

# A CASE STUDY OF ENGINEERING ETHICS: LESSON LEARNED FROM BUILDING COLLAPSE DISASTER TOWARD MALAYSIAN ENGINEERS

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## ABSTRACT

*This paper presents the case study on the Hotel New World tragedy. The building collapsed on 15th March 1986 and an investigation was conducted to determine the main cause of this tragedy. There were several speculations made on the cause of the collapse such as internal explosion, bad concrete mixture and swampy land affecting the building's foundations. However, after thorough investigations, these speculations were proved to be inappropriate and the main cause was found to be due to the engineer's miscalculation during the designing stage which leads to this catastrophic failure of the building. Rescue operation was initiated immediately after the collapse to rescue the victims and the aftermath of this tragedy had led to multiple reclamations. These reclamations include the endorsement of Building Control Act 1989 along Building Control (Accredited Checkers) Regulations 1989 as a stricter quality control measure. The analysis shows that this case may be due to unwanted mistakes or negligence of the engineers in carrying out their duties. Several actions were taken according to the ethical theories and codes of ethics. However after the analysis and evaluation were done, duty ethics and right ethics were more relevant to the collapse of Hotel New World case as compared to the other ethical theories and thus reclamations were done based on duty ethics and right ethics.*

**Keywords:** Hotel New World tragedy, engineer's miscalculation, Building Control Act 1989, Building Control (Accredited Checkers) Regulations 1989, ethical theories, code of ethics.

## INTRODUCTION

Singapore, with a population of over 4 million people, is one of the fast growing countries in South-East Asia. Development of skyscrapers in Singapore is inevitable as it has limited land while the population in the country is growing fast due to the growth in economy which increases the people's standard of living. The Hotel New World was built in 1971 and it is situated in Little India, which is 6 kilometers from downtown of Singapore. Being six stories and 24 meters high, The Hotel New World is one of the tallest

buildings residing in Little India for its time even though it was small compared to high rise buildings in the central city [1]. The building has 36 concrete columns that support 6 concrete floors with a total weight of 6000 tons. The underground floor was the parking lot, the ground floor was the bank branch, the first floor was a popular nightclub frequently visited by tourists or locals, the remaining floors were occupied by a budget hotel called The Hotel New World which the building is named after and lastly the roof accommodating all of the mechanical tools such as water tanks and air conditioning system that was used to maintain comfortable temperature in the building during hot weather [2].

According to its history, the building had never experience huge structural or catastrophic damage. Only one minor case has been reported which was the leaking of poisonous gas in 1975. However, everyone in the building managed to recover from their sickness without any loss of lives. The gas pipes were checked and the building was given approval to continue its operation since there is no damage inflicted to the building by the incident [3]. However, the Hotel New World suffered a catastrophic failure when it collapsed in an instant around 11.20 am resulting to the entrapment of 50 people, where eventually 17 of them were rescued while 33 of them were killed. All emergency response units, together with the Air Force and Singapore Army were dispatched immediately after the collapse to rescue the victims buried under the rubble[4]. Multiple theories were presented as the possible causes to the failure of The Hotel New World building. Wee Kim, the president at that current time has ordered a full investigation to find the root cause of the incident with Justice L. P. Thean as the head commissioner of the investigation. The purpose of the investigation is to prevent future recurrence of similar tragedy. As a conclusion, the investigation pointed out that there is no external force or impact that contributes to the collapse but rather the poor structural design deemed to be inadequate to support the building weight [2].

## **DESCRIPTION OF LITERATURE**

### *A. Speculations*

This circumstance has been thought of being out of the typical as the engineers study the leftover rubble and the speed of the collapse. This leads to three speculations which are:

- i. internal explosion,
- ii. poor concrete mixture and
- iii. swampy land.

