London Borough of Hammersmith & Fulham

Hammersmith Bridge

Safe Operation of Hammersmith Bridge

Issue 1

December 2020

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Introduction

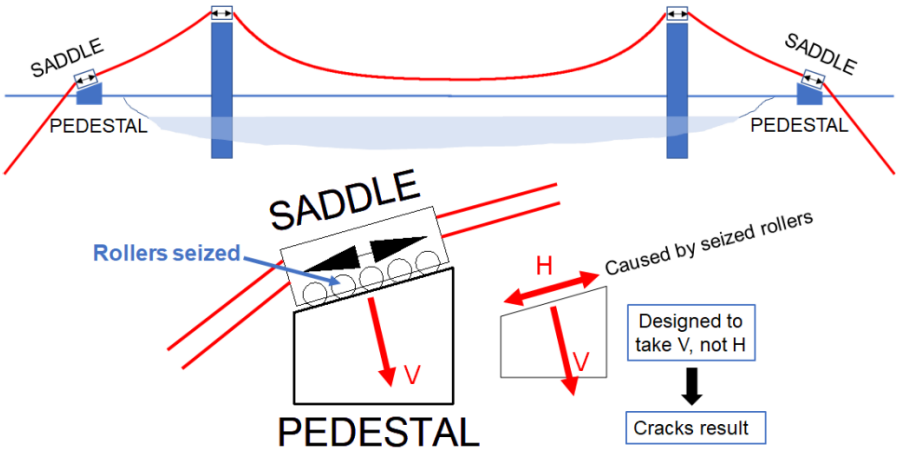
There are now a number of detailed technical engineering reports available in respect of Hammersmith Bridge, some in the public domain, some not, some produced by agents of Hammersmith and Fulham Council (H&F) such as Mott MacDonald (MM), and some produced by AECOM and others supporting the government taskforce.

Underlying these reports is a growing body of test and inspection data. These things combine to improve understanding of the bridge condition and structure, but not all reported information is consistent or correct. Following inputs from the government task force and recent reporting, there is growing public expectation and interest in future plans. This report is provided by Xanta as the author of the Case(s) for Continued Safe Operation to provide context to support H&F in its decisions on the next steps.

1. History since 2017

Annexed to this report is a timeline which details major events since 2017, which began with a clear expectation that the condition of the bridge was something that must be subjected to thorough analysis. The timeline is accompanied by an estimate of perceived safety risk associated with major events. This climbs with the passage of time leaving it as a "*structure of immediate risk*", a self-explanatory term.

The problem is summarised in this diagram:



The suspension chains (red) are subjected to temperature changes which causes them to contract and expand. That movement is accommodated by rollers. Once the rollers seized, loads (H) were applied to the pedestals that they were not designed to take, and cracks in them resulted.

2. The primacy of the Case for Continued Safe Operation (CCSO)

The management arrangements for the bridge in its current condition include the Case for Continued Safe Operation (CCSO). This is designed to take into account all possible opportunities available for safe operation unlike standards such as Highways England's CS 470 (2020), which has a narrower focus.

- There is a duty in law to prevent exposure of the public to unacceptable safety risk backed up with HSE oversight and defined expectations in 'Reducing Risks, Protecting People', aka 'R2P2', published in 2001.
- A CCSO is a reasoned case demonstrating that safety risk exposure is at an acceptable level. H&F uses this to discharge its legal duties for safe operation.

It works with two key principles:

1. If there is an unquantifiable risk of an unacceptable outcome, then the focus must be on preventing the unacceptable outcome – such as bridge collapse

2. Demonstration of 'no change' in bridge condition in order to demonstrate no change in risk. The acceptable use of the bridge is determined by how much risk there is, and its continued use in that way requires no change in the risk. Monitoring provides the evidence of 'no change'.

