrooms, bathrooms, and loading docks are available and adequate in most big box store formats and would support the conversion of a big box store to an Insulsteel modular factory. Table 5.2 Insulsteel Plausibility Summary below summarizes and compares the plausibility of Insulsteel's requirements compared to the big box store amenities.

Pods #2						
Insulsteel	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Insulsteel Requirements	60,000	2	50 at 200 SF (*A)	2	1	336
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				

Table 5.2 Insulsteel Plausibility Summary

Oldcastle Surepods

Oldcastle Surepods is the biggest "pod" manufacturer at 100,000 SF and would require multiple retrofits to establish an operation in one of the big box store formats. Oldcastle Surepods constructs prefabricated bathroom pods, but at a higher volume than Pivotek which would require a larger production space. The four (4) larger big box stores provide adequate square footage at a minimum of 128,000 SF (Home Depot). Again, the BI-LO (48,000 SF), Publix (47,000 SF), and Wal-Mart Neighborhood Market (41,000 SF) store formats do not provide enough space to house Oldcastle Surepods. Retrofits for Oldcastle Surepods would possibly also have to include more loading docks and office space. Oldcastle Surepods current operation uses eight (8) loading docks for the importation of building materials and exportation of bathroom pods. The Wal-Mart Supercenter has six (6) standard loading docks, which possibly may meet Oldcastle Surepods needs, but the addition of only two (2) more loading docks would supply the company with the same amount as their current factory. Costco and Home Depot both have four (4) loading docks that might work for Oldcastle Surepods, but an additional four (4) loading docks could be retrofitted into the two (2) big box store formats. Office space requirements for Oldcastle Surepods is currently 12 full offices. Without the uncertainty of exact square footage gathered for office space in both the factories and big box stores, all four (4) larger big box stores could plausibly support Oldcastle Surepods office space needs. The Wal-Mart Supercenter has the most number of offices at 10, which may be sufficient for the company. These minimal retrofits for the larger big box store formats could allow Oldcastle Surepods to easily rehabilitate an existing big box

store for a new modular manufacturing operation. Table 5.3 Oldcastle Surepods Plausibility Summary below summarizes and compares the plausibility of Oldcastle Surepod's requirements compared to the big box store amenities.

Pods #3						
Oldcastle Surepods	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Oldcastle Surepods Requirements	100,000	8	12	3	1	70-120
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				

Table 5.3 Oldcastle Surepods Plausibility Summary

Summary of Pod findings

The pods manufacturer amenities are generally available for all store formats except for loading docks and office space. The office space requirement for the modular operations is difficult to assess due to the potentially inaccurate and estimated square footage of offices present with both the big box stores as well as the factory information resulted from the interviews. The actual number of offices might be sufficient, but may not be large enough to accommodate the management staff. Retrofitting additional office space would be minimal and plausible for new interior or exterior office space for the big

box stores. The last major obstacle would be the addition of more loading dock retrofits for the exportation and importation of materials and finished modules. Multiple factories responded with information indicating multiple loading dock were needed for moving materials and finished pods in and out of the factory. The Wal-Mart Supercenter had the most loading docks with six (6), which might be desirable for factories that utilize J.I.T. (Just in Time) delivery, short lead times for exporting final products, and a large volume of work or multiple projects. More loading docks would be desirable, but the right logistics for delivering materials and shipping modules could result in a better cost effective solution for deliveries instead of just constructing more loading docks.

For pods manufacturers, the feasibility of using abandoned big box stores to house modular factory operations would need minor additions and retrofitting to the existing buildings when it would be necessary. Additional retrofit work would involve adding more loading docks and increasing office space. When the right amount of square footage is chosen for each particular pod manufacturer, additional amenities can simply be implemented in the existing store format through retrofitting or adapting the store format to meet each pod manufacturer's operations requirements. Most needed amenities indicated during the companies' interviews are available inside the existing big box stores making them an ideal choice for modular operations. Pod manufacturers would save significant costs with eliminating the need for constructing a new factory, as well as time lost waiting for a new factory to be constructed. Less initial capital would be required to construct a new factory, and costs could be saved by retrofitting an existing structure. The pod manufacturer's feasibility of using an abandoned big box store for modular

construction factory purposes is a more cost effective and time saving result for moving their operation instead of constructing a new construction operation.

Findings of Module group

Modules represent the second largest builder of permanent or relocatable prefabricated building segments. Modules consist of larger prefabricated modules including residential, commercial, and light industrial applications. The modular construction companies interviewed, which were included in the modules category, include Indicom Buildings, Inc. and Suttor Modular Homes. Both companies produce modular housing and commercial products that are too large to be considered pods and too small to be grouped with containers. The two module manufacturers Suttor Modular Homes and Indicom Building, Inc., which have moderately large warehouse needs that make larger big box store formats more suitable spaces for housing the module companies' operations.

The modular manufacturer factory sizes are currently 75,000 SF for Indicom Building, Inc. and 120,000 SF for Suttor Modular Homes. Indicom Building, Inc. and Suttor Modular homes produce similar building modules in size, design, and client's uses. Both companies possess multiple requirements that may need to be retrofitted/added to the existing big box stores for the feasibility of using big box stores to foster their modular factories needs. Based on the variables and functional needs for module manufacturers, conclusions were derived for each manufacturer as to which big box store

formats have the most suitable arrangements. Multiple characteristics and comparisons between the two (2) module manufacturers include the following:

- Module product sizes which are roughly 8-10’ wide, 10-12’ high, and 20-40’ in length for shipment using semi-trucks
- Larger overall production spaces
- Large average of management/labor personnel
- Multiple offices and bathrooms
- Multiple or specially sized loading docks

Both factories have similar amenities included in their current operations, but any retrofits to the big box store formats would specifically conform to the individual requirements of the two (2) “module” manufacturers Indicom Building, Inc. and Suttor Modular Homes. Figures 5.3 and 5.4 display a plausible modular process and overlay of the process in a typical Costco floor plan. This is a similar process explained before at the end of the Wal-Mart Supercenter data collection section (Pg. 32).