The first speculation for the collapse of building is suspected to be due to the internal explosion caused by astonishing case or terrorist attack. To proof this conjecture, engineers have taken action to evaluate the history of the building with the gas leak incident in 1978. As the investigation progressed, there was no evidence of such explosion can be found in the scene since explosions will leave a distinctive hint or clue such as small debris of walls, shattered glass and fragments of rubble blown to tens or hundreds of meters away [2].

Second speculation is the poor concrete mixture of the buildings cause the building failed suddenly and collapsed vertically. Engineers tried to investigate all of the witnesses due to the curiosity about the vertical failure. When they debriefed the rescuers, there were some hints found. The rescuers had reported that when drilling through the collapsed concrete, the drilling process was soft, smooth and fast. Therefore, engineers judged this phenomenon had happened based upon two main reasons: due to badly mixed concrete causing decreasing strength or due to fractures of collapsed resulting in softness of concrete. To meticulously determine the exact reason, samples of the debris were brought into the lab for consistency and strength test. Surprisingly, the samples had met all of the international standards and proving the strength of the material was not the problem in this tragedy. Hence, this speculation was remove from the list [1].

Afterwards, the third hypothesis was made by engineers. The engineers examined the land supporting the building and found out that the land used to be a swampy flat drained. However, it was never a major problem in that areas since the other buildings are not as tall as The Hotel New World. The foundation and the residue of the basement wall were then checked. If movement had occurred, the walls would have rather huge cracks that can be easily detected. Unfortunately, there was nothing found in this case. Hence, forensics take actions by analysing the composition of the soil but finally with the conclusion that there is no failure in the foundation even though minor movements had occurred.

### *B. Actual Reasons Behind The Tragedy*

This building contained a hotel, a bank and a nightclub, all of which breakdown into pieces of rock and twisted metal, killing 33 people [5]. A missing piece of clue was required to discover the secret of the Hotel New World collapsed. The root cause was found after the collection of briefings and reports given by the witnesses of the incident. There was a correspondence in the reports given by the witnesses where they all had stated that they saw cracks or failures inside the building but different location were pointed out by different witnesses.

By referring to this evidence, investigators and engineers had taken the approach to refer back to the blueprints and building development plan. Surprisingly, the reported failure or cracks corresponded to different columns of the building. With this being said, the investigators speculated that the columns had collapsed due to they were stressed to their maximum limit of the building [2]. After examined the mixture concrete by using a microscope, this speculation was proven. In microscopic level, there is a crack called micro-cracks that is hidden from the naked eye but poses danger to the building support system.

These micro-cracks had reduced the weight that was supported by the pillars and eventually initiated a progressive collapse. Hence, forensics had checked the loads applied to the building to investigate the causes of the cracks. It could be either the miscalculation on load of the supporting elements during construction process or under-design and uncontrolled weight management during the building's operation that brought these cracks [2]. After intensive research, investigators discovered a horrible mistake in the original design of the building which is the structural engineer had absolutely left out the buildings "dead load," in other words, the weight of the building itself was doomed from the beginning [5].

Fig. 1 shows that heavy equipment, which were not stated in the original design plan, were found in the debris. Those equipment are the extra loads added by the owner during the building's 15 years of lifespan.

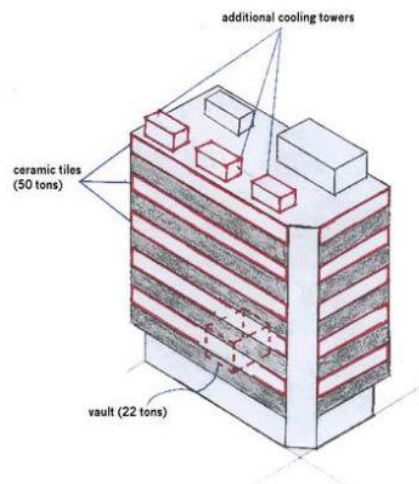


Fig. 1: Additional loads to the building [2].

