

CONSTRUCTION IN OCCUPIED SPACES

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Abstract

Conducting construction activities in occupied environments presents a great challenge due to the additional logistical requirements and the presence of the building occupants. The aim of this research is to gather and evaluate the means and methods to successfully plan, manage, and execute construction activities in occupied spaces in an effort to provide consolidated industry tools and strategies for maintaining a schedule and minimizing the impact on the occupants. The methodology of the research utilizes an exploratory approach to gather qualitative data. The data was collected through interviews with industry professionals to identify industry best practices. The semi-structured interviews provided a platform for the documents, lessons learned, and the techniques and strategies used for occupied construction by the construction industry. The information obtained in the interview process identified six themes that are critical to achieving and maintaining quality in occupied construction. These themes of the schedule, cost, customer satisfaction, planning, fire/life safety and utilities, and contractor management are reviewed in detail, and the paper discusses how to manage each element. The analysis and extracted management techniques, procedures and strategies can be used by the construction industry for future projects by focusing on the critical aspects of occupied construction and the manner in which to succeed with it.

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1 INTRODUCTION

Planning the execution of construction activities is a critical component of the successful management of a project. The traditional means and methods employed to execute any construction project require detailed planning and oversight to execute the numerous activities involving an array of resources. Planning for construction projects “requires an intimate knowledge of construction methods combined with the ability to visualize discrete work elements and to establish their mutual interdependencies” (Sears et al, 2008).

The strategies and plans to execute work are further complicated by an occupied environment. The International Code Council defines “occupiable space as a room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes or in which occupants are engaged at labor, and which is equipped with means of egress and light and ventilation facilities meeting the requirements of this code” (“International Code Council - Definitions,” 2015). The attributes described as egress, light, and ventilation are explored further in our research as maintaining those components during construction is essential. For

the purposes of this research, an occupied space is further defined as a space in which the owner, tenants, or pedestrians are present during construction. The management team must take into account the logistical hurdles required to deliver a finished product that under normal circumstances may have a logical sequence to complete.

When conducting construction activities, there are regulations that establish minimum criteria for safety. Some of those become specifically integral when conducting work in occupied spaces. An example is maintaining safe passage for workers and building occupants; “exits are to be so arranged and maintained as to provide unobstructed egress from all areas, at all times, when occupied” (Reese and Eidson, 2006) the Handbook of OSHA Construction Safety and Health addresses the occupational safety and health issues faced by those working in the construction industry. The book covers a vast range of issues including program development, safety and health program implementation, intervention and prevention of construction incidents, regulatory interpretations, understanding, and compliance, OSHA’s expectations, health and safety hazards faced by those working in the construction industry, and sources of information. Highlighting contract liability and multi-employer sites, this second edition features updates for construction regulations, construction job audit, training requirements, and OSHA regulations. It includes new record-keeping guidelines and forms with additional material on focused inspections. Containing updated contact information for the newest agencies, the text also presents a model safety and health program, examples of accident analysis and prevention approaches, sample safety and health checklists, and more than 200 illustrations. Taking a comprehensive approach to construction safety and health, the authors address issues seldom discussed in the construction arena such as perceptions and motivation while also discussing issues gleaned from the safety and health disciplines such as the analyzing of incidents and accident prevention techniques. Including an in-depth discussion of regulations promulgated by the Occupational Safety and Health Administration, the book lays the foundation upon which to build stronger safety and health initiatives, while intervening and preventing jobsite deaths, injuries, and illnesses.”, “ISBN”: “9781420006230”, “language”: “en”, “author”: [{ “family”: “Reese”, “given”: “Charles D.” }, { “family”: “Eidson”, “given”: “James Vernon” }], “issued”: { “date-parts”: [[“2006”, “3”, “23”]] }, “schema”: “https://github.com/citation-style-language/schema/raw/master/csl-citation.json” } . This example of minimum criteria establishes a baseline for the specific inputs of an occupied space.

The next step in delivering a plan to execute in this type of space can be illustrated by some of the best practices. The Ramsey County Courthouse in St. Paul, Minnesota, is a prime example of weighing the cost/risk benefits of continuing business versus the impact of ongoing construction. The project was executed utilizing a strategy to renovate a floor at a time, while the rest of the building remained occupied and operational. The impact resulted in the customer conducting business in some other than normal methods, “but phasing the job saved \$1 million over temporary relocation” (Bartolic).