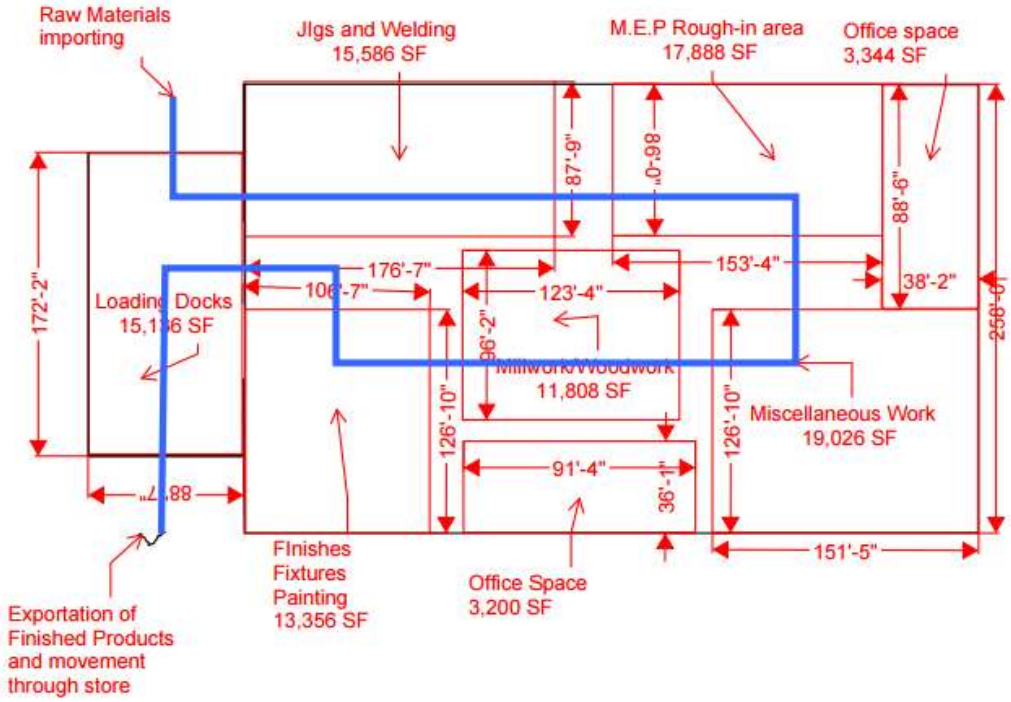

Figure 5.3 Costco Modular Factory Overlay Example

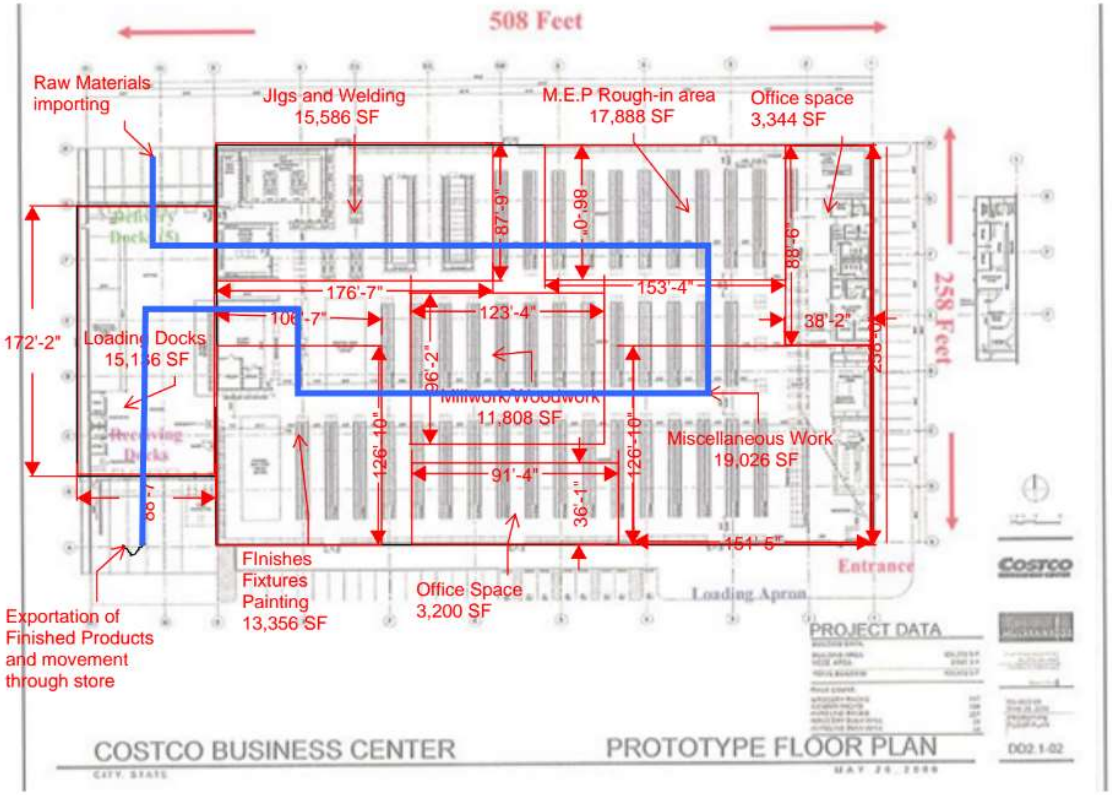

Figure 5.4 Costco Overlay/Publix Floor plan Example

Indicom Building, Inc.

