Exponent®
Engineering & Scientific Consulting

Robert Locke, Ph.D., P.E.

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Professional Profile

Dr. Locke is a licensed professional focused on the failure analysis, damage assessment, and risk mitigation of structural systems. In his time at Exponent, Dr. Locke has participated in investigations concerning a variety of structural systems (single & multi-family residences, high-rises, dams, bridges, historical buildings, etc.) composed of various building materials (concrete, steel, wood, masonry, etc.). He specializes in structural health monitoring and the evaluation of structures when subjected to different sources of vibration (blasting, construction, earthquakes, vehicle traffic, and wind). He also has years of valuable experience evaluating the condition of interior finishes and building envelope components (façades, flashing, weather barriers, etc.).

As a consultant, Dr. Locke routinely attends site investigations, performs destructive and non-destructive testing, reviews various project specific documentation, and conducts analyses utilizing code prescribed and mechanics-based procedures. He is well versed in the international building and residential codes and numerous industry standards, and he routinely utilizes these resources when developing opinions and disseminating technical reports. He is familiar with an assortment of engineering software packages (SAP2000, ETABS, RAM Structural Systems, Matlab, etc.) that he frequently leverages when evaluating planned and as-built structural designs, assessing performance of damaged or failed structures, and analyzing field data. His reliable engineering judgement and integrity provide a basis that allows him to give the dependable advice necessary for owners, insurers, and other stakeholders to make informed decisions.

Prior to joining Exponent, Dr. Locke was a graduate student researcher at Clemson University, where he earned a Ph.D. in civil engineering. He was the recipient of the Graduate Assistance in Areas of National Need (GAANN) and National Science Foundation Research Traineeship (NRT) fellowships awarded to Clemson University by the US Department of Education and National Science Foundation, respectively. As a GAANN and NRT fellow, Dr. Locke took additional courses and worked on interdisciplinary research teams to solve problems related to infrastructure resilience; specifically, he conducted research identifying and mitigating the vulnerabilities of complex, critical, and interdependent infrastructure systems. Dr. Locke's primary research focused on the development of a mobile health monitoring strategy that utilizes vehicle mounted sensors and operational modal analysis procedures to continuously evaluate the health of bridges. Through his work, he was able to experimentally demonstrate the system identification capabilities of the indirect methodology, while also developing a Bayesian estimation framework capable of classifying physical damage through finite element model updating.

Apart from his primary academic institution, Dr. Locke has conducted research at the Los Alamos National Labs - Engineering Institute in New Mexico and at the Fraunhofer Institute for Structural Durability and System Reliability in Germany. While at these institutions, he gained experience conducting static and dynamic experiments on lab- and full-scale systems, working with nonlinear systems, performing data-driven uncertainty quantification on computational models, and utilizing

machine learning techniques for structural health monitoring. Dr. Locke also has industry experience from internships and co-ops with various engineering firms. His industry work allowed him to gain experience overseeing construction projects, conducting visual inspections, and performing ASTM standards testing.

Academic Credentials & Professional Honors

Ph.D., Civil Engineering, Clemson University, 2021

M.S., Civil Engineering, Clemson University, 2017

B.S., Civil Engineering, Clemson University, 2015

Best Student Paper Award in the Dynamics of Civil Structures Technical Division at IMAC-XXXIX, 2021

NRT Fellowship, 2019-2021

GAANN Fellowship, 2016-2019

Los Alamos Dynamic Summer School Fellowship, 2017

RCI-IIBEC Student Scholar, 2013

Licenses and Certifications

Professional Engineer, Florida, #96183

Professional Engineer, Georgia, #PE050399

Professional Engineer Civil, Mississippi, #36093

Professional Engineer Civil, North Carolina, #060214

Professional Engineer Civil, South Carolina, #43544

Prior Experience

International Exchange Student, Fraunhofer Institute for Structural Durability and System Reliability LBF, 2018

LADS Intern, Los Alamos National Labs – Engineering Institute, 2017

Co-op Student, Infrastructure Engineering (Now CONSOR), 2014-2015

Summer Intern, NCDOT, 2014

Co-op Student, Construction Science and Engineering, Inc., 2013

Professional Affiliations

American Society of Civil Engineers (Member)

American Institute of Steel Construction (Member)

Publications

Journal

Locke W, Redmond L, Schmid M. Evaluating OMA System Identification Techniques for Drive-by Health Monitoring on Short Span Bridges. Journal of Bridge Engineering. 2022 Sep 1;27(9):04022079.