The following are the loads added during the building's lifetime [1]:

- i. In 1975, there was a vault with 22 tons placed in the bank on the ground floor.
- ii. In 1978, two additional cooling towers were added by the owner on the roof of the building.
- iii. In 1982, exterior layer on each floor were fixed with a heavy duty ceramic that carries a total of 50 tons due to architectural reasons.
- iv. In 1986, an extra cooling tower was added on the roof by the owner again.

Nevertheless, all these additional loads was already accounted under the live load category in the design plan. The engineer's calculations proved that the extra amount of weight does not contribute much to the collapse [4].

Again, the engineers checked the blue prints and original design plan of the building. After calculation process, the root cause behind the collapse was finally discovered. Throughout this investigation, it was found that the dead load of the building was not accounted in the original design plan and it means that the building itself had been stressed to the allowable limit from the first day and the collapse cannot be avoided [4].

As a conclusion, the source of collapse was determined to be the fault of the engineers responsible for the structural integrity of the building as they overlooked the importance of dead load in the construction stage which caused the under-designed columns and foundation of the building's supporting elements to crack easily during the addition of the huge live loads. The tragedy of the Hotel New World building is a type of progressive collapse. Progressive collapse occurs when a structural failure in an area continuously spread to other area through connective structure causing an enormous destruction of a building. In this case, it is due to over stressed column that caused micro-cracks in the building and subsequently downfall.

The two major columns that were affecting the overall collapse of the Hotel New World are shown in Figure 2. Column 26 experienced micro-cracks initially due to the over stressed condition. The weakening of the support structure in column 26 caused the other load propagate to another column which was the column 32. As a consequence, column 32 also unable to support the additional weight hence experienced the micro-cracks. Thus, other columns in the other corners are eventually having the same problem due to the large live load and dead load which led the whole building to collapse [6]. Fig. 3 shows the before and after the Hotel New World collapsed.

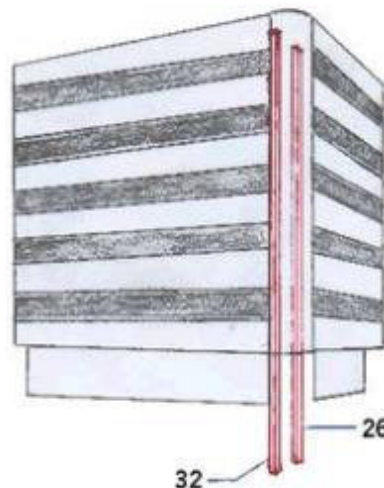


Fig. 2: Two columns that collapsed in the beginning [2].



Fig. 3: Before and after the building collapsed.

### *C. Rescue Actions*

After the collapse, many fire fighters and polices were dispatched to aid the rescuing operation at the scene. They were soon united by the Singapore Civil Defence Force and Singapore Armed Forces (SAF). However, the rescue operation does not go well as the rescuers were not trained to handle such crucial situation, neither were they equipped with the appropriate tools.

Experts from Britain, Ireland and Japan were summoned by the authorities to assist local personnel and the arrival of specialized equipment such as the state of the art cutting tools, infrared imager and life detector had helped to hasten the rescue operation. A nearby Piano Company was used as a centre for the rescue operation while a park was chosen as the helicopter landing location. As there were survivors buried in the rubble, the rescue was a delicate operation. Debris was carefully removed by the rescuers to rescue the victims.

After five day rescue operation, 17 people were rescued but 33 people were killed. Fig. 4 shows the rescue operation conducted at the day of collapse.



Fig. 4: Rescue operation [7].

### **AFTERMATH**

After identifying the causes for the Hotel New World collapse tragedy, Justice L. P. Thean as the head commissioner of the investigation had handed the report to the president which then leads to the reformation of the code and standard in civil engineering. Since the collapse was mainly due to the mistake of the structural engineer and draftsman where they neglected the dead load during the design process, one of the reforms that had been made was any structural plans or calculations made by a professional engineer must be checked by another professional engineer before submitting to the Development and Building Control Division. The design stage is a crucial stage as calculations are made on the safety of the design which involves the support beam, foundations and columns. Thus, in the reformation, it now requires another

independent consultant engineer with at least 10 years of experience in the related field to check the calculations before any approval on the design [4].

