Upgrading of the Penang Hill Funicular System – Challenges in the Conservation of an Industrial Heritage

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Built in 1923, the Penang Hill funicular system is the oldest funicular system in Southeast Asia.

The antecedent system comprised two sections, with a lower section of 907m and an upper section of 1312m. The travelling speed was 1.4m/s on the lower section and 1.8m/s on the upper section. Each section had two non-air-conditioned coaches of 80-person capacity. The government had proposed the upgrading work with a view of arresting the increasing maintenance demand as well as improving the safety, comfort and capacity of the system. Amongst the proposed upgrading works were to connect the two sections into one to minimise future operational and maintenance costs, to increase the speed and capacity of the coaches to cater to the increasing number of tourists, to air-condition the coaches so as to provide better comfort, and to enhance the system's safety measures.

Several concerned parties, on the grounds of heritage conservation and environmental protection, had objected to increasing the maximum travelling speed of the funicular system from the current 1.4m/s and 1.8m/s to 10m/s; connecting the two-section funicular system into a single section; and air-conditioning the coaches.

Several consultations with these stakeholders were held. The meaning of an industrial heritage, its conservation and contemporary relevance were seriously challenged and debated during these consultations. The need to meet the present day social and engineering demand was also deliberated. This paper examines the conflicts and challenges arising from the proposal to upgrade the system, and how they were eventually resolved.

1. INTRODUCTION

The Penang Hill funicular system is the only means of public transport on Penang Hill (although there is a jeep track running from the Botanical Garden to the peak of the hill, it is officially not open to the public). Penang Hill was probably the first hill station of its kind within the British colonies because it originated in the late 18th Century, whereas the earliest hill stations in India dated around 1820 (Aiken, 1987). At that time, hill stations in the British colonies were established primarily as resorts for the colonial officials (King, 1976) and to serve as places of refuge from the hot and humid tropical climate (Mitchell, 1872). This was certainly the case for Penang Hill.

To access Penang Hill, a rough track had been cut as early as 1787 through the rainforest to the signal house on the crest of the ridge overlooking Georgetown. Access to the hill station was done in two stages: from Georgetown to the foot of the ridge on horseback or by palanquin or gharry (usually a two-wheeled carriage or cart drawn by a horse or pony and plying for hire), and from there to the crest of the ridge by a Sumatran pony or in a sedan chair (Denny, 1894) (Figure 1).

Figure 1: The earliest mode of Penang Hill transport

To improve access to the hill station for the colonial officials, the British made an attempt to construct a funicular line to the hill station in 1890s. The line was opened in 1906 but the equipment failed to operate and the company that built it went under (Ric Francis, 2006).

After the First World War, the British made another attempt. A new funicular system was designed by Arnold R. Johnson who had studied funicular systems in Switzerland. The new system featured numerous viaducts and a precipitous tunnel near the top end of the line, making its construction a considerable engineering feat. The construction of the funicular system started in 1920 and was opened to the public on 21 October 1923, although it was only officially declared opened in 1924. Today, the Penang Hill funicular system is the oldest funicular system in Southeast Asia (Ric Francis, 2006).

The main purpose of building the funicular system then was to provide a convenient means of transport for senior British officials to reach their bungalows uphill. However, with the opening of the funicular system, Penang Hill soon became a popular tourist attraction. The number of visitors to the hill station increased from 136,000 before the war to 351,000 in 1951, according to a 1952 guidebook on the island (Aiken, 1987). Recent statistics show that about 500,000 tourists per year make use of the funicular system. It is obvious that the system now transports mainly tourists.

The funicular system comprised two sections, with a lower section of 907m and an upper section of 1312m inclined length (Figure 2). It ran through tropical scenery with a maximum gradient of 27.9 degrees, rising from 36m above sea level to 727m above sea level. The travelling speed was 1.4m/s on the lower section and 1.8m/s on the upper section. Each section had two non-air-conditioned coaches of 80-person capacity. The hourly capacity was 200 people. The coaches were not the original ones installed in 1923 as the four original coaches were replaced in 1977 and one of the replaced carriages is on display at the top of the hill (Figure 3).

