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Autor: Sriskandan, K.
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Maintenance of the Structures of the Existing Severn Crossing

Entretien des ouvrages actuels de la traversée de la Severn

Unterhalt der Tragwerke der bestehenden Severn-Ueberquerung

K. SRISKANDAN
Consultant
Mott MacDonald Ltd
Croydon, UK



K. Sriskandan joined Mott MacDonald (MM) in 1988 after 20 years in the UK Department of Transport, where he was the Chief Highway Engineer from 1980-87. At MM he was the Manager of the Bridge Division and Project Director for the Maintenance Management of the Severn Crossing.

SUMMARY

In 1992, the operation and maintenance of the structures comprising the existing Severn Crossing passed from UK Department of Transport to a private company, who had won the franchise to also design, finance, build and operate a second Severn Crossing. Both crossings would revert to the Government at the end of the concession period. This paper describes the findings of a handover inspection, the requirements for routine inspection and maintenance, and for other repairs, and also the arrangements for managing all this work.

RÉSUMÉ

En 1992, la responsabilité de l'exploitation et de l'entretien des ouvrages actuels de la traversée de la Severn ont passé du Département des Transports Britannique à une société anonyme, qui a gagné la franchise pour la conception, le financement, la construction et de la deuxième traversée de la Severn. Les deux ouvrages seront rendus au gouvernement à la fin de la concession. L'article décrit les observations lors d'un contrôle de réception, les critères de l'inspection et l'entretien habituels, les diverses réparations, et aussi la gestion des travaux.

ZUSAMMENFASSUNG

Im Jahr 1992 wechselten Betrieb und Unterhalt der Tragwerke, die den Fluss Severn überspannen, vom britischen Verkehrsministerium zu einer privaten Gesellschaft, die auch die Konzession für den Entwurf, die Finanzierung, den Bau und den Betrieb einer zweiten Severn Brücke bekommen hatte. Beide Flussüberquerungen fallen nach Ablauf der Konzession an die Regierung zurück. Der folgende Beitrag beschreibt die Befunde bei der Uebergabeinspektion, die Erfordernisse laufender Inspektionen und Wartung, sowie die Vorkehrungen zu deren Management.



1. INTRODUCTION

The existing Severn Crossing was completed in 1966. It consists of the Aust Viaduct (a three span double box girder structure 156.7m long), the Severn Suspension bridge (length 1683m including anchorages [1], the Beachley Viaduct (length 745m) and the Wye Cable Stayed Bridge (length 409m) all with a total length of just under 3km. The Aust Viaduct has an RC deck acting compositely with the steel box girders, cross girders and side cantilevers. All the other structures are of single cell steel box girders with an orthotropic deck. Following a structural assessment in the 70's and early 80's, the entire crossing was strengthened and refurbished between '85 and '91 [2]. Some aspects of these works were not complete at the time of the Concession to SRC in April '92. The whole crossing was maintained by Avon County Council acting as Agent Authority to the DoT. They had set up a team of inspectors and maintenance personnel housed in a compound close to the Crossing and named it the Severn Bridge Maintenance Unit (SBMU).

2. MAINTENANCE ORGANISATION

Some 6 months before concession SRC appointed Laing Offshore (LO) as their maintenance contractor. LO would also manage staff from SBMU who SRC took over under the Concession Agreement (CA). At the same time SRC also appointed Mott MacDonald (MM) as their Engineer to administer the contract between them and LO and also to undertake the pre-concession inspection of the crossing as required in the CA. The DoT appointed Flint & Neill Partnership (FNP) to act as the Government Representative (GR) in matters relating to the operation and management of the existing Crossing.

3. PRE-CONCESSION INSPECTION

3.1 Objective

It was a requirement of the CA that a close visual inspection of the surfaces of all the structures be carried out in the presence of the GR. MM were instructed to represent SRC. The aim was to inspect the

- condition of structural members and attachments
- condition of paintwork
- signs of unexpected movement
- mechanical damage
- obvious signs of corrosion or deterioration
- completeness of items

and prepare the following:-

- inspection records giving observed conditions of all members
- defect schedule listing all known and observable defects (for this purpose MM defined 'defects' as departures from current relevant standards and specifications)
- condition report setting out the general condition and state of repair of M&E equipment
- our inventory of the assets forming the existing Severn Crossing as transferred to SRC
- a list of items of outstanding or deferred maintenance

3.2 Access for Inspection

A close visual inspection requires access to within touching distance. Parts of the structures that were inspected without special access equipment were:

- inside of all the boxes
- inside of all towers and tower legs (ladders and inspection platforms are available)
- anchorage shoes of main cable of Severn Bridge and splay saddles
- surfacing, parapets, safety fences, bearings and expansion joints.

