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Extending the Useful Life of the Tower Bridge in London

Prolongement de la durée de vie du Tower-Bridge à Londres

Verlängerung der Nutzungsdauer der Tower-Bridge in London

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SUMMARY

Tower Bridge was completed in 1894 and having survived the coming of the motor car and the bombing of the second World War, it continues to provide road access into the City of London and to open for shipping on a daily basis. Its longevity and the extension of its use for tourism are the result of regular maintenance and occasional repairs to the structure combined with a philosophy of ensuring that the bridge continues to serve the community. The paper reviews the most recent repairs and the provision of tourist facilities as an extension of the useful life of the bridge

RÉSUMÉ

Le Tower-Bridge, achevé en 1894, a survécu à l'apparition de l'automobile ainsi qu'aux bombardements de la Seconde Guerre Mondiale. Il continue à offrir un accès routier à la City de Londres et à s'ouvrir journellement pour la navigation fluviale. Sa longévité et son attraction touristique sont le résultat d'une maintenance régulière et de réparations occasionnelles combinées à une philosophie visant à ce que le pont continue à servir la communauté. L'article passe en revue les réparations les plus récentes et les aménagements touristiques pratiqués dans le cadre du prolongement de la vie du Tower-Bridge.

ZUSAMMENFASSUNG

Die Tower-Bridge wurde 1894 fertiggestellt und überlebte die Entstehung des Automobilzeitalters wie auch den zweiten Weltkrieg. Immer noch stellt sie die Strassenverbindung in die Londoner City sicher und öffnet sich täglich für Schiffsdurchfahrten. Ihre Langlebigkeit und touristische Bedeutung sind das Ergebnis regelmässigen Unterhalts und gelegentlicher Reparaturen im Verein mit einer Philosophie, den Gemeinnutzen der Brücke zu sichern. Der Beitrag berichtet über die jüngsten Reparaturen und touristische Einrichtungen zur Verlängerung der Nutzungsdauer der Brücke.

1. INTRODUCTION

Tower Bridge, which is now a national tourist attraction and one of the most distinctive trademarks of the City of London celebrated its centenary in 1994[2]. It is a hybrid structure with two suspended side spans and the steel towers are connected by a high level walkway. Twin leaf bascules rotate into chambers located within the piers on which the towers are built.

The bridge provides for two lanes of traffic between the London Boroughs of Southwark and Tower Hamlets and when opened for shipping there is 42.9 metres of clearance from high water level in the River Thames. Located adjacent to the Tower of London, the steel structure is clad in Portland Stone and Granite to harmonise with the ancient buildings.[3]

Recent years have seen the bridge being transformed with the aid of audio visual displays into a major educational and tourist attraction.

Tower Bridge opening for shipping

2. REPAIR AND MAINTENANCE

2.1 Repairs since 1931

In 1928 when the bridge was approaching 50 years of age it received a major refit to alleviate the effects of steel corrosion and to prepare it for the age of the motorcar. It was found to have a reserve of strength because the bridge's design was carried out soon after the Tay Bridge disaster and it has been adequate for all loading up to the present day. A 17 tonne weight limit and a 20 mph speed restriction are currently maintained in the interest of preservation and to reduce some vibration which continues to be a concern within the towers.

Cast iron panels on the high level walkways were replaced with steel and in the 1950's lattice girders were added to carry some 75 tonnes of the dead load on the ties between the towers.[4]

Originally the public was permitted to cross the river, even when the bridge was open to river traffic. In the early years the bridge appeared to be more open than closed and the staircases within the towers and the walkway across the top were open to the public and frequently used. The need for pedestrian access reduced as the road traffic dominated the river and the bridge became more closed than in the lifted position; the high level walkways were closed to the public in 1909.

The high level walkways in particular have had a considerable amount of engineering applied to them. In the 1960's suspenders were added to transfer more of the dead load onto twin 60mm diameter catenary cables formed from galvanised locked-coil wire ropes. Since the walkways are often used for receptions and corporate entertainment they are also serviced by two lifts. The lifts are located within the northwest tower and the southeast tower and can accommodate wheelchairs for the disabled and up to 40 persons or a maximum dead weight of 3175kg. The lift cars have 1200mm doors and a plan area 3725mm x 1375mm and each is driven by 40 HP motors which can generate a speed of 45m per minute.

In order to maximise the view out through the girders, double glazed windows have been fitted into the openings between the lattice girders and some of the original cast iron panelling has been replaced with steel and grp.

2.2 Regular Maintenance

A full time staff of fifteen, supervised by the Maintenance Manager provide not only for the regular maintenance but also the operating crews for bridge lifts. A Senior Technical Manager, a Technical Officer and three Technical Assistants make up a maintenance team and are on duty each day. A planned maintenance system was devised for the bridge following installation of modernised machinery in the 1970's. The system covers both the mechanical and electrical equipment and the bridge structure with service and inspection intervals ranging from once a day to once every five years.