The collapse of the Hotel New World was also partially due to the improper maintenance throughout its operation period. Thus, the Building Control Act 1989 was endorsed together with the Building Control (Accredited Checkers) Regulations 1989 where the “accredited checker” serves the purpose of providing additional checking or inspection of the work conducted by the engineer in charge. The accredited checker must be appointed by the owner of the construction and these accredited checkers must be registered with the Building Authority. In addition to that, the owner is responsible to have their building checked every 5 years by professional engineers to ensure the building’s safety during its operation. This measure taken is part of a stricter safety control in order to prevent future disaster such as the Hotel New World tragedy [4].

The Building Authority now have the rights given by the legislation to refuse any building plans that they deem inappropriate and by anytime, they can appoint an accredited checker to investigate any structural designs that seems faulty. Lastly, mandatory material testing and spot checks at the construction site conducted by the owner and engineers has been implemented by the government to prevent corruption, misuse of individual authority and malicious act during the construction process [6].

## **ANALYSIS AND RECOMMENDATIONS**

After the overview of the Hotel New World tragedy, it is essential to analyse the reasons for the collapse in accordance with various aspects that are important in engineering ethics. A total of seven aspects, namely utilitarianism, duty ethics, right ethics, virtue ethics, managing the unknown, whistle-blowing, and code of ethics will be discussed in this section. The analysis is carried out to give a picture on how the violation of these aspects can lead to a disaster, in this case, the collapse of a building.

### *D. Utilitarianism*

Utilitarianism, as in [8], is defined as the balancing between good and bad consequences of an action whereby the effects are taken into consideration for everyone affected by the action. Utilitarianism also emphasizes on maximizing the well-being of a society, rather than maximizing the well-being of an individual. In a nutshell, utilitarianism focused on balancing the individual needs with the society needs and stressed on the aspects that will provide the most benefit to most of the people.

It is unknown to the public why the engineers choose to neglect the dead load in the original design. Perhaps the engineers did not realize the need to include the dead load or they have their own reasons for omitting it. This action gives both good and bad consequences. The positive outcome of this action is lesser materials and shorter construction times were used to complete the building. Cost minimization is achieved since the amount of material used, the workers’ working time, and the duration of renting the equipment can be reduced. On the contrary, this dreadful mistake meant that ever since its construction, the building was on the brink of collapse as the building columns had been stressed to their maximum limit all along. Before the design is implemented, it should be send to another professional engineer for checking. This particular professional engineer has to be someone who does not gain any benefit from the project, so that he does not simply approve the design without proper inspection. From the utilitarian principle’s point of view, while the process of approving the design might consume longer time than it should and thus causing delay to the project, it is worthwhile to ensure the design is appropriate and safe to be constructed. The engineers might be reluctant to disclose their designs to another person, fearing that their work will be copied and plagiarized, but it is better to have someone to check the viability of the design because sometimes other people can detect the flaws in the design which might have been overlooked by the original engineers.

### *E. Duty Ethics and Right Ethics*

According to [8], duty ethics stated that there are duties that should and should not be performed, no matter these acts lead to the most good or not, whereas right ethics emphasized that any action that is against the moral rights is intolerable. Unlike the utilitarian approach which focused more on the well-being of the whole society, duty and right ethics emphasized on the individual. Duty ethics is inter-related with the right ethics. When someone has identified his duties, automatically he will know the types of moral actions which are ethically acceptable.