Figure 2: The antecedent Penang Hill funicular system

Figure 3: The original coach displayed on top of the hill

The government had proposed the upgrading of the funicular system with a view of arresting the increasing demand for maintenance as well as improving the safety, comfort and capacity of the system. The antecedent system broke down frequently and its unreliability was a great blow to the hill tourism industry. From 2003 to 2004, the funicular system was closed for eight months due to equipment failure. On 24 April 2005, a load of tourists was trapped on the hill for three hours when a brake malfunctioned. On 31 July 2009, 300 tourists were stranded on the hill when the traction system failed.

The worn rails (Figure 4), the over-welded bull wheel (Figure 5) and the deteriorated coaches needed replacement to ensure safety. In addition, sub-structures at certain stretches of the track were badly eroded and needed to be repaired as well as reinforced (Figure 6). An independent consultant engaged by the Malaysian government had also recommended a complete upgrade.

Figure 4: Rails width worn off by 5mm and rail head worn off by 1mm

Figure 5: The over-welded bull wheel

Figure 6: Sub-structure of track badly eroded

Amongst the proposed upgrading works were: to connect the two sections into one to minimise future operational and maintenance costs, to increase the speed and coach capacity to cater to the increasing number of tourists, to air-condition the coaches so as to provide better comfort for the passengers, to repair and reinforce the tracks which were eroded at certain stretches, and to enhance safety measures. Ancillary works such as repair to the tunnel and stations, and the installation of a new ticketing system were also included.

Technically, the upgraded funicular system would be powered by a 711KW motor of 1450rpm nominal speed. The speed would be further reduced at a ratio of 25.11:1 by a gearbox, which would be connected to the bull wheel. The nominal diameter of the bull wheel would be 3.2m. The rotation of the bull wheel would be used to pull a wire rope with a diameter of 38mm. The two ends of the wire rope would be connected to the two coaches, which would run on continuously welded steel rails of 1058mm gauge. A summary of the technical data of the upgraded system is shown in Table 1.

Table 1: Technical data of the upgraded Penang Hill funicular system

Particulars	Data
System	Single track with passing loop
Inclined Length	2097m
Lower station level	36m asl
Upper station level	727m asl
Max. travel speed	10m/s
Coach capacity	100 people
Coach weight	Tare wt per coach: 14,500kg, payload 7500kg, nominal wt 22,000kg
Drive	710KW motor, 3200mm bull wheel and counter bull wheel, beconit lined
Rail	S-33, continuous weld, 1058mm gauge
Rope	38mm, galvanised FW compacted, 1860N/mm^2 tensile strength, 1199KN calculated load
Sleeve	542 no., rubber lined
Safety features	Electro-motor brake (activated at every station approach or manually) Brake on rapid shaft (activated at 10% over speed or manually) Emergency brake in bull wheel (activated at 15% over speed or manually) Track brake (activated at 25% over speed or manually)

The layout plan of the engine room is as shown in Appendix A. Initially, the upgrading work was estimated to cost RM58 million. When the project was completed, the cost had increased to RM63 million. The slight increase was mainly due to the cost of replacing the TNB cable which ran along the rails.

2. WHAT DOES HERITAGE CONSERVATION MEAN?

In proposing the aforementioned works, the need to conserve the system as an industrial heritage was taken into consideration. To begin with, the designers for the upgrading work – a team of professionals from the Public Works Department believed that the developmental needs of the present time need not contradict heritage conservation. On the contrary, a heritage could be better conserved if the industrial legacy is upgraded to enhance its functional integrity, to extend its functional lifespan and to make it relevant to present day needs.

This is in line with the philosophy enunciated by David Lowenthal: *A heritage disjoined from ongoing life cannot enlist popular support. To adore the past is not enough; good caretaking involves continual creation. Heritage is ever revitalised; our legacy is not simply original but includes our forebears' alterations and additions. We treasure that heritage in our own protective and transformative fashion,* *handing it down reshaped in the faith that our heirs will also become creative as well as retentive stewards (Lowenthal, 1998).*

In proposing the upgrading works, the designers noted that the funicular system, if left in its current condition, would not be capable of providing an efficient and comfortable ride, and would therefore not enjoy public support. This was evident by the fact that more and more tourists chose not to go up the hill due to the long queuing time of three to four hours and the long travelling time of one hour each way.