However, the works so far are temporary solutions pending structural repair. They cannot be used indefinitely and, following crack extensions, **the public cannot be allowed to use the bridge until it is repaired because it has proved to be unstable and still contains unknowable features.**

3. Monitoring and Control

The bridge is instrumented for monitoring and with controls:

- Acoustic Emission (AE) alerts – microphones 'listening' for cracks to prompt physical inspection and confirmation.
- Strain gauges measuring changes in load caused mostly by temperature changes.
- Anchor chain heating and cooling – this mimics the effect of rollers by expanding and contracting the chain and keeping loads minimised. This is the principal management control to keep operation safe within the limits that it is possible to do so.
- Visual inspection was applied before AE was available, and was then discontinued as being unnecessary with justification detailed in MM report 417457-MMD-HSB-TN-SE-MON-000001
- Temperature monitoring is used to warn of increasing risk and need for temperature control. Identification of a 'safe' temperature range has been made. But it is only 'safe' when seen against an already stable position. Once cracks have grown, as now, a more conservative approach is needed.
- Management procedures use all these to determine acceptable use, need for evacuation, or need for inspection.
- But some cracks have extended. Analysis by MM indicates that they are likely to be stable despite this extension. However, the analysis cannot account for unknowable residual stresses and hidden defects from manufacture, among other things, and they provide an unquantifiable risk of failure. MM states that: "*The findings from the analysis must therefore be interpreted with caution. The intention of the analysis is to investigate relative changes in stressed state (e.g. the impact of crack propagation, the impact of temperature control) and overall behaviour at cracks, rather than focussing on the absolute magnitudes of stress or absolute safety factor against collapse, which might be affected by the aforementioned manufacturing defects.*"

The impact of all these things is summarised in this timeline:

Time	Event	Consequence
Prior to 2017	Saddle rollers seized	Slow, cumulative, long term damage to the bridge.
Late 2018	Effect of seized rollers on pedestals assessed for first time	Areas of major overstress within all cast iron pedestals determined, prompting a BD79/13 risk assessment and associated interim measures.
April 2019	Cracks found on special intrusive inspection prompted by MM risk assessment	Bridge closed to motor traffic – CCSO created. **Removal of cars and buses reduced the risk to acceptable levels allowing continued use by pedestrians, IF, AND ONLY IF, the risk didn't change. Existing cracks were stable. Temperature controls and monitoring made this sustainable.**
August 2020	Cracks extended	Bridge closed to all public use – new CCSO. **The risk changed, and, because it was also not quantifiable, and was demonstrably less stable, there was a legal duty to positively prevent the consequences of collapse. No public access.**

Time	Event	Consequence
Nov 2020	Further assessment of safety risk	Bridge available for limited river traffic under PLA supervision and control, and for inspection and remedial works to trained staff only – new CCSO. **PLA and trained staff are involved in limited numbers, so procedures for acceptably safe operation are possible. Not possible to achieve this for public access.**

Without a funded plan for repair, even the limited current use must cease. It is not acceptable in managing safety risk to rely upon interim measures indefinitely.

4. Unknown factors

There are still a number of unknowns. Principal among these are:

1. The condition of the pedestals on the west side of the bridge which it has not yet proved possible to inspect in detail - these include hidden critical elements of cast iron in tension; and
2. The detailed locked-in stressed state of the pedestals as influenced by original manufacturing methods in the 1880s; and
3. The 'bedding' details of the pedestals on their bases which can provide stressed 'hot spots'; and
4. Demonstration has yet to be made that the temperature controls have the necessary reliability and can actually cope with the full range of ambient temperatures likely to be experienced. This latter item is focused on sustainable stability. Failure to function could lead to overloading and further damage.

Items 2 and 3 will remain unknowable and provide a hidden risk to understanding the ultimate stability and safety of the bridge.

Some items, such as the loads applied to the pedestals by the seized rollers (H, on the diagram) are also not known. But this has been accommodated in analysis by MM checking that for the range of likely operational loads no overstressing due to chain loads is likely to occur if, and only if, the temperature controls are working correctly and are applied correctly to minimise the loading. This cannot provide sure protection against gross failure as other sources of loading, as detailed above, remain unknowable.