One of the ethical action that can be classified in the list of duties is not to cause suffering to others. It is the engineers' duty to ensure their designs are safe to the public. When the designs are accepted and used in daily lives, it is an honour and recognition to the engineers, so one of the ways to express their gratitude is to make sure that the design does not cause any harm or side effect to the users. In this case, proper designing should have been done before the construction. What if the engineers had knew that the hotel is an insecure building but they decided to cover up the matter? If so, these engineers are being dishonest and their actions are morally unacceptable. Although the collapse of the building is unavoidable and the lives of occupants are threatened ever since the day they start to occupy the building, the occupants do not have any clue about this because nobody had enlightened them about the flaws in the building design. This is where another ethical duty, the honesty, comes in handy. The thirty-three death tragedy might not happen if the engineers had acknowledged the appropriate authority sooner about the dangerous structure. Engineers have the right to exclude anything that they considered to be inessential to their designs. This is acceptable as long as the action does not violate the ethical and moral rights.

### *F. Virtue Ethics*

Virtue ethics is conceptualized for differentiating the actions, whether it is good or bad, based on the character traits supported by the action [8]. This theory is closely associated to one's personality, and at a glance, it might seem to be irrelevant with the engineering ethics. But if seen from another perspective, it is hard for a person to change his behaviors; eventually he will exhibit the same characteristics regardless of personal life or professional life.

The omission of dead load calculation in the design can be viewed as a vice because this is the main reason that the hotel collapsed. Two conjectures can be made for this action. First, the engineers might not have adequate knowledge in designing a building. They had accounted the live load but not the dead load. This is rather incomprehensible because a truly qualified engineer should have known better than anyone else regarding the importance of these two parameters and the impact that it will provoke for neglecting the parameters. Next, irresponsibility of the engineers can be deduced from the incident. It could be the mistakes are made either on purpose or unintentionally. No matter what, the responsibility still lies on the engineers. For clarification, if the mistakes are intentional, the engineers had already violated the code of ethics and their professionalism should be questioned. Engineers with this kind of attitude should not be allowed to involve in the project anymore and they should be dismissed with immediate effect. On the other hand, even if the mistake is not done on purpose, the engineers should also be blamed for being careless during the designing stage. They should have double checked the design to find out whether any minute detail has been overlooked. Other than that, the engineers can ask for the assistance of another professional engineer or qualified personnel to verify the viability of the design.

### *G. Managing the Unknown*

The skill of managing the unknown does not merely apply to engineering field, but basically it can be applied to almost everything in the world. Uncertainties or unknowns can arouse anytime, anywhere

regardless of the situation. The severity of the troubles caused by unknown varies, thus it is up to the people in-charged to manage the unknown and control or reduce the risk to a minimum level. If the unknown is controlled properly, there will be lesser or no harm induced to the living organisms, non-living things and environment.

On the 14th March 1986, when setting up for the evening, a nightclub hostess heard a noise and witnessed a crack in one of the columns. These abnormalities were then confirmed as safe on the next day. But, things are getting worse on the faithful day, 15th March 1986. More noises, cracks, falling debris and even vibrations had occurred. Eventually, at 11.27am, the hotel transformed into rubble and dust. Out of the fifty victims, only seventeen survived.

The lesson learnt from this event is to never underestimate an unusual thing that is observed randomly, because it might serve as a clue that leads to the revelation of a much serious problem. Cracks are observed at different columns. This is because the columns had been stressed to their maximum limit and these failures are actually hinting for the existence of mistakes in the designing phase. If the unusual cracks were reported to the related personnel earlier, a thorough investigation will lead to the discovery of the designing mistakes. Besides that, sense of danger played an important role here. People should have evacuated from the hotel when they noticed the increasing number of unusual phenomena that were happening in the building. If the people managed to evacuate the building sooner, the harm inflicted by the collapse could be reduced. The owner should also have consulted the related personnel before he started to install additional weight onto the building. The six-storey hotel was one of the tallest buildings in Little India at its time. All high-rise buildings have a limit on the weight that they can support. When the limit is exceeded, it is just a matter of time for the building to collapse. The best chance is to get a consultation on how much weight and the way it can be installed in the building. Other than that, the management should have scheduled regular maintenance and inspection for the building. These cracks could probably be detected during the inspection, if so, the engineers or related personnel need to carry out further investigation and testing to ensure the building safety.