Frequent breakdowns had also casted doubts in the minds of tourists on the safety and functional integrity of the funicular system, and this had also driven some tourists away. Passenger volume had become erratic in recent years. Table 2 shows the passenger volume from 2007 to 2009.

Therefore, the designers felt that the funicular system should not be left as it was, merely for people to remember its past, but should be revitalised and given good care. This would mean protecting and transforming the funicular system, which had already undergone some alterations in the past (especially in 1977, when the 40-person capacity wooden coaches were replaced with 80-person metal coaches). The upgrading proposal was, therefore, proposed as a timely intervention to ensure that the funicular system would continue to be a functional transport system that would serve the public reliably and safely for many decades to come.

Table 2: Passenger volume of the Penang Hill funicular system

	2007	2008	2009
Passenger volume	461,237	509,735	442,154

The above approach was also in compliance with a statement in the Nizhny Tagil Charter for Industrial Heritage which states that t*he conservation of an industrial heritage depends on preserving the functional integrity of the heritage, and interventions to an industrial site should therefore aim to maintain this as far as possible* (TICCICH, 2003). The proposed upgrading works will help ensure that the funicular system would continue to function reliably and safely. Non-intervention at this stage would eventually render the funicular system non-functional, thus making it a mere museum piece. The consensus in heritage conservation is that a museum piece would have a lesser heritage value that one that is functional and serving the public reliably.

However, some concerned parties in heritage conservation and environmental conservation opposed the move. They had a different perception on the meaning of heritage conservation and believed that industrial heritage conservation could only mean non-intervention and maintenance. The designers did not dispute the importance of these approaches, but took note that when these approaches would not work any longer, then right and timely intervention must be put in place. This is in line with the principle of "do as little as possible, but do as much as necessary" – a principle applied to most heritage conservation works. In this case, struggling to maintain a run-down funicular system would not offer a long-term solution, and thus the right intervention must be engaged.

The idea of non-intervention and maintenance is probably rooted in the widespread notion that this world is characterised by stability, balance, harmony and equilibrium. The reality is that we live in a *'non-equilibrium world, in which change takes place all the time, in all sorts of directions and at all sorts of scales, catastrophically, gradually, and unpredictably'* (Stott 1998: 1). Change is the norm, while stability is illusionary. Therefore, the designers believed that what was required was to recognise and accept that change is the only constant, and that if change was necessary to prolong the life of a heritage, then it should be carried out.

Fortunately, both sides shared one common objective, which is to preserve the heritage value of the funicular system and conserve the environment. Hence, a series of interactions were held and some consensuses were eventually reached. The following are some examples of points of controversies, which were resolved eventually.

3. TWO SECTIONS OR ONE SECTION?

The proposal to join the two sections into one was made mainly to reduce future operational and maintenance costs. It also helped to reduce the capital expenditure of having two machine rooms instead of one as it would escalate the project cost by about 30%. This proposal would also improve passenger comfort, especially for the aged and the handicapped, as passengers need not have to change coaches at the middle station.

Strangely, the main argument against the single section proposal was not so much on heritage conservation but was about doubting the technical feasibility of having a 2km section. The concerned parties argued that the single section proposal was first attempted by the British way back in 1898. Although it was completed in 1906, the system failed due to technical reasons. Hence, they argued that a single section would be a highly risky venture. In a meeting held at the Ministry of Tourism, Malaysia, in June 2009, Mr. Ric Francis, a spokesman for the NGOs, illustrated this point by pulling a string. Like pulling the string, he argued that pulling a wire rope through the winding path where the two sections join into one would generate too much friction and make it technically risky.

The doubt on technical feasibility was clarified as the designers reasoned that technology had improved over the years, and it was no longer an issue to have a funicular system stretching more than 2km. The longest funicular system in Sierre-Montana-Cran, stretching more than 4km, was mentioned as a reference.

