New Hospital

Commercial Collaborative

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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 analyze 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 that 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 Hospital

2.1. Overview

The project featured in this case study was the construction of a new 9 story, 780,000 square foot hospital with a 3 story diagnostic and treatment building. This commercial project was performed collaboratively using Integrated Project Delivery (IPD). IPD as a method of project delivery emphasizes the collaboration and communication amongst stakeholders earlier on in the project. A goal of IPD is strong collaboration that will yield a final product that will better meet the needs of the facility's users.

2.2. Project Profile

2.2.1 Case Background

The idea for a hospital to serve the nearby area was first conceived in 1863 by the German American School Association (Owensboro Health, n.d.(a)). The original hospital building was constructed in 1898 at a cost of $5,200. The new building offered twelve patient rooms in addition to an upstairs operating room. The first patient was admitted in 1899. In 1900, the hospital's first nursing school opened up with 48 new students. The hospital's first surgery was also recorded on the same year. An additional building, the "Annex," was constructed in 1908 which added 25 beds at the cost of $16,000. The hospital continued to grow through the 1920's, with nursing school graduates filling administrative roles within the hospital and teaching roles within the school.

By the late 1930's, the hospital decided to build a new building to meet the increasing healthcare demands of the growing community. The hospital applied for Works Progress Administration (WPA) which was a Depression-era program that helped cities fund projects which would provide jobs for local workers. In order to remain eligible for WPA, the city hospital was required to restructure and partner with the county. This restructuring led to a name change and a new board that included both city and county members. Construction on the new $350,000, 7 story building was started in 1939 and finished two and a half years later. The new facility increased the hospital's capacity to 125 beds.

Three years after the completion of the new hospital building in 1941, there were fundraisers for a new Catholic hospital which opened in 1948. This new hospital operated independently of the city hospital until merging in 1995.

Post-WWII growth prompted further expansion of the hospital facility. In the twenty years following the end of World War II, the hospital constructed new south and east wings, a gift shop, and expansions to older buildings. The original hospital building was also demolished during that period. Another significant change to the hospital was the closure of the nursing school after 69 years and 676 graduates. The old dormitories were converted into patient rooms.

The 1990's was a decade of significant growth for the hospital. The city, county, and hospital entered into an Interlocal Cooperation Agreement in 1991, followed by a merger with the catholic hospital four years later. Construction of a new patient tower, cancer center, heart center,

transitional care center, improved family waiting areas, centralized registration facilities, and connections of the medical plaza to the main hospital structure was completed by 1994. In 1998, the HealthPark was built on the former site of the catholic hospital. The HealthPark is a 100,000 square foot medical-based fitness facility that includes outpatient diagnostic services, physical therapy, medical offices, and a fitness center with a pool, gym, exercise equipment, and classrooms.

The hospital continued to grow into the 2000's, with a final name change in 2003 and the opening of a world-class cancer center in 2004. An assessment of the hospital was conducted in 2006 and looked at the facility's future and the needs of the community. The population of the hospital's eleven county area was aging and the number of patients was expected to grow over the next ten years (Berry & Ellers, 2006). The hospital could either expand the current 57-acre downtown campus or construct a new facility on a larger site. The analysis led to the decision to build a new hospital since it would be unfeasible to expand the current site, where some parts of the facility were over 70 years old. Ground was broken for the new hospital on June 5, 2010. Construction lasted almost three years, with hospital staff officially moving into the new building on June 1, 2013.

Berry, R. B. & Ellers, F. (2006). Should OMHS Build a New Hospital? *Public Life Advocate*. 3(5). 12-15

Owensboro Health. (n.d.(a)) The History of Owensboro Health. Retrieved from http://www.owensborohealth.org/about-us/history/ on 16 July, 2014

2.2.2 Case Narrative

Structural Steel Erection

The new hospital was designed with a steel structure. The beams were lifted into place using a crane. The CM had two columns and a beam attached while on the ground before being lifted into place with the crane. This process meant less lifts were required which reduced the likelihood of a worker being struck. Another benefit was that fewer connections had to be made at height, so the fall hazard was greatly reduced. Fall protection was installed while the beams were being assembled on the ground. D-rings were installed on the steel deck to allow extra tie-off points for workers on the structure.

