Elizabeth Tower- Renovation phase Risk Management

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Abstract. This paper manages the risk of the renovation of the Elizabeth Tower. After a series of field visits and literature research, this paper focuses on the importance and rigour of the renovation of the Elizabeth Tower, and after collecting risk information and data on it, hazard identification is carried out, 15 potential risks of its renovation phase are proposed, and they are analysed in two dimensions: Consequence (C) and Likelihood (L), and then the risk level of each potential risk is assessed through a risk matrix, and a risk response is given to each of them, and the risks are ranked again, and finally recommendations for improvement and suggestions for the arrangement of future work are made to reduce the risks of this renovation project.

Keywords: Risk management; Elizabeth Tower; Brainstorming.

1. Introduction

The Elizabeth Tower (commonly known Big Ben) is the most important landmark in the history of the UK, and to better present the tower to the world in the future, the UK government plans to carry out refurbishment works on Big Ben from 2017 to 2022. The restoration of Big Ben has been underway since 2017 and is expected to last for three years. However, the restoration of Big Ben has not yet been completed. The reason for the increase in the monetary and time budgets is that the extent of the damage has been more severe than expected, but it may also be due to the lack of risk management in the renovation project. Risk management in the construction of building projects is an important part of the engineering management of building projects, and as the process of the Big Ben renovation continues, the financial losses in the construction are unpredictable due to the two main characteristics of the renovation process, which are uncertainty and objectivity. Given the historical status of the Elizabeth Tower and its geographical location, this refurbishment is far more specialized than other projects, making risk management more necessary. Stakeholders in this project include the UK Government and Council, the refurbishment team, and the people of London (London's Big Ben, 2022). This paper will collect, identify, analyse, and respond to the risks associated with the refurbishment of the Elizabeth Tower, using Brainstorming, Delphi, and Process Decomposition Methods to minimize the monetary and time budgets of the refurbishment from a risk management perspective.

2. Risk management requirements for the renovation to be analysed

Project risk management is the management of project risk through risk identification, risk analysis and risk evaluation to understand the risks of the project, and based on this, reasonably use a variety of risk response measures, management methods, techniques, and tools to implement effective control of project risks, and properly deal with the adverse consequences of risk events to ensure the achievement of the overall project objectives at a minimum cost. Risk management in construction project construction is an important part of construction project engineering management, because of the two main characteristics of uncertainty and objective existence in the construction process, the economic losses in construction are unpredictable and unpredictable, so it is important to strengthen the risk management in the construction process, which is an important way to ensure the economic and social benefits of construction enterprises. Considering the professionalism and importance of this refurbishment project as a symbol of Britain, the risk management of this project is necessary. Considering the importance of the Elizabeth Tower, this paper will manage project risks in terms of economic impact, social impact, and construction and worker safety.

3. Risk information and data collection

In this paper, risk information was collected in two main ways, namely literature research and fieldwork (London's Big Ben, 2022). This paper mainly refers to the engineering data released by the government or the renovation team and finds that this project includes five aspects, which are Deep cleaning, Restoration of external structures, Improving internal areas, Renovating its clock In addition to this, reference was made to reports on the renovation of the Egyptian pyramids (Amy Woodyatt, 2022) and the Eiffel Tower in France(LeBoutillier, 2007), listing more than thirty possible risks associated with this type of renovation, and a site visit to the Elizabeth Tower in early 2022, which, following hazard simulations of its interior and environment, resulted in Fifteen risks were collected and categorised into five levels of likelihood of occurrence and severity of consequences(London's Big Ben, 2022). Some risks are certain to occur, for example, the loss of the bells during the renovation could affect the lives of the residents. This step was assessed mainly based on risk management reports from other buildings and reports issued by government departments.

4. Hazard identification

In this paper, following a site visit to Elizabeth Tower and extensive data collection on potential hazards, risks were identified throughout the refurbishment project using the brainstorming, Delphi and process decomposition methods, resulting in the identification of 15 significant potential hazards, which are recorded in Table , and then the characteristics and timing of the risks were recorded and classified according to the identification results.

The hazards identified (HID) in Table will be referred to by their HID though out this paper.