Another reason cited for opposing the single section was that the work would involve hill cutting, and this would mean disturbing the natural environment and degrading the environment (Penang Heritage Trust, 2010). Such a view was probably based on the belief that unsullied nature is always superior to any product of human intervention in nature, a belief which many environmentalists held onto very strongly.

This belief, unfortunately, overlooked the fact that humans have been transforming the natural world since the dawn of prehistory; that consequently, very few, if there are any left, truly 'natural' environments still exist on Earth today; and, that in many parts of the world, *'human intervention has created and maintained environments which are arguably richer and more diverse in species, scenic beauty, historical interest and recreational opportunity than the natural forest and other ecosystems they have replaced' (Green 1995: 405)*. The designers, therefore, believe that careful and proper "intervention" on the environment, in this case, clearing some parts of the hill to enable the two sections to be joined, would only create a "richer environment" for the tourists, and would not in any way degrade the environment and disturb the overall scenic beauty of the hill.

In any case, the designers gave assurance that there would be minimal stress on the environment as the hill-cutting work would be confined and limited, and the existing two-section track would still be used. Furthermore, the hill-cutting work would be done on existing earth platforms manually or by hand-operated tools. No explosives would be used to blast the rocks and no huge plants and machinery would be employed. Subsequent construction works showed that this assurance had been complied with (Figure 7). Water quality and noise levels were monitored throughout the construction period as required under Malaysian law (Figure 8). The results showed that the stress on the environment was almost nil.

Figure 7: Using manual and hand-operated tools to break up rocks

Figure 8: Noise monitoring during construction

From the heritage conservation perspective, the concerned parties questioned what would happen to the middle station if the single section proposal was adopted. The designers proposed that the middle station could be preserved as a museum – a museum where tourists would have the opportunity to see an actual funicular machine room. One of the four displaced coaches would also be placed at the middle station to complete the museum.

4. HOW FAST SHOULD IT BE?

The designers had proposed that the funicular speed be upgraded from the existing 1.4m/s and 1.8m/s to a new maximum speed of 10m/s. This is to cater to the increasing passenger demand. The maximum speed is likely to be used during the peak season so as to cut down the antecedent waiting time which could be more than three hours (Figure 9). Most of the time, however, the operating speed would be about 5m/s to 6m/s.

(Continued on page 16)

Figure 9: Large crowd and long queuing time

The concerned parties believed that the "roller coaster" speed of 10m/s would cause dizziness to the passengers, and would deprive the passengers the pleasure of taking a slow ride and taking in the surrounding tropical scenery (Penang Heritage Trust, 2010).

