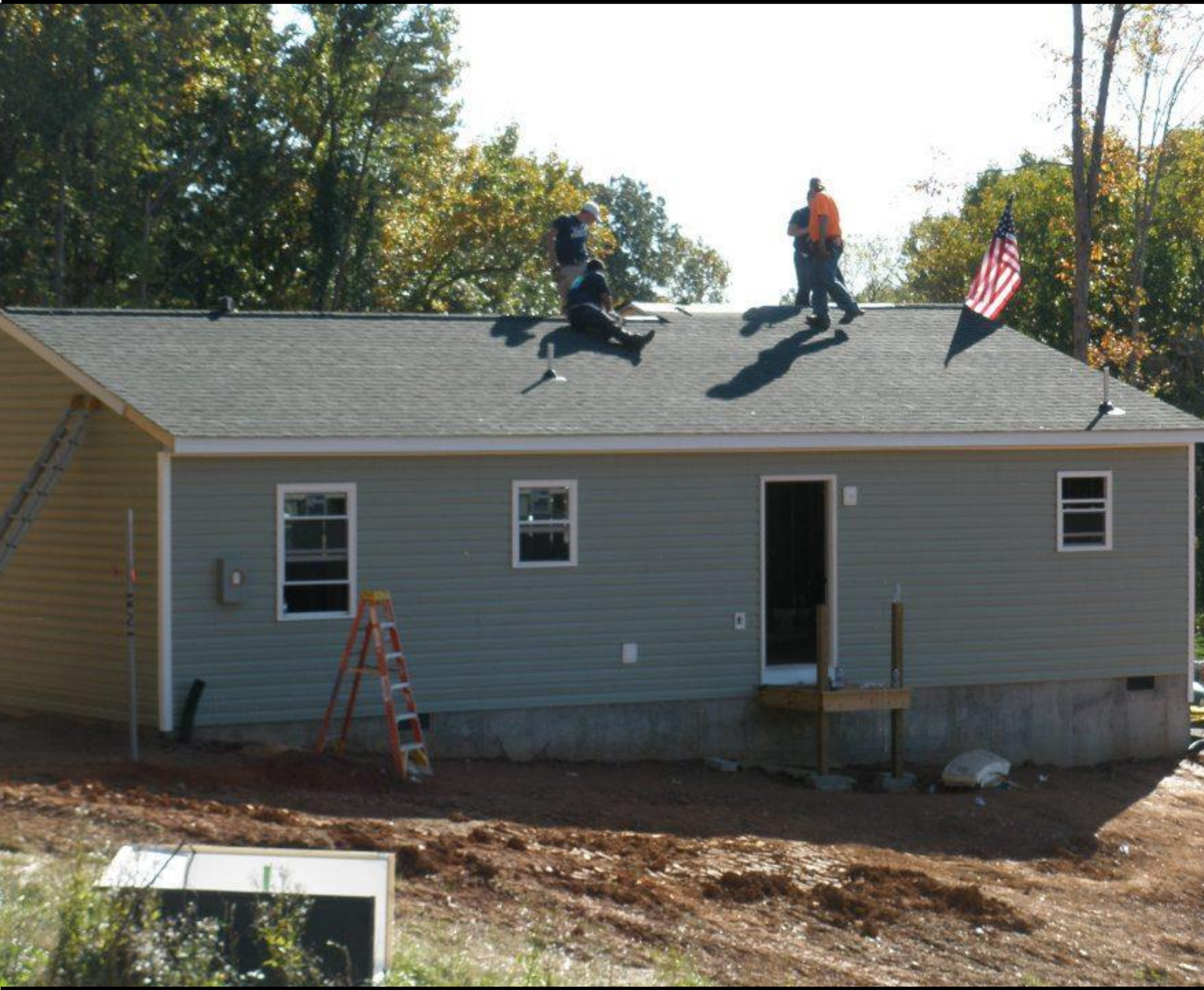
Blitz Build

Residential Accelerated

Innovation Center for Construction Safety and Health,
Myers-Lawson School of Construction at Virginia Tech



This work was supported by Cooperative Agreement #OH009761 from the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). Its contents are solely the responsibility of the writers and do not necessarily represent the official views of the CDC.

Table of Contents

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 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. Habitat for Humanity "Blitz Build"

2.1. Overview

The project involved in this case study was a pair of homes built by volunteers for a local Habitat for Humanity chapter.

