An Analysis of the Sampoong Department Store Collapse through the Lens of Virtue Ethics

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

In 1995, the newly-built Sampoong department store in Seoul, South Korea collapsed in its entirety, resulting in the devastating loss of over 500 lives and the injury of many more. The massive five-story structure crumbled to the ground floor-by-floor, trapping store staff and customers for days, some even for weeks, within the rubble. The collapse was attributed to structural failure, with further investigations revealing that these failures were enabled through poor management, construction, and techniques (Marshall, 2015).

I would first like to preface and say that the extent of this paper will be limited due to language; thus, the following discussion may not reflect viewpoints or works written in Korean. In an attempt to understand the mechanics behind the incident, professionals have reviewed the case through a purely technical perspective by examining the structural causes that contributed to the collapse of the store. This scholarly discussion, however, is limited because it does not explore the morality behind the decisions of the team of engineers involved in the design, construction, and post-construction phases of the project. Focusing on the technicalities of the case deprives students and future engineers from understanding how to judge their own morality when faced with a similar situation.

I will study the design and structural engineering team involved in the Sampoong building collapse in order to judge the morality of their decisions throughout the project's duration. Virtue ethics, which is a framework that focuses on the nature of the actor in question, will be utilized (van de Poel & Royakkers, 2011). I argue that the engineers involved in the project did not act morally in their decision-making and performance due to their lack of two key virtues: competence and commitment to quality. Forensics documentation from reports of the collapse, as well as survivor testimony from a documentary series, will be reviewed.

Background

Even though the following area of discussion is not highlighted in scholarly sources, I would still like to acknowledge it. Many media and public sources point attention towards the ownership of the Sampoong department store, who, in the midst of the economic boom in South Korea, abused their wealth and power to advance their own greed through this project. Legally speaking, owner Jun Lee and other Sampoong executives were sentenced to prison for gross negligence; they prioritized quantity over quality, speed over safety, and money over lives (Marshall, 2015). My argument is not to undermine the actions of the Sampoong owners, nor is it to question the legality of the case; rather, it is to point a spotlight towards the morality of the involved engineers, since their involvement is overshadowed by the technical causes and the egregious behavior exhibited by the executive team.

Literature Review

Many scholars have researched the Sampoong department store collapse to identify and better understand the principal causes of the incident. These analyses are technical in nature and thus mainly focuses on the structural failures at hand. While the causes do allude to poor practices in design and construction, this area of focus lacks direct discussion regarding the morality of the decisions made by all involved parties, particularly the team of engineers responsible for reviewing building plans and the safety of the fully developed building.

In *Lessons from the Sampoong Department Store Collapse*, Gardner and Chung utilize building standards from different nations to run a series of calculations that predicts the effects of various design considerations, ultimately leading to the argument that it was a multitude of intertwining issues that led to the collapse (Gardner et al., 2002). They explain that the change in floor use from a roller skating rink to a restaurant on the fifth floor, as well as the repositioning

of the air conditioning cooling tower on the roof, made the applied load on the floor levels much larger than originally accounted for (Gardner et al., 2002). Additionally, support columns were too small, the strength of concrete was too low, and poor construction techniques were implemented (Gardner et al., 2002). Although this argument does hold implications that the design engineers made calculation errors and incorrect assumptions during the design process, there is no formal assessment of the morality of the choices that they made.

Likewise, in *Inspection of Collapse Cause of the Sampoong Department Store*, Park lists the technical causes of the collapse, which are comparable to that of Gardner and Chung. He asserts that the incident occurred due to non-structural changes increasing the design load on the building, a reduction in the diameters of concrete support columns, improper placement of reinforced bars, and separate pours of concrete for slabs and drop panels during the construction phase (Park, 2012). He relates these causes to unapproved design changes, poor construction management, inadequate design planning, and a lack of a secure factor of safety (Park, 2012). However, unlike Gardner and Chung, he also dedicates a section to clarify the role of the architects and structural engineers in a building project. He notes that the former works on the structural drawings while the latter performs structural calculations, all while making decisions involving use, the number of floors, and structural support details (Park, 2012). Although he reveals that a mishap in coordination with respect to the ongoing design changes played a role in the collapse, Park does not make any explicit judgment on the morality of the processes and designs made by the engineering team.