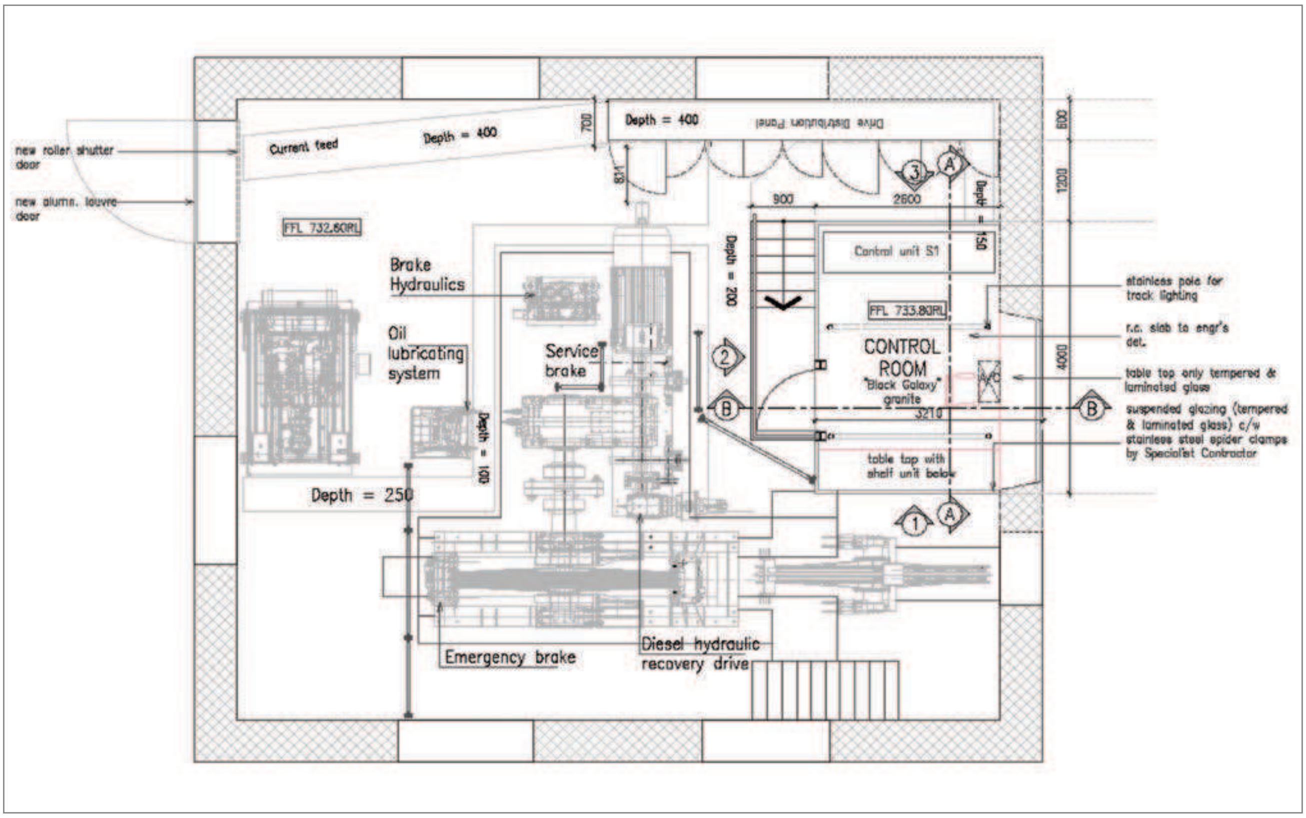
The designers clarified that, in the first place, the maximum speed is the maximum limit and need not be used when not necessary. The normal operating speed of 5m/s to 6m/s, amounting to an 8-minute journey, would be ideal for passengers to enjoy the ride, take in the scenery and cut queuing time. Furthermore, the antecedent coaches, with passengers sweating profusely in the hot, humid and crowded compartments, simply did not provide the opportunity for passengers to enjoy the ride and scenery as claimed.

The concerned parties were also told that the CEN code had allowed a maximum speed of 12m/s, and the 10m/s speed would not cause dizziness to the passengers.

This was later proven during testing and commissioning when no one complained of dizziness. The designers believe that such an upgraded transport capacity would make the funicular system more relevant to the tourists, the tourist operators and other members of the tourism industry, and hence enjoyed popular support.

However, some stakeholders, such as the bungalow owners uphill, may not find this palatable as a higher capacity means bringing in more tourists, and more tourists mean more disturbance to their peaceful and leisurely life. This is an example of how the conflicting interests of stakeholders can make decision-making a challenging task. However, all this would in no way reduce the heritage value of the funicular.

The designers also took note that the first generation coach with a 40-passenger capacity transported about 351,000 passengers per annum in 1951. In 1977, the coaches were changed to an 80-passenger capacity and, operating at the same speed, the traffic volume recorded was about 500,000 per annum. This was about the maximum traffic volume achievable as the long queuing times had driven others away. To cater to the ever increasing traffic demand, the most plausible way out was to increase the speed as well as the coach's capacity, and in this case, a speed of 10m/s was considered optimum. A capacity comparison of the antecedent system and proposed system is shown in Table 3. Finally, the maximum speed of 10m/s was adopted.