Indicom Building, Inc. may require multiple additions to the existing big box stores to meet current operating conditions in their existing factory. Indicom Building, Inc.'s current factory is 75,000 SF where the four (4) larger big box stores Wal-Mart Supercenter (203,622 SF), Costco (148,000 SF), Home Depot (128,000 SF), and Lowes (169,000 SF) contains an ample amount of space for housing the Indicom Building, Inc. modular process. The BI-LO (48,000 SF), Publix (47,000 SF), and Wal-Mart Neighborhood Market (41,000 SF) formats provide an insufficient amount of overall square footage and would not meet the Indicom Building, Inc. (75,000 SF) current production space requirements. Indicom Building, Inc. uses only one loading dock/warehouse door not found in big box store formats. The 18' X 24' warehouse door currently used by Indicom Building, Inc. is used to export multiple modules without the issue of changing the size of larger modules. The Wal-Mart Supercenter, Costco, and Home Depot are shown as plausible for loading docks due to the company typically producing a standard module size. The three (3) big box stores also provide enough wall area to retrofit in the 18' X 24' warehouse door opening for specially sized modules. The next retrofit for Indicom Building, Inc. would incorporate the addition of office space. Office space for Indicom Building, Inc. is currently 20 full offices, which is the most amount of offices for all modular factories interviewed. Without the uncertainty of exact square footage gathered for office space in both the factories and big box stores, all four (4) larger big box stores could plausibly support Oldcastle Surepods office space needs. Additional office space for Indicom Building, Inc. would be a relatively easy and simple

addition considering that one of Indicom Building, Inc.'s current modular products is relocatable office space. The last possible issue to retrofit in a big box store for Indicom Building, Inc. would be the addition of bathrooms. Indicom Building, Inc. presently has four (4) bathrooms, which is more than most of the big box stores. The Wal-Mart Supercenter is the only store with six (6) bathrooms that exceeds the requirement for the minimum four (4) bathrooms currently located in Indicom's factory. BI-LO and Publix exceed the required number of bathrooms, but do not meet the spatial requirements. The other large big box store formats would probably need to add additional bathrooms to maintain a clean and productive work environment best suited for Indicom Building, Inc. The table 5.4 Indicom Building, Inc. Plausibility Summary below summarizes and compares the plausibility of Indicom Building, Inc.'s requirements compared to the big box store amenities.

Modules #1						
Indicom Buildings, Inc.	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Indicom Buildings, Inc. Requirements	75,000	1 18' X24'	20	4	1	85-120
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				

Table 5.4 Indicom Building, Inc. Plausibility Summary

Suttor Modular Homes

The Suttor Modular Homes current modular factory operation includes extensive amenities exceeding most of the features in the big box store formats. Suttor Modular Homes current facility is 120,000 SF and would fit the four (4) large big box store formats which includes the Wal-Mart Supercenter (203,622 SF), Costco (148,000 SF), Home Depot (128,000 SF), and Lowes (169,000 SF). The BI-LO (48,000 SF), Publix (47,000 SF), and Wal-Mart Neighborhood Market (41,000 SF) store formats do not possess the appropriate square footage to meet Suttor Modular Homes current requirements. Additional retrofits necessary to meet Suttor Modular Homes needs in the large big box formats possibly include; adding 2 to 4 loading docks, increasing office space, and installing additional bathrooms. Suttor Modular Homes currently has eight (8) standard loading docks, which is more than all the large big box stores. The Wal-Mart Supercenter has six (6) loading docks, and would require only adding two (2) additional loading docks to be installed. Costco and Home Depot both have four (4) loading docks or half of what Suttor Modular Homes might require. The next possibility of adding/retrofits to the big box stores would be the addition of office space. Eight (8) offices are located currently in Suttor Modular Homes facilities and only the Wal-Mart Supercenter possesses enough offices (10) to meet the need. The three (3) other large big box store formats do not contain enough offices, and additional space would have to be added to support the new operation management's needs. The last retrofit installation for Suttor Modular Homes would be increasing the number of bathrooms located in the big box stores. The only current store format with enough bathrooms is the Wal-Mart

Supercenter. BI-LO and Publix exceed the required number of bathrooms, but do not meet the spatial requirements. Costco, Home Depot, and Lowes would need to add 1-2 bathrooms if necessary to meet the Suttor Modular Homes current number in their existing factory. Table 5.5 Suttor Modular Homes Plausibility Summary below summarizes and compares the plausibility of Suttor Modular Home's requirements compared to the big box store amenities.

Modules #2						
Suttor Modular Homes	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Suttor Modular Homes Requirements	120,000	8	8	4	1	144
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				

Table 5.5 Suttor Modular Homes Plausibility Summary

Summary of Module findings

The module construction factories adaptability into the large big box store formats is feasible with minimal retrofits and increasing certain amenities. The amenities that possibly might need to be added/increased include bathrooms, office space, and loading docks. Bathroom additions might not be necessary, but if needed, would be minimal

demolition work and rework to tie new bathrooms into the existing store's sanitary and domestic plumbing lines. Possible cautions for increasing bathrooms would be an overflow in waste through the sanitary system and insufficient water due to the addition of new fixtures using the existing domestic plumbing. Office space existing in the plausible big box stores may be sufficient, but without exact square footages, this amenity would need to be assessed by each company to determine the exact need for additional office space. Increasing office space in the big box formats for module manufacturers would be simple through relocatable office space (Indicom) or simple prefabricated wall panels (Suttor) constructed together for an office format. The Wal-Mart Supercenter amenities came close to providing the needs for the module manufacturers and would require the least amount of retrofits for the module factory operations.

The feasibility of module manufacturers using abandoned big box stores with minimal retrofits for increasing the amenities to foster the modules manufacturers operations is feasible. Increasing bathrooms, office space, and loading docks would be cost effective additions to the existing big box store formats as compared to the construction costs and time-consuming process of constructing a new factory site. The big box store formats have demonstrated the ability to house the module manufacturers with sufficient space. Existing big box store amenities including loading docks, bathrooms, and office space, which can easily be altered or increased to meet the needs of the module companies. The module manufacturer's feasibility of using an abandoned big

box stores for modular construction factory purposes is feasible with minimal work necessary.

