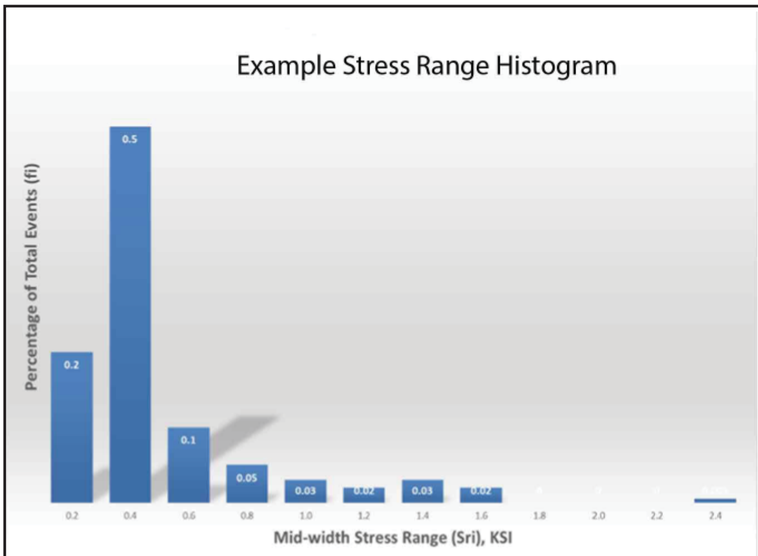
Structural Life Extension

A majority of the U.S. transportation infrastructure is more than 50 years old with 1 in 9 bridges considered structurally deficient. Fatigue damage accumulation in bridge structures has led to shorter service lives. The dilemma of bridge management is how to prioritize and better allocate insufficient funds for construction, rehabilitation, and maintenance. One successful approach is the implementation of structural health monitoring to extend the service life of existing bridge structures that may be classified as deficient based on visual inspections or conservative evaluations.

Geocomp conducts structural life extension of critical infrastructure to help in assessing the safety and reliability of infrastructure systems by verifying modelling that takes a less conservative approach at detecting damage before it reaches a critical state. Key risk indicators, such as deformations, loads, groundwater, and weather, can be monitored to optimize the operational and maintenance activities of complex structures.

Geocomp's monitoring programs provide critical data, which informs owners of the impacts that everyday operations, maintenance, repair, and replacement have on structural health. Monitoring can provide early detection data that can be integrated into design modifications and structural management systems to ultimately increase the quality and cost effectiveness of decisions by providing reliable and unbiased information. Monitoring also can be used to validate less costly structural retrofits versus complete replacement. This leads to better decisions for asset management.

Geocomp has worked on several projects that have provided cost-effective solutions to the structural life extension of bridges where welds and/or connections were identified to have defects that could lead to fatigue issues requiring expensive repairs. Fatique analysis generally is carried out using conventional analysis using the AASHTO Manual for Bridge Evaluation guidelines. If results show fatique stresses exceed AASHTO values, one could design and initiate costly repairs OR take an approach using structural health monitoring to verify actual constant effective stress range from the vehicle load history. Using this approach, Geocomp addresses the areas of concern on a bridge structure with the instrumentation of strain gages to collect data in real-time. The data is then processed through a "rain flow" software algorithm to generate a stress range histogram. Using Minor's Rule, Geocomp calculates a constant effective stress range.