Table 1. Potential Hazard Identification

HID	Item	Category* (Stage)	T/O**	Description
1	Issues with Structural	Technical (D/B/O)	O	The renovation plan will add a new elevator, which will dig an elevator shaft in the clock tower, potentially harming the internal structure of the clock tower.
2	Issues with Stone products	Technical (C/B/O)	T	Big Ben is made of stone, the construction of elevators and scaffolding will cut the stone and cause irreversible damage.
3	Damage to workers' hearing	Technical (B/O)	T	Before the bells are turned off, the loud sound of the bells can hurt the hearing of the workers doing the pre-work.
4	Working at heights	Health & Safety (B/O/E)	T	The height of Big Ben is 95 meters, and there is a risk of workers falling during scaffolding and renovations.
5	Issues with the electrical circuit	Technical (B)	T	This renovation will add a new lighting system in addition to the new elevator, the new circuit design is unreasonable, and the old circuit will create the risk of electricity leakage .
6	Damage to the clock face	Commercial (B/O/E)	T	The clock face of Big Ben has 312 precious stones, and there is a risk of losing them when refurbishing it, resulting in a huge financial loss.
7	Injury to pedestrians	Technical (B/O/E)	O	After the installation of scaffolding, bad weather can make the scaffolding risk collapse.
8	cultural transmission	Economic (C/E)	T	Big Ben has been built 163 years ago and has always been an icon of Britain, this repair is four years long, the construction of the fencing of Big Ben will have an impact on the spread of British culture.
9	The Covid spread	Health & Safety (D/B/O)	T	During the renovation process, the world-shaking outbreak of the epidemic, working in a confined space would allow the epidemic to spread among the workers.
10	Loss of timing function	Economic (E)	O	There have only been a few times in the history of Big Ben where the bells have stopped ringing and the bells have become a part of the lives of Londoners who would be affected by a prolonged renovation.

11	Economic harm	Economic (E)	T	The refurbishment of Big Ben cost £80,000,000 and the high cost generated a certain amount of negative public opinion.
12	Public Opinion	Political (B/O/E)	T	The renovation will change the appearance of part of Big Ben, including the colour material. There is a risk that it will be unacceptable to residents.
13	Traffic Jam	Economic (E)	T	During the erection of scaffolding, the transport of construction materials, etc. will affect nearby traffic.
14	Confusion of components	Technical (C/D/B/O)	T	The refurbishment process involves the removal and repainting of many small parts, with the risk of loss and confusion of parts in the process.
15	Colour mismatch of stonework	Technical (D/B/O)	T	Big Ben has suffered varying degrees of damage to the exterior and interior stonework due to war and weather damage, and most of the materials used to repair it are no longer manufactured, and there is a risk that the surface colour will not match the new colour due to ageing .

(Key: * C = Conception, D = Design, B = Build, O = Operate, Env = Environmental ** T = Threat, O = Opportunity)



Figure 1. Masterplan of the preferred site showing potential hazards

5. Risk analysis

This paper reviews similar building refurbishment reports and draws on their classification of risk levels, ranking the likelihood of potential risks and the severity of consequences in terms of the degree of economic loss caused and the length of impact. Table 2 shows the range of definitions used to classify hazards, and the scale is used to estimate the pre-management classification of hazards.

Table 2. Classification Scheme

Rank	Likely hood (L)	Consequence (C) (cost, delay, key H&S)
5	Very High > 80%	Serious >£30m, >10 months, fatality
4	High 51% to 80%	Significant £20-30m, 8 to 10 months, serious injury
3	Medium 21% to 50%	Moderate £5-20m, 3 to 8 months
2	Low 1 to 20%	Minor £1-5m, 1 to 3 months
1	Very Low <1%	Insignificant <£1m, < 1month

A risk matrix is a screening tool that can be used to rank hazards according to risk level, risk source or risk response. This section will be used to classify the hazards in Table 1 according to risk level.