Findings of Container group

Container modular manufacturers are the largest group that require large spaces for the adaptation and reconfiguration of shipping containers as their modular building blocks. Container manufacturers include multiple modular products used for many applications including residential, retail, industrial, and commercial. The Modular factories interviewed that fall into the container category include Falcon Structures and Boxman Studios. The two container operations are very different from each other due primarily to the types of warehouses used by each. Each manufacturer utilizes different types and sizes of spaces to house their operations. Falcon Structures uses barrel vault-style large warehouses. Boxman Studios is located in an industrial business park with their factory being similar to a big box store using a post and lintel structure with open webbed steel web joists (lintels) spanning from column to column (posts) and supporting the roof. The following sections summarize the plausibility and variables applicable to the container manufacturers operations with the requirements of each factory setting.

The two container manufacturers are Boxman Studios whose existing operation uses 65,000 SF, and Falcon Structures, which uses 660,000 SF. Both companies shipping container products are constructed through similar manufacturing processes from start to finish. Although the two (2) container manufacturers have similar requirements, certain aspects in the container manufacturers operation could not be accommodated in the

existing big box stores. Certain variables possessed individually or for both container manufacturers reinforce the resistance of converting a big box store include the following:

- Massive building sites and production warehouses (Falcon Structures)
- Large shipping container products roughly 8-10’ wide, 10-12’ high, and 20-40’ in length typically, but possibly might be larger
- Numerous offices
- Special sized loading docks

The two (2) container manufacturers have unique qualities to each company that determined the feasibility and ability to renovate a big box store for container manufacturing. Boxman Studios and Falcon Structures have different requirements which results in exclusive needs for both companies. Figures 5.5 and 5.6 display a plausible modular process and overlay of the process in a typical Wal-Mart Supercenter floor plan. This is a similar process explained before at the end of the Wal-Mart Supercenter data collection section (Pg. 32).

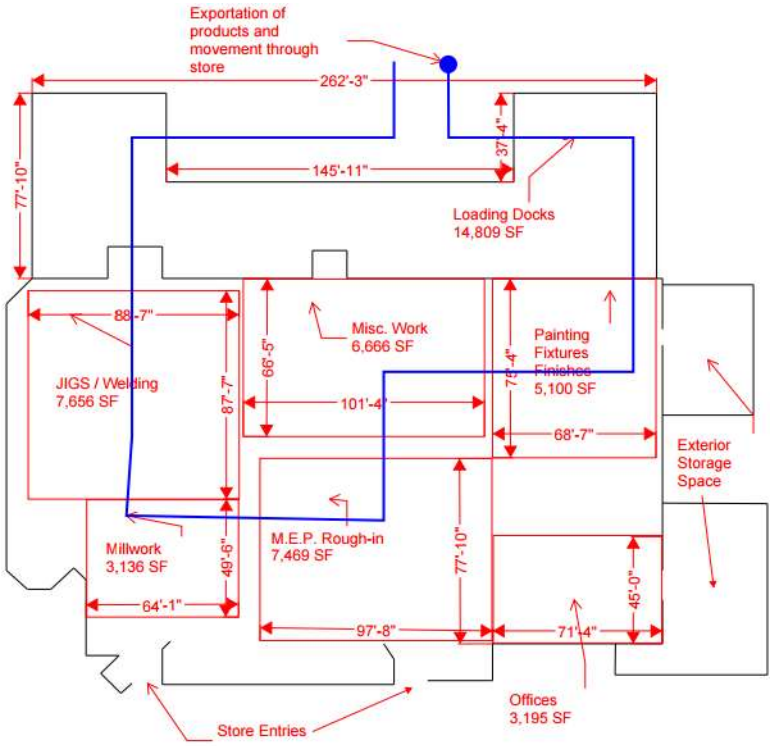

Figure 5.5 Wal-Mart Supercenter Modular Factory Overlay Example

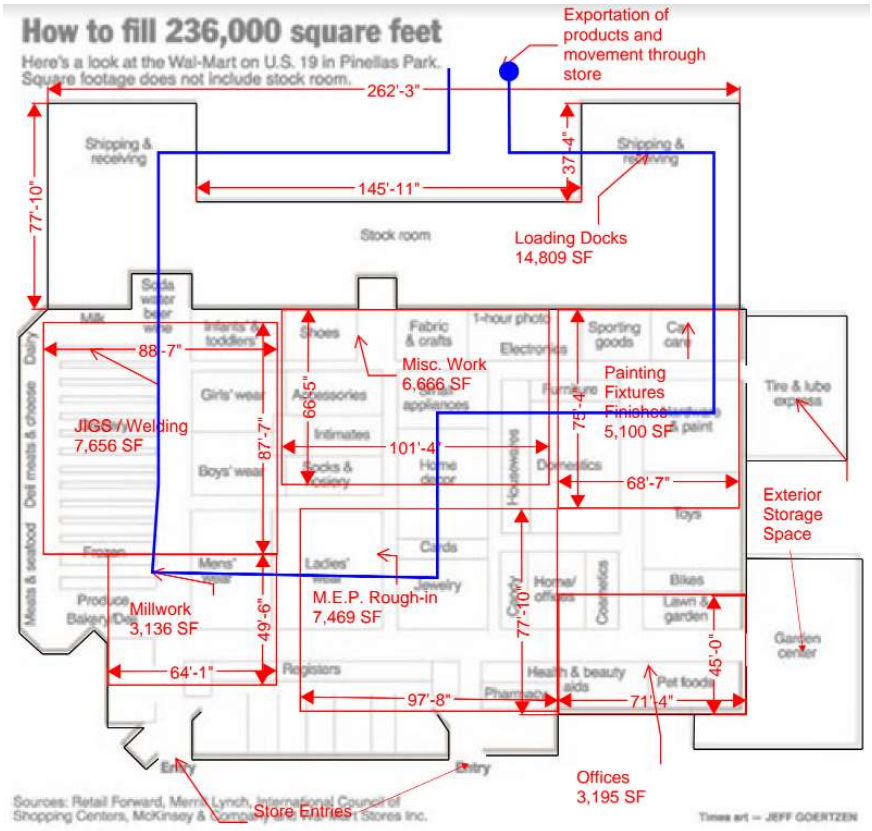

Figure 5.6 Wal-Mart Supercenter Overlay/Publix Floor plan Example

Falcon Structures

Falcon Structures is by far the largest modular construction company interviewed with three large dome warehouses at 216,000 SF each and one small dome at 12,000 SF. None of the big box stores has enough available space to house the operations of a factory this large. Falcon Structures also is located on a 51-acre site where they can expand their existing location and maintain their existing dome style warehouse format. Falcon Structure's ability to retrofit abandoned big box stores is not feasible due to the square footage needs required by the company, large volume of work that is produced, and the need for exterior stacking of additional shipping containers. Falcon Structure's operation requirements does not make it a viable candidate for retrofitting big box stores to house future modular operations. Table 5.6 Falcon Structures Plausibility Summary below summarizes and shows the inability for big box stores amenities to meet Falcon Structure's requirements.