Gantries were available to inspect the external surfaces of the boxes of Aust Viaduct. However the corresponding inspection was delayed until the access gantries were available

- for the Wye Bridge and Viaduct in 1992/93
- for the Severn Bridge in 1994.

Inspection of the outside of the Severn Bridge tower legs was carried out by a specialist subcontractor using abseiling techniques.

Although gantries were available for painting the main cable of Severn Bridge, these are too slow for inspection which was done by men walking on the cable. The results of a full inspection carried out by SBMU in August 1991 were accepted for the purposes of the pre-concession inspection.

Special climbers were used to inspect the longer hangers of Severn Bridge when they became available in 1992.

Attempts to inspect the external surfaces of the Wye Bridge towers using a mobile hoist were thwarted by strong winds. In the end they were inspected with binoculars, as were the concrete surfaces of the anchorage chamber.

3.3 Findings of Inspection

3.3.1 As the main members of each structure of the Crossing were stiffened steel boxes, there were literally thousands of components to be inspected and recorded. Every plate panel, every stiffener and every weld was inspected. Fortunately a proven referencing system which identified each component uniquely, was in existence. It was therefore relatively easy to use proformas to record the findings.

3.3.2 Most of the defects found inside the boxes were weld irregularities, some weld cracks, local paint deterioration and some stiffener distortion. Most of these defects were in parts of the original structure and had been there for over 25 years. No action was taken on these except to record them on the inspection sheets. Defective welds were repaired in accordance with the maintenance manual and paint deterioration was made good at the next painting session.

3.3.3 No structural defects were found on the external surfaces. However there was paint deterioration over significant areas, particularly on Severn Bridge, due to lack of maintenance caused by unavailability of access gantries. Painting work has however started in 1994 following availability of the gantries.

3.3.4 The stay cables of Wye Bridge and the hangers of Severn Bridge were all new and were therefore in good condition. There was some loss of paint on the main cables of Severn Bridge. These have since been made good at repainting. There had been some corrosion and breakage of one or two wires of the main cable in the anchorage chamber. However, there has been no further deterioration since the whole of all four upper anchorage chambers were dehumidified.



3.3.5 Shortly before handover of the crossing an inventory was taken of all the equipment on and within the crossing. This was done by walking through internally and externally and ticking off items against a prepared list.

4. INSPECTION AND MAINTENANCE

4.1 Requirements

The type, nature and frequency of inspections to be carried out were all specified in a draft Maintenance Manual prepared by FNP. The CA allowed SRC to modify the procedures in agreement with the GR.

Structural members have the usual Routine Superficial, General and Principal Inspections except that the frequency of General Inspection is determined by the "Criticality and Vulnerability Ratings" (CR&VR) of each component. CR relate to anticipated fatigue endurance, tolerable crack lengths, tensile stress levels etc., whilst VR relate to propensity to deterioration due to corrosion, damage or wear. Frequencies of inspection are 6 months, 1 year, 2 years and 6 years for CRs of A, B, C & D respectively or VR's of 1, 2, 3 & 4 respectively. Only a few critical welds require inspection every 6 months. All cables, hangers, stays and connecting welds have CRs of B.

4.2 Inspections and Audit

All inspections are done through LO in accordance with the requirements of the Maintenance Manual. At the start results were recorded on proformas, but now they are recorded on hand held data capture devices and down-loaded directly into a computer. The computer data is accessible to MM who audit it to ensure that inspections have been done and that any defects found are repaired. Most of the defects found are weld cracks for which standard repair methods are available. If these are not available, method statements are prepared by MM and agreed with the GR before repair is put in hand.

4.3 Maintenance

4.3.1 Apart from the general good "bridge-keeping" to enable free movement of traffic, there are numerous items of routine maintenance that have been carried out. Some typical items are:

- lubrication of structural parts such as pins and strands on Severn & Wye bridges and tower column guide bearings on Severn bridge
- replacement of seals on Severn cable covers at towers and at main cable clamps
- replacement of worn parts on roadway joints, bend limiters, column guide bearings at lateral bearings on Severn Bridge
- replacement of parts damage by accident
- a complete maintenance of all access gantries whether in use or in storage.