2.2. Project Profile

2.2.1 Case Background

Habitat for Humanity is a charity organization that utilizes volunteers to construct houses for local families in need that meet the organization's guidelines. Volunteer builds are either scheduled to take place over several weekends or as a "blitz build," where the construction takes place quickly over a period of a few days (usually a weekend). In the case of this project, it was desirable to select a blitz build schedule since it would be easier to get volunteers for a single weekend. Also, volunteers tend to be more excited about completing the build in such a short period of time. Most of the volunteers had little to no experience in construction, which posed unique safety risks to this project. Since the organization is not-for-profit, they are not required to adhere to OSHA standards (Admin, 2008).

The local Habitat for Humanity chapter was responsible for building 21 homes since its establishment (Thomas, 2011). The first house for the blitz build had two bedrooms, one bathroom, and a total area of 948ft^2 while the second house had three bedrooms, one bathroom, and a total area of 1,056ft^2. The build was scheduled to take place on the weekend of October 15-16, 2011.

Admin. (2008, September 9). OSHA's reach falls short of non-profits. DailyReporter.com. Retrieved from http://dailyreporter.com/2008/09/09/osha8217s-reach-falls-short-of-nonprofits/ on 24 July 2014.

Thomas, M. (2011, November 16). Habitat, families partner for new homes. Altavista Journal. Retrieved from http://www.altavistajournal.com/news/article_7d8ab160-97ba-5c0d-8d5e-119fbc023547.html on 24 July 2014.

2.2.2 Case Narrative

The accelerated residential project involved in this case study was a pair of homes built by volunteers for a local Habitat for Humanity organization. Habitat for Humanity is a charity organization that utilizes volunteers to construct houses for local families in need that meet the organization's guidelines. Volunteer builds are either scheduled to take place over several weekends or as a "blitz build," where the construction takes place quickly over a period of a few days. In the case of this project, it was desirable to select a blitz build schedule since it would be easier to get volunteers for a single weekend. Also, volunteers tend to be more excited about completing the build in such a short period of time. Most of the volunteers had little to no experience in construction, which posed unique safety risks to this project.

The homes were each designed according to basic Habitat guidelines and the needs of the partner families that the homes are being built for. In the case of this build, each house was a wood-frame single story dwelling with a crawlspace. One of these houses was also built with a wheelchair ramp, which was built to a 1:12 slope as specified by the project manager.

After choosing a house plan from the main Habitat website, the project manager opted to modify the plan by moving the windows from the gable end walls to the front and back walls. This did not impact egress areas in any way and allowed for the windows and doors to only be on the front and back walls of the house.

The front and back walls were pre-fabricated off-site before the day of the build by a selected group of volunteers. These volunteers were more knowledgeable with building skills and using power tools, so the risk of injury was minimized to a controlled environment. The framing on both walls was more complex and required more cuts to be made, so it was desirable to have this work done exclusively by the chosen volunteers. Due to their experience, it was also easier to maintain an acceptable level of quality control and ensure beforehand that the framing and alignment of the studs was correct. Making such a mistake on the day of the build would cost valuable time to correct.

Since the gable end walls did not have any windows or doors, the frames were relatively simple and consisted solely of full-length studs. These studs were cut beforehand at the same off-site cutting station and their desired location in the wall was clearly marked. These studs were set aside for the day of the build and could easily be placed by the other volunteers without the need of cutting tools.

In a manner similar to the exterior wall framing, the studs for the interior walls were measured and cut by the same volunteer crews that created the front and rear exterior walls. Reducing the number of cuts on build day greatly reduced the chances of a volunteer being injured. Having the interior studs cut by more experienced volunteers allowed for a greater degree of quality control and saved time on build day.

After the studs were cut by the chosen volunteers, the desired location of each stud was clearly labeled in a way that volunteers on build day would understand where to place it. This eliminated variability and the potential for a stud to be incorrectly placed, which takes time to correct.

Once the interior wall framing was completed, there was a period of three hours during which tradesmen fitted the house with complete plumbing and electrical systems. While the tradesmen were working inside the house, no volunteers were allowed inside. This was partly due to the subcontractors feeling more comfortable working without additional people around. It is also because no additional volunteers were needed inside the house during this time, and removing them from inside the house reduced potential hazards.

