Case Study of Second Penang Bridge Ramp Collapse and Case Study of Hyatt Regency Kansas City Walkways Collapse

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***Abstract*—two cases that happened in Malaysia and foreign country are discussed in this paper. Case in Malaysia happened in Penang Island which is the collapse of the Second Penang Bridge ramp while the case that happened in foreign country is the collapse of the Hyatt Regency Kansas City Walkways in United States of America. The cases happened in year of 2013 and 1981 respectively. Several aspects were discussed in this study. The aspects are the background of the incident, the details about the incident, the possible causes of the incident, effects and action take, and the lessons learned. The possible causes is being discussed in terms of code of ethics, the designation of the project, the management, and the nature. These two incident were related one to another because both cases have similar causes which is the designation.**

Keywords—collapse of the Second Penang Bridge ramp; Hyatt Regency Kansas City Walkways; code of ethics

I. INTRODUCTION

Penang Second Bridge is one of the biggest project in Malaysia. The incident was happening while the project is under construction. The overall construction period is 60 months which starts from 8th November 2008 to 8th November 2013 and was opened to publics on 1st March 2014.The total cost of the project is 4.5 billion MYR. The length of the bridge is 16.4km while the length of the expressway is 7.1km and gives 23.5km of the total length. The bridge connects the mainland (Seberang Perai) to the island (Penang Island) which are Batu Kawan and Batu Maung respectively. The land configuration is dual traffic lanes and one motorcycle lane each other.

Hyatt Regency Kansas City is one of the hotels that use popular design with large atriums that helps create very dramatic architectural spaces in hotel lobbies. This hotel located at Kansas City Missouri, United States. The design include walkways suspended over the atrium. Development for this design started in 1976, construction began in 1978 and completed in summer of 1980. The development is initiated by Crown Center Redevelopment Corporation, which hired Gillum-Colaco, Inc. of Texas as the consulting structural engineers.

II. DETAILS OF THE INCIDENT

A. Penang Second Bridge ramp collapse

On the 6th June 2013, 30-meter length of a section connector of the bridge at Batu Maung Interchange which was under construction at Batu Maung had collapsed at around 6.50 pm. The project is a big project, so that this project needs to be divided into several sub-project. Table 1 shows the division of the project and each sub-project were handled by different contractor or company. The collapsed ramp is from the project Package 3A. Figure 1 shows the several division of the projects. It can be observed that project Package 3A is located at Batu Maung which is on the island. From the Table 1, its shows that the project Package 3A is costing up to 152.7 million MYR.

Figure 1 The locations of the sub-projects

Also from the Table 1, the contractor or the construction company that responsible to this Package 3A sub-project are local companies which are Cergas Murni Sdn. Bhd. and Giga Engineering & Construction Sdn. Bhd.

Table 1 Shows the division the project to the different companies

Package	Project Description	Contractor	Project Cost (RM Mil.)
1	Main Navigation Span and Substructure and Foundation Works for Approach Spans	CHEC Construction (M) Sdn. Bhd.	2200
2	Superstructure Works of Approach Spans	UEM Builders Bhd.	1550
3A	Batu Maung Interchange	Cergas Murni Sdn. Bhd and Giga Engineering & Construction Sdn. Bhd.	152.7
3B	Batu Kawan Expressways	IJM Construction Sdn. Bhd.	349.9
3C	Batu Kawan Trumpet Interchange	HRA Teguh Sdn. Bhd.	67.3
3D	Toll Plaza, Administration Building and Related Works	S.U Citra Bina Sdn. Bhd.	79.8
3E	Toll Collection System	TERAS Teknologi Sdn. Bhd.	14.97
3F	Traffic Control and Surveillance System	Itramas Technology Sdn. Bhd.	19.8
3G	Electrical Installations	TN Synergy Sdn. Bhd.	13.38

The incident caused the dead of one civilian and injured to others four which is two civilian and two workers which is from Indonesia and Myanmar. The list of the victims can be observed from Table 2. The victim that was killed in the incident was trapped in a crushed light green Kelisa. Figure 2 and Figure 3 shows the photo the light green Kelisa and the collapsed ramp respectively. In order to set free the victims, four hydraulic jacks are being installed to lift the debris and rubble of the collapsed ramp. The injured victims were hurt by the falling concrete and steel girders when the interchange ramp collapsed.