The main findings in a review of the existing literature reveal the industry’s understanding of the complexities involved in delivering a construction project in an occupied environment. Julie Knight of the Triad Business Journal states “renovations of existing, occupied space can create headaches and hassles, and...pre-project planning is critical to making such projects run as smoothly as possible” (Carlock, 2013) “container-title”: “Triad Business Journal”, “abstract”: “Customers and passers-by may not be able to tell by the building’s exterior, but the 1618 Wine Lounge in Greensboro is undergoing an extensive renovat ...”, “URL”: “http://www.bizjournals.com/triad/print-edition/2013/06/14/renovating-occupied-space-requires.html”, “author”: [{ “family”: “Carlock”, “given”: “Catherine” }], “issued”: { “date-parts”: [[“2013”, “6”, “14”]] }, “accessed”: { “date-parts”: [[“2015”, “8”, “11”]] } }, “schema”: “https://github.com/citation-style-lan-

guage/schema/raw/master/csl-citation.json” } Construction managers are faced with a number of logistical challenges in many different environments. The logistical challenges increase respectively from the standard twelve-hour facility to twenty-four hour facilities and furthermore in critical facilities. A critical facility is “a structure or other improvement that because of its function, size, service area, or uniqueness, has the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if it is destroyed or damaged or if its functionality is impaired”. Examples of a critical facility include hospitals, utility services, facilities containing significant hazardous materials, government facilities, etc. There are opportunities across these environments to improve the execution processes in occupied areas. Therefore, the aim of this research is to gather and evaluate the means and methods to successfully plan, manage, and execute construction activities in occupied spaces in order to provide consolidated industry tools and strategies to maintain the schedule and minimize the impact on occupants. The scope of the research is limited to building construction activities for all building types in operational facilities where general construction is required in or adjacent to sites with ongoing operations.

LITERATURE REVIEW

Planning for an Occupied Space

Globally, green initiatives, budget constraints, and other logistical considerations are driving a larger section of construction toward renovations of spaces; many times they take place in occupied buildings. The environmental constraints have spawned “initiatives [that] have been steered toward retrofitting existing buildings” (Hwang, Zhao, See, & Zhong, 2015). Performing construction activities in buildings or spaces that are occupied presents unique challenges. Therefore, “careful preconstruction and logistics planning” (“Logistics Planning Is Critical for Working in Occupied Areas, Wise Construction,” n.d.) is required to carry out projects in this environment. The challenges to contend with are more than some contractors are willing to take on. Some contractors who perform successfully on many projects are “not comfortable or able to build in an office environment” (Varian, 2008). The attention to detail is highlighted, and some contractors “avoid these projects because you spend at least twenty-five percent to one-third of your day cleaning up and getting ready to work again” (Carlock, 2013) “container-title”: “Triad Business Journal”, “abstract”: “Customers and passers-by may not be able to tell by the building’s exterior, but the 1618 Wine Lounge in Greensboro is undergoing an extensive renovat ...”, “URL”: “http://www.bizjournals.com/triad/print-edition/2013/06/14/renovating-occupied-space-requires.html”, “author”: [{ “family”: “Carlock”, “given”: “Catherine” }], “issued”: { “date-parts”: [[“2013”, “6”, “14”]] }, “accessed”: { “date-parts”: [[“2015”, “8”, “11”]] } }, “schema”: “https://github.com/citation-style-language/schema/raw/master/csl-citation.json” }

Cost Impact

Performing construction activities in an occupied environment can be prohibitive. The building owner and tenants are attempting to maintain operations while construction activities generate dust, debris and noise. There are further impacts to the construction project or the owner’s operations when it comes to activities dealing with utilities, life-safety, and communications. Owners and customers are left with a difficult decision, i.e., to deal with construction nuisances while attempting to maintain operations, pay a premium to have

work done during off hours, or relocate operations during construction. “Obviously there is a cost attached to temporary relocation” (Jones, 2013). Relocation of operations only addresses part of the concerns because adjacent spaces may still be occupied, so the contractor and/or customer still have issues to contend with. Relocation “is simply too expensive and complicated for many firms to consider” (Varian, 2008).

On the other hand, relegating the contractor to after hours for construction activities “takes much longer and is typically much more expensive for the owner or tenant than if temporarily emptying the space” (Carlock, 2013). “Triad Business Journal”, “abstract”: “Customers and passers-by may not be able to tell by the building’s exterior, but the 1618 Wine Lounge in Greensboro is undergoing an extensive renovat ...”, “URL”: “http://www.bizjournals.com/triad/print-edition/2013/06/14/renovating-occupied-space-requires.html”, “author”: [“family”: “Carlock”, “given”: “Catherine”], “issued”: [“date-parts”: [“2013”, 6, 14]], “accessed”: [“date-parts”: [“2015”, 8, 11]]], “schema”: “https://github.com/citation-style-language/schema/raw/master/csl-citation.json”. The increase in the after-hours cost can be attributed to the overtime pay scale. The owner must plan and account for the overtime multiplier in their project estimations and budget.

Owner Relationship

A familiar exercise in any business is stakeholder identification. Stakeholders are “those who influence or are influenced by the business” (Preece, Moodley, & Smith, 1998). For the construction industry this includes clients, the government, the city, and suppliers or subcontractors. Identification of stakeholders plays a part in occupied construction projects in that the stakeholders in the full environment are included. In these circumstances this also pertains to the occupying tenants of adjacent space or those tenants directly within the location of the construction. They have an influence on the project and are affected by the project regardless of whether they are the direct customer or an outside entity due to the nature of the construction.