Containers #1						
Falcon Structures	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Falcon Structures Requirements	660,000	Hangar door	12	3	1	35
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				

Table 5.6 Falcon Structures Plausibility Summary

Boxman Studios

Potential retrofit issues for Boxman Studios include the number and size of loading docks, and big box store office space. Boxman Studios currently has five (5) loading docks in which they use mainly two for importing and exporting materials and final products. One of the loading docks has a special size of 11' 6" for exporting the extra wide final shipping containers. All the larger big box store formats have two or more loading docks, but the loading docks are at standard 10' X 8' sizes. The Wal-Mart Supercenter store format has six (6) loading docks, but none are large enough to accommodate the transportation of the wide containers. The four (4) large store formats would need to invest in additional loading docks as well as provide a larger size addition to the loading docks. A retrofit is needed to accommodate the larger shipping container sizes for exportation and increase the loading dock(s) dimension. Boxman Studios has currently 10,000 SF for office space including 12 cubicles. Most big box stores have minimal office space, but Boxman Studio's existing factory has relocatable office space built within the production space. The most suitable big box store with adequate office space would be the Wal-Mart Supercenter with ten (10) offices. Additional office space would possibly need to be constructed in all the plausible four (4) large big box store formats to provide the sufficient square footage for office space. The minimal additional retrofit time and cost benefits for Boxman Studios to be able to convert an abandoned big box store into a modular factory significantly outweighs the alternative of constructing a new production factory. Table 5.7 Boxman Studios Plausibility Summary on the listed

below summarizes and compares the plausibility of Boxman Studio's requirements compared to the big box store amenities.

Containers #2						
Boxman Studios	**Square Footage**	**Loading Docks (#, Size)**	**Offices**	**Bathrooms**	**Break Rooms**	**Average number of workers**
Wal-Mart Neighborhood Market	41,000	2 at 10' X 8'	2	2	1	20- 30 max
Wal-Mart Supercenter	203,622	6 at 10' X 8'	10	6	1	152 max
Costco	148,000	4 at 10' X 8'	1	3	2	75 max
Home Depot	128,000	4 at 10' X 8'	3	2	2	55 avg.
Lowe's	169,200	3 at 10' X 8'	4	3	1	150 max
BI-LO	48,000	2 at 10' X 8'	2	5	1	30-35 max
Publix	47,000	1 at 10' X 8'	4	5	1	90 max
Boxman Studios Requirements	65,000	5	10,000 SF (12 cubicles)*A	3	1	30
Notes	Green	fits the variable				
	Yellow	variable is plausible				
	Red	Variable does not work				
*A	Boxman Studios requires 10,000 SF for office space, but assessed into an average for multiple offices and work stations					

Table 5.7 Boxman Studios Plausibility Summary

Summary of Containers findings

The container manufacturer's practicality for using abandoned big box stores for modular construction purposes relies on the specific requirements of each company. The first issue for container manufacturers is a space requirement. Falcon Structures production space is exceeding all of the big box store formats. Falcon Structure conformity into an existing big box store is not possible due to insufficient building square footage alone. Boxman Studios adaptability in a big box store is more suitable for the conversion into a big box store. Boxman Studios reorganization in a big box store would need retrofitting for additional office space and increase the number of loading

docks and re-sizing. The additional retrofits for rehabilitating an abandoned big box store to meet Boxman Studios requirements would deliver a time and cost savings for the company. The feasibility of using abandoned big box stores for container manufacturers is feasible, but depends on the specific operation of the container companies. Big box stores possess the framework for container companies similar to Boxman Studios to convert for their modular purposes, but do not have the means of housing container companies like Falcon Structures.

Summary of Findings

Investigation of converting abandoned big box stores to house modular construction factories for manufacturing purposes shows the adaptation of the abandoned spaces for new modular production facilities is achievable. Certain findings were derived from the initial research and data collection leading to validation/rejection of the initial question for the research conducted. Findings resulting from the research include:

- Retrofitting abandoned big box stores for modular construction purposes is feasible
- Big box stores square footage is a key indicator/factor to determine big box stores adaptation for a modular factory
- Certain larger big box stores with their current available amenities are more adaptable for modular factory operations and would require minimal retrofits as compared to other smaller store formats

- Retrofits in the big box store formats would include adding loading docks, increase office space, and installation of additional bathrooms

Findings developed through the data collection in this study provided a framework for understanding the feasibility of the question posed that are abandoned big box stores feasible to be used as a modular construction companies production space. The findings show that all factory formats, except Falcon Structures due to its current production operation using 660,000 SF of warehouse space, demonstrates suitable variables for converting big box stores to manufacturing operations. The data supports the feasibility of renovating abandoned big box stores with the minimal retrofits including increasing office space, additional installation of bathrooms, and retrofitting the number and sizes of loading docks. The possible future of modular construction may advance through the rehabilitation of big box stores and turnout an assembled future for the construction industry.