Appendix A: Layout plan of the engine room at the upper station

Table 3: Capacity comparison

	Old system	Proposed system
Coach capacity	80	100
Travelling speed	1.4m/s and 1.8m/s	10m/s
Hourly capacity	200 people	1000 people

5. THE COACHES – DESIGN AND AIR-CONDITIONING

The designers had proposed that the four 80-passenger, non-air-conditioned coaches be replaced with two 100-passenger, air-conditioned coaches. The main reasons for this proposal were that the old coaches had deteriorated over the years and could not be modified to travel at a higher speed. The concerned parties agreed that the coaches needed to be replaced, but not at the present moment, and suggested a replacement about five years later. In a meeting held with the Tourism Ministry in June 2009, Mr. Ric Francis, a spokesman from the NGOs, put forth the proposal to replace the coaches in 2015.

The designers were of the view that there was no reason to further delay the changing of the coaches. The designers also proposed that the architecture of the new coaches might be fashioned along the same design as the antecedent one so as to connect it to its historical past. However, both sides took note of the fact that the antecedent coaches were not the original ones, as the original coaches were, in fact, replaced in 1977. The previous change did not maintain the original architecture. Eventually, during construction, the Malaysian government opted for a design which is as shown in Figure 10.

Figure 10: The original coach, the antecedent coach and the new coach

The idea to air-condition the coaches was to provide better comfort to the passengers. The interior temperature of the antecedent non-air-conditioned coaches was usually between 33°C and 38°C, making them too hot for the passengers. To meet the criterion of good indoor air quality, it was proposed that the coaches be air-conditioned to between 23°C and 27°C. The concerned parties argued that passengers would like to enjoy the natural cool breeze as they travelled (Penang Heritage Trust, 2010). However, the designers provided evidence to show that it was a mistaken belief to assume that there would be cool breeze around! Evidence showed that while the temperature uphill may be 2°C lower than downhill (which is about 31°C at 3.00pm, the hottest time of the day), the interior of the coaches easily warmed up to between 33°C and 38°C under the tropical sun.

Furthermore, non-air-conditioned coaches would need to have high window openings for safety reasons (as the coaches pass through a tunnel), and this would result in poor ventilation as experienced in the antecedent coaches. Random interviews with frequent users of the funicular system (schoolchildren and residents along the funicular line) also revealed that all of them preferred to have air-conditioned coaches. Eventually, it was agreed that the coaches would be air-conditioned. The attendant benefit of air-conditioning the coaches is that the coaches would be free from rain splash, thus making cleaning and maintenance easier.

6. MINIMAL INTERVENTION ON SITE

In designing the upgrading work, the designers also took into consideration the importance of preserving the original site as much as possible, in line with the Nizhny Tagil Charter for Industrial Heritage. While the mechanical equipment which had reached the end of their lifespan were replaced, other infrastructure such as the track and rail, stations, viaducts and tunnels were repaired and reinforced to last (Figures 11,12 and 13).

Figure 11: The same tunnel, reinforced to last

Figure 12: The lower station – no visual change

Figure 13: The middle station – the building remains unchanged

The middle station, which became defunct on completion of the upgrading work, would become a museum where tourists would be able to see at close range a machine room of a funicular system. After being dismantled, one coach was placed at the antecedent upper passing loop while the other was placed at the middle station. This would help bring back recollection of the past for those who cherish this industrial heritage.

7. CONCLUSION

The functional integrity, safety and reliability of the Penang Hill funicular railway, which was built in the 1920s, had deteriorated over the years. Non-intervention or mere maintenance would not be enough to prolong its lifespan further, and would have reduced it to a mere museum piece if the right and timely intervention was not carried out. The services it provided, in terms of safety and capacity, also could not cope with the present day demand. Hence, intervention in the form of significant upgrading work was deemed necessary.

The upgrading works carried out followed the principle of "do as little as possible, but as much as necessary". Little was done to the viaducts, tunnels, stations and tracks, except to reinforce them to last. However, the machinery, which could not be further maintained effectively, were replaced and upgraded to cater for the present day demand.

The upgraded funicular system would now be able to fulfil the present day demand for a safer, speedier, more comfortable and reliable ride, as well as the need for reduced operating and maintenance costs. At the same time, its heritage value would be preserved not only for this generation but also for future generations to come.

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