

Psychiatric Hospital Commercial Design-Build

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1. Case Study Method

The Project Case Study Method involves an in-depth examination of a single project, the case. It provides a systematic way of looking at events, collecting data, analyzing information, and reporting the results. Case Studies are one of the most effective tools you can use to promote best practices and cost-effective, experiential training. A recent search on Google.com for the term “case study” showed over 15 million hits. Of those hits, almost 750,000 hits included references to Java, which demonstrates a phenomenal uptake in the IT industry. Like its close cousin the White Paper, case studies appear to be growing in popularity every year.

1.1. NORA Goal 10

This Case Study was developed under a Cooperative Agreement with NIOSH in support of the National Occupational Research Agenda (NORA), Goal 10. Goal 10 is concerned with improving understanding of how construction industry factors relate to injury and illness outcomes; and increasing the sharing and use of industry-wide practices, policies, and partnerships that improve safety and health performance (NIOSH, 2013).

More specifically, the aim of NORA Goal 10.1 is to: Analyze how construction industry complexity and fragmentation can affect safety and health performance. Evaluate safety roles, responsibilities, interactions, and oversight among the multiple parties involved with complex construction projects. Address regular and accelerated construction project lifecycles. Identify obstacles and opportunities for improving system performance.

National Institute for Occupational Safety & Health. (2013, April 24). “NORA Construction Sector Strategic Goals.” Retrieved from <http://www.cdc.gov/niosh/programs/const/noragoals/Goal10.0/>

1.2. Case Study Design

The research adopted a comparative case study approach (Yin, 1994). Data were collected from a total of 23 construction projects, 10 in Australia/New Zealand and 13 in the United States of America. For each project, features of work were purposefully identified by project participants in consultation with the research team. Features of work were selected as the unit of analysis because they presented a particular health and safety problem or challenge.

“Features of work were selected as the unit of analysis because they presented a particular health and safety problem or challenge.”

For each feature of work, comprehensive data was collected to capture decisions that were made in relation to the design of the feature of work, the process by which it was to be constructed and the way that health and safety hazards were to be addressed. Data were collected by conducting

in-depth interviews with stakeholders involved in the planning, design and construction of the selected features of work. These interviews explored the timing and sequence of key decisions about each feature of work, and the influences that were at play as these decisions ‘unfolded’ in the project context. During the course of the research 288 interviews were conducted (185 in Australia and 103 in the USA). The average number of interviews per feature of work was 6.7.

Projects chosen for data collection represent four different construction sectors (residential, commercial, industrial, and heavy) as well as four different delivery methods (Design-Bid-Build, Design-Build, accelerated, and collaborative). This was done to help determine the role OSH plays in each type of construction project. The projects were then placed on a matrix. Figure 1 represents the 14 projects studied within the United States with the project featured in this case study highlighted in yellow. Figure 2 shows where American and Australian projects overlap on the matrix.

Figure 1: Matrix of American projects

	Residential	Commercial	Industrial	Heavy
Design-Bid-Build	Roanoke House	Dining Hall	Wastewater Tank	Highway Expansion
Design-Build	Blacksburg House	Psychiatric Hospital	Server Farm	New Highway
Accelerated	Blitz Build	Football Stadium	Chemical Plant	Bridge Project
Collaborative	Mountain House	New Hospital	Coal Plant*	Coal Plant*

**Note: The coal plant project is considered to be both an industrial and a heavy construction project.*

Figure 2: Overlap of American and Australian Projects

	Residential	Commercial	Industrial	Heavy
Design-Bid-Build	US	AUS+US	US	US
Design-Build	AUS+US	US	AUS+US	AUS+US
Accelerated	US	AUS+US	AUS+US	AUS+US
Collaborative	US	US	US	AUS+US

From: Wakefield, R., Lingard, H., Blismas, N., Pirzadeh, P., Kleiner, B., Mills, T., McCoy, A. & Saunders, L. (2014). ‘Construction Hazard Prevention: The Need to Integrate Process Knowledge into Product Design’. Paper presented at the CIB W099 International Conference: Achieving Sustainable Construction Health and Safety, 2-3 June 2014 Lund, Sweden.

1.3. Case Study Analysis

Dependent variable

Data was collected about OSH hazards and the risk control solutions implemented within the case examples. This data was elicited during the interviews and supplemented with site-based observations and examination of project documentation (e.g. plans and drawings). For each feature of work, a score was generated reflecting the quality of implemented risk control solutions. This score was based on the hierarchy of control (HOC).