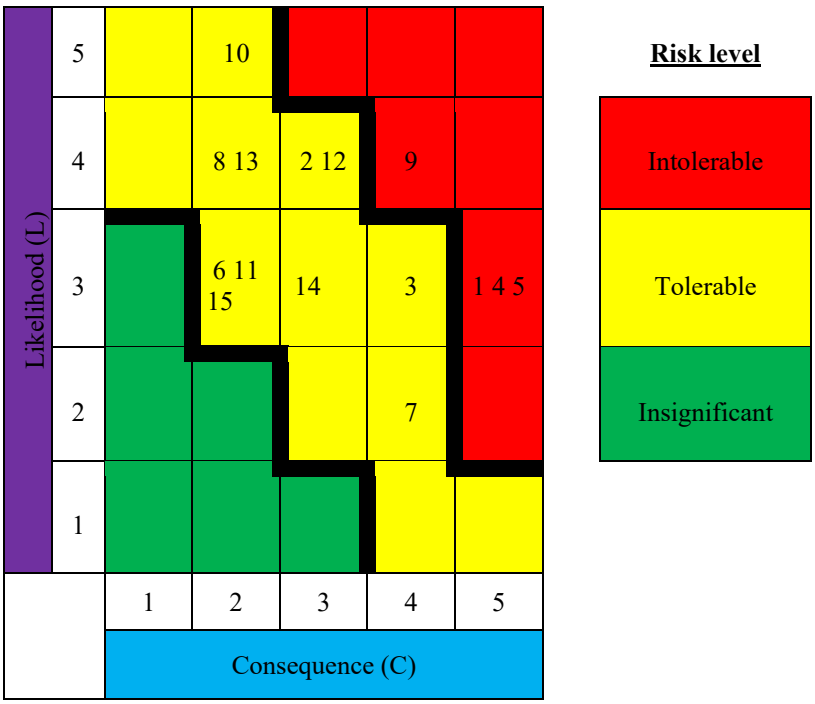
Table 3. Risk Classification pre-management

HID	Consequence description, factors and Score		Likelihood description, factors and Score	
1	Issues with Structural	5	Depends on the ageing of Big Ben and how well designed it is	3
2	Issues with Stone products	3	Almost certain	4
3	Damage to workers' hearing	4	Difficult to ascertain	3
4	Working at heights	5	Difficult to ascertain	3
5	Issues with the electrical circuit	5	Difficult to ascertain	3
6	Damage to the clock face	2	Difficult to ascertain	3
7	Injury to pedestrians	4	Depends on the safety of the scaffolding	2
8	cultural transmission	2	Almost Certain	4
9	The Covid spread	4	Almost Certain	4
10	Loss of timing function	2	Certain	5
11	Economic harm	2	Difficult to ascertain	3
12	Public Opinion	3	Almost Certain	4
13	Traffic Jam	2	Almost Certain	4
14	Confusion of components	3	Difficult to ascertain	3
15	Colour mismatch of stonework	2	Difficult to ascertain	3

6. Output analysis and discussion

Table 4 Presents the Risk classification Matrix for the Hazards identified in Table 3. This arrangement enables risk managers to focus on the key hazards that need to be Risk Managed.

Table 4. Pre-management Classification



In the table, there are six green, seven red and twelve yellow cells, corresponding to intolerable, tolerable, and insignificant risks.

The intolerable hazards identified are HID5 associated with the electrical circuits ,9 The Covid spread, 4 Working at heights and 1 Issue with Structural. These critical items would prevent the progression of the project as they stand and require a risk response. All other items fall within the tolerable region but will still be considered for Risk Management as they may incur >£10m cost impact.

7. Recommendation of improvement

7.1 Risk Response

Typically, engineering risk responses like the Elizabeth Tower renovation project include the following: risk avoid, risk reduces and risk transfer.

