C35 Defective Jack Causes Fatal Collapse of Overpass Falsework

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The goal of this presentation is to illustrate methods of determining the load on construction jacks and some of the inherent risks in using jacks in construction and will describe some of the defects found in hydraulic jacks often used in construction which are probable causes of failure.

This presentation will impact the forensic community and/or humanity by exposing internal construction of some hydraulic jacks which renders them dangerously susceptible to failure under seemingly ordinary usage.

Falsework was being installed for a concrete box girder overpass in Fresno, California. The falsework bents had been erected and the steel beam stringers had been placed on the bents when it was found that the elevation of one of the bents needed to be adjusted. A single nominal 12 ton hydraulic jack was used between the steel bent sill beam and the timber pads which served as the footing for the bent. One worker operated the jack while two others were placing and removing shims at the corbels (The short cross beam which distributed the load from the bent sill beam to the pads) when the bent toppled toward the jack operator. An adjacent bent also fell and the steel stringers fell. The jack operator was fatally injured, and the two other workers suffered minor injuries.

There were questions as to what caused the collapse and where did it originate. There were allegations that the tip-over was caused by the lateral component of the cable guys being increased by the jacking, that the jack had no steel plate under it to keep the bearing pressure on pads within the strength of the wood perpendicular to the grain, that the jack failed because it was overloaded, and that the jack was an automotive jack not suited for use in construction. There was also a question as to whether there was one more stringer beam on each span than the falsework plans called for. Furthermore, there were differing statements as to where the jack had been placed.

Study of the many scene photographs and the falsework plans revealed that the construction followed the plans except for the extra stringer which weighed 4000 pounds and except for a slope of the pads of approximately four degrees. The weight on the bent that would have been borne by the jack was then calculated for each of the stated positions of the jack with and without the extra stringer but allowing for the slope of the surface under the jack. These calculations showed that the load on the jack was well under the required test load on a five degree slope according to the ASME-ANSI standards for the jack.

Then the bearing pressure under the jack was computed allowing for the eccentricity of its base with respect to the ram and allowing for its minimum and maximum extensions. The pressure so computed was about 1400 psi, almost twice the proportional limit of the Douglas fir pads. If in fact this pressure was applied, the surface of the pad would have shown sig- nificant depressions or gouges at the jack location. Excellent photographs of the upper surface of the pads revealed no such deformations. Therefore it was concluded that the jack was most probably supported on a steel plate that was lost in the debris of the collapse and the clean up.

The effect of the maximum stroke of the jack on the tension forces in the guy cables was calculated and was found to be a small fraction of the force required to overcome the simple friction of the stringers on the cap beam of the bent. Therefore, the guy cables could not have been a factor in the collapse. The conclusion thus far was that the jack failure at loads it should have endured was the primary cause of the collapse.

Extensive photogrammetric examination of the failed structure pro- vided verification of important artifact locations and dimensions. The doc- umentation by site investigators was used to recreate the scene envi- ronment, and aid in the reconstruction of the collapse events.

A further analysis of PALD (Portable Automotive Lift Devices) test methods illustrated the limitation of the standard. At full extension, or within 25mm of full extension, the tested exemplar jacks offered little resis- tance to lateral instability. The moment coupling between the ram and the cylinder bore was insufficient to transmit moment forces to the jack base. A modified test protocol was designed to allow continuous deflection beyond the five degrees specified in the PALD standard. Comparisons were made between the two test methods.

The findings will be presented, including failure modes that were evident in the failed hydraulic jack. Going beyond the events of this par- ticular case, this method arguably demonstrates a more realistic lab test that reflects the actual vertical and lateral loads applied under foreseeable con- ditions of use. Also, the paper address the continuing deterioration of applicable safety factors as the production of these units has been shifted to China and other countries.

Hydraulic Jacks, Bridge Collapse, Falsework

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