The Hierarchy of Control classifies ways of dealing with OSH hazards/risks according to the level of effectiveness of the control

The hierarchy of control (HOC) is a well-established framework in OSH (see, for example, Manuele, 2006). The HOC classifies ways of dealing with OSH hazards/risks according to the level of effectiveness of the control. At the top of the HOC is the elimination of a hazard/risk altogether. This is the most effective form of control because the physical removal of the hazard/risk from the work environment means that workers are not exposed to it. The second level of control is substitution. This involves replacing something that produces a hazard with something less hazardous. At the third level in the HOC are engineering controls, which isolate people from hazards. The top three levels of control (i.e., elimination, substitution and engineering) are technological because they act on changing the physical work environment. Beneath the technological controls, level four controls are administrative in nature, such as developing safe work procedures or implementing a job rotation scheme to limit exposure. At the bottom of the hierarchy at level five is personal protective equipment (PPE) – the lowest form of control. Although, much emphasized and visible on a worksite, at best, PPE should be seen as a “last resort,” see, for example Lombardi et al.’s analysis of barriers to the use of eye protection (Lombardi et al. 2009). The bottom two levels in the HOC represent behavioral controls that they seek to change the way people work (for a summary of the limitations of these controls see Hopkins, 2006).

Each level of the HOC was given a rating ranging from one (personal protective equipment) to five (elimination). The risk controls implemented for hazards/risks presented by each feature of work were assigned a score on this five point scale. In the event that no risk controls were implemented, a value of zero was assigned.

Independent variable

Social network analysis (SNA) was used to map the social relations between participants involved in making design decisions about each feature of work. SNA is an analytical tool to study the exchange of resources between participants in a social network. Using social network analysis, patterns of social relations can be represented in the form of visual models (known as sociograms) and described in terms of quantifiable indicators of network attributes. In a sociogram, participants

are represented as nodes. To varying extents, these nodes are connected by links which represent the relationships between participants in the network.

SNA has been recommended as a useful method for understanding and quantifying the roles and relationships between construction project participants (Pryke, 2004; Chinowsky et al. 2008). The technique has been used to analyse knowledge flows between professional contributors to project decision-making (see, for example, Ruan et al. 2012; Zhang et al. 2013). Network characteristics have also been used to explain failures in team-based design tasks (Chinowsky et al. 2008) and identify barriers to collaboration that arise as a result of functional or geographic segregation in construction organizations (Chinowsky et al. 2010). More recently, Alsamadani et al. (2013) used SNA to investigate the relationship between safety communication patterns and OSH performance in construction work crews.

In order to gauge the construction contractor's prominence in a project social network, the contractor's degree centrality was calculated. Degree centrality refers to the extent to which one participant is connected to other participants in a network. Thus, degree centrality is the ratio of the number of relationships the actor has relative to the maximum possible number of relationships that the network participant could have. If a network participant possesses high degree centrality then they are highly involved in communication within the network relative to others. Pryke (2005) argues that degree centrality is a useful indicator of power and influence within a network.

Degree centrality can be measured by combining the number of lines of communication into and out of a node in the network (see, for example, Alsamadani et al., 2013). This presents an aggregate value representing the participant's communication activity. However, the independent variable used in this research was calculated using only the construction contractors' outgoing communication. This was a deliberate choice because the research aim was to investigate whether OSH risk control is of a higher quality when project decisions are made with due consideration of construction process knowledge. Thus, the flow of communication from the construction contractor to other network members was deemed to be of greater relevance than the volume of information they received.

From: Wakefield, R., Lingard, H., Blismas, N., Pirzadeh, P., Kleiner, B., Mills, T., McCoy, A. & Saunders, L. (2014). 'Construction Hazard Prevention: The Need to Integrate Process Knowledge into Product Design'. Paper presented at the CIB W099 International Conference: Achieving Sustainable Construction Health and Safety, 2-3 June 2014 Lund, Sweden.

1.4. Benchmarking and Best Practices

Benchmarking is a powerful management technique that can be used to improve an organization's performance by searching for a partner organization that is the best at a given process and constantly adapting or adopting the partner's practices to increase performance (Kleiner, 1994). The process to be benchmarked is usually determined by analyzing performance figures and other data. A process that has relatively low performance figures and could be improved is often chosen to be benchmarked. Demand for benchmarking comes from several sources, such as increasing enforcement activity, regulations, investor and liability concerns, customer perceptions, and competition with other organizations. The results of effective benchmarking include increased productivity, efficiency, employee morale, and a competitive advantage.