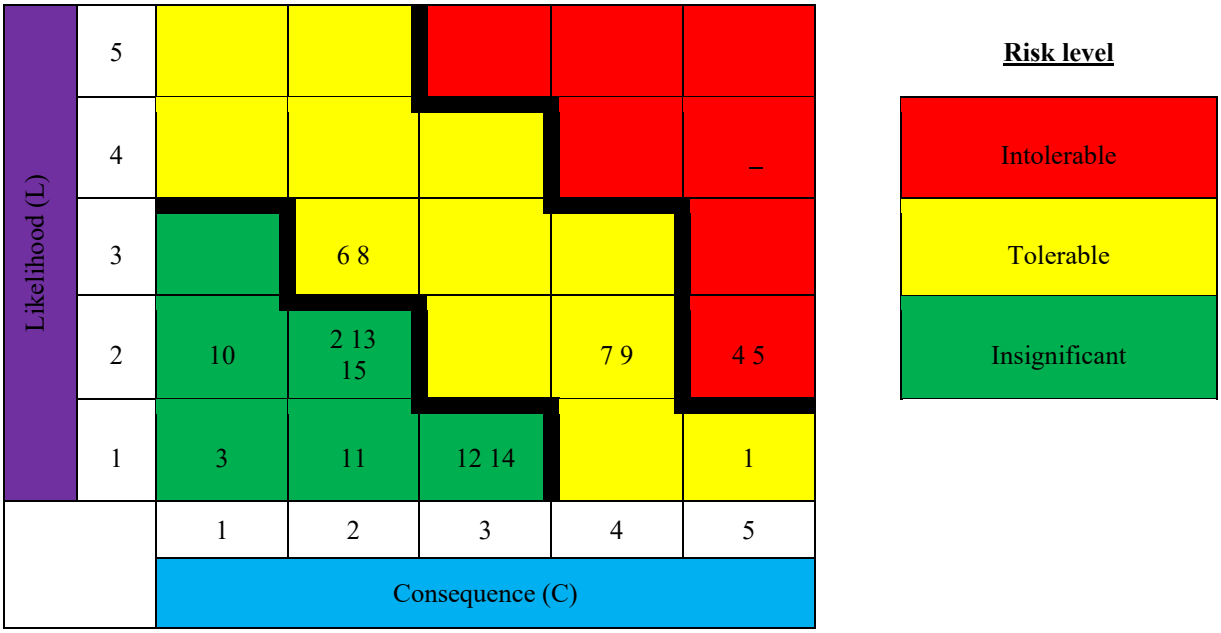
Table 5 responds to the potential risks raised in Table 2 and proposes measures to address them，and an estimate of the post-management values for consequence (C) and likelihood (L).

Table 5. Risk Responses

HID	Response	Mitigation / Opportunity Options	C	L
1	Reduce	The Big Ben was thoroughly inspected before the refurbishment work, including an inspection of the foundations; the original lift shaft was inclined, which was a huge hazard to the structure and should be converted to a vertical shaft as far as possible. (The Chimes Tower structure, n.d.)	5	1
2	Reduce	When building scaffolding, it is easy to have an impact on the surface of the stonework, you can choose sponge or foam shims to protect its surface. (PRODUCTION TECHNOLOGY OF STONE FRUITS, 2022)	2	2
3	Reduce / Avoid	Turn off Big Ben bells as soon as possible and protect workers carrying out preliminary work, for example by wearing earplugs. (Della Sala, 2022)	1	1
4	Reduce	Scaffold containment and safety are enhanced, and workers are made aware of safety and are forced to wear safety harnesses. (Blog, Heights, Blog and Heights, 2022)	5	2
5	Reduce / Avoid	Removal of ageing circuits, redesign of circuits due to upgrading of lifts and lighting systems; use of safer and more stable wiring; ensuring that the tower is dry. (Basic Electrical Safety | EHS, 2022)	5	2
6	Reduce	To refurbish a clock, the jewels on the face are first removed and marked, and then reinstalled according to the number after the refurbishment is completed; unlike other areas, the refurbishment of the clock face should be left to a more professional worker. (CanStock, 2022)	2	3
7	Reduce	Improve the tightness of the scaffolding; close roads and footpaths that are likely to be affected; inform the public in advance so that they can bypass the construction section and put up a protective net at the base of Big Ben. (Administration, 2022)	4	2
8	Reduce	The renovation work will be divided into several parts and the work will be carried out in separate enclosures so that the parts that are not under construction will be displayed to visitors and the loss in terms of cultural communication will be minimised. (London's Big Ben, 2022)	2	3
9	Realise	Frequent disinfection of workers and workshops; workers wear masks at work; workers should be up to date with vaccinations.(Hegde, 2020)	4	2
10	Realise	The main functions of Big Ben are the chimes and the countdown to special festivals. The chimes can be replaced by loudspeakers on the corners of the city. (What is the function of Big Ben? - Answers, 2022)	1	2
11	Reduce / Avoid	Reduce spending where it is not necessary, make public the bill for the Big Ben renovation, solicit donations from the private sector, and reduce the government's share in spending, thereby reducing negative public opinion. (Jeong and Cho, 2021)	2	1
12	Reduce / Avoid	Vote publicly on the internet to change the colour of the Big Ben clock face and decide whether to change it in the light of reality, thus reducing negative public opinion. (Ex-Stealers on the Big Ben problem in Pittsburgh, 2022)	3	1
13	Reduce / Avoid	Reduced construction time and thus reduced road blockage time; only half of the road will be closed to reduce travel impact on nearby residents .(Big Ben to chime again after five-year restoration project, 2022)	2	2
14	Reduce	When working with complex components, they are labelled, photographed, and archived, and modelled on the computer; the possibility of confusion is minimised. (BGBN), 2022)	3	1
15	Reduce / Avoid	For larger components, the original colour is analysed, and the colour is tinted before painting to avoid damage to the component. For smaller components, the whole can be removed, and the colour studied to ensure that the new colour remains uniform with the old one. (Green, 2007)	2	2