Many valuable lessons can be learned from examining the design and structural failures of the Sampoong department store. Nevertheless, it is imperative to study the way in which these failures were allowed to occur as well. Existing scholarly sources stem from journals that

specialize in civil engineering knowledge and calculations, and thus, they are limited to discussions about the technical causes of the collapse. I will advance the current understanding of the factors contributing to the incident by questioning the morality of the engineering team using the framework of virtue ethics.

Conceptual Framework

My analysis of the engineering team's involvement in the Sampoong department store project draws on virtue ethics, which allows me to evaluate the morality of their decisions. Virtue ethics is a normative ethical theory in which the nature of the moral actor is judged (van de Poel & Royakkers, 2011). The framework was developed by the Classical Greek philosopher Aristotle, who believed in eudaimonia, or "the good life," which is the ultimate state of one becoming a good person (van de Poel & Royakkers, 2011). According to Aristotle, humans are rational by nature, so ethics can be judged using a set of virtues. Examples of virtues include reliability, responsibility, honesty, and solidarity, all of which represent the midpoint between "two extremes of evil," an excess and a deficit (van de Poel & Royakkers, 2011). Therefore, in order to strive for eudaimonia, one must learn to actively live by these moral virtues, revealing their character as a person. However, it is important to note that since this framework analyzes character as opposed to action or consequences, it cannot provide a universal set of clear principles for how to respond to a situation, making it a case-by-case application.

There are many virtues that extend beyond the generic list of dispositions and are specifically relevant to professional engineering practice. While these virtues do not guarantee responsible behavior, they do serve as indicators for moral decision-making; specifically, a conclusion of immorality can arise from the absence of a virtue in practice (Pritchard, 2001).

Michael Pritchard affirms that the following list of virtues in Figure 1 are the fundamental set of virtues that should be expected of a responsible engineer (Pritchard, 2001).

1. competence
2. ability to communicate clearly and informatively
3. cooperativeness (being a good "team player")
4. willingness to compromise
5. perseverance
6. habit of documenting work thoroughly and clearly
7. commitment to objectivity
8. openness to correction (admitting mistakes, acknowledging oversight)
9. commitment to quality
10. being imaginative
11. seeing the "big picture" as well as the details of smaller domains

Figure 1. List of Virtues Relevant to Engineering Practice

In the analysis that follows, I draw on virtue ethics and will begin by establishing the team of engineers who worked on the Sampoong department store project as the moral actor in question. I will then analyze their decisions leading up to the collapse of the building from the perspective of two virtues outlined by Pritchard: competence and commitment to quality. I will determine whether the engineers had acted accordingly or not to these virtues throughout the design, construction, and inspection phases of the building project.

Analysis

Throughout the processes that eventually led to the devastating collapse of the Sampoong department store in 1995, the design and structural engineers involved in the project failed to make moral decisions on the basis of two virtues: competence and commitment to quality. I will be analyzing the design process, which involves calculations and a review of the structural soundness of the building plans, the construction process, which involves routine quality checks of the concrete pours and columns, and the post-construction process, which involves inspections of the fully developed building. As stated by Pritchard, an obvious lack or inconsistency in any one of the virtues from Fig. 1 can be a means of deducing the immorality of the engineering

practices that took place (Pritchard, 2001). The following sections will review each of the three virtues in detail and assess how the engineers failed to meet the expectations that are associated with them.

Competence

When judging the morality behind the decisions that were made in the incident, it becomes apparent that the structural engineer responsible for conducting inspections on the day of the collapse failed to exhibit competence. According to the Merriam-Webster dictionary, competence is defined as the quality of being able to fulfill a particular duty through sufficient knowledge, judgment, skill, or strength (Merriam-Webster, n.d.). As an engineer, it is vital that tasks are conducted promptly, accurately, and thoroughly because oftentimes, a person's life could be at stake if they are not. Engineers hold credentials that make them professionals in a specific area of expertise, allowing others to place trust in them to do their work in a proper manner. As experts, engineers must respect this high level of responsibility, as others are looking up to them to be skilled in their studies, findings, and advice in order to protect the safety and well-being of the public.