Therefore, when entering into a construction project in an occupied environment, it is helpful to empathize with the owner and occupants of the space. When construction is ongoing and the normal operations of the workplace are interrupted, the “occupants feel that their work environment is out of their control” (Hall, Ellis, & Hardin, 1995). “source”: “eric.ed.gov”, “abstract”: “This manual, written in response to requirements of the Washington State legislature, focuses on practices which can be undertaken during the siting, design, construction, or renovation of a school, recommends practices to help ensure good indoor air quality during building occupancy, and suggests protocols and useful reference documents for investigating and handling indoor air quality complaints and problems. Sections cover: why indoor air needs management; the factors influencing indoor air quality; the basic strategies for good indoor air quality; the siting, designing, and constructing of schools for good indoor air quality; and the operating and maintenance of heating, ventilation, and air conditioning (HVAC. This effect of construction “can create anxiety among...employees and affect morale” (Varian, 2008). Attention to these concerns is applicable when starting the construction process and throughout the process. The construction managers should be available to hear any concerns and be sensitive to the impact of the work. The metaphor to consider a building as the owner’s house appropriately conveys the level of care and consideration that should be demonstrated. The construction managers should take the time to understand the ongoing operations to “determine the best way to renovate the space with as little disruption as possible” (Varian, 2008).

Indoor Air Quality (IAQ)

In a construction project, dust, debris, and other airborne contaminants involving building materials are generated. On a project site that is occupied, these contaminants can pose a problem. Air contaminants can have an effect on the building occupants, and “precautions should be taken before, during and following completion of the project to protect [occupants] from unnecessary exposure” (Hall et al., 1995). “source”: “eric.ed.gov”, “abstract”: “This manual, written in response to requirements of the Washington State legislature, focuses on practices which can be undertaken during the siting, design, construction, or renovation of a school, recommends practices to help ensure good indoor air quality during building occupancy, and suggests protocols and useful reference documents for investigating and handling indoor air quality complaints and problems. Sections cover: why indoor air needs management; the factors influencing indoor air quality; the basic strategies for good indoor air quality; the siting, designing, and constructing of schools for good indoor air quality; and the operating and maintenance of heating, ventilation, and air conditioning (HVAC. Irritants can attack the eyes, nose, and throat. There are even dermal effects to consider. Dermal irritation refers to irritation of the skin. These issues, while generally acute, must be mitigated. “OSHA sets exposure limits to the [construction] workers, not occupants indirectly exposed to contaminants” (Varian, 2008), so the owner must insist on proper controls for their building inhabitants, and the contractor should proactively address these issues. IAQ issues that arise on a project result in negative customer relations and lost time for the building occupants.

Fire/Life Safety

Fire/life safety refers to the protection of occupants and building systems during construction. The construction manager should maintain life safety features and the means of egress at all times. The construction area may block an exit that is not available to the building occupants. An alternate path of egress can be provided during the construction. Notification of these changes is communicated through temporary signage for directional and emergency guidance. Temporary signage should meet “OSHA standards” for all projects done in the USA. Protecting pedestrians and occupants requires the construction of additional structures such as covered walkways and protective barriers. These constructed safety features protect the occupants from materials and equipment. They can extend to wall and floor penetrations that require covering to prevent slips, trips, and falls. Barriers should be inspected daily. Inspections are a form of control to ensure that proper precautions are being exercised to protect building occupants. Protection of occupants is the primary concern when operating in inhabited spaces.

Noise

Several solutions are utilized in the industry to mitigate noise-generating activities during construction. Equipment used in occupied spaces can be equipped with “mufflers for air operated tools and engine powered equipment” (“Construction Design Guidelines For Working Within And/Or Near Occupied Buildings,” n.d.). Not all noise is generated by equipment, so enclosing the space via construction barriers can provide sound attenuation. The level of construction of temporary walls can be dictated by the level desired by the building owner. Full acoustical insulation with airtight seals can be provided to maximize keeping the sound contained within the construction space. The alternative can be plywood or plastic in environments where

noise control is lower on the list of priorities. A final solution to noise impacts in occupied spaces is to prefabricate off-site assemblies to the greatest extent possible prior to delivering them to the site. There are cost impacts from the preceding sound-attenuation methods with additional materials, labor, quality control concerns, and transporting assembled project components.

Housekeeping

Construction activities require a great deal of physical disturbance. Demolition generates waste that must be hauled from the site. New construction requires the storage of materials and laydown space. Material storage management in occupied spaces “must occur in designated areas only to prevent pedestrian slips, trips, and falls” (“Construction Design Guidelines For Working Within And/Or Near Occupied Buildings,” n.d.). Boundaries must be established for the construction zone. The construction manager should restrict or control workers and construction traffic “within the confines of the construction zone” (“Construction Design Guidelines For Working Within And/Or Near Occupied Buildings,” n.d.). By controlling the construction pathways to deliver and remove materials to formalize a perimeter, the construction manager can better maintain the area and, even more importantly, ensure the outside occupied area is in suitable condition for the occupants.