The benchmarking process can be divided into five stages: Planning, analysis, integration, action, and maturity. During the planning stage, the organization identifies the process that needs to be benchmarked. This selection is usually done to fulfill a predetermined need, such as boosting performance figures in an area that needs improvement. Measurable performance variables are also identified. Benchmarking partners are selected based on their best-in-class performance in the targeted process. The partner does not necessarily have to be in the same industry. The organization concludes the planning stage by determining the data collection method and collecting the data. It is important for the organization to be able to distinguish between ethical and unethical means of data collections, especially if it involves handling sensitive information from the partner company.

During analysis, the organization determines the current performance gap for the process that will be benchmarked. The team then predicts future performance levels.

The integration stage involves the organization communicating their benchmark findings. Communication is crucial during this phase of benchmarking, especially when seeking approval from those with more organizational authority. Operational goals and plans are established from the benchmarking findings.

The action stage is characterized by implementing practices, monitoring progress and results, comparing results to stakeholder needs, and adjusting the benchmark goals as necessary. Since benchmarking is a continuous process, the last step will certainly be repeated as industry standards and the needs of stakeholders change over time.

A benchmarking process reaches the maturity stage after the best practices are fully implemented into the targeted process. While benchmarking begins with management, the employees involved in the process are the ones who ultimately integrate the new process.

Kleiner, B. M. (1994). Environmental benchmarking for performance excellence, Federal Facilities Environmental Journal, 5(1), 53-63.

1.5. Learning Objectives

- ✘ *Understand sociotechnical systems complexities of a construction work system*

- ✘ *Understand different sectors, delivery systems, and cultures*

- ✘ *Understand project and industry supply chain and work system complexities*

2. New Psychiatric Hospital

2.1. Overview

The project involved in this case study was the construction of a new psychiatric hospital. There was a large amount of discussion on the front end of the project about how many stories to make the facility. As a mental hospital, there was a group from the medical side that advocated for a one story building for care-giving purposes. The state had recently completed another similar facility however, and had reservations about this option because of how spread out the facility would be. It was decided that a two story facility could be built in which each wing was mirrored on each story, but that three stories would be too many stairs for personnel and patients.

The building design was configured with three enclosed outside courtyards. The courtyard walls were pre-cast concrete panels to match the exterior façade of the rest of the building. One difference between the interior courtyard design and the building exterior were larger windows on the exterior allowing more natural light in for patients without access to the courtyards. The diversity of window sizes affected the design solution by reducing panel standardization and resulting in additional panels of varying sizes and increased complexity in panel connections.

2.2. Project Profile

2.2.1 Case Background

The original psychiatric hospital opened up in 1828 as the state's primary care-giving facility for the mentally ill (VA DBHDS, n.d.). The hospital's first director was a strong believer in "moral medicine," which emphasized that even the most severely ill patients could be rehabilitated through a comfortable and peaceful environment. The first campus featured beautiful neo-classical architecture and an abundance of green spaces. Towards the end of the 19th century, the facility started to become overcrowded and more forceful techniques of patient control were used. Straitjackets, isolation, frontal lobotomies, and even sterilization were practiced by hospital staff well until the 1970's. By 1950, a new site was opened adjacent to the current hospital's site and the old campus was vacant by the 1970's. The original site was used as a medium security men's prison and then abandoned. The original site's downtown location is ideal for developers, and there are already plans to redevelop and restore the campus into condominiums.

The hospital also has a history of working with higher education institutions. Since 1978, the University of Virginia has associated itself with the hospital by offering joint faculty appointments and training experiences for students.

The idea for a new hospital was first brought up in 2005 in a discussion between the city and the state (Graham, 2009). This state was particularly interested in building a new hospital since the current, 24 building campus was aging and becoming inefficient to operate. The campus was built to handle a peak population of 3,300 in 1963, but by 2005 patient enrollment had dropped to around 245. New models of care-giving that centered on the individual patient were harder to implement on a sprawling campus that was built to 20th century care-giving standards.

In 2008, the general assembly agreed to contribute \$110 million towards the construction of a new mental hospital. The state also made a deal with the town where the town contributes \$15 million and the deed to 66 acres of open land next to the current hospital site. In exchange, the hospital agreed to give the town the old hospital's 250 acre site, which was prime commercial real estate, after construction of the new facility was completed.