Table 6 shows the risk matrix after potential risk management. Table 6 indicates that all risks will have different levels of risk reduction after risk response.

Table 6. Post-management Classification



As can be seen from Table 6, there are hazardous consequences that cannot be reduced, such as HID1 and HID5. The measures are taken in the table reduce to some extent the likelihood of the event occurring (L) or the severity of the consequences (C), for example.

Significant reduction in the likelihood of incidents in HID 4 and HID 5 (through training of staff and better preparation for construction).

Reduced severity of consequences in HID 10 and HID 11 (by substitution of other things).

HID 4 remain in the intolerable region, and an Emergency Preparedness Plan is advised - a recommendation for this is presented in the following section. All “tolerable” hazards should continue to be monitored and controlled.

7.2 Emergency Preparedness

During the preliminary survey and preparation for the work, it was inevitable that workers would have to work under the bells for a period, which could cause irreversible damage to their health, particularly their hearing, so HID 4 was unbearable. In HID 5 the safety of the electrical circuits had to be prepared for a crisis, the ageing of the original circuits and the wet weather in London would have made this potential hazard intolerable, and not only that, but if leakage or electric shock had occurred, it would have had a serious social impact. It is therefore recommended that emergency preparedness plans be developed in conjunction with further value management activities.

7.3 Emergency Preparedness Plan

If HID 4 and HID 5 occur and a worker is injured as a result and work is stopped as a result, the following planned activities should be carried out.

1) identify the cause of the worker's injury because of the accident and repair it.

2) take the injured worker to the best possible hospital and reassure the injured worker's family members.

3) proactively negotiate with the injured worker for compensation.

4) use traditional media or social media to reduce negative public opinion of the accident and to promote the safety of the renovation work.

5) resume work as soon as possible to minimise the cost and time lost.

8. Future work

The Elizabeth Tower refurbishment is an ongoing project with a potential delivery date of 2022. While the potential risks may not necessarily occur, there is work that is essential in the future. For example, training workers in safety so that they can work in a way that ensures their safety and reporting the progress of the project to the public in real-time to reduce the likelihood of negative social opinion.

9. Conclusions

This paper manages the fifteen risks in the renovation phase of the Elizabeth Tower responds to each of them and proposes emergency preparedness steps, which to some extent reduces the economic and time losses of this project, however, such risk management has certain limitations and cannot systematically reduce the risks of the project. In addition, due to space limitations, it is not possible to fully analyse all the risks arising from this refurbishment project and only fifteen of the more important ones can be selected. It is recommended that future quantitative analysis techniques be used to determine how these risks can be further reduced. As one of the most iconic buildings in the UK, risk management is essential for refurbishment projects. During this study, it was found that the most important way to reduce the risks of this refurbishment is to develop a sufficiently professional refurbishment team.

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