Mokalled S., Locke W., Abuodeh O, Redmond L, McMahan C. Drive-by health monitoring of highway bridges using Bayesian estimation technique for damage classification. Structural Control and Health Monitoring. 2022 Jun;29(6):e2944. Mokalled and Locke share joint first authorship.

Locke W., Sybrandt J., Redmond L., Safro I., Atamturktur S. Using drive-by health monitoring to detect bridge damage considering environmental and operational effects. Journal of Sound and Vibration. 2020 Mar 3;468:115088.

Conference/ Textbook

Edwards M. and Locke W. Development of a characterization method for high-speed vehicle-induced vibrations in the built environment. In Proceedings for Noise-Con 2024. June 2024.

Abuodeh O., Locke W., Redmond L., Sreenivasulu RV., Schmid M. Examining Methods for Modeling Road Surface Roughness Effects in Vehicle–Bridge Interaction Models via Physical Testing. In Society for Experimental Mechanics Annual Conference and Exposition 2023 Jun 5 (pp. 33-47). Cham: Springer Nature Switzerland.

Bishop C., Moncarz P., Locke W., Emmenegger L. Using a Performance-Based Approach to Predict the Effect of Defective Construction on Deaths, Dollars, and Downtime. The 6th International Conference on Protective Structures (ICPS6) 2023 May.

Locke W, Mokalled S, Abuodeh O, Redmond L, McMahan C. A Bayesian Estimation Technique for Multilevel Damage Classification in DBHM. In Leveraging Artificial Intelligence in Engineering, Management, and Safety of Infrastructure 2022 Nov 17 (pp. 232-260). CRC Press.

Locke W, Redmond L, Schmid M. Experimental Evaluation of Drive-by Health Monitoring on a Short-Span Bridge Using OMA Techniques. In Dynamics of Civil Structures, Volume 2: Proceedings of the 39th IMAC, A Conference and Exposition on Structural Dynamics 2021 2022 (pp. 109-127). Springer International Publishing.

Locke WR, Mokalled SC, Abuodeh OR, Redmond LM, McMahan CS. An intelligently designed AI for structural health monitoring of a reinforced concrete bridge. The Concrete Industry in the Era of AI. 2021 Jan.

West BM, Locke WR, Andrews TC, Scheinker A, Farrar CR. Applying concepts of complexity to structural health monitoring. In Structural Health Monitoring, Photogrammetry & DIC, Volume 6: Proceedings of the 36th IMAC, A Conference and Exposition on Structural Dynamics 2018 2019 (pp. 205-215). Springer International Publishing.

Presentations

Edwards M. and Locke W. Development of a characterization method for high-speed vehicle-induced vibrations in the built environment. Oral presentation, Noise-Con, New Orleans, LA, 2024.

Locke W. Matrix Analysis – Models and Case Studies. Oral presentation. Clemson University Department of Civil Engineering Matrix Analysis Class, Clemson University, 2023.

Bishop C. and Locke W. Applications of Structural Dynamics in Forensic Consulting. Oral presentation.

Clemson University Department of Civil Engineering Structural Dynamics Class, Clemson University, 2023.

Bishop C. and Locke W. Science and Engineering for a Complex World: Exploring Performance and Failures Within the Built Environment. Oral presentation. Clemson University Department of Civil Engineering Seminar, Clemson University, 2023.

Bishop C. and Locke W. Structural Engineering, Mechanics and Materials PhD Seminar. Oral presentation. Georgia Tech Graduate Student Seminar, Georgia Tech, 2021.

Locke W. Experimental Evaluation of Drive-by Health Monitoring on a Short Span Bridge Using OMA Techniques. Oral presentation, IMAC-XXXIX, Virtual, 2021.