CHAPTER SIX

Conclusion

Modular construction can produce multiple benefits tailored to the improvement of the construction industry including decreased project schedules and delay factors, reduced construction costs, increased quality control, and improved working conditions and safety. Modular construction currently makes up only around 3 – 5% of the construction industry with the capability for rapid growth in the construction industry (Smith, 2015). The warehouse or factory component associated with modular construction is critical to the development of the product on time and under budget. Developing a possible existing space for modular construction companies to rehabilitate would facilitate and support the growth of the modular industry. The research for this study has validated the possibility of utilizing abandoned big box stores to accommodate modular construction factories through minimal retrofitting to sustain most of the modular manufacturer's requirements. Conclusions for each company are listed in the following section to determine the feasible state for big box stores to house their individual operations. Tables 6.1-6.7 display the retrofit requirements of each modular manufacturer and the most suitable big box store currently to house the company's modular operation. The tables are similar to the plausibility summaries in Chapter 5 FINDINGS using color coordination to best present the data. Tables 6.1-6.7 indicates if amenities listed in the horizontal axis are present or absent in the big box store formats. The color guideline displays green for "present in big box stores," yellow for "might have to be a retrofit," and red for "not present in big box stores," for determining where

retrofits in the existing box stores might have to be added and the possible quantity to add.

Pivotek

Retrofitting abandoned big box stores to meet Pivotek's requirements indicates that simple additions or reformatting is feasible for many of the big box store formats to improve Pivotek's modular process. Minimal work/retrofits would be required to reshape the big box store formats in order to meet the needs of Pivotek's current factory operations. Currently the best store format to house a Pivotek's operation without the need for retrofitting would be a Wal-Mart Supercenter. A Wal-Mart Supercenter exceeds square footage requirements, contains multiple full offices for management purposes, and provides multiple loading docks to meet the requirements of Pivotek's modular operations. Pivotek could construct additional office space with interior office expansions using modular or typical construction methods for the big box stores if the current office space capacity for the store location does not meet Pivotek's requirements. If a Wal-Mart Supercenter store's square footage space significantly exceeds Pivotek's ability to fill the space, suitable retrofits of multiple other big box stores would be minimal and still satisfy Pivotek's space requirements. The suitability of a Wal-Mart Supercenter and possible additional modifications for other big box stores provides compelling support for the feasibility of Pivotek utilizing an abandoned big box store to foster Pivotek's prefabricated building process. Table 6.1 Pivotek Retrofit Requirements/Best Store Format on the next page explains the retrofits required by Pivotek to operate in a big box store and which store format best suits the company's requirements.

Pivotek	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Pivotek Requirements	50,000 SF	5	9, 4 cubicles	2	1	25-30
Retrofit Requirements			Possibly add offices			
Best Store Format	**Wal-Mart Supercenter, Home Depot, Lowes, Costco**					

Notes	Pivotek has no neccesary needs for retrofit in the large big box store formats
	Green: Present in big box formats
	Yellow: Might have to be a retrofit
	Red: Not present in big box formats

Table 6.1 Pivotek Retrofit Requirements/Best Store Format

Insulsteel

Insulsteel's production requirements and amenities fit reasonably well with the larger big box store formats. The four (4) larger big box store formats (Wal-Mart Supercenter, Costco, Home Depot, and Lowes) surpass the required square footage, and possess a sufficient number of loading docks, along with adequate office space. Minimal retrofits for the larger big box stores potentially would include increasing the square footage to 10,000 SF for extra offices and multiple workstations. Additionally, with the inclusion of new office space, the four (4) larger big box store formats would support the feasibility of a big box store conversion for Insulsteel's new modular factory operation. Insulsteel's retrofits for the larger big box formats would require additional office space to meet Insulsteel's requirement for 10,000 SF for multiple workstations and office space. Insulsteel's adaptability into the big box formats is feasible and would require only minimal retrofits once the most suitable big box format is chosen. Table 6.2 Insulsteel Retrofit Requirements/Best Store Format on the next page explains the retrofits required

by Insulsteel to operate in a big box store and which store format best suits the company's requirements.

Insulsteel	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Insulsteel Requirements	60,000 SF	2	50 at 200 SF	2	1	336
Retrofit Requirements			10,000 SF in office space			
Best Store Format	**Wal-Mart Supercenter, Home Depot, Lowes, Costco**					

Notes	Insulsteel will require additional office space to meet 10,000 SF

Green	Present in big box formats
Yellow	Might have to be a retrofit
Red	Not present in big box formats

Table 6.2 Insulsteel Retrofit Requirements/Best Store Format

Oldcastle Surepods

Oldcastle Surepods would require only minimum retrofits for the conversion of an abandoned big box store to house Oldcastle Surepods modular construction factory. Small retrofits for additional office space and loading docks could easily transform a big box store suitable for the Oldcastle Surepods operations. The best existing store format would be a Wal-Mart Supercenter that provides most of the amenities needed such as square footage, loading docks, and offices as the framework required for Oldcastle Surepods. The simple additions required provide support for the compliance of converting a suitable big box store for the Oldcastle Surepods modular factory operation. Table 6.3 Oldcastle Surepods Retrofit Requirements/Best Store Format on the next page explains the retrofits required by Oldcastle Surepods to operate in a big box store and which store format best suits the company's requirements.

Oldcastle Surepods	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Oldcastle Surepods Requirements	100,000	8	12	3	1	70-120
Retrofit Requirements		Add 2-4	Add 2-11			
Best Store Format	**Wal-Mart Supercenter, Costco, Home Depot**					

Notes	Oldcastle Surepods will require possibly 2-4 more loading docks and 2-11 offices depending on the big box format choosen

Green	Present in big box formats
Yellow	Might have to be a retrofit
Red	Not present in big box formats

Table 6.3 Oldcastle Surepods Retrofit Requirements/Best Store Format

Indicom Building, Inc.