4.3.2 In addition to routine maintenance, monitoring of some structural items is also being carried out.

Examples are:

- deck levels and tower tilts on Wye Bridge to decide whether loads in stay cables are changing
- levels on Aust viaduct to see whether there is any breakdown in composite action
- rocker loads on Severn Bridge to monitor effects of bedding down of new hangers and bearing wear
- humidity within shrouds surrounding the cables in Severn Bridge anchorages to

ensure a low (<25%) relative humidity measurement and analysis of water from Severn Bridge cables to monitor effectiveness of protection and determine the presence of harmful chemicals.

So far the results have all been satisfactory and no corrective action has been needed.

5. REPAIR OF DEFECTS

5.1 Weld cracks

5.1.1 Most of the work has been in reinstating/repairing fillet welds in the orthotropic deck, joining trough stiffeners to deck or to the diaphragms. Standard repair methods have been devised. For the first, Fig 1(a), the existing 6mm weld is cut out over a certain length and replaced by a larger fillet weld which includes some preparation of the stiffener web. In the Second, Fig1(b), a shaped strap is fillet welded to the trough and also the diaphragm. Table 1 gives the numbers of these repairs on each structure from concession date to the present time.

Weld Type	Severn Bridge	Beachley Viaduct	Wye Bridge
Deck	18	24	8
X Girder	74	2	30

Table 1

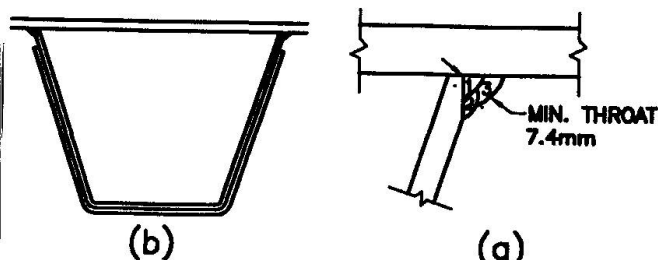


Fig. 1

5.1.2 In the Severn Bridge, temporary diaphragms were fitted at one end of each of the 18.3m long boxes to help float the boxes out. These were welded to the underside of the trough stiffeners and were not removed. Fatigue cracks began to occur at these welds early in the life of the structure. The repair method adopted was to free the trough from the stiffener, cut out a portion of the bottom flange of the U shaped stiffener containing the crack and bolt in two plates to the webs of the stiffener. There were in all 84 temporary diaphragms each welded to 36 stiffeners. So far it has been necessary to carry out repairs at 447 locations.

5.2 Other Repairs

Other repairs that have been necessary are reinstatement of barriers and barrier posts that have been damaged by vehicle collision and also replacement of the shell grip in certain areas of the carriageway where it has lifted from the mastic asphalt.

6. WORKS OTHER THAN ROUTINE MAINTENANCE

6.1 Finishing Off Works

Typical items of work were unfinished painting inside and outside of the boxes, checking and adjusting clearances in the guide bearings (which were at every 6m of each of the 120m high and 406mm dia. tubular steel columns inside each of the towers of Severn Bridge) and fixing bend limiters at the upper end of the Severn Bridge hangers (bend limiters were already in place at the lower ends).



6.2 Access Gantries

6.2.1 At concession there were only three underdeck gantries in place on the Severn Bridge, the other having fallen off in an accident. These gantries had been out of use for some time and MM were appointed to design a refurbishment plan and oversee its execution and also take responsibility for the design of the gantries. Most of the refurbishment was to the electrical parts and the control systems. However MM also checked the structural design of the gantries. Strain gauging was used to determine the dynamic amplification of the loading and this was found to be about 15%. The design was found to be satisfactory and was used for the replacement of the fourth gantry. At the time of writing the gantries are all useable.

6.2.2 The tower access gantries for the Severn Bridge were also procured after concession. This was let as a design and build contract based on an outline design and performance specification. What was required was a 4 sided cradle and platforms suspended from the four corners of the towers with provision for removal and replacement of one part as the cradle passed the cross beams. The tender that was finally accepted (and is now fully operational) is a lightweight space frame based on the Beeche System in USA.

7. THE FUTURE

When these entrusted and additional works are completed, it is envisaged that the work, for the next few years, will be mainly routine inspection and maintenance with repair of cracked welds. In the longer term major maintenance such as refurbishment of expansion joints, replacement of bearings and even hangers may become necessary. However with diligent maintenance it is expected that these structures will be handed back to the DoT, in a good state of repair, at the end of the Concession period.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

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