Table 2 The list of the victims

No	Name	Status	Condition
1.	Tajudin Zainal Abidin	Civilian	Killed
2.	Thilasheni Rajendran	Civilian	Injured
3.	Gajashantini Gajanujan	Civilian	Injured
4.	Slamet Toket	Worker	Injured
5.	Tin Maung Lwin	Worker	Injured

Figure 2 Crushed victim's car

Figure 3 The collapsed ramp

B. Hyatt Regency Kansas City Walkways collapse

Development of the Hyatt Regency Kansas City was initiated in 1976 by Crown Center Redevelopment Corporation. 2. Crown Center Redevelopment Corporation hired Gillum-Colaco, Inc. of Texas as the consulting structural engineers. Gillum-Colaco worked together with Crown Center Redevelopment Corporation and project architects to develop the plans and create structural drawings and specifications.

Figure 4 Situation at Hyatt regency Kansas City Walkways

However, Gillum-Colaco did not perform the structural engineering but subcontracted this work to its subsidiary, Jack D, Gillum and Associates, Ltd. General contractor for the project is Eldridge Construction Company, then hired Havens Steel Company as the subcontractor for fabrication and erection of the atrium steel. First and original design for the project is for the walkways to be hung from rods connected to the atrium ceiling and there will be two walkways connected to each rod by separate nuts. Figure 5 shows original schematic drawing of second and fourth-floor walkways.

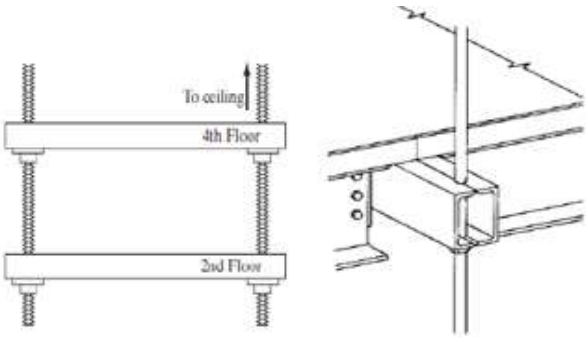

Figure 5 Original schematic drawing for second and fourth-floor walkways

This design required that the rods be threaded for most of their length in implementation process and this process increase the costs of the rods. Then, change in design is suggested by Havens to avoid requirement for threading long pieces of rod. Figure 6 shows new design after change is done to the original schematic drawing. The rods are not connected continuously from the ceiling to the fourth and second floor but only connected to fourth floor. Then, another rod is connected from fourth floor to the second floor.

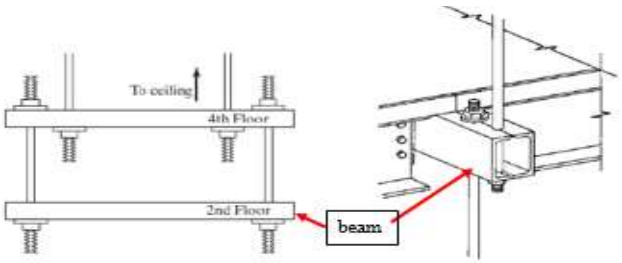

Figure 6 New schematic drawing for second and fourth-floor walkways

III. POSSIBLE CAUSES OF THE INCIDENT

A. Penang Second Bridge ramp collapse

The possible causes that lead to the incident is being investigated from several aspects. The first one is from the code of ethics which is related to Board of Engineer Malaysia (BEM) & Occupational Safety and Health Act (OSHA). The second one is from the designation of the project. The third one is from management aspect and the last one the nature aspect.

Department of Occupational Safety and Health (DOSH) stated that there was procedural and technical negligence by the contractor. The contractors did not register their workers with the Construction Industry Development Board (CIDB), said Datuk Ir. Dr. Johari Basri as the the Department of Occupational Safety and Health (DOSH) Director General. Initial investigations revealed that some of the workers at the construction site of Package 3A were not registered with the board. From CIDB Malaysia Act 1994 (Act 520), workers at construction sites must have Industrial Personnel Registration Cards or Green Card to prove that they were registered with the CIDB.

Penang DOSH Director, Mohd Anuar Embi said that early investigations by his team found that failure of the formwork support was the cause of the collapse of the ramp. Before start a certain project, the designation of the project must have been approved by the responsible engineer. According to the act, contractor or workers needs to follow the exact design and any changes needs to be approved by the engineer or the designer. This is because, every parameter or calculation in the designation were designed to achieve the maximum quality of the project, then if the design was changed, it is could affect the quality of the project.

The incident also caused by the weak risk management. The risk management of a project must be scrutinized to prevent the unwanted incident. This is because it is involved the lives of road users. Why the route not closed or diverted away from the construction and why does the public have to take risks to pass under the concrete ramp which was under construction? Every construction project must take into account and study in depth risk management involving public, workers, and project. Three main items which should be scrutinized deeply when implementing any construction project are technical aspect, environment aspect, and risk management aspect.