In the documentary *Blueprint for Disaster*, survivor Seung-hyun Park, who worked on the basement level of the store, revealed, "They [the store staff] received a notice that there was a crack on the fifth floor. Someone said that it was too dangerous to turn the air conditioning back on" (Video Times, 2016). As it turned out, the executives turned off the air conditioning in response to the fear of cracks emerging on the upper floors, since the air conditioning towers were sitting on the roof, causing vibrations (Marshall, 2015; Park, 2012). In response to these rumors and staff reports, a specific member from the team of engineers, structural engineer Hak-soo Lee, was responsible for conducting inspections (Video Times, 2016). He documented

the column cracks on the fifth floor, as well as the “large bulge” that caused the restaurant kitchen floor tiles to shatter and a crack to crumble on the roof (Video Times, 2016). However, “despite the evidence of imminent danger, he believed the building was still sound” (Video Times, 2016). In other words, he advised the building executives by telling them that an immediate fix and evacuation was unnecessary, despite complaints heard from the store staff. That same afternoon, the air conditioning towers tore through the roof, causing the support columns to buckle and the floors to fall, one on top of the other, until finally, the store had collapsed in its entirety (Marshall, 2015). However, in order to focus solely on Lee’s decision, I will disregard the fact that the building happened to have collapsed on the same day, as his response to his inspection findings should have been the same regardless of when the building was expected to break down.

Since competency is related to knowing knowledge, it must be known whether Lee had a sufficient amount of knowledge from the inspection to conclude that an immediate evacuation was necessary. First and foremost, one of the most common warning signs before a building collapse is cracks, something that even a non-structural engineer, such as survivor Seung-hyun Park, could identify upon inspection; cracking along structural elements like columns are an even more potent sign, as observed in this case (Thomsen, 2021). Second, the building was built using flat-slab construction, which is a technique that requires precision in both construction and design because it is notorious and susceptible to detrimental failures known as punching shear failure (Thomsen, 2021). This type of construction involves placing concrete slabs directly on top of columns, making it a very economical choice; however, if done incorrectly, the columns would slowly pierce through the slabs, until suddenly, they fail and the floors fall down like a stack of pancakes (Thomsen, 2021; Video Times, 2016). This phenomenon was clearly seen with

the bulging of the fifth floor, to the point where tiles began to crack. Since the collapse is almost instantaneous and deadly when failure is reached, time is of the essence during decision-making. Lastly, the construction of the store began in 1987, the building opened in 1989, and the collapse occurred in 1989, meaning that the building was new and only six years old (Park, 2012). Per standards, buildings are typically expected to be in need of repair after a minimum ten years of use, since a newly constructed building should have very little wear in materials, connections, and equipment (Park, 2012). However, the results of the inspection indicated the opposite, easily alluding to the existence of a much more fundamental issue that was causing the building to experience such impairments early on in its life cycle.

Note that as a certified structural engineer, Lee should have had an understanding of flat-slab construction and the potential devastating consequences of different failure modes, including punching shear. It is reasonable to state that Lee could have attributed the damage found from the inspection to this failure type, especially since the damage was very specific to its common warning signs. This notion should have led him to advise a different course of action that immediately prioritized the safety of customers and staff in the building. Additionally, his expertise on maintenance and building repair timelines should have made him even more alarmed by the inspection findings. All of these points suggest that Lee lacked either the standard knowledge or judgment needed to make decisions as a structural engineer, proving that he did not respond in accordance with the virtue of competence.