Unlike the previous two sites that offered a campus-like atmosphere with multiple buildings, this new facility is contained within one building. The new hospital departed from the old model of care-giving by placing an emphasis on patient safety, healing, and dignity. Classrooms, private rooms, and a small shop with donated clothes and accessories are available to the hospital's 250 patients. Large windows give patients views of the mountain landscape while also allowing hospital staff to keep an eye on patients.

Ground was broken on December 1, 2009. At that time, construction was projected to last until spring of 2013. The official ribbon-cutting ceremony for the finished building was held on September 25, 2013. Patients and staff began moving into the new facility on October 29, 2013.

Graham, C. (2009, December 1). Groundbreaking development at new WSH. *Augusta Free Press*. Retrieved from <http://augustafreepress.com/focus-groundbreaking-development-at-new-wsh/> on 1 August 2014.

Virginia Department of Behavioral Health and Developmental Services. (n.d.). Western State Hospital. Retrieved from <http://www.wsh.dbhds.virginia.gov/history.htm> on 1 August 2014.

2.2.2 Case Narrative

Pre-cast Concrete Panel Design

To match other buildings and for cost-saving purposes, pre-cast concrete panels were chosen for the outside façade of the building. The only other option explored was using pre-cast concrete panels to window sill height ($\pm 3'-6"$) and then use cement plank siding on metal stud framing above the present height. For aesthetic reasons, the architect advocated against the siding option.

The building design was configured with three enclosed outside courtyards. The courtyard walls were pre-cast concrete panels to match the exterior façade of the rest of the building. One difference between the interior courtyard design and the building exterior were larger windows on the exterior allowing more natural light in for patients without access to the courtyards. The diversity of window sizes affected the design solution by reducing panel standardization and resulting in additional panels of varying sizes and increased complexity in panel connections.

The decision was made to have the pre-cast concrete panels manufactured to the full building height where possible in order to minimize the total number of deliveries and lifts required for installation. This was a scheduling decision, but it did also have an effect on safety since fewer deliveries and lifts mean fewer opportunities for incidents.

Shear Wall Design

The original building design included a shear wall design requiring shear panels to have a direct connection to the footing. Non-load bearing panels were designed to connect to a one foot high concrete stemwall. The CM and pre-cast panel subcontractor made a recommendation during the construction drawing phase to eliminate the stemwall and connect all panels to the foundation. This increased panel lengths by one foot and allowed elimination of the concrete stemwall. The PM said this eliminated remedial jack-hammering and sawing of the stemwall to vertically align all panels.

The net effect is faster and safer construction. This decision was made primarily due to constructability and scheduling, and the CM said the original design could have been made to have direct footing connections.

Pre-cast Panel Installation

One of the key decisions that affected the panel installation was the logistics of the structural steel erection. It was decided by the CM to start installation at one building wing and work clockwise wing by wing. This plan allowed the panels to be installed simultaneously with the wing framing once the structural steel frame and concrete floor slabs were complete. Slab completion was needed to provide internal strength for the steel frame and embed plates for panel connections. The subcontractor's fabrication schedule was set according to this plan allowing panel installation to closely follow steel erection.

Construction Schedule

One important decision affecting the pre-cast panel installation and construction schedule is crane selection and placement. Option #1 was to use a smaller crane that could enter the courtyard through a gap in the steel frame. Option #2 was to use a larger crane that could lift the pre-cast panels over the building and into the courtyard to be set in their final position. This option has increased safety implications because panels would have to be lifted blind over the building. The CM's decision was to use an 80-120 ton crane could be used to perform blind lifts into the smaller courtyards since they were close enough to the outside of the building and it was only two stories. Each courtyard required thirteen 20 ton full-length panels and 10-12 smaller panels around the windows. Scheduling also played a part in this decision, as the CM wanted to minimize crane movement and setup. The CM said not installing panels on the outside of the building to prevent blind lifts would have impacted the schedule too severely to be feasible. A gap in the steel frame construction was left for a crane to be placed within the large courtyard, as it was beyond the selected crane's reach. The large 80-120 ton crane was used for the outside of the building and large courtyard, while a smaller crane was used to place panels within the two smaller courtyards.