The last possible cause is the poor drainage system at the construction. Weather and soil condition factor is also another cause that has led to the incident. Land filling works have raised the height of the surrounding areas by about two to three meters. The land where the collapse occurred is still at its earlier level. This has created a water-retention pond of about one acre in size. The scaffolding was erected on ground that was dry. Rain had turned the low-lying ground into a water retention pond as there is no drainage to quickly remove rainwater from the area.

In conclusion, the main causes that lead to the incident are the workers were not registered with the board, the failure of the formwork support, the weak risk management, and the poor drainage system.

B. Hyatt Regency Kansas City Walkways collapse

There are two possible reasons for the collapse of the Hyatt Regency Kansas City Walkways which are:

1)Heavy load that cannot be supported by beam for the walkways of both fourth and second floor.

- There are approximately 2,000 people gathered to participate and watch dance party at the walkways. This increase the load that the walkways can hold. The walkways design should be able to withstand this heavy load due to safety measure taken before design is approved
- In original design, beam for fourth and second floor is independently hung their weight to the ceiling. But, in the new design, beam at second floor is dependent on the fourth floor. This make the beam at second floor need to support weight from both fourth floor and second floor.
- Analogy that can be used to understand this design is when two people is hanging on the rope for support and grip. The first design is when two people hanging on the rope independently and the second design is when one people is hanging on the rope and the other one is hanging on the leg of the people hanging on the rope. Figure 7 shows the analogy. When one people is depending on other people to stay hanging on the rope makes the weight that the ceiling need to support increase and the grip that the first person is not strong.

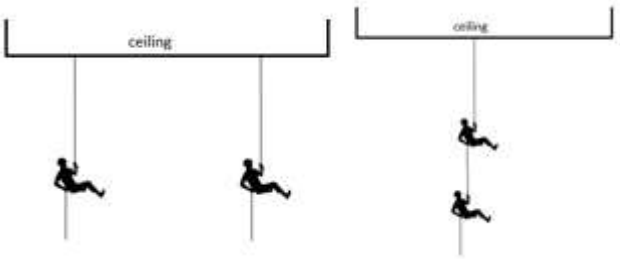

Figure 7Analogy of the design

- With this new design, even before people entering walkways, the beam at fourth floor already support weight of the second floor. Added with 2,000 people entering walkways for both floor when the incident happens, weight that the beam need to support is doubled and become overload causes the beam cannot support the walkways anymore and collapse of both walkways happen.

2) Negligence of person in charge (Engineer) who gives approval for the design of the walkways.

- Subcontractor for fabrication and erection of the atrium steel, Haven Steel Company suggested the design to be change to reduce the cost of the rods. It is uncommon for the subcontractor to suggest change in structure, especially if the changes can lead to cost savings or easier fabrication.
- Gillum and Associates however claimed that they never seen the document about the change in design. They also stated that they have never been informed about the change by Havens or Eldridge company. The problem arises because the document is sealed by Gillum stamp despite saying that they never know about the change.
- This became ethical problem for the engineers. The engineers give approval for the design without confirming, examining and analysing the schematic design that has been change. This approval makes the contractor to begin construction without knowing that the design is unsafe.
- It should be known that according to the specification for the project, no work could start until the design shop drawings for the work had been approved by the structural engineer which for this case approval from Gillum-Colaco. Due to this negligence of duty as an engineer, the collapse of the walkways happens tragically.

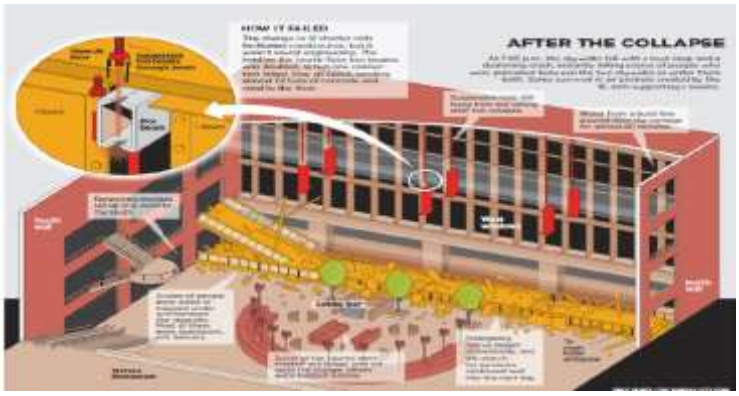

Figure 8 Situation after the collapse

IV. EFFECTS AND ACTION TAKEN

A. Penang Second Bridge ramp collapse

There are several effects of the incident. The first one is the project had to be pushed back by one month to give way for the DOSH to perform the complete investigation regarding the incident. The second one is caused mentally traumatized and loss of productivity.