As I have argued, the engineer acquired enough information from his inspection to be able to utilize his knowledge of structures and come to the conclusion that the building needed to be promptly evacuated. The lack of such a conclusion indicates that he did not act with competence, which is a virtue required for an engineer to be morally responsible. However, it is

important to consider alternative points of view as well. Some, such as Lee himself, may contend that he did act with competence, since he advised that "repairs could be made after hours" and "suggested that the cracks be filled with an additional support added to the upper floors" (Video Times, 2016). In essence, he used his expertise to acknowledge that a structural issue did exist and decided that repairs must be done as a result of it. As someone who could not foresee the future chain of events that would take place, he may have believed that a call for repairs once the store had closed was a swift enough response, since it would occur within the same day. In that case, it is rational to conclude that his advice was to the best of his judgment within the limits of the unknown. Yet it should be noted that on the day of the collapse, reports say that the "number of customers in the building was unusually high, and the store was not intending to lose potential revenue" by closing early in response to initial staff reports (Park, 2012). On top of this, Lee admits that he would say things that he believed the ownership wanted to hear (Video Times, 2016). It can be deduced that Lee was prioritizing the owner and execs' greed instead of providing a genuine report of his inspection. Referring back to its definition, competence encompasses having the strength to fulfill a particular task. This was something that Lee failed to exhibit, since he lacked the courage to stand up to the executives and overcome their intimidation. Thus, the engineering team, as highlighted by the engineer responsible for inspections on the day of the collapse, did not act morally on the basis of competence during the post-construction phase of the project.

Commitment to Quality

The structural engineers responsible for the integrity of the building's construction and design also failed to showcase a commitment to quality when the morality behind their decisions is assessed. A commitment to quality means that engineers do their due diligence to uphold the

promised standard of care and are conscientious of the stakes of their past, present, and future decisions (Schultz-Bergin, 2021). One of the ways in which civil engineers meet this commitment is through quality control, or QC. This task is vital during all stages of the project, but happens most during the construction phase, since engineers are expected to oversee the development and make sure that the building is being constructed per the blueprint. QC is defined as a periodic sampling of a particular party's engineering performance throughout the span of the project in order to catch shortcomings and errors, and it is a crucial step to saving money as well as the lives of consumers (Arkansas State University, 2016).

To begin, a brief background and a couple of points of clarification are needed. First, when the project began, the engineering company hired at the time warned owner Jun Lee of the dangers of his ambitions, but rather than listening to them, he fired the team and used his own Sampoong construction company instead (Video Times, 2016). In order to preserve continuity with previous discussions, my argument will be referring to the engineering team under the Sampoong construction company, since they were the group that was involved throughout the rest of the project's duration. Second, after the collapse took place, a forensics team of engineers was responsible for documenting the leftover debris to provide a report highlighting the causes of the incident. One outcome of this documentation was photos of the upper level support columns that showed the size of the cross-section and the internal reinforced bar, or rebar. As shown in Figure 2, the column on the left has a diameter of 80 cm, whereas the column on the right has a diameter of 60 cm with 8 rebars (Park, 2012). According to the structural drawings, the columns should have all been 80 cm in width with 16 rebars (Park, 2012).

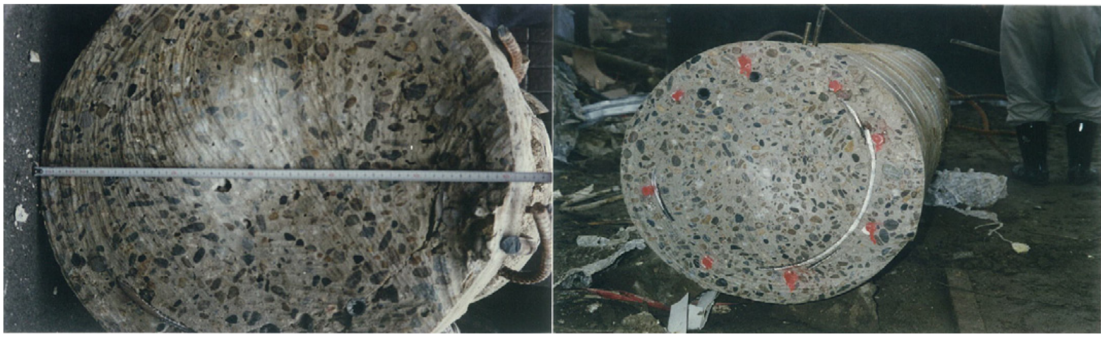

Figure 2. Cross-sections of the columns found from the collapse debris

These specifications are significant because the size of the support column plays a vital role in the amount of load that it can withstand before failing. It was revealed that amongst numerous other appalling calculation errors, such as using an incorrect dead load for the concrete roof or neglecting the self-weight of the column drop panels, the disparity in column size between the design and actual construction also significantly impacted the original design calculations that the building project was relying on (Gardner et al., 2002). Arguably, the most important responsibility of a structural engineer is ensuring that the building's required stress load is accurate in both the design and construction phases, as this is what dictates the stability of the structure (Norwich University Online, 2017). However, the original load calculations were never updated to reflect the construction changes in the column sizes. In addition, having the correct number of reinforced bars is crucial because while concrete is very durable under compressive conditions, it is also very brittle, so the steel rebar strengthens the column under tensile states.