The roofing system for each house consisted of a series of pre-fabricated trusses. Using pre-fabricated trusses versus stick-building eliminates a lot of the risks associated with constructing beams and supports at an unsafe height. While it was necessary to have ten volunteers go up on the roof to put the truss in place, it demanded significantly less time spent on the roof than stick-building would. Also, using pre-fabricated trusses allowed for better quality control in ensuring that the roof pitch is correct. The trusses also covered the porch with a cantilever, so no header was needed. This reduced the amount of time that workers would need to be working at unsafe heights. While the workers on the roof wore protective equipment, no tie-offs were used.

The rest of the roofing system was constructed by first nailing down plywood and then laying on the sheeting and shingles. Other homebuilders in the past have used machinery to hoist these materials onto the roof. However, the project manager for this project felt that these machines would pose a greater safety risk to the volunteers and instead opted to have the materials lifted by hand. A system was set up where the materials were carried up the ladder by a designated volunteer. This method still posed a great safety risk to the volunteer who had to climb the ladder while at the same time holding a bundle of shingles. This volunteer was not allowed to step off the ladder onto the roof, and instead was instructed to hand the materials to a worker already on the roof. The supplies were staged on a low point of the roof. An important element of the safety of the project was to ensure that nobody was in the area underneath where roof work was taking place. The only injury recalled by the project manager was when a volunteer was eating lunch in the shade of the roof and was hit in the head by a dropped triangle.

Habitat required that all houses were to be built with exterior siding. On typical builds, the siding is installed once the roofing is complete, but in a blitz build schedule it can be installed as the roof trusses are being put in place. This places the workers below at heightened risk of injury from falling tools or materials being used by the roofing crews. The siding was started on the opposite side of the house from where the trusses were being installed in order to eliminate that hazard. Those working on installing the siding were instructed to wear protective wear such as glasses and gloves, and to exercise caution while using ladders.

Since the siding is much lighter than the framing, it could easily be prepared and staged away from the main build site without much additional effort. Cuts to the siding were made at the same cutting station used in creating the 2x4's for the gable ends of the exterior wall. Only experienced volunteers who were assigned to the cutting station were allowed to use the saw.

2.2.3 Stakeholders

Internal supply for this project came from a variety of sources. The local Habitat organization served as one of the major suppliers for this project. They raised the money for the build, selected the recipient, worked with the owner to choose the design from the Habitat-provided options, made minor changes to the chosen design, and managed and helped with the construction on the day of the build. Volunteers performed most of the labor during the build day, and the core group of more experienced volunteers tackled tasks that required greater experience and attention to detail, such as operating the cutting station and assembling pre-fabricated wood frames. Trade contractors installed the plumbing, electrical, and dry wall once the interior of the house was framed. Material suppliers were on call during that weekend to get supplies to the site as needed so that the schedule would not get too far behind.

Internal demand came from two sources. The home owner (client) applied to Habitat for Humanity for the house, helped with work during the build, and lived in the home once it was complete. The Habitat for Humanity Organization served as the financier for the project. The organization financed the project, laid out rules for type and size of the house based on the size of the client’s family, and had sets of plans for the house that the contractor was required to choose from.

2.2.4 Project Objective

The objective of this project was to build two homes in one weekend using volunteer workers from the local Habitat for Humanity chapter.

2.2.5 Sector x Delivery System

This project is an example of accelerated residential construction.

2.2.6 Features of Work

Those features are the framing of the exterior and interior walls, installation of interior systems, roof structure, and construction of the façade.

3. Problem

3.1. Context

The project featured in this case study was the construction of two residences by Habitat for Humanity using volunteer labor. The project had a PM who planned the build and supervised all construction activities. This build in particular was done on an accelerated schedule that took place over the course of a weekend. The presence of mostly unskilled volunteers working on an accelerated construction process presented several safety hazards which had to be addressed by the PM to ensure that the build went smoothly and safely.

3.2. Objectives

After Habitat for Humanity chose the families that would receive the homes, the PM chose a house design from an online catalog approved by the organization. While Habitat dictated most of what the design could or could not include, the PM was allowed to make some changes to the design at their own discretion. One alteration was moving windows and doors on the gable end walls to the front and back walls. This simplified the framing of the gable end walls, which was to be performed by volunteers.

In order to save time on the day of the build, the PM had the complex wooden frame and roof trusses pre-fabricated by a more skilled group of volunteers. Having more skilled workers was safer and allowed for a greater degree of build quality, which also prevented wasting valuable time fixing mistakes. Also, the only power tool permitted on the site was a power saw to cut the siding. Only pre-approved volunteers were allowed to use the power saw at any time. PPE such as gloves, sturdy shoes, and safety glasses were required for all volunteers.