Another factor for housekeeping is the dust and debris created when performing construction activities, which is discussed within the IAQ section above. Note that compressed air is not permitted as a means of housekeeping. Blowing dust and debris away from one area and into an occupied environment only exacerbates the problem.

METHODOLOGY

In an effort to discover industry best practices to manage the additional efforts required for construction in occupied space, qualitative research was conducted. The research sought to understand how construction managers plan and execute construction activities in occupied spaces by collecting the experiences of industry professionals. The exploratory research strategy supported the goals of the study to achieve the next level of understanding beyond what the existing literature provides. The existing literature does not explain how occupied space construction activities are planned and managed. This insight can only be provided by construction managers who have experienced this kind of work firsthand. Therefore, a best practices research design was warranted. “Best practices” are defined as practical experience on projects in an occupied setting that includes successes and failures.

Data Collection

Interviews

The primary method of data collection for this research was conducted through interviews. The subjects for the interviews were construction industry professionals, contractors or construction managers. The participants were selected as a result of their involvement in construction projects within occupied spaces. The interviewees and their companies varied in their size and expertise. Due to the personal touch required to acquire the lessons learned and the shared tools that this research sought to reveal, a convenient sampling method was used. The interview sample pool was based on past professional relationships and secondary contacts.

The interview questions consisted of a focused line of questioning broken down into the categories and questions as depicted in Table 1, Interview Questions.

Table 1 Interview Questions

1	Please provide your name, company, and position/role.	2	What do you consider a successful project?
3	Does that definition differ when the project takes place in an occupied space?	4	What is your experience in executing construction activities in occupied spaces?
5	Does conducting work in occupied spaces differ in comparison to unoccupied spaces?	6	What are the critical areas of focus for conducting work in occupied spaces?
7	How do you mitigate the cost impact of conducting work in occupied spaces?	8	How do you maintain a schedule on projects in occupied spaces?
9	What differs in the way work is executed in standard, twenty-four hour, and critical facilities?	10	What tools/processes does your company utilize to manage construction activities in occupied spaces?
11	What strategies have you implemented to manage occupied projects?	14	How does your company address?
12	Do you have any standardized templates to manage projects?	a	Noise
13	Can you tell me about your most successful project in an occupied space?	b	Fire/Life Safety
a	What were the success factors?	c	IAQ
15	Can you tell me about your least successful project in an occupied space?	d	Customer relations
a	What were the failure factors?	e	Housekeeping

The semi-structured interviews followed a designed set of standard questions. As an introduction, a sharing of project examples, tools, samples, and opinions was encouraged. To facilitate acquiring multi-faceted forms of data, the interview questions were provided in advance. Based on the responses to the standard set of questions, unstructured follow-up questions were provided. Further analysis was undertaken to extract means and methods for a better quality data retrieval.

Case Study

The second form of data was collected through a case study analysis of a construction organization for government facilities. For purposes of anonymity, the organization and location will remain undisclosed. The case study was a review of the process and procedures of the organization in their execution of construction activities in occupied spaces. The case study is not a single project, but includes all the procedures utilized by the organization to execute a project in an occupied facility. The documentation sought to support the primary data and provide a further in-depth understanding of the process. The case study was selected based on a couple of criteria; the first criterion was the number of construction projects executed by the case study organization within occupied spaces; and the second criterion was that the case study project should be of a critical facility. Based on these criteria, the authors wanted to select an organization for the case study in order to improve the management of construction activities in occupied spaces carried out by the organization.

DATA ANALYSIS

Interview Analysis

The data received from the open-ended interviews was analyzed in multiple ways. The open-ended interview questions led to in-depth answers. The answers were reviewed and categorized by theme in an Affinity Diagram. The themes were analyzed utilizing a Pareto Chart. A Pareto Chart arranges data in a bar graph and line graph, displaying a quantity by category and the total quantity, respectively. The data collected was tabulated by the frequency of the theme used by the interview subjects to describe the data. The result was a formulation of the themes that are critical to quality. Those items bring into focus what was determined by industry professionals as the factors that demand attention. The other data components were reviewed analytically to extract management techniques, strategies, and procedures to successfully deliver results in an occupied environment. Specific questioning sought to identify specific methodologies for standard, twenty-four hour, and critical facilities. An analysis of differing facility types were conducted to evaluate mitigation techniques that can be implemented to improve performance in all environments. Data from the industry interviews and case study were assembled to compare and contrast the different facility types.

Case Study Analysis

The case study was followed by a review of the organizational processes to identify strengths, weaknesses, and areas identified as opportunities for improvement. Using the data obtained in the interviews, the practices were compared and evaluated in comparison to standard industry practice. Areas of strength were also further highlighted to provide lessons learned for the industry.

RESULTS AND DISCUSSION

Participants' Information

Twelve interviews were conducted with construction industry professionals. The participants ranged in their experience, company role, and geographic location. All the participants had experience in managing construction activities in occupied spaces. Some participants' experience was extensive in occupied and unoccupied construction, while others had more moderate experience in occupied spaces. Only a few participants had exclusive experience in occupied construction environments.