The CM said his decision was based on balancing cost effectiveness and schedule with safety management, and they concluded that blind lifts are a fairly common condition for crane operators and hazards could be mitigated via administrative controls, such as communication over walkie-talkies. One controlling factor voiced by the CM was to minimize large crane rental time, and thus both of the interior courtyards were all set at the same time.

Hoisting

In order to attach the pre-cast panels to the building structure, adjustable connections were designed into the panels so that they could be adjusted into their final position without remaining suspended by crane. The panels could be disconnected from the crane after it was bolted in at the adjustable connections and spot welds were made. A common feature of pre-cast concrete panels is that temporary bracing and lifting eyes are structurally integrated into the panel's design, so installation can be as efficient and safe as possible. The one aspect of the panel installation that had to be determined was how workers would connect the panels to the frame at height. Lifts or ladders were an option, but the most cost-effective and safest option was to have all workers weld the inside of the panels from the second floor slab or roof while being tied-off.

The administrative controls implemented for the blind lift plan were roping off the wing where the blind lifts were occurring and using horns to alert workers that the lifts were ongoing. These were in addition to the Job Safety Analysis plans, site safety plans, tailgate meetings, safety orientations, and PPE requirements that were required of all subs by the CM. One aspect of the CM's safety management program that was different from others was that sections of the building were assigned to members of management (PM, assistant PM, superintendent, project engineers) in which they were in charge of safety. This meant that they had to complete safety audits of their area and generally ensure that safety was a focus for workers in their area.

Equipment Screen Construction

One of the major concerns of the owner and their designers was the visible aesthetics of rooftop HVAC equipment. The owner therefore required that the HVAC units be screened from view. There were three screening options. One option was to construct a screen of some type of material that matched the building around each unit. The owner did not agree for aesthetic reasons and requested a perimeter screen to be designed around the edge of the roof.

Parapet Design

During the design stage, the original standard standing seam design for the roof of the facility was changed to a flat roof with a PVC membrane based on input from the CM and cost. The roof parapet was designed below 42 inches and by building code was not considered a roof barrier. The CM, PM, and assistant PM said that this was done for cost reason, and the parapet height was reduced to sufficiently allow only the roof flashing and coping, effectively reducing pre-cast wall panel lengths.

Equipment Screen Design

Two screening options were explored. Option #1 was installing metal louver screens that allow wind to pass through and Option #2 was installing solid white metal sheeting. The metal sheeting was selected based on the higher cost of stabilizing the more extensive louver supporting system during high winds.

The roof screen estimates were higher than the owner had expected. A cost allocation discussion was held among stakeholders regarding perimeter screen costs and best use of funds for more interior features. These discussions led to a screen option; eliminate full perimeter screen and replace with screens localized around each HVAC unit. This caused a framing redesign requiring additional roof beams installed to support the frames at these locations. The steel frames designed would typically attach directly to the building columns. This was not an option on this building because the design required the frame to be bolted to the roof using a steel base plate. The design called for bolts at each of the base plate corners. The steel erector would have preferred to install the entire vertical and horizontal framing before the roof system was installed. The erector said that they were not getting involved early enough for this to happen and so they left vertical posts sticking through the roof where they knew each frame would go. The CM stated that they preferred just the vertical posts regardless to minimize steel frame erectors' exposure on the roof while it was unprotected.

Roof Edge Protection

The CM said that a full guardrail system was not required and had a series of perimeter cables installed by the steel erector for fall protection during roof deck installation. Workers were required to tie off to these cables during roof deck construction. The perimeter cables were systematically

removed as the roof installation progressed, and a leading edge system using flagging and a competent person monitor was put in place for the remainder of roof deck construction. Workers were then required to tie off to the roof screen for work access beyond the flagged perimeter. The final roof screen designs served as fall protection for maintenance workers inside the screens after construction and the posts as tie off points when workers needed to get outside of the roof screen structure.

Façade Construction

The steel panel screen assembly was done on the roof, where the screens were then mounted to the existing roof structure. While assembling and installing the screens, workers faced risks of overexertion and bodily reaction as well as falls to lower level. The first hazard was solved with training as an administrative control while fall arrest systems were used along the roof perimeter in response to the second hazard.

2.2.3 Stakeholders

Internal supply for this project came from several sources. The CM was part of the project's DB team, was responsible for hiring and managing trade contractors, and oversaw site safety during construction. The architect of record was also a member of the DB team and was responsible for designing the outside of the building, which included the pre-cast concrete panels and the design of the roof screen to conceal the rooftop HVAC units. There also was a functional architect who was responsible for designing the facility's interior in a way to optimize caregiving for the patients. The structural engineer designed the foundation and the steel structure and the mechanical and electrical engineers designed the building's HVAC and electrical system based on their own calculations.