Indicom Building, Inc. would be able to utilize a big box store format with minimal effort and minor retrofits as compared to the cost of a newly constructed factory. Retrofits for Indicom Building, Inc. could possibly include additional bathrooms, reshaping the loading dock area(s), and increasing office space in the existing big box formats. The best store format to accommodate Indicom Building, Inc. currently would be the Wal-Mart Supercenter that best meets the present requirements for Indicom Building, Inc. A conversion would include minimal additions of adding 4-5 office space, add 1-2 bathrooms, and adding a loading dock sized 18’ X 24’. In order for the other three (3) large big box stores to be rehabilitated for Indicom Building, Inc. retrofit changes for the stores would include increasing the number of bathrooms, reconfiguring the loading dock area(s) to accommodate the large warehouse door, and adding additional office space. The transformation of an abandoned big box store for Indicom Building, Inc. is feasible through slight retrofits and adding more amenities including additional

bathrooms, loading docks, and office space. Table 6.4 Indicom Building, Inc. Retrofit Requirements/Best Store Format below explains the retrofits required by Indicom Building, Inc. to operate in a big box store and which store format best suits the company's requirements.

Indicom Buildings, Inc.	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Indicom Buildings, Inc. Requirements	75,000	1 18' X24'	20	4	1	85-120
Retrofit Requirements		1 sized at 18' X 24'	Add 4-5	Add 1-2		
Best Store Format	**Wal-Mart Supercenter**					

Notes	Indicom Building, Inc. will require 1 18' X 24' new warehouse door and 4-5 new loading docks depending on the big box format choosen
Green	Present in big box formats
Yellow	Might have to be a retrofit
Red	Not present in big box formats

Table 6.4 Indicom Building, Inc. Retrofit Requirements/Best Store Format

Suttor Modular Homes

The large big box store formats possess most of the amenities necessary for Suttor Modular Homes to successfully adapt a big box store for housing production processes. The retrofits needed for a Suttor Modular Homes reconfiguration into a big box store format would include; additional bathrooms, increasing office space, and reconfiguring or adding more loading docks. The best-suited big box store format currently would be the Wal-Mart Supercenter, which provides all amenities except for the possible addition of more loading docks. Home Depot would be the second closest store format, but would require new bathrooms, increased office space, and more loading docks. The large big box stores current amenities mostly exceed or are close to meeting the needs of Suttor

Modular Homes and with minimal retrofits, support the feasibility of converting one of the larger big box store formats into a successful factory work environment. Table 6.5 Suttor Modular Homes Retrofit Requirements/Best Store Format below explains the retrofits required by Suttor Modular Homes to operate in a big box store and which store format best suits the company's requirements.

Suttor Modular Homes	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Suttor Modular Homes Requirements	120,000	8	8	4	1	144
Retrofit Requirements		Add 2-4	Add 2-11			
Best Store Format	**Wal-Mart Supercenter**					

Notes	Suttor Modular Homes will require possibly 2-4 more loading docks and 2-11 offices depending on the big box format choosen
Green	Present in big box formats
Yellow	Might have to be a retrofit
Red	Not present in big box formats

Table 6.5 Suttor Modular Homes Retrofit Requirements/Best Store Format

Falcon Structures

Falcon Structure's manufacturing requirements currently exceeds all the big box store characteristics including square footage and loading dock size. Falcon's 660,000 SF spatial requirement exceeds all big box formats and concludes Falcon Structures requirements for space making the existing big box formats not suitable for Falcon Structures operations. Space is the essential requirement that must be achieved in the big box store formats before any additional requirements can to be examined for retrofit possibilities. Big box stores use for modular manufacturing for Falcon Structures is not plausible and would potentially reduce the company's volume of work and reduce profits.

Most amenities in the big box stores might work for Falcon Structures, but the space requirement deficiency in the big box stores would not establish a good fit to house Falcon Structures factory operations. Table 6.6 Falcon Structures Retrofit Requirements/Best Store Format below displays the unsuitable amenities in big box formats and the inability for Falcon Structures to operate in big box stores.

Falcon Structures	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Falcon Structures Requirements	660,000 SF	Hangar door	12	3	1	35
Retrofit Requirements						
Best Store Format	**Big box store formats would not feasibly house Falcon Structures factory operations**					

Notes	Falcon Structures operations do not fit into existing big box store formats
Green	Present in big box formats
Yellow	Might have to be a retrofit
Red	Not present in big box formats

Table 6.6 Falcon Structures Retrofit Requirements/Best Store Format

Boxman Studios

Boxman Studios represents a container manufacturing process with variables that align with the possibility for using big box store formats as production spaces. The Boxman Studios existing modular factory is 65,000 SF, which multiple big box store formats could accommodate. Boxman Studios current operation would fit into the four (4) largest big box store formats including the Wal-Mart Supercenter (203,622 SF), Costco (148,000 SF), Home Depot (128,000 SF), and Lowes (169,000 SF). The BI-LO (48,000 SF), Publix (47,000 SF), and Wal-Mart Neighborhood Market (41,000 SF) store formats do not possess the appropriate square footage to meet Boxman Studios spatial

needs. Table 6.7 Boxman Studios Retrofit Requirements/Best Store Format below explains the retrofits required by Boxman Studios to operate in a big box store and which store format best suits the company's requirements.

Boxman Studios	Square Footage	Loading Docks (#, Size)	Offices	Bathrooms	Break Rooms	Average number of workers
Boxman Studios Requirements	65000 SF	5	10,000 SF	3	1	30
Retrofit Requirements		1 added	10,000 SF in office space			
Best Store Format	**Wal-Mart Supercenter, Lowes**					

Notes	Boxman Studios will require 1 new loading dock at 11' 6 " and add 10,000 SF in office space in certain big box store formats
Green	Present in big box formats
Yellow	Might have to be a retrofit
Red	Not present in big box formats

Table 6.7 Boxman Studios Retrofit Requirements/Best Store Format

Summary of Findings

Conclusions from the research conducted indicate a great feasibility for several modular factory operation processes that have the ability to be operated in retrofitted abandoned big box stores. Six (6) out of the seven (7) modular factory companies interviewed demonstrate an ability to use the big box store format except Falcon Structures due to the extremely large production facility and storage space required for its operations. Retrofits would include adding additional loading docks or increasing loading dock sizes, additional office space, and installing more bathrooms. Developing existing big box stores for modular factory purposes would provide a significant cost savings to the company as compared to the time delay of constructing a new factory, and eliminating the risks associated with a new factory construction project. The reality of

using rehabilitated big box stores is already occurring with multiple new uses for big box stores including libraries, multi-family housing, hotels, restaurants, antique markets, churches, and multiple other formats. New warehouse facilities to house new modular operations could result in major growth for the modular industry. Modular factories using big box store to foster their factory operations will change the future of the construction industry by improving worker safety, faster construction project schedules and schedule delay factors, increasing quality control with all of these factors reducing construction costs.