Interview Analysis

Interviews were conducted in person and via conference calls and were transcribed to break down the information provided by the participants. The transcripts were broken down into twenty-two (22) repeated themes, which were comprised of five hundred thirty seven (537) responses. The categories and responses were placed in an Affinity Diagram, which is a "graphic tool designed to help organize loose, unstructured ideas...related ideas are grouped into meaningful categories called affinity sets. These categories tie different concepts together with one underlying theme, clarify the issues, and provide a structure for a systematic search for one or more solutions" ("What is affinity diagram?," n.d.).

The information compiled in the Affinity Diagram was able to be quantified by frequency of theme. The quantities were used in a Pareto Analysis to further refine the data. The cumulative percentage cutoff was established at fifty percent (50%). Therefore, the themes that make up the majority of the interview responses are identified as the most vital (vital few). The six themes that make up the majority of the interview responses are Schedule (69), Cost (51), Customer Satisfaction (48), Planning (45), Fire/Life Safety/Utilities (36), and Contractor Management (35). The first six (6) themes cover 52.89% of the total frequency of the responses (See Figure 1).

The top six themes that were identified as the most vital (Vital Few in Figure 1) were examined in detail as they are critical to quality in occupied construction. The responses organized in the affinity diagram by theme were reviewed in aggregate to extract management techniques, procedures, and strategies utilized to manage projects in occupied spaces. The findings are presented individually by theme as follows:

Schedule Analysis

The most frequent theme throughout the industry interviews was resoundingly centered on the project schedule. A large number of instances referenced the schedule in defining what makes a project successful and were attributively used to describe successful projects. Interestingly, schedule and cost were routinely linked throughout the transcript review. The link was not a surprise, but proved to validate the value and dependent nature of the costs and schedule that exist in construction management. Operating in occupied spaces results in greater schedule pressures and an increased challenge.

There were multiple strategies identified to plan and establish construction schedules in occupied spaces. The emphasis on planning will be further examined in the analysis, but specifically with regard to scheduling, planning is imperative. It should be realized that more planning up front is required when dealing with scheduling occupied construction. Conducting up-front planning should incorporate ev-