4. Results

4.1. Safety-Critical Decision Making

The presence of unskilled volunteers on the jobsite presented a major safety problem for the PM. Having volunteers with little to no construction safety experience operate a power saw to frame the walls or cut pieces of siding would have been downright dangerous. It was the PM's decision to recruit a core group of 6-8 volunteers who had some sort of construction background to cut the wall studs and frame the exterior walls before the day of the build. This decision confined the hazard to a smaller group in a more controlled environment. Another advantage of this was that the PM could assure a greater degree of quality control among the more experienced volunteers.

Decisions, Decisions: Quick View

Thom's table here

Roof trusses were also pre-fabricated and lifted into place as opposed to being stick-built up on the roof. This reduced the time workers would need to be up on the roof unsecured. An added benefit of using pre-fabricated trusses was a greater degree in quality control by ensuring that the pitch of each truss was correct.

When delivering roofing materials such as shingles and sheeting up to the roof, the PM decided to have these items delivered by hand via a ladder and handed off to a worker already on the roof in a way that the worker on the ladder would not have to step from the ladder onto the roof. This was a poor safety decision since workers climbing up the ladder with materials could only have one hand on the ladder at any given time. To climb up to the roof would require that worker to let go of the ladder rung, leaving no hands on the ladder, in order to climb up to the next rung. This was a huge fall hazard since at times the worker would have to rely on their own balance in order to not fall off.

4.2. Hierarchy of Controls

An example of elimination in this project was using pre-fabricated roof trusses instead of stick-building. All volunteers needed to do to assemble the roof structure were to lift and secure each truss into place. This meant that volunteers did not have to be working unsecured at heights for as long as a stick-built roof would require. Another example of elimination was the usage of a cantilever for the porch overhang. No framing was required for the porch roof which eliminated the need for workers to be unsecured at heights constructing a frame.

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. The tasks accomplished by the experienced volunteer group, such as the wall framing and sizing of studs, are all an example of substitution by the PM. These tasks were safer for the experienced volunteers as opposed to those who had little to no experience in construction.

Engineering control is the third most effective form of hazard control. No notable examples of engineering controls occurred during this project.

Administrative controls such as communication were used extensively during the assembly of the exterior frame and the hoisting of roof materials. In addition, volunteers were banned from using personal power tools or being inside the house while the tradesmen were installing utilities and fixtures.

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. PPE such as gloves, sturdy shoes, and safety glasses were absolutely required for all volunteers on the site.

4.3. Social Network Analysis

Due to the low complexity of the social networks in this project, no social network diagrams are available.

4.4. Project Performance

The project was completed on schedule. Over 100 volunteers showed up to help build the two homes (Thomas, 2011). Only one injury was reported when a volunteer was eating lunch under the partially-completed roof and was struck in the head by a dropped roofing triangle. The families were able to move into the new homes by December 2011.

Thomas, M. (2011, November 16). Habitat, families partner for new homes. *Altavista Journal.* Retrieved from http://www.altavistajournal.com/news/article_7d8ab160-97ba-5c0d-8d5e-119fbc023547.html on 1 August 2014.

5. Case Evaluation

5.1. Results

The build received media coverage from the local newspaper and recognition on the charity chapter's website. The project did not receive any special awards or ratings. One injury was reported but there were no deaths during the project. The homeowners were able to move into their new homes in December 2011 (Thomas, 2011). One of the homeowners commented about her new house: "It feels great to me. That's something I thought I'd never have. I love it. Real excited."

Thomas, M. (2011, November 16). Habitat, families partner for new homes. *Altavista Journal.* Retrieved from http://www.altavistajournal.com/news/article_7d8ab160-97ba-5c0d-8d5e-119fbc023547.html 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

Admin. (2008, September 9). OSHA's reach falls short of non-profits. DailyReporter.com. Retrieved from http://dailyreporter.com/2008/09/09/osha8217s-reach-falls-short-of-nonprofits/ on 24 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/

Thomas, M. (2011, November 16). Habitat, families partner for new homes. Altavista Journal. Retrieved from http://www.altavistajournal.com/news/article_7d8ab160-97ba-5c0d-8d5e-119fbc023547.html 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.