The DB team also hired trade contractors for the project. The pre-cast panel manufacturer and erector worked with the DB team to determine panel requirements such as windows and doors that would prevent using full-height panels. As a materials supplier, the sub was also responsible for delivery of the panels to the site and installation. The steel frame fabricator and installer worked with the structural engineer to develop a sequencing process before delivering and installing the steel frame. The roof installation sub installed the roof based on the design. After roof installation, the air unit sub installed the rooftop HVAC equipment based on the mechanical engineer's specification.

Internal demand came from three different sources. The state's Department of Mental Health was the client for this project. They manage all hospitals in the state and made the ultimate decision on the design and construction of the new facility. The Hospital's employees, including doctors and nurses that worked in the previous facility, were the main drivers for the hospital layout and patient rooms. The decision to make the hospital as few stories as possible for ease of use was largely based on input from these employees. Patients in the hospital were end customers after the facility was completed.

There were also two external public and one external private stakeholder for this project. The two public stakeholders were the local town and state governments. The state government gave the final approval for the project by approving the budget. The local town government gave the hospital the 66 acres of land for the new site along with \$15 million for construction costs in exchange for ownership of the 275 acre old hospital site once the new building was complete (Stuart, 2013). The town also sent officials to conduct relevant inspections prior to opening. The private stakeholders

were the local residents that lived and commuted near the site. While the construction slightly affected some local traffic, there were also interactions between local residents and the large delivery trucks.

2.2.4 Project Objective

The objective of this project was to construct a new psychiatric hospital to replace the old outdated facility. The facility was designed to depart from the old model of mental health caregiving by offering an open environment that promotes safety, dignity, and healing.

2.2.5 Sector x Delivery System

This project is an example of commercial Design-Build (DB) construction.

2.2.6 Features of Work

Three notable features of work were identified within this project. These features of work are the concrete pre-cast panels, roof construction, and façade construction.

3. Problem

3.1. Context

The purpose of building a new hospital was to replace the aging older facility. The former site for the hospital was more of a campus layout with multiple buildings that were constructed in the early 1950's. Aging buildings and declining enrollment meant that it would be impractical for the hospital to continue maintaining a 60 year old, 24 building campus.

The new building's design called for pre-cast concrete panels to be used on the exterior and courtyard walls. The panels were made to be full building height wherever possible in order to reduce the number of truckloads needed for deliveries. Due to the shape of the building, this meant that installation of the panels would have to be sequenced with the erection of the structural steel and it was possible that some panels would have to be installed using blind lifts.

The design also featured rooftop HVAC equipment, which the owner wished to have concealed from view. The design team came up with several different alternatives to conceal the HVAC units.

3.2. Objectives

The new building was designed to be logically laid out to enhance care-giving services for the patients. A two floor layout reduced the number of stairs that patients and hospital personnel would need to climb. Nurse stations and patient rooms were located in a manner to reduce travel times for hospital staff and allow for more time to be spent with patients. Adding in three enclosed courtyards also provides patients with access to the outdoors and natural lighting while allowing the staff to maintain a level of safety and security.

The CM decided on using blind lifts to simultaneously set the panels for the smaller two courtyards. This decision was made by balancing cost and scheduling versus safety. The CM felt that blind lifts were common and could be controlled with administrative controls. Delaying the installation of exterior panels until the courtyard was complete would have set the schedule too far back.

One option to conceal the HVAC equipment from view was to surround each individual unit with panels that matched the rest of the building's exterior. The owner did not like the looks of this option and preferred to have screens installed along the full perimeter of the roof. Metal sheeting was chosen over louver screens because the louvers would need extra bracing for stability during high winds. A cost-allocation discussion led to the decision to have the screens around the HVAC units instead of along the entire perimeter, in order to save money to use for more interior features.

4. Results

4.1. Safety-Critical Decision Making

A construction project consists of multiple components that all have different decision-making processes. For each project, different decisions from the earliest planning stages through construction all have an impact on occupational safety and health (OSH) based on how the hazards are controlled.