Pareto Analysis

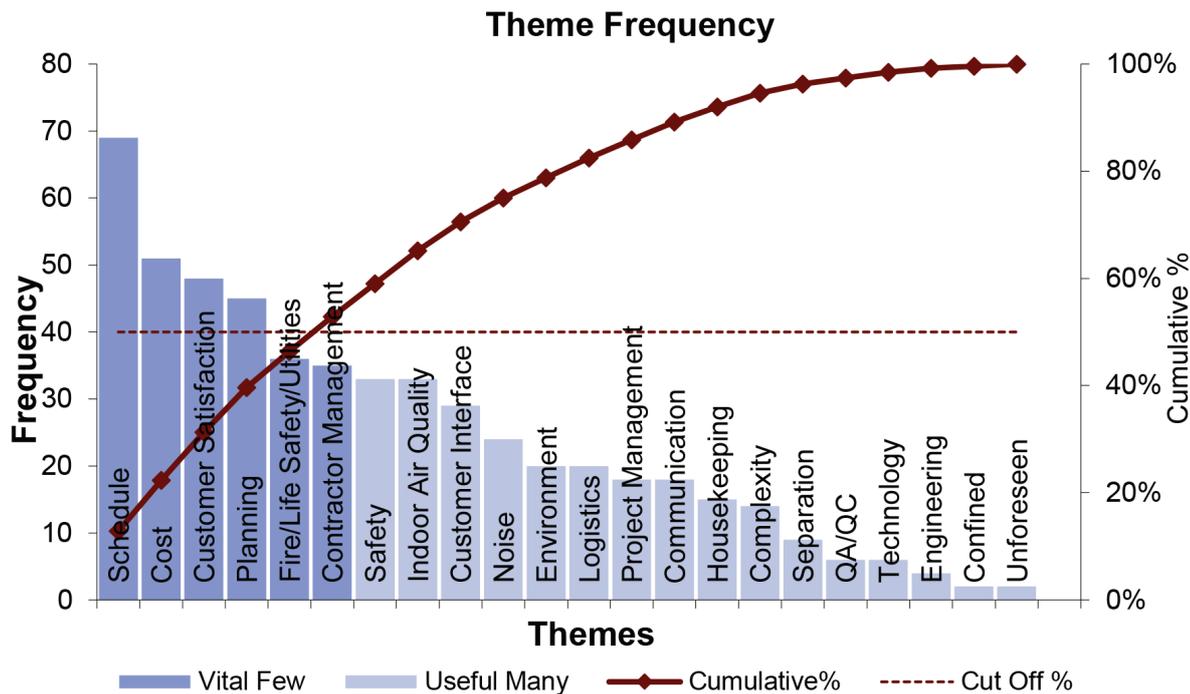


Figure 1: Interview Theme Frequency Analysis

everyone involved before establishing the schedule. The involvement of all parties in the schedule planning allows for the incorporation of the occupants' schedule. Either by taking information from the customer or through observation, the construction manager should identify peak times in the customer's schedule. The work should be scheduled around these times to minimize the impact on the occupants. This is further emphasized in the scheduling of outages. In most instances this avoidance scheduling results in executing construction activities during altered or other than normal working hours. Utilization of night work and weekends can be an opportunity to control the schedule during the unoccupied times of a normally occupied space. Resource management can be a tool for construction managers to get the most out of the available work schedule. Managing resources to the greatest extent can include extended shifts, overtime, multiple crews or shift work. A creative approach identified through the research called for utilizing more crew members than the job would typically require to ensure the task could be completed within the established schedule. Taking into account the schedule planning, customer schedule, and resource management, it should be expected that the duration of the construction would be extended when operating in occupied spaces. As described by a senior superintendent, a project that would traditionally take eighteen to twenty months could take up to three years in an occupied environment.

When schedule impacts are unavoidable, owners and prime contractors need to plan to react accordingly. If stoppages are not built into the project's scheduled duration or exceed the durations allotted, a contingency plan should be in place to address delay claims or acceleration charges when project completion dates cannot be changed.

The project schedule is not just a required document, but is recognized as a tool. It is the baseline to guide the work. Many contractors utilize scheduling software such as Primavera and Microsoft Project to automate the scheduling algorithm. These programs use the Critical Path Method (CPM). The critical path is the "longest sequence of activities in a project plan which must be completed on time for the project

to complete on due date. An activity on the critical path cannot be started until its predecessor activity is complete; if it is delayed for a day, the entire project will be delayed for a day unless the activity following the delayed activity is completed a day earlier". Identifying the critical path gives the construction manager the information to direct his focus on the activities essential to maintaining the schedule. The frequency of updates is important to the accuracy of the information. The more frequently the schedule is updated, the better the information.

When operating in an occupied environment, the attention to detail is highlighted. Occupied project schedules require greater detail as well as activities to be broken down to the next level. The detail is needed due to the complexity an occupied environment creates. Along with greater detail, establishing interim milestones can segment the work to maintain progress.

Cost Analysis

The cost of the project was the second most common theme throughout the industry interviews; it followed the schedule as a theme with fifty-one (51) occurrences. Cost management is a recurring critical focus area in the investigation of occupied construction. One general contractor simply stated that "we are 'here to make money'". There is always pressure on the project team to achieve financial success. This can be pressure to come in under budget or make a little bit of profit for the company. In the end meeting these goals keeps the stakeholders in business.

An alternative perspective on the cost of construction in an occupied space relates to the impact on existing operations. What is the operating cost to the owner? A halt to business may result in a loss of cash flow. It is important for owner's representatives or contractors to understand this impact and mitigate its effects on the owner and their customer service.

The best method to manage the cost impact of conducting construction activities in occupied spaces is to plan for it and price the

project accordingly. Planning the project requires an understanding of its scope to deliver the project in a cost-effective manner. Having an up-front game plan allows the project team to review the inputs to the project. A successful strategy is to plan on paper first to mimic the flow of the job in an effort to work through the inputs to evaluate the most efficient method to deliver the project. Projects in occupied spaces require a great deal of logistical planning. An interview participant serving in the role of an owner's representative can work on a team dedicated to the logistical planning and execution of space management and occupant moves. This not only illustrates the importance of this component of occupied construction, but also provides a management technique that can be duplicated on large-scale operations.

There are many costs that are not able to be avoided even with planning when operating in occupied spaces. One interview participant noted the need to "spend money to mitigate cost". Paying for the preventive measures in the beginning results in less cost in the end in contrast to the cost of reactionary mitigation efforts. There is an increased cost for noise mitigation materials and built components to provide separation such as temporary partitions and protective materials for existing conditions. In addition to materials there is an increased cost for altered work shifts that may include overtime or night shift differentials. The inescapable cost of doing business in occupied spaces must be priced or budgeted for accordingly. In bringing the materials and labor together, pricing or budgeting should account for the labor to install, remove, and clean those temporary partitions and protection materials.

A significant lesson learned emerged from the interviews: a general contractor finished the project over budget, and the primary driver was a subcontractor that went out of business during the project. The bond was called, but the cost to the general contractor was irrecoverable. The success of contractors is an important factor. A post-project review of the buyout processes can be invaluable to identify successes and failures to be taken into account when moving forward.

Customer Satisfaction

A major component of occupied construction is maintaining customer satisfaction. Unlike new construction projects, customer satisfaction must be maintained throughout the duration of the work, not just with the final product. The customer satisfaction requirement is highlighted because they are closer to the project and sometimes right behind a wall. With the customer in such close proximity, it is important to maintain operations and minimize disruption to occupants.

The first hurdle to overcome is the perception of construction. Identifying with the customer and their feelings can assist the construction manager in maintaining customer satisfaction. The customer does not like the fact that construction is ongoing. The occupants may not know why you are performing work; all they know is that you are altering their method of operations. The construction manager must adopt the mindset that this is the customer's house and be compassionate to their feelings during the project construction. Clients have varying levels of understanding of construction and its impacts. It is the construction manager's responsibility to communicate those items to the client to help them understand everything while minimizing the impact.

