Retrofit Technical Analyses Table of Contents and Conclusions
October 2008

- Seismic Vulnerability of the Alaskan Way Viaduct: Summary Report, Washington State Transportation Center (TRAC) – July 1995
    - Conclusions:
        - The Alaskan Way Viaduct is clearly vulnerable to severe damage and potential collapse in a design-level earthquake.
        - Widespread liquefaction is expected to occur in a design-level ground motion and could cause multiple sections of the viaduct to collapse.
        - Significant damage is likely even if the ground motion is considerably less intense, and hence more likely, than the design level earthquake motion.
- Alaskan Way Viaduct: Report of the Structural Sufficiency Review Committee – June 2001
    - Conclusions:
        - The Alaskan Way Viaduct should be replaced in kind with a new structure as soon as possible.
        - The committee does not recommend retrofitting the Viaduct as a long-term solution. The estimated costs of retrofit are similar to the estimated costs for replacement, and the committee believes that replacement offers far greater value and reliability that comes with a completely new structure.
- Alaskan Way Viaduct Phase 1 Retrofit Option Report, American Society of Civil Engineers Review – July 2002
    - Conclusions:
        - The structures that make up the seawall were not designed to handle seismic loadings.
        - It appears that trying to fix one aspect of the structure's response to a seismic event may well cause another part of the structure to become the weakest link.
        - There is probably nothing that can be done to improve the earthquake resistance of the existing Alaskan Way Viaduct to the level needed.
        - The proposal from Gray and Twelker is not technically sound and the options by the project team are not economically justified.
        - The proposal … does not provide adequate reduction in the risk of the viaduct failure with a highly questionable method of base stabilization.
        - The existing structure has numerous deficiencies… requiring major rebuilding or replacement of key structural elements.
        - Retrofitting the 50 year-old facility is not the technically preferred solution since it is doubtful that retrofitting is an effective approach to fully satisfying current design standards.

- Rebuild/Retrofit Alternative Report, Parsons Brinckerhoff – August 2002
    - Conclusions:
        - In many Viaduct locations, the seismic design leads to the complete replacement of the major structural elements… A rebuild would solve the seismic vulnerabilities, correct the load ratings and degradation deficiencies, address the railing/deck deficiencies, and improve some known operational deficiencies.
        - There are sections of the Viaduct where a seismic retrofit in combination with strengthening of the superstructure for highway loading and bridge railing/deck replacement is sufficient to meet the project design criteria… this approach is applicable to about 20% of the structure at the northern end of the Viaduct.
- Rebuild/Retrofit 500, Parsons Brinckerhoff – April 2003
    - Conclusions:
        - The Rebuild 500 Plan is far superior to the Retrofit 500 Plan when seismic performance, aesthetics, cost, and risk are balanced.
        - The facility as a whole does not lend itself to a retrofit approach. However, the exception is a retrofit of the single-level structures between the Battery Street Tunnel and Pike Street, which do perform well.
- Rebuild/Retrofit 500, Appendix B: Preliminary Deep Foundation Engineering Analyses, Existing Piles, Alaskan Way Viaduct Project, Shannon & Wilson – January 2003
    - Summary:
        - Of the 78 bridge bent foundations studied, it was found that the piles supporting 39 of the bents (50 percent of the bents) would fail under vertical loads if soil liquefaction were to occur during an earthquake.
        - Furthermore, for all 78 bridge bent foundations studied it was found that the ability of all piles to resist lateral forces, due to horizontal earthquake loads, was questionable and requires further study.
- Alaskan Way Viaduct Summary: Safety and Service Limitations of the Alaskan Way Viaduct – 2005
    - Conclusions:
        - The acute and latent damages caused by the Nisqually earthquake change the need from normal programming to an emergency status.
        - From the risks of falling concrete spalls, to the structural deterioration due to bond loss and increased foundation settlement, the current condition of the viaduct is not reliable. As a result, regular closures are required for extensive structural inspections, just to assure that additional latent defects do not unduly compromise public safety.
        - When the risk of future earthquakes is considered, the Viaduct fails precipitously according to any modern engineering standards.
        - The [Nisqually] earthquake not only caused direct and immediate damage to the Viaduct, but it also created latent deterioration throughout the structure. This condition greatly heightens the need for replacement, future earthquakes not withstanding.