5. Other action since closure on 13th August 2020

The government taskforce AECOM report contains reviews of 13 reports of the work undertaken by MM, Mistras, Pell Frischmann and of the various CCSOs. Prof. Norman Fleck's report focuses on securing more detail from extant analyses. AECOM has undertaken modelling work itself in confirmation of elements of the MM work. It is important to recognise that the latest MM work on stress distributions on the North East pedestal provides a focus on just one element among many which affect the stability of the bridge and its safe operation.

There are significant issues with the AECOM review, and these have been documented by those whose reports feature in the AECOM review. Overall, matters can be summarised as follows:

- No flaws of any significance in the work undertaken on behalf of H&F have been identified, and any doubts raised by AECOM on details are easily answerable.
- AECOM has made 16 recommendations. Most confirm the value of continuing in the direction already set by H&F, some demonstrate misunderstanding by AECOM of the reports they have seen, and some ask for more details on analyses just completed, or for more testing, inspection or monitoring.
- AECOM'S recommendation 13 asks for a CCSO for imminent pedestrian use of the bridge but without undertaking any remedial works to ensure the safety of the structure. This is despite AECOM's own commentary on such a CCSO offering the view that, "*this may prove to be unworkable*". Prof. Norman

Fleck makes no such recommendation. This demonstrates a significant misunderstanding of the basis of the current CCSO, namely ignoring hidden defects and unknown and unknowable conditions which militate against any use of the bridge by the public. Furthermore, such factors are directly contrary to HSE guidance on dealing with unknowable conditions which may cause unacceptable outcomes. **The focus must be on prevention, which in this case means not using the bridge.**

The AECOM report offers an opinion that H&F's approach is, or may be, "*overly conservative*", but at no point has evidence been provided to support this assertion, either directly or in consequence of valid criticism of work undertaken on behalf of H&F. **Nor has evidence in support of its recommendation to prepare a CCSO for imminent use of the bridge by pedestrians been produced.**

The valid concerns about factors which remain hidden or unknown have simply been ignored other than to say, "*AECOM agrees that it is difficult to quantify the magnitude of residual stresses*", but then fails to address the significance of that remark. That, of itself, is sufficient reason to set aside recommendation 13.

H&F is the duty holder, advised by its agents, all of whom can be held accountable for the safe operation of the bridge. AECOM and others have no such accountability and so may feel free to go further in their recommendations than any duty holder could. AECOM, and others, have always been free to create the case for pedestrian use before remedial works, and to take duty holder risk, but have never done so. The assertion that something should be done does not mean that it can be done, and there is evidence in this case based on unknowability that it should not be done.

6. Advice to H&F

In deciding how to treat recommendations in the AECOM report the following are of prime relevance:

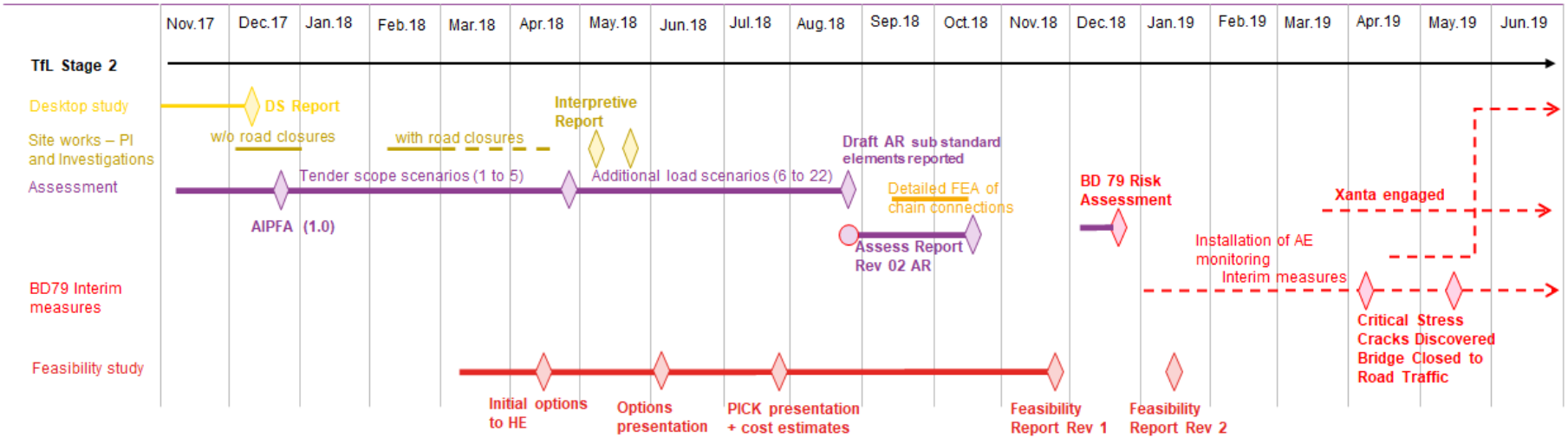
- The most recent MM report provides a good deal of evidence to suggest that the NE pedestal is likely to be stable. However, that does not provide the degree of certainty required to reintroduce pedestrians in the short term because the necessary degree of independent checking has not been applied.

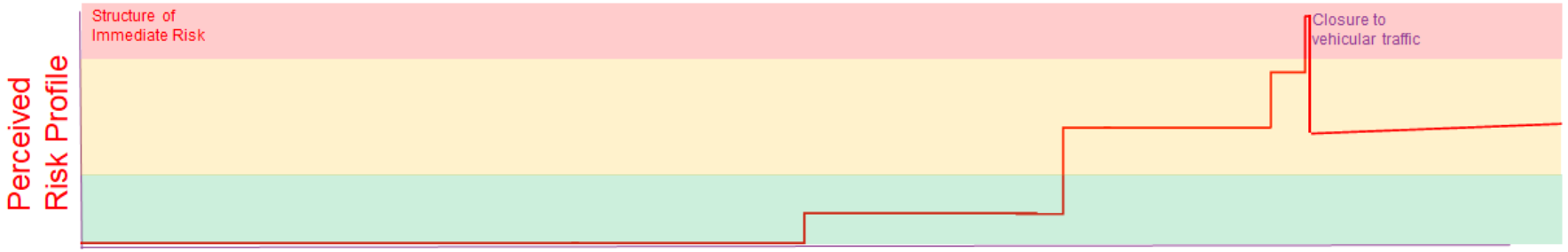
- Amid the plethora of detail there is the simple position that H&F, AECOM and Prof Norman Fleck all agree upon - remedial works must be undertaken to restore any meaningful use of the bridge.

- At a meeting on 15th December 2020, DfT's representative asserted that. "…*the department was equally keen to see the bridge permanently fixed but, given the timescales currently anticipated to do that, he felt other opportunities to allow pedestrian and cycle traffic, albeit with strict conditions, had to be explored*". This is an objection to an inconvenience and not to a point of physical laws which determine the safety of the bridge. AECOM has already commented that, "*this may prove to be unworkable".* Prof. Norman Fleck is silent on the matter. The term '*strict conditions'* implies that what is good for boats (fewer than ten people passing each hour) would apply also to pedestrians. That is truly unworkable. AECOM and DfT remain free to propose their own solutions while also taking duty holder risk.

- H&F must bear in mind that the safety of the bridge depends on one brittle cast iron pedestal known to contain cracks which have shown movement, one which does not, and two others, still with paint needing removal, but known to contain some cracks that are of unknown condition. Those two pedestals must be investigated fully before consideration is given to any changes although unknowns will remain even then. It is obvious, and intuitive, to any member of the public that even with detailed knowledge of all the pedestals the case for any use of the bridge would be finely balanced. Therefore, with the unknowns which apply here, the case is clearly for no use of the bridge without remedial works.

Timeline and Risk Profile





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