During the planning stage, a two-story layout was chosen for the building. A one-story layout was preferred by the hospital, but it would have a large footprint. A layout with three stories or more would be more expensive to build and the stairs would be too much for patients and hospital staff. After the layout was determined, the project team was able to create conceptual drawings, hire a pre-construction services firm, and hold constructability reviews to help make decisions about the building design. For the exterior façade, pre-cast concrete panels were chosen over brick and metal sheeting. This decision was made because of the panels' low cost, constructability, and commonality with other buildings in the region. Courtyards were included in the design to maximize natural lighting into the building and allow outdoor space for patients. Having the courtyards completely enclosed by the building enhanced patient security and privacy. The courtyard walls consisted of the same pre-cast panels as the exterior of the building. One option for the courtyard walls was to have the panels go up to window sill height with siding continuing up to the full building height. The architect did not like how this option looked on the design, so the panels were designed to full building height. The design of the building also included rooftop HVAC units. Instead of leaving the rooftop units exposed, the owners wanted to have them screened from view.

During the design and procurement stage, the project team went into greater detail on the pre-cast exterior panels. The panels on the exterior of the building were all designed to be full building height and rest on the footing. This decision was made with input from the CM and panel designer. Using full-size panels where possible allowed for fewer deliveries, fewer crane lifts, lower cost per panel, and quicker installation. Installing the panels clockwise around the building instead of from the inside out meant that the overall lifting schedule was shorter. For the cranes, an open path was left for the big courtyard but not for the two smaller courtyards. The open path permitted a smaller crane to be moved inside the larger courtyard while a larger 80-100 ton crane was used for the smaller courtyards.

The project team also worked on the design for the rooftop HVAC screens. Initially, a screen around the full building perimeter was chosen since the aesthetics of screening each individual unit did not please the owner. Later on in the design, there was a cost-allocation discussion which led to the screens being redesigned to follow only part of the building perimeter around the rooftop units. The roof was originally a standing seam metal roof but this was changed to a flat roof with PVC

Decisions, Decisions: Quick View

Thom's table here

membrane on metal decking for cost-saving purposes. The roof parapet was designed to be minimum height (42 inches) to minimize the height of the pre-cast concrete panels therefore reducing costs. Two options for the roof screen material were louver screens or solid metal sheeting. Louver screens were considered, however they would require extra stabilization during high winds. Cost estimates from the steel supplier indicated that solid sheeting would also be less expensive to use.

During the construction phase, the CM decided to use blind lifts for installing the courtyard wall panels. While it was possible to install the courtyard panels before the rest of the exterior panels, this would have set the schedule too far back. The CM stated that blind lifts are normal for construction projects. Additional safety controls for the blind lifts included a Job Safety Analysis, site safety plan, area safety audit, horns for the crane, and roping off of the area underneath the crane. Workers installed the panels from the 2nd floor deck and rooftop and were tied off. Compared to using ladders and lifts, this process was less expensive, safer, and still met OSHA regulations for fall protection.

The rooftop screens required a support frame that needed to be tied into the rest of the building's structure. Vertical posts were installed before the roof was complete to which the steel frames attach to. This process was chosen due to cost, constructability, and ensuring quality. Fall protection for the roof construction consisted of perimeter cables. This option had a shorter installation time than guardrails while still offering adequate fall protection and compliance with OSHA regulations. Input from the CM and steel erector, JSA's, safety audits, and site safety plans also influenced this decision. A leading edge system served as final fall protection after the roof was complete. Tie-off points outside of the roof screen were installed for workers and future maintenance crews who needed to work outside of the screens.

4.2. Hierarchy of Controls

Elimination is considered to be the most effective form of hazard control, which makes it the most desirable from an OSH standpoint. There are two examples of elimination being used during this project. Having workers attach the pre-cast panels from the second floor deck instead of from lifts and ladders eliminated the fall hazard. The design of the roof screen also eliminated the fall hazard by serving as fall protection for workers working on the rooftop HVAC and drain systems.

If elimination is not a possibility to solve a safety problem, the next desirable alternative is substitution, which could mean substituting in a safer material or a safer process. One example of this was the designer's decision to use a PVC membrane system instead of built-up bitumen roofing. This decision limited worker exposure to harmful substances or environments.

Engineering control is the third most effective form of hazard control. Perimeter cables were installed along the edge of the roof as fall protection. Workers on the roof were required to tie off to these cables while working outside of the roof screen.