Also several actions were taken when the incident happened. As the project were conducted by two construction companies which are Cergas Murni Sdn. Bhd. and Giga Engineering & Construction Sdn. Bhd. For the actions taken, Cergas Murni Sdn. Bhd. was fined RM50000 according to Section 17 of the OSHA 1994 and CIDB Malaysia Act 1994 (Act 520). Giga Engineering & Construction Sdn. Bhd. was fined RM35000 according to Section 15(1) of the OSHA 1994 and CIDB Malaysia Act 1994 (Act 520).

According to CIDB Malaysia Act 1994 (Act 520), workers at construction sites must have Industrial Personnel Registration Cards called as Green Card to prove that they were registered with the CIDB. The act states that a person

shall not be involved or undertake to be involved as a construction personnel unless he is registered. He shall be guilty of an offence and be liable to a fine not exceeding five thousand ringgit.

B. Hyatt Regency Kansas City Walkways collapse

There are several effects of the incident. The first one is about 114 people were killed and over 200 injured. Besides, the structural engineers lost their licenses to practice engineering in the State of Missouri. A part from that, the certificate of authority as an engineering firm revoked. Besides that, emotional trauma associated with disasters. The effect after incident of victims who survived are nightmares and recurrent dreams, fear of overhead structures, hypersensitivity to sudden noise, extreme fatigue, insomnia, difficulty of concentrating and also guilt and anger.

Also several actions were taken when the incident happened. Wayne G. Lischka, an architectural engineer, was hired by The Kansas City Star newspaper to investigate the collapse. They discovered the change in design that caused the failure to happen. After the investigation, there are change in code of ethics. American Society of Civil Engineers (ASCE) changed a code to state that the responsibility of the design lies with engineer's seal. The engineer that places the seal of the approval upon the set plans carries responsibility for the building and its outcome.

According to the ASCE code of ethics, there are a few of violation occurred in the Hyatt Regency case. The fundamental canon label 1 states that "Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties." It is shows that the change of original design to new design rendered the structure hardly able to hold its own weight. If the structural engineers are concerned about the potential risk the change would produce, the flawed design will not produce.

The label 2 of canon states "Engineers shall issue public statements only in an objective and truthful manner." The code is violated when GCE is attempted to accuse others about their flawed design and states that the change of design is not approved by them.

According to canon label 3, "Engineers shall act in such manner as to uphold the honour, integrity, and dignity of the engineering profession." The engineers that involved in the case are being charge of "gross negligence, incompetence, misconduct and unprofessional conduct in the practice of engineering". This charge is greatly tarnished the respectability and dignity in the engineering profession.

V. THOUGHT AND LESSON LEARNS

Table 3 Causes of incident from both cases

Penang Second Bridge Ramp Collapsed Under Construction	**The Collapse of Hyatt Regency Kansas City Walkways**
Stability of footing foundation that support formwork	Stability of beam
Engineering Design Ethics	Engineering Design Ethics
Robustness of design	

Based on Table 3, one of lessons that can be learned from the case study of Penang Second Bridge Ramp Collapsed Under Construction is stability of footing foundation that support formwork are really important to make a structure stable. The collapse of the ramp is caused by the failure of the formwork support. Meanwhile, stability of beam is really important for the design of the walkways in the case study of The Collapse of Hyatt Regency Kasas City Walkways. Overload because the beam cannot support the walkways both fourth and second floor anymore and collapse.

Next, civil engineer construction should have ethical considerations when deals with the designing, planning, construction and management of infrastructures and also in term of safety aspect. For the case study of Penang Second Bridge Ramp Collapsed under Construction, engineer should be considered about material adequacy when design of structure, so make sure the sizing of material is sufficient for stability of structure. Furthermore, when construction sites at low level area, engineer should design drainage system to eliminate standing water. For the case study of The Collapse of Hyatt Regency Kasas City Walkways, engineer should measure maximum weight that the beam can support. Negligence of engineer who gives approval for the design is caused the collapse of the walkways. Lesson learn from this case study is engineers should not neglect his or her responsibility when evaluate, verify and endorse the engineering design.

Engineers also should be focus on robustness of design because it will minimize the negative effects of the uncontrollable factor. Besides that, the prevention to avoid accidents in construction sites is client and design consultants should do more frequent inspection at construction sites. Regular inspection will ensure that the works progress as intended, both in terms of quality and compliance. The problems that actually happened in construction sites can be detected early.

VI. CONCLUSION

As a conclusion, Engineer should follow code of ethics when dealing with their job since it will makes the engineer to become honesty, impartiality, fairness, equity and become dedicated to the protection of the public health, safety and welfare. Engineers also should follow all the procedure that have been decided throughout completing their job. Engineers also need to consider all the possibility that will occur when making a decision. Everyone need to play their roles in order for the job to be done successfully based on the planning.

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