Modular construction has provided multiple benefits that could contribute to a transformation of the construction industry and greatly influence how construction projects are delivered. Abandoned big box stores could be the beginning for a potential growth for the modular industry, and enhance a proven construction delivery process. Research conducted supports the feasibility of successfully converting existing big box store structures into modular construction factories. The feasibility of using abandoned big box stores as modular construction factories is supported and explained through the research for developing abandoned big box stores for modular construction. Modular construction's benefits will reshape the future of the construction industry, but will need a sufficient warehouse space to prefabricate the future of modular construction.

Future Research

Future research into the field of producing new construction applications as a result of using modular construction operations in abandoned big box stores could be of

great interest to affordable housing residential builders such as Habitat for Humanity. Affordable housing builders rely upon construction workers to complete the construction process in order to make single-family homes more affordable for low-income families. The possibility of constructing house components including wall panels, flooring systems, and roofing structures in retrofitted big box stores and shipping completed products to the site would be beneficial in cost and time savings. The modular process explained in depth on page 32 described during the Wal-Mart Supercenter Investigative Study would bring construction craft workers inside a factory and help retain labor on a set schedule while reducing multiple delays. This approach could increase production, improve construction labor safety, better utilize unsuitable construction months during bad weather, and allow workers to build housing components year round. A factory environment could attract and retain craft workers through better working conditions and eliminate reduced hours and layoffs during unsuitable weather months. The affordable housing's business model could be streamlined to promote efficient factory construction and allow "Just in Time" delivery practices to a site, which would utilize labor more efficiently. The retrofit of a big box store for affordable housing builders could save time and money, which would allow more homes to be built quicker and increase the number of affordable low-income housing units.

Future investigation might also result in an additional use for the smaller format big box stores by repurposing them for smaller component based modular manufacturers. Smaller prefabricated building components such as wall panels, flooring systems, and other minor modular parts could be fabricated using these spaces. Assembly lines would be

minimized for producing the smaller prefabricated building components and take advantage of the smaller big box store formats. Smaller big box stores including Wal-Mart Neighborhood Market, Publix, and BI-LO might have the right amount of space and amenities for operating smaller modular factories. This possibility allows the smaller prefabricated builders to reduce overhead costs by developing their product in a lesser-sized big box format.

Additional future research could include an investigation into the possibility of relocatable modular construction factories to reduce shipping costs. Since multiple abandoned big box stores are available nationwide, modular manufacturers could move operations closer to their construction sites to reduce shipping costs for their clients. Material could be bought locally to save money and decrease delivery times for obtaining certain materials. Research could also determine the feasibility of what type of modular factories would be able to best utilize this business model depending on factors including certain equipment needed in the factories and willingness of personnel to move. Potential other factors include the location of closed big box stores, overhead costs vs. shipping costs to determine which is more a cost effective approach, and possible supplier cost reductions. All of these factors could provide positive outcomes and support the feasibility/possibility of developing relocatable modular factories/companies.

APPENDICES

Appendix A

List of Big Box Store Questions

1. What is the size of the store in SF?
2. What is the column spacing of the store?
3. What is the size of the opening of loading dock? Number of dock bays?
4. What is the size of the following spaces in SF: office space SF? break areas? Number of offices/break rooms?
5. How many bathrooms are located in your store? Both public and employee only?
6. What is the average amount of workers at one time in your store?
7. What is the lighting height of the store? Ceiling height?
8. What is the parking lot size in SF?
9. Do you know the total construction cost of the big box store?

Appendix B

Modular Construction Factory Interview Questions

Case Study Research for Modular Construction Factories
Modular Construction Factories
Interviewed/Date

1. Company Background
    a. Give a brief explanation of the company's history?
    b. Where is your company located?
    c. Who are some of the clients you have served in the past?
    d. What type of work does your company perform?
    e. What is the geographical area your company has served (area of operations)?

2. Factory
    a. What is the total square footage of your factory?
    b. Howe much space do you allocate to layout square footage?
    c. What is the sequence of you factories assembly line? Square footage per bay?
    d. How much space does your company use for materials storage (SF)?
    e. What is your factory's ceiling height?
    f. What is the height of your lighting / type of fixtures/ are they adequate?
    g. What was the cost of building or monthly lease?
    h. Do you have an Assembly Yard/ Outside storage?
    i. What is the size of your parking lot for workers (sf or # of cars)? Separate from storage lot?
    j. How many offices does your company have? (number, sf)
    k. How many bathrooms does your company have? (number, sf)
    l. What are the amenities in your factory? (cafeteria, break room, locker rooms, etc.) number, sf
    m. What is the configuration of factory?
    n. How many loading docks is in your factory? Specialty loading docks?
    o. What's the number of modules to be worked on at one time? (Clearance around modules)
    p. Zoning issues?
    q. Noise level of factory?
    r. Factory floor load issues for slab thickness?
    s. Special equipment to move factory equipment?
    t. Looked for incentives to move factory or current location? State and local?

3. Work Force
    a. How many modules can be worked on at one time (capacity)
    b. How many Workers/Management Personnel are on average working at one time?
    c. Assembly Line work or singular Modular work?
    d. Do you use multiple shifts?
    e. Number of workers on one module at one time?
    f. Are workers local?
    g. Specific training for workers?

4. Transportation
    a. Do you use 3rd party transportation?
    b. Where is it located?
    c. What is the farthest distance the company has transported modules?
    d. Do you use rail roads? / 4 lane Highways near shop?
    e. Does you transportation need wide load / heavy load / or other limitations?

5. Open Questions
    a. Does your company plan for future expansion?
    b. Do you think big box stores can be rehabilitated for your business?

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