2.3 Development of Tourism Facilities

In addition to maintaining Tower Bridge as an operational lifting bridge which plays a key role in the highway network around the City of London, the bridge's fame throughout the world and its role in promoting tourism has been recognised for more than 20 years. It is this extension of the bridge's use which can be a prototype for other structures around the world.

As a major tourist attraction and a public building many ideas have been developed through the years. It was proposed to surround the bridge and towers in a glass cocoon to provide large areas of office space which would have raised revenue in the same way as the shops and businesses which had occupied the space over the river in previous centuries. Proposals for a traditional pub and a restaurant to serve visitors' needs have been put forward and promoted, even to the tendering stage. The original engines which powered the bridge were recognised as part of the historical legacy of the 1894 bridge. One engine was found a safe home at the Forncell Industrial Steam Museum and others have been included in the provisions for tourism.

One of the original bascule drive engines remains within the machinery rooms and one is on display within the museum area located under the south approach. Two Armstrong Mitchell steam driven pumps each with a capacity of 360 HP are also on display within the original engine rooms.

The road decking has had considerable attention over the years. Originally there was timber laid onto steel buckle plates. Three layers of softwood and Greenhart were first replaced in 1949 and the entire deck was stripped out in 1962. Corroded buckle plates were replaced and foamed polyurethane blocks were grouted into position below Acme flooring panels. Water seepage into the decking continued to be a problem and during the 1970's further repairs to the decking were carried out. The present deck surface is based on Acme decking panels consisting of an 18mm base panel encapsulated in epoxy resin, an intermediate liquid applied waterproof membrane and another surface panel coated with a Cicol ET epoxy slurry and an anti-skid layer of Dynagrip.

Another problem which has occurred over the years is vibration induced by the passage of vehicles for which the bridge was not originally designed. A study carried out in the 1960's resulted in bracing rods and block walls being constructed at strategic places to tune out the most significant movements. Application of the 17 tonne weight limit and constant attention to the quality of the running surface both assist in restricting the vibrations to an acceptable level.

A significant replacement of the original hydraulic engines and the boilers and pumps which supplied them was carried out in 1976. The modern electric powered operating and bridge lifting system includes two low speed hydraulic motors, two independent electric motors driving piston pumps and a control panel. An 11 kV power supply is taken from the South Bank and an alternative supply is also available from the North Bank together with a 135 kVA standby generator, either of which can open or close the bridge at half speed.

From time to time throughout the years the ornamental balustrading and steelwork along the outer edges of the superstructure has been repaired and renewed. In a contract during 1978-9 most of the cast iron balustrading was removed and repaired, with new elements being cast where weld and metal infill could not repair the damage.

In 1992 further work was carried out to repair and renew balustrades on the lifting spans. Corroded sections of the steelwork supporting the balustrades and the decking under the bascule footways were the subject of extensive reconstruction works. Timber infilling was found to be retaining rainwater, leading to continued corrosion and increasing the bascule weight which was also overloading the lifting mechanism. A lighter fully sealed plywood decking was used as a replacement.

As a result of the most recent repairs and in order to minimise the demands on the lifting mechanisms a rebalancing and counterweight adjustment is to be scheduled in 1995.

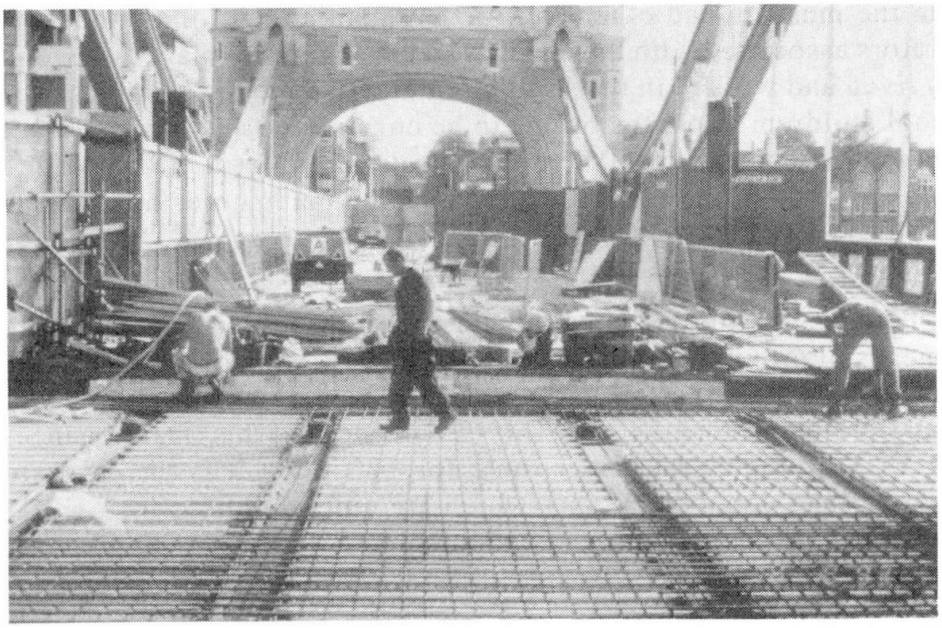
The most recent work to be carried out on the bridge structure has been an investigation of the vibration which continues to be of some concern although it has been established that the level of vibration is not structurally significant. It is proposed to update the vibration readings taken in 1960-70 by relocating gauges at the same locations. During a two day closure to vehicular traffic, isolated separate readings will be taken, while two vehicles of different weights (a single deck and a double deck bus) will travel across the bridge at different speeds.

