MANAGEMENT OF LONG LEVEL CANTILEVER SIGN STRUCTURES

Eight Long Lever Cantilever Sign Structures were constructed and installed along the northbound carriageway of the Kwinana Freeway as part of Perth's new Smart Freeways project.

This project supported the development of an appropriate risk management system for long leaver cantilever sign structures (CSS) by reviewing documented premature failures of similar structures from other jurisdictions over the last two decades. As a result, it was identified that there are various opportunities to adjust the Main Roads monitoring and governance system for managing these structures.

Background

Main Roads WA currently manages a large number of sign support structures of which 64 are classified as long lever cantilever structures (i.e., a cantilever length >10 m) including eight structures (with 16 – 22 m cantilever arms) that have recently been constructed as part of the Smart Freeways - Kwinana Northbound Project. Concerns have been raised regarding the compliance of structural components to the relevant Australian Standards and Main Roads WA specifications. Over the last two decades, a number of long lever cantilever sign structures have failed within Australia and overseas. There have been numerous causes for these failures which include issues with design and construction which led to failure mechanisms like fatigue. Recent studies indicate that higher stresses and a greater number of fatigue cycles than were previously anticipated are caused by wind and upward pressure from large vehicles passing beneath the structures. While there have been improvements in the Australian Standards and Main Roads Technical Standards based on the learning from these past events, the overall safety and long-term performance have not been assessed/verified.

This project focussed on developing an effective risk-based management framework for these structures.

Literature Review

- Primary cause of failure in CSS structures is fatigue caused by wind-induced vibrations, coupled with defects incurred during construction and operation.
- Defects usually occur at the connection of the mast arm to the pole, at the base of the pole, top of stiffeners, perimeter of hand holes and anchor rods.
- Australian road agencies have a more stringent inspection regime than in the USA.
- A risk management focus by road agencies sees a regular inspection regime similar to that applied to road structures.
- Short-term monitoring for fatigue defects is not an effective means of managing the risks of failure.

Trial Risk Workshop

The risk workshop confirmed the learnings from the literature review with respect to the need to focus efforts on assessing and monitoring long term structural performance, including relevant governance oversight to ensure the controls are effective and identified that some controls were ineffective.

Risk-Based Framework for Management of CSS structures

- The high level of uncertainty and dynamic nature of CSS technical risks needs to build two levels of risk review:
  - prevent losing sight of the strategic risk outcomes outside of safety.
  - ensure risk controls are being reviewed regularly
- High levels of uncertainty require professional judgement need to be employed to select the

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critical risk factors for prioritisation of inspection, testing, repairs and asset replacement.

Current expertise limitations include:

- Quantification of the response of CSS structures to typical daily excitation and the corresponding effects that these have on typical structures, and
- The limit states design/assessment approach, which is typically focussed on the response to extreme events.

Findings

- The uncertainty in current fatigue performance understanding requires additional inspection regimes to trigger maintenance and replacement strategies that may impact the expected life of the assets.
- Main Roads inspection levels for CSS are lower than some Australian counterparts and require increased inspection levels.
- Short-term monitoring of CSS structures for fatigue defects is not an effective means of managing the risks of failure.
- Asset integrity risk can be measured and evaluated at a physical asset management control level and at a second line assurance level using two levels of risk assessment.
- The high level of uncertainty and the dynamic nature of CSS technical risks requires two levels of risk review to ensure risk controls are being reviewed regularly. Building two levels of governance is essential to ensure the risk communication is linked to the Main Roads risk operating model.
- Professional judgement is required to select the critical risk factors for prioritisation of inspection, testing, repairs and asset replacement. Over time, this will be improved as knowledge increases of the current CSS asset base.

- Long term fatigue in CSS structures is caused by wind-induced vibrations.
- Main Roads CSS inspection levels are lower than other Australian counterparts.
- Short-term monitoring of CSS structures for fatigue defects is not an effective means of managing the risks of failure

- Implement two levels of risk review.
- Establish second line assurance process to ensure monitoring and inspections occur.
- Review risk control effectiveness regularly as per monitoring outcomes.
- Increases the CSS monitoring budget that critically prioritises inspection and maintenance.

FUTURE CONSIDERATIONS

A proposed medium term monitoring program over five (5) years demonstrates due diligence and addresses the above expertise limitations.

Due to high levels of uncertainty, a higher level of focus on control effectiveness checking and inspection is required until asset base performance and a 5-year testing program is completed.