Engineers visit construction sites on an almost daily basis in order to mediate issues, oversee coordination work, and conduct QC walks. This evidence shows that the structural engineering team either did not conduct quality control checks, or if they did, conducted them hastily, since they should have explicitly been checking the cross-sectional details of each column that was being built directly on the site. Checks such as these would have enabled the

engineers to take the appropriate measures to prevent columns from being built in such a way, and it would have also drawn their attention to more of the underlying issues, such as the errors in calculation. However, their complete disregard to doing proper QC emphasizes their lack of devotion to producing quality work, yielding outcomes that not only depreciates the protocols involved in the project's processes, but the safety of consumers as well. Thus, when judging the morality of the engineering team, they fail per the virtue of committing to quality.

Conclusion

Even though the only known individual on the team is Hak-soo Lee, the engineering team as a whole can be morally judged through the decisions that they made throughout the span of the project. They failed to exhibit the virtues of competence and a commitment to quality, both of which are required to be a morally responsible engineer. Virtue ethics outlines the character traits needed for an actor to be ethically evaluated.

As stated previously, this was a major building failure contextually set during an economic boom in South Korea, which unfortunately opened doors for corruption and greed. Even though the decisions made by the Sampoong executives and the technical causes of the collapse are integral components of the incident, it must be made known that the decisions made by the engineers matter as well. Engineers not only advance society, but protect it as well. Therefore, for the sake of protecting the public's safety, engineers must learn how to morally reflect on their own-decision making.

References

Arkansas State University. (2016, June 22). *Quality control in engineering management.* https://degree.astate.edu/articles/engineering/quality-control-in-engineering-management.aspx

Gardner, N. J., Huh, J., & Chung, L. (2002). Lessons from the Sampoong department store collapse. *Cement & Concrete Composites*, *24*(6), 523–529. https://doi.org/10.1016/S0958-9465(01)00068-3

Marshall, C. (2015, May 27). Learning from Seoul's Sampoong department store disaster – a history of cities in 50 buildings, day 44. *The Guardian*. https://www.theguardian.com/cities/2015/may/27/seoul-sampoong-department-store-disaster-history-cities-50-buildings

Merriam-Webster. (n.d.). *Competence definition & meaning*. https://www.merriam-webster.com/dictionary/competence

Norwich University Online. (2017, April 3). *Structural engineer job roles and responsibilities*. https://online.norwich.edu/academic-programs/resources/structural-engineer-job-roles-and-responsibilities

Park, T. W. (2012). Inspection of collapse cause of Sampoong department store. *Forensic Science International*, *217*(1–3), 119–126. https://doi.org/10.1016/j.forsciint.2011.10.039

Pritchard, M. S. (2001). Responsible engineering: the importance of character and imagination. *Science and Engineering Ethics*, *7*(3), 391–402. https://doi.org/10.1007/s11948-001-0061-3

Schultz-Bergin, M. (2021). *The primacy of the public.* College of DuPage. https://pressbooks.ulib.csuohio.edu/principles-of-engineering-ethics/chapter/professional-responsibility/

Thomsen, I. (2021, July 2). *What are the warning signs before a building collapses?* Northeastern Global News. https://news.northeastern.edu/2021/07/02/what-are-the-warning-signs-before-a-building-collapses/

van de Poel, I., & Royakkers, L. (2011). *Ethics, technology, and engineering: an introduction*. Wiley-Blackwell.

Video Times. (2016, December 21). *Blueprint for disaster* [Video]. YouTube. https://www.youtube.com/watch?v=HEBu14HzgvE