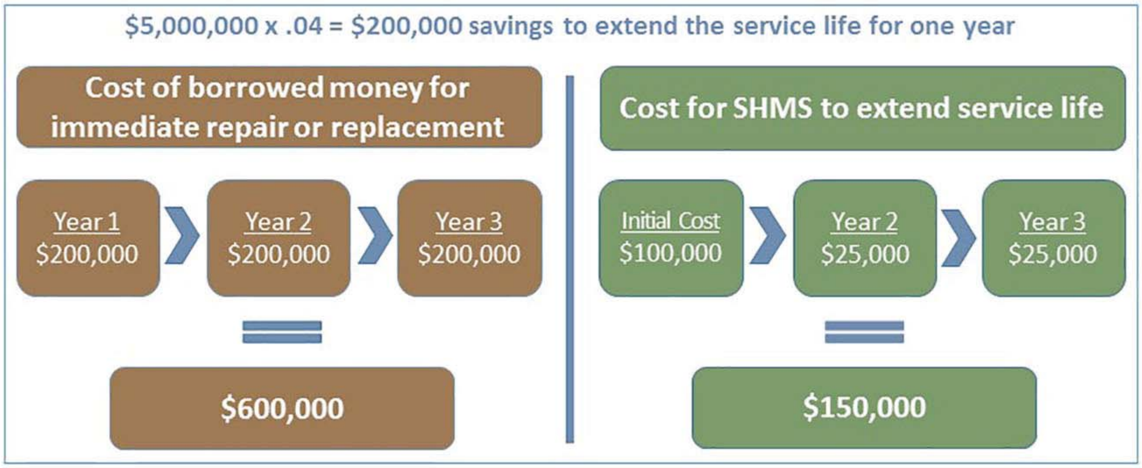


Mid-width stress Range	Percentage of Total	(fi*Sri^3)
0.2	20	0.0016
0.4	50	0.032
0.6	10	0.0216
0.8	5	0.0256
1	3	0.03
1.2	2	0.03456
1.4	3	0.08232
1.6	2	0.08192
1.8	0	0
2	0	0
2.2	0	0
2.4	0.5	0.06912
	Sr miner=	0.37872

Economics of Service Life Extension

According to the 2015 Federal Highway Administration (FHWA) National Bridge Inventory (NBI), there were more than 58,000 bridges in the United States classified as structurally deficient (SD). It is estimated the total cost of replacing these structures would be more than $45 billion. Almost all of these bridges have not been tested and often (not always) when tested are found to have a higher load capacity than estimated by analysis. This can be due to over simplified structural analysis, inaccurate modeling of boundary conditions and load bearing capacity of non-structural elements based on conservative designs and/or conservative design guidelines. It could be reasonable to assume that service life could be extended on some Bridges through monitoring to better utilize assets for repair/replacement of more critical structures.

The cost of a Structural Health Monitoring System (SHMS) can be readily justified if it can extend the service life of the structure while providing a cost savings for immediate repair or replacement. As an example, assume the cost of a bridge repair or replacement to be $5,000,000. With an interest rate of 4% for borrowed money, a savings of $200,000 (interest on borrowed money) can be achieved each year this expenditure is delayed. For a 3-year extension of service life, $600,000 would be saved. In some cases, a SHMS can be on the order of $100,000 for capital expenditure and $25,000 for annual maintenance and reporting. Therefore, a $150,000 expenditure would save $600,000.



The extension of service life must provide the information needed to assure structural performance is maintained without reducing allowable safety factors. Through protocols using live load testing, fatigue evaluation, and data analysis, threshold response values can be established and programmed into the system to alert owners when conditions of the structure may change and can provide immediate notification for focused maintenance or inspection. This is a significant and recognized return on investment for asset management purposes.

Representative Projects

GOLDSTAR BRIDGE, Groton/New London, CT

Benefit/Role: Verified structural model used to predict remaining service life of structural components/connections.

Geocomp, worked with CME Associates, and installed strain gages at critical locations and collected dynamic data from ambient traffic conditions from a remotely positioned solar-powered data acquisition system. The data was accessed remotely via IP Phone and processed using a “rainflow” software algorithm that converted strains to stress and created a Stress Range Histogram for the series of data. Based on Geocomp results, a more cost-effective solution of peening the welds and performing annual inspections was recommended.

WALT WHITMAN BRIDGE, Philadelphia, PA

Benefit/Role: Structural model verified by measured data under live load conditions to categorize and prioritize gusset plate repairs.

Geocomp worked with HAKS and the Delaware River Port Authority to extend the service life of the 57 year-old suspension bridge over the Delaware River in Philadelphia. Rusted gusset plates were discovered below the recently re-decked bridge structure during routine inspection. This prompted emergency repairs based on inspection and classification of gusset plate deterioration. The repair schedule for gusset plates was based on classification importance from engineering calculations and verification through field instrumentation and data collection and evaluation.

I-91 SPRINGFIELD VIADUCT, Springfield, MA

Benefit/Role: Structural model verified by data to predict 35 additional years of service life.

Geocomp worked, with CME Associates, and installed 150 spot weldable strain gages on superstructure steel members and collected data continuously for a two week time period using a remotely accessed high-speed data logging system. Data processing consisted of the development of an automated program to perform the stress loading cycle counting for the fatigue analysis in accordance with ASTM E1049-85 Standard Practices for Cycle Counting in Fatigue Analysis. The data collected also allowed for differentiation between traffic stress loading and thermal induced stresses that can often be magnitudes greater than live load stresses.

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