Of particular interest to tourists are always the views from high places and Tower Bridge is particularly endowed with fine views and a fine viewing platform in the form of the high level walkways. Their use has been exploited in several ways.

3. RECENT MODERNISATION

3.1 Repairs to Road Deck

Extensive redecoration was carried out in 1992 in preparation for the celebration of the Bridge's centenary and it was during this operation that timber bulkheads were removed within the base of the towers, exposing parts of the steelwork not normally accessible.[5] Corrosion was observed and the removal of steel plating exposed internal voids and areas of corroded steelwork which had probably not been observed for 100 years. In some places there was no remaining capacity whatever and repairs were therefore necessary to restore the load carrying capacity while minimising the disruption to traffic and preserving both appearance and as much of the original structure was reasonably possible. For thirteen weeks in the summer of 1993 the bridge was closed to road traffic and the road deck under the towers was removed, exposing the underlying steelwork and enabling extensive cleaning, repairs and replacements to be effected.[6]



1993 Deck Repairs

3.2 Tourist Facilities

For the bridge's centenary a major modernisation of the tourism facilities within the bridge has been carried out. The new exhibition has been devised and designed by Bowes Darby & Associates in close co-operation with the City Engineers Department. Tourists enter by a new entrance in the northwest tower and leave by the southeast tower before walking along the south approach to the final experience, engine rooms and retail facilities under the southern arches.

The new entrance provides a waiting area adjacent to the ticketing equipment with a wall of video monitors which show the history of the bridge and the surrounding area. Tourists are taken by lift to the second floor of the tower to commence an educational and cultural tour which is illustrated in various ways.

An interesting audio visual display is provided, with the history of the structure being explained by an animatronic model of the chairman of the committee responsible for the bridge itself. The story and the engineering behind the bridge unfold in a variety of ways. Lifelike figures explain the detailed history and background of the bridge and models of the many alternatives considered are displayed. Theatrical lighting techniques and high

technology projection equipment conjure up the ghostly image of Horace Jones whose brainchild the bridge was. The principle of the bascule is expounded on video.

Visitors pass over the river through the high level walkways, viewing the ever changing skyline of the City of London, and an extensive exhibition of pictures and exhibits which describe the construction of the bridge. A static display in the south tower includes tools and equipment set in and around an engineer's office of the 1880's and lighting exposes figures depicting construction work within the roof space of the tower itself.

In the south tower the visitors are shepherded into a model of the bascule chamber and having had a graphic explanation of the opening mechanism they experience the noises and communications signals associated with bascule movement. With a rumbling sound the roof of the viewing area begins to rotate intriguing the tourists and school children who visit to experience and learn.

On leaving the southeast tower by a lift festooned with contemporary newspaper cuttings visitors are led to the museum and other facilities. Again animatronic models depicting workers and operators associated with the original steam engines explain the circumstances under which they lived and worked in the 1880's. Interactive models, which are extremely popular with school children, allow the bridge to be constructed and the model machinery to be operated. Finally a reconstructed Victorian Theatre provides a further stage for more animatronic figures to explain the festivities and opening ceremonies held in 1894.

4. CONCLUSION

Although Tower Bridge, like most other bridges around the world, was intended to be a very functional means of providing a road and pedestrian crossing of the river its designers could not have envisaged it as the tourist attraction which it has become. The care and attention lavished on the bridge by the City Engineer and his maintenance staff is extending its life as a strategic cross river route for traffic but it is the extension of the bridge for educational and commercial uses which are quite unique.

5. ACKNOWLEDGEMENTS

The staff on the bridge itself and the engineers within the City Engineers Department who are responsible for the maintenance, together with the engineers at Mott MacDonald consider it an honour to be associated with the unique example of engineering which Tower Bridge has become. It is to the bridge that this paper is dedicated.

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