Customer satisfaction is focused on keeping people happy and completing the project with a satisfied owner. Throughout the interview process customer satisfaction was identified as a main attribute of a successful project. Construction companies rely on repeat business and making sure that the owner is pleased with the quality of the final product and that their experience is a positive one. This can increase the opportunities for repeat business or references. Creating

a positive experience often requires catering to the owner's needs. Their needs stem from maintaining operations and providing the product they are looking for in the agreed-upon timeframe. The construction manager must be customer relations-oriented to meet their expectations. A customer relations mindset requires honesty, integrity, and keeping the client's interest in the forefront.

The primary technique for customer relations is maintaining their expectations. A common approach is to under-promise and over-deliver or, at a minimum, to do what you say you are going to do. The best method of communication is to have detailed discussions with the owner and follow through with the information that is communicated. During the meetings with the customer, it is imperative to coordinate with the client on the schedule, plans, and approvals.

Planning

Planning is a significant part of occupied construction projects. According to one interview participant, planning is the "most important thing." Planning should be early on and upfront in the project lifecycle. Creating a project plan requires foresight and a proactive approach to develop a plan. Thorough planning activities can mitigate cost impacts by creating a game plan. Conducting these upfront planning activities has costs associated with it and may take months or years, depending on the size of the project. Spending the money at the front end of the project validates its worth because without proper planning, it "will cost you one hundred times that on the back end" according to another interview participant.

The plan has to be a good one. The planning team should consist of the right people. The selection of the project team and leadership is important to build a proper plan. Experienced leadership working in occupied spaces can be a major advantage in understanding how to operate in an occupied environment. A way to make sure the project team is strengthened is to get the contractor on board. Early contractor involvement can confirm constructability and buy-in from the contractor on the plan. Space planning and the logistics to move people cannot be overlooked. Lessons learned highlight clean and organized logistics planning for success.

The project plan should align with the site environment. How will the construction space be separated from the occupants? The flow and access through the building need to be considered and predetermined. The environment requires an evaluation and study before the start of the construction. How do the occupants move around the site? Research is necessary to understand the requirements of the space. Restrictions need to be identified to put together a plan and schedule, which can involve limitations on hours of operation. The construction manager must put in due diligence to make sure everything flows smoothly. Utilizing the information gained through research, the project team can forecast the impact of the proposed actions, and decisions can be made to finalize the plan to execute it with the least amount of impact on everyone involved. It is good practice to draft the plan on paper before putting it into action in order to step back and evaluate the potential effects.

The occupied environmental review requires inclusion of the occupant's schedule to create a formal project schedule. Occupied construction requires putting addition levels of detail into a project schedule's breakdown. A more detailed work breakdown structure provides a plan for sequencing activities. It is advised to utilize every hour of the day in an occupied environment or whatever time is available to minimize time in the space. A project preconstruction meeting can be a platform to go over the plan to ensure the outline is followed.

Periodically it is advised to go back and re-analyze the plan and see what is working and what can be improved. The plan will need to be reworked for unforeseeable items. Nothing ever goes exactly as

planned in the field. In phased projects, the transition from phase to phase provides the opportunity to conduct a lessons-learned application to plan the subsequent phases.

The best strategy for construction planning is to have a strategy. Conducting operations in occupied spaces requires outside-the-box planning. It was noted by one interviewee that “some of the brightest people work in the occupied renovation” sector.

Fire/Life Safety/Utilities

Considerations for fire/life safety plans are usually provided to a general contractor in a pre-approved plan. It is important to follow a plan that has been approved by the Authority Having Jurisdiction (AHJ). Beyond the plan, the contractor needs to maintain a position of safety for the occupants during all aspects of the project and also to avoid interruptions to service. Apart from the procedures discussed in the research, the manager should refer to local code elements for lighting and clearances and other fire/life safety requirements.

During the course of the construction, the contractor utilizes a number of tools and materials to separate the construction space and the occupants. Barricades may change or alter pathways that modify the occupants' egress pathway. Contractors and owners need to plan for alternate routes and provide advance notice of changes. If the changes to the pathway are not part of a pre-approved plan from the AHJ, the plan must be reviewed by the Fire Marshal. Changing routes needs to be physically done correctly and with the right materials. Temporary shifts can use cones or caution tape. Long-term modifications need more substantial barriers. Tunnels are routinely used to protect pedestrians when overhead work is taking place. Changes in egress paths need proper identification with exit signs. The changes to the environment need to be properly communicated to the building occupants with clearly marked signage. Emergency procedures need to get occupants out safely when an egress path meshes with the construction site. An emergency egress should lead to a rally point that must also be shared. The comingled work site and pedestrian areas must be clear of construction debris for the safety of all in emergency situations.