#### *H. Whistle-Blowing*

Whistle-blowing describes the disclosure of an unethical or illegal wrongdoing within the organization by an employee to the public or the higher management. The four different forms of whistle-blowing are internal whistle-blowing, external whistle-blowing, anonymous whistle-blowing, and acknowledged whistle-blowing. All these forms of whistle-blowing served the same purpose, which is to report the wrongdoing to someone who can take action against it.

Every single detail in a construction, i.e. from designing to the materials used, is essential to ensure the safety of the building's future occupants. In this case, the mistakes made during the design stage have caused the hotel to collapse. These designing mistakes might have been observed or noticed by other co-workers, but there is no reports made to the higher management or the appropriate authority. The rationale behind this could be due to dearth of knowledge in the related field, where the co-workers do not have adequate knowledge to judge whether the design is suitable or not. Only people who have architectural, engineering and technical knowledge in designing a building will be able to determine the viability of the design. Examples of occupations that required these knowledge are structural engineers, architects and draftsmen. In another word, it is nearly impossible for people without appropriate knowledge to identify the flaws in the design.

On the contrary, what if another engineer, architect or draftsman happens to see the design, but they choose not to report about it? They might be afraid of losing their job as a consequence for meddling with the project. In their perspective, it is better to stay out from the trouble they might be getting for trying to pursue



the related personnel to modify the building design. That kind of mind set should have been discarded. As a matter of fact, it is unacceptable for one to ignore a matter that is related to the public's safety. Instead, they should have just perform anonymous whistle-blowing to higher management, appropriate authority or the public, where they do not have to worry that other people will know the identity of the whistle-blower. This action could have saved many lives.

### *I. Code of Ethics*

Based on the investigation, the downfall of Hotel New world is due to the exclusion of dead load in the design phase calculation. Two codes from Board of Engineering Malaysia (BEM) code of professional that can be used in this tragedy as following:

- a) Code 5.0: A Registered Engineer shall conduct himself honorably, responsibly, ethically and lawfully so as to enhance the honor, reputation and usefulness of the profession [9].
- b) Code 5.3: A Registered Engineer shall check with due diligence the accuracy of facts and data before he signs or endorses any statement or claim. He shall not sign on such documents unless, where necessary, qualifications on errors and inaccuracies have been made [9].

From the mistake that happen, the engineers in Malaysia whom in charge the building constructions have break the BEM code of ethics 5.0 and 5.3 which turns to causes the collapse of the building and numerous loss of life. The engineers should check the final design of the plan, calculation and other details thoroughly before approving the plan to prevent any unwanted tragedy.

### **CONCLUSION**

On 15th March 1986, the Hotel New World tragedy had occurred and it was deemed as one of the Singapore's deadliest civil catastrophe. The unexpected news had shocked the public, including the Prime Minister at that time, Lee Kuan Yew. An investigation team, led by Justice L.P. Thean, was formed to reveal the cause of the collapse. After much investigation, the team had concluded that the collapse is due to the miscalculation of the building's load. Ever since the construction, the columns were fully stressed and it is just a matter of time for the building to collapse. The endorsement of Building Control Act 1989 and Building Control (Accredited Checkers) Regulations 1989 along with the enactment of a few other rules were done following the finding, in hope to avoid similar mishap from happening in the future. An engineer should never breach the code of ethics, where they need to understand the serious outcome that can be caused by their violation of the code. Instead, they should stay firm with their beliefs and ensure that every action or decision they made are ethically acceptable whilst considering the well-being of the people affected by it.

### **ACKNOWLEDGEMENTS**

The authors would like to thanks the lecturers of engineering ethics' classes and Universiti Teknikal Malaysia Melaka for the all support.

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