Interior Wall Framing

The interior headwalls were pre-fabricated at an off-site location. This was done because pre-fabrication was quicker, cheaper, and safer compared to building on-site.

Interior Systems

In a manner similar to the headwalls, rough-in of trades was also done at an off-site warehouse. This was quicker than roughing in on-site since off-site work could already be done by the time the interior of the building is ready for installation of trades. Isolating the construction also eliminated hazards that the workers would have faced if they had roughed in the trades on-site. Shared racks were used for overhead systems because it was cheaper and could be done quicker than using separate racks for each system. Ductwork was also pre-fabricated off-site and brought to the site in large pieces. Before lifting the ductwork into place, as many connections were made on the ground as possible so that fewer lifts were required overall. As a rule, the carts used for delivery had to be able to fit on the lift.

2.2.3 Stakeholders

Internal supply for this project came from a variety of sources. The CM firm was contracted by the client to construct the building based on the designs. The CM also was in charge of hiring subcontractors and supervising the construction process. The architect developed the building's design based on input from the client, the client's representative, and the structural engineer. The representative helped manage the project on behalf of the client. The structural engineer developed the requirements for the building's structure and foundation based on loads and the type of soil on the site. Another engineering firm was in charge of the building's MEP systems, fire protection, and IT. Different subs were hired to install the steel decking, HVAC, electrical, mechanical, and technology systems.

Internal demand for this project came from the client (owner), client's tenants, and the client's customers. The clients were the owners of the hospital who developed the need for the new hospital, approved the overall budget, and were in charge of operating the finished facility. The client's tenants were the hospital staff that gave some input for the design. The common layouts for patient rooms and work areas were designed to optimize efficiency and familiarity for the tenants. The customers were the patients that would visit and stay in the facility once it was complete. One objective of this project was to provide state-of-the-art healthcare for the customers.

2.2.4 Project Objective

The objective of this project was to construct a new hospital facility consisting of a nine story main hospital wing and a three story diagnostics and treatment building.

2.2.5 Sector x Delivery System

This project is an example of a collaborative commercial project delivered using Integrated Project Delivery.

2.2.6 Features of Work

Features of work in this project include structural steel erection, interior wall framing, and installation of interior systems.

3. Problem

3.1. Context

The decision to build a new facility started in 2006 when the hospital realized that it had to expand to accommodate an increase of patients in the next ten years as the region's population grows older (Berry & Ellers, 2006). To accommodate for this growth, the hospital could either add 545,000ft^2 of additional space to the existing 57-acre campus or construct a new hospital. Both options were considered carefully, but the hospital ultimately determined that the existing campus was too old, confined from expansion by surrounding roads and railroad tracks, and that a major renovation project would disrupt operations in the hospital. Building a new facility would allow for more modern technology on par with comparable hospitals, better room designs that would increase the efficiency of the hospital's staff, and more efficient systems that would result in lower annual costs.

Berry, R. B. & Ellers, F. (2006). Should OMHS Build a New Hospital? *Public Life Advocate*. 3(5). 12-15

3.2. Objectives

The new facility was designed with 21st century healthcare standards in mind. Having a common layout for all floors and wings allows for hospital staff to work more efficiently. Modern building technologies translate into lower annual maintenance and utility costs. The project used IPD where all the suppliers worked under one contract. The goal of this is to increase collaboration and allow the project to move along more smoothly.

4. Results

4.1. Safety-Critical Decision Making

The building was designed to be narrow and curve-shaped which, compared to a symmetrical or linear design, looked the best and worked well with the site's topography. Moment braces were used on the building's frame because of the potential for seismic activity. This was also less expensive and labor-intensive than other options including using IC braces or a rigid frame. Tack welds and plates for the curved steel was done off-site by the fabricator. This process is safer and can be done in advance while the site is still getting ready for structural steel erection. During the erection of the steel structure, the CM had workers weld two columns to a beam while still on the ground before it was lifted into place. This meant that fewer lifts and fewer welds at height were required to assemble the structure. A tower crane was used for the hoisting of the steel. A crawler-type crane was also considered, however the geotechnical engineer determined that the ground capacity could not support the weight of the crawler. To reduce fall risks, temporary fall protection for the structure was installed while the beams were on the ground instead of after the beams were placed at height. For additional exterior tie-off points, d-rings were cast in place on the steel deck instead of being drilled in or having workers tie-off around columns.