Performing construction in occupied environments presents the hazard of accidentally cutting off utility services. A focus should be directed toward mechanical, electrical, and plumbing (MEP) systems for the occupant's operations. Renovation projects inevitably have to interact with the building utilities. Beyond building services, it is even more important to not affect life safety utility operations such as sprinkler systems and emergency lighting. Errors in an unoccupied space may be an inconvenience, but unscheduled outages affect the operations of the customer. The contractor's mindset is that services must stay on and that mistakes are not an option. At some point in time utilities will overlap from ongoing building operations and the construction site. The construction manager can coordinate with the client to help him understand the impact of the work and whether the utilities may be down for a couple of hours. Depending on the duration and type of operations, the owner may require temporary utility systems in place. When conducting outages, it is advisable to always have a backup plan, which may include spare parts or temporary systems for system restoration as required. Outage coordination is such an important activity that a dedicated planning meeting can be a strategy for success.

Prior to any interaction with building systems, industry professionals suggest metering and testing in advance to validate the status of the system's performance. The engineering drawings may provide guidance, but no assumptions should be made when interacting with building systems. Utilizing a project risk assessment was cited as a technique to identify the potential impacts on a building system.

Some facility organizations utilize permits to track and manage building system interactions as a matter of control. As-built information varies in reliability. Industry best practices trace out field conditions to verify them as built documentation. When planning for building outages, construction managers can evaluate the scheduled work to condense outages to minimize their impact on occupants. An example shared during the interview process involved a project team building a full building utility shaft and performing a single switchover to the new utility risers for a single event.

Contractor Management

Executing a successful project requires a variety of contributors, including contractors and tradesmen. Managing those contractors and subcontractors to work effectively and efficiently can make the difference in a project's success. Many industry professionals cited project failure due to a lack of contractor oversight, not following up on their work, and not putting controls in place to stay on top of the contractor. It is a matter of supervision, especially of critical activities. The project manager is the authority on the project, and allowing the contractors to control the project is a recipe for disaster. When the contractors work or if the schedule does not look right, it is the project manager's responsibility to question the contractor. For each project and each contractor, identifying how to get the desired performance is a challenge. Successful construction managers identify what works for each contractor and adapt as needed.

Having a quality contractor is vital to the project team, i.e., a contractor that takes ownership of their project responsibilities and is a partner. An adversarial owner/contractor or prime/subcontractor relationship makes all aspects of the project difficult. The key is to find a contractor who insists on meeting expectations, is committed to quality, and is flexible. The adversarial relationship mentioned above could stem from the contractor submitting many change-orders in order to take advantage of the owner. These complications result in projects being over schedule and over budget. In contrast, contractors who work through changes with the owner find commonality in a shared direction to deliver the project and come in on schedule and under budget.

It is good practice to conduct an analysis of contract buyouts post award and at the project's completion. A collection of lessons learned on the buyout process can identify keys to make future bid evaluations. One example is related to forecasting the contractor's ability to deliver the project at the bid value. When contractors submit fair bids, everyone can be successful. Prequalification can be a successful strategy to maintain a short list of vendors that meet the standards of the company performing the buyout. Retaining contractors that have delivered successful projects eliminates the uncertainty of open bid scenarios.

Contractor manuals are often utilized to communicate specific information on a facility. A written document of procedures and guidelines provides the contractors with an understanding of the facility, the site specific safety inputs, and other environmental specifics to conduct operations. The contract documents are able to cite the standardized manual to supplement the contract terms. An example of specific information on a project site housed in a contractor manual addresses space boundaries. The manual establishes restrictions on the contractor personnel for access to parts of the facility. In general, industry guidance limits contractors to the location's site work and service areas. This requirement segregates contractors from pedestrians to eliminate interaction that could cause unnecessary issues. The policy referenced has a zero tolerance enforcement. If the rules are not followed, the contractor is removed from the facility. Another aspect of this control is contractor identification. All contractors are

required to wear safety vests with the contractor's name on the back to remove anonymity.

Many contractors and owners utilize web-based tools to house and communicate project information. A sample tool is Autodesk's Constructware. The software is a construction technology solution platform for project management and information sharing. Software solutions offer a shared database to submit and house Requests for Information (RFI), submittals, approvals, drawings, and other construction documents. The transparency of a shared tool provides a distinct advantage for the owner, contractor, and subcontractors.

CONCLUSION

Conducting construction activities in occupied spaces leads to unique challenges in an effort to maintain a balance between building

operations and completing the project. The desired results for occupied construction projects remain unchanged as revealed by industry professionals, i.e., to deliver on schedule and under budget to a satisfied owner. The challenge lies in how to deliver with the additional challenges of an occupied environment. The data collected through industry interviews revealed the critical focus areas that are deemed critical to quality when performing construction activities in occupied spaces. The industry leaders' responses highlighted the schedule, cost, customer satisfaction, planning, fire/life safety and utilities, and contractor management as the formula to successfully deliver occupied construction projects. A collection of management techniques, procedures, and strategies were extracted from the data analysis of the top six themes to apply to each of the critical focus areas. Construction managers can reference the summarized data to apply industry knowledge to better plan and manage construction projects in occupied spaces.

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