Administrative controls were used extensively throughout the project. When the pre-cast panels were being installed via crane, the nearby area was roped off and a spotter with a bullhorn was used for the blind lifts. Workers were trained to properly install the roof screens and avoid overexertion and bodily reactions.

The least effective form of hazard protection is Personal Protective Equipment (PPE), which was a common response for many tasks throughout the project where the above mentioned controls

would not have been possible or economically feasible. Aside from typical worker PPE such as gloves, hardhats, and boots, the most prevalent form of PPE used during this project was a fall arrest system where workers tied off to the perimeter cable installed on the roof during roof deck construction.

4.3. Social Network Analysis

4.4. Project Performance

Groundbreaking for the new psychiatric hospital took place on December 1, 2009. The state's general assembly contributed \$110 million to the project. The town contributed an additional \$15 million and the deed to the 66 acres of land for the new hospital. In exchange for the new land, the hospital agreed to cede the old hospital property back to the town after construction. The state's governor at the ribbon-cutting ceremony described this deal as a "win-win." (Graham, 2009)

Construction on the hospital was completed after almost three years. An official ribbon-cutting ceremony for the new building was held September 25, 2013 (Stuart, 2013). An open house for the general public was held September 28th from 10 a.m. to 3 p.m. Patients and staff moved in to the new facility on October 29th.

It is not known at this time if any injuries or deaths were reported on the site during construction. The new facility did not receive any special ratings or awards.

Graham, C. (2009, December 1). Groundbreaking development at new WSH. *Augusta Free Press*. Retrieved from <http://augustafreepress.com/focus-groundbreaking-development-at-new-wsh/> on 25 July 2014.

Stuart, B. (2013, September 22). Finishing touches being put on the new Western State. *The News Virginian*. Retrieved from: http://www.dailyprogress.com/newsvirginian/news/finishing-touches-being-put-on-the-new-western-state/article_a5c7bc64-22fb-11e3-888e-001a4bcf6878.html

5. Case Evaluation

5.1. Results

The opening of the new psychiatric hospital was celebrated by politicians, local leaders, and mental healthcare professionals (Austin, 2013). One congressman stated, "It's a great day for mental healthcare in Virginia."

Moving the 250 patients into the new facility also allowed for the hospital to release the old property to the city. The old property sits on prime land for commercial storefronts and there are already plans for redeveloping the property.

Austin, A. (2013, September 25). Managers introduce new, improved Western State Hospital. *NBC29.com*. Retrieved from: <http://www.nbc29.com/story/23529741/managers-introduce-new-improved-western-state-hospital>

5.2. Best Practices

Describe the positive aspects of project implementation, the problems encountered and how (if) were they addressed. Describe how other parties could use the solution. Describe best practices that can be adopted or adapted.

(15 to 25 lines)

6. References

Austin, A. (2013, September 25). Managers introduce new, improved Western State Hospital. *NBC29.com*. Retrieved from: <http://www.nbc29.com/story/23529741/managers-introduce-new-improved-western-state-hospital>

Graham, C. (2009, December 1). Groundbreaking development at new WSH. *Augusta Free Press*. Retrieved from <http://augustafreepress.com/focus-groundbreaking-development-at-new-wsh/> on 25 July 2014.

Kleiner, B. M. (1994). Environmental benchmarking for performance excellence, *Federal Facilities Environmental Journal*, 5(1), 53-63.

National Institute for Occupational Safety & Health. (2013, April 24). "NORA Construction Sector Strategic Goals." Retrieved from <http://www.cdc.gov/niosh/programs/const/noragoals/Goal10.0/>

Stuart, B. (2013, September 22). Finishing touches being put on the new Western State. *The News Virginian*. Retrieved from: http://www.dailyprogress.com/newsvirginian/news/finishing-touches-being-put-on-the-new-western-state/article_a5c7bc64-22fb-11e3-888e-001a4bcf6878.html

Virginia Department of Behavioral Health and Developmental Services. (n.d.). Western State Hospital. Retrieved from <http://www.wsh.dbhds.virginia.gov/history.htm> on 1 August 2014.

Wakefield, R., Lingard, H., Blismas, N., Pirzadeh, P., Kleiner, B., Mills, T., McCoy, A. & Saunders, L. (2014). 'Construction Hazard Prevention: The Need to Integrate Process Knowledge into Product Design'. Paper presented at the CIB W099 International Conference: Achieving Sustainable Construction Health and Safety, 2-3 June 2014 Lund, Sweden.