Decisions, Decisions: Quick View

Thom's table here

For the interior of the hospital, the headwalls were fabricated at an off-site location and delivered to the site. This decision was made because pre-fabrication was safer for the workers (by isolating construction), less expensive, and could be done while the building was still being prepared for the headwalls. In a manner similar to the headwalls, rough-in of trades was also done at an off-site warehouse. This also isolated any hazards associated with roughing in the trades and saved time on construction. Shared racks were used for overhead systems because it was cheaper and could be done quicker than using separate racks for each system. This saved time and money during assembly. Ductwork was also pre-fabricated off-site and brought to the site in large pieces. Before lifting the ductwork into place, as many connections were made on the ground as possible so that fewer lifts were required overall. As a rule, the carts used for delivery had to be able to fit on the lift. This was done in the interest of safety and allowing the delivery process to flow smoothly.

4.2. Hierarchy of Controls

Elimination is the most effective method of hazard control. An example of elimination in this project was having the head walls fabricated off-site. This eliminated the risk of workers coming into contact with objects and equipment that is usually present during head wall assembly. Elimination was also used when the constructor decided to have the fall protection installed on the ground. This eliminated the need for workers to be working at heights unrestrained for any period of time.

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. There were several examples of substitution in this project. When erecting the steel structure, the constructor decided to have two columns attached to one beam while on the ground and have the unit lifted into place with a tower crane. This process required less lifts, so the probability of a worker being struck was much lower. Connecting the columns and beams on the ground also meant fewer connections needed to be made at height. For the interior systems, the rough-ins were done at an off-site warehouse and delivered to the site. This saved time on construction and also lowered worker exposure to the equipment and materials used to do the rough-in. This hazard was also considered when the constructor decided to have the overhead interior systems connected on the ground so fewer pieces had to be lifted into place.

Engineering control is the third most effective form of hazard control. If the hazard cannot feasibly be eliminated or substituted, and engineering control reduces worker exposure to the hazard. Tag lines were used during crane lifts to reduce the likelihood of a worker being struck by object or equipment. The project management team decided to have d-rings tied into the steel deck, which reduced the probability of a worker falling to a lower level. Shared racks were required for the interior systems, which reduced worker contact with objects and equipment. Parts required for installation were required to be delivered on carts that would fit on the lift, in order to reduce worker overexertion in lifting.

Administrative controls such as worker training and pick plans were used extensively throughout the project.

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. The most common form of worker PPE aside from gloves, hardhats, and safety glasses were fall arrest systems where workers installing the economizer and steel frame tied off to the man-lift.

4.3. Social Network Analysis

4.4. Project Performance

The groundbreaking ceremony for the new hospital was held on June 5, 2010. The new building opened on June 1, 2013. The groundbreaking and opening ceremonies for the new facility both received media coverage. The hospital earned Best Project 2013 (Healthcare) for ENR Midwest (Gregerson, 2013). It is not known if any injuries or deaths occurred during the project.

Owensboro Health. (n.d.(b). Features of the New Hospital. Retrieved from http://www.owensborohealth.org/community-wellness/new-hospital/numbers/ on 1 August 2014.

Gregerson, J. (2013, November 18). ENR Midwest Best Projects 2013. *ENR Midwest.* Retrieved from http://midwest.construction.com/midwest_construction_projects/2013/1118-enr-midwest-best-projects-2013.asp on 30 July 2014.

5. Case Evaluation

5.1. Results

The new hospital was among the nation's top ten largest healthcare projects and the second largest construction project in the state. This was also the largest single construction project that used Integrated Project Delivery. The project created 1,000 construction jobs and 800 new jobs post construction, 500 of which are long-term healthcare jobs for the next five years (Owensboro Health, n.d.(b)). The finished hospital also netted over $24 million in new payroll earnings for the immediate five-county area.

Owensboro Health. (n.d.(b). Features of the New Hospital. Retrieved from http://www.owensborohealth.org/community-wellness/new-hospital/numbers/ on 1 August 2014.

5.2. Lessons Learned

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

Berry, R. B. & Ellers, F. (2006). Should OMHS Build a New Hospital? *Public Life Advocate*. 3(5). 12-15

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