- Proposed Retrofit of Alaskan Way Viaduct Using Fluid Viscous Dampers: Preliminary Phase, Miyamoto International, Inc. – July 2006
    - Conclusions:
        - Geotechnical evaluation as related to the foundations and condition of the underlying soil was beyond the scope of the work presented here.
        - No analysis of maintenance costs was performed. Benefit-to-cost analysis to determine the merits of replacement vs. retrofit was not conducted.
- Evaluation of Gray's Retrofit Proposal, T.Y. Lin International Review – July 2006
    - Conclusions:
        - Miyamoto's evaluation does not include foundation elements, which omits review of a major vulnerability of the structure.
        - There is no consideration of soil liquefaction, pile connects, potential uplift, or the potential effects of ground improvement (Gray's proposal) on the effective ground motion.
        - Miyamoto's evaluation is based on an inadequate performance standard, which is stated in the report to … achieving the response of the structure to the Nisqually event. That performance does not meet any codified design standard, and there is no assurance that subsequent exposure to an earthquake like the Nisqually event will not result in far greater accumulated damage to the Viaduct.
- Additional Retrofit for Gray's Modified Proposal, T.Y. Lin International Review of modified retrofit proposal – November 2006
    - Conclusions:
        - Performed further analysis to determine the character of additional retrofit measure that would be needed for a satisfactory retrofit of the viaduct.
        - In addition to those retrofit measures recommended by Gray, we concluded that the footings of the viaduct require retrofit.
        - Another identified concern, not addressed by Gray's retrofit proposals, is the poor anchorage of the bottom bars of the lower floorbeams at the columns. We recommend improving the connection of the lower floorbeams to the columns…
        - We also recommend replacement of the knee joints between the columns and the upper floorbeams.
- Report of the American Society of Civil Engineers Review Committee – December 2006
    - Conclusions:
        - The relatively narrow difference in costs between the choice of retrofit or rebuild weighs heavily in favor of rebuilding.
        - The cost differential between the two choices is expected to narrow when considering the higher life cycle maintenance costs, short life span and substandard operations geometry of a retrofitted structure.
        - We do not view the retrofit option as presented by the Viaduct Preservation Group as a viable option.
- Cost Comparison between Elevated Structure and Gray Retrofit – December 2006
    - Summary:
        - WSDOT cost estimates for two Alaskan Way Viaduct options:

        - Complete replacement of the viaduct with a new, elevated structure, including wider lanes, roadway shoulders, improved acceleration and deceleration lanes, and seismic design according to current WSDOT standards.
        - Retrofit of the viaduct according to the Viaduct Preservation Group (VPG) damping proposal. Estimate is based on the analysis and schematic design by T.Y. Lin International.
- Cost comparison between elevated structure and Gray retrofit, *with comments from Victor Gray* – December 2006
    - Summary:
        - Victor Gray provided a version of this estimate in which he commented on the WSDOT estimate of the costs of the VPG proposal, and provided his own, line by line, revisions to the WSDOT estimate.
- Seismic Vulnerability Analysis Report, Parsons Brinckerhoff – November 2007
    - Conclusions:
        - This review was prompted by new data on the frequency and distribution of earthquakes in the region. To better understand how the Viaduct would react during an expected seismic event, we used advanced structural analysis techniques to reexamine the interaction of local soil conditions and the Viaduct structure that could cause its collapse.
        - There is approximately a 1-in-10 chance in the next ten years of an earthquake that would cause portions of the Viaduct to collapse.
        - This change in risk is based on new geotechnical information and a better understanding of local and regional seismic behavior.
- Alaskan Way Viaduct: Evaluation of Seismic Retrofit Options, KPFF Consulting Engineers – September 2008
    - Conclusions:
        - Any plan replacing the Alaskan Way Viaduct shall provide a long-term solution.
        - The existing Alaskan Way Viaduct (including foundations), is in an advanced state of deterioration and is approaching the end of its functional life.
        - The damping retrofit scheme proposed by the Viaduct Preservation Group would cost approximately 80 percent of the cost of replacing the viaduct.
        - Construction of any of the retrofit schemes proposed to date would result in significant and long-term disruptions to traffic both on and around the viaduct.
        - A retrofit approach to improving the Alaskan Way Viaduct is neither technically or fiscally prudent.