Locke W. Techniques for Simulating Frozen Bearing Damage in Bridge Structures for the Purpose of Drive-by Health Monitoring. Oral presentation, IMAC-XXXVIII, Houston, TX, 2020.

Locke W, Kupis S. Applying Uncertainty Quantification to Structural Systems: Parameter Reduction for Evaluating Model Complexity. Oral presentation, IMAC-XXXVII, Orlando, FL, 2019.

West BM, Locke WR, Andrews TC. Applying Concepts of Complexity to Structural Health Monitoring. Oral Presentation, IMAC-XXXVI, Orlando, FL, 2018.

Project Experience

Construction Defect Disputes

Airport Runway: Investigated reported defects associated with construction of a concrete runway at a major airport. Investigation consisted of reviewing civil and structural plans, daily construction reports, concrete mix designs and test reports, maintenance logs, and flight data to determine potential causes of runway cracking and spalling.

Hospital: Investigated reported construction defects with structural wall and building envelope construction for a hospital campus composed of two six-story medical support structures and an energy plant. Role consisted of reviewing a repository of over a hundred thousand construction documents and helping draft a report to assess reported issues with improper dimensional control of wall systems, construction sequencing of structural and building envelope components, window and door installations, and fireproofing application.

Residential Housing Complex: Performed approximately 50 site investigations over the course of two years to investigate reported defects with building envelope construction on two student housing complexes. The structures combined were approximately 600,000 square feet in area, were clad with various facades (e.g., fiber cement lap siding, fiber cement panels (board and batten), and brick veneer), and constructed with typical drainage wall systems. Investigations consisted of monitoring the demolition of portions of each building's façade, documenting the as-built condition of building envelope components, and comparing the as-built conditions against the architectural plans, building codes, and industry standards to identify potential construction defects. Investigations also entailed evaluating deterioration of structural wood components and determining the extent to which components needed to be removed and replaced.

Sewage Pumping Station: Investigated cracking observed at the base of a subterranean precast concrete lift station (sewage pumping station). Role consisted of performing investigation to obtain concrete core samples per ASTM standards and developing finite element models (SAP2000 models) to obtain likely stress profiles of the station when it was being lifted and transported.

Warehouse Facility: Investigated reported construction defects with conventionally reinforced and fiber reinforced concrete slab-on-ground construction at a one million square foot facility. Role consisted of performing visual inspections of concrete slabs, reviewing tens of thousands of construction documents, researching various industry standards for concrete slabs-on-ground and industrial truck facility pavements, and helping draft a preliminary assessment discussing investigation findings and responding to over a dozen opposing expert reports.

Failure and Damage Investigations

Adjacent Construction Damage: Investigated damage claims for a historic masonry structure, over 100-years-old, reportedly caused by the removal of an adjacent structure that shared a foundation wall. Role consisted of visually investigating the historic structure to evaluate if observed damages were new or pre-existing, identifying potential causes for the new or pre-existing damage, and assessing the stability of the structure. Investigation also consisted of reviewing vibration data collected at the site to determine if peak particle velocities exceeded thresholds for cosmetic and structural damage.

Elevator Counterweight Failure: Investigated incident where an elevator counterweight system slipped off its rails, causing significant damage to elevator components. Exponent was tasked with inspecting steel components of the rails to identify potential mechanisms that allowed the counterweight to slip; owners also tasked Exponent with determining if pads beneath the ends of the rails played a role in the failure. Role consisted of collecting field data and developing a finite element model (SAP2000 model) to analyze peak stresses and displacements in rail components when exposed to varying boundary conditions and load effects (e.g., creep and shrinkage).

Floor Collapse: Investigated the collapse of an arched floor system inside a historical structure undergoing rehabilitation. Exponent was tasked with identifying the cause of the failure and opining on who was potentially responsible for the collapse; owners also tasked Exponent with reviewing rehabilitation activities in other parts of the structure to identify potential issues. Role consisted of reviewing historical architectural and structural drawings and comparing them against multiple versions of the rehabilitation drawings to identify which building elements were being removed or staying in place. Also analyzed photographs of the collapsed area to determine if critical building elements were accidentally removed or were misidentified in the rehabilitation drawing. Reviewed calculations for construction loads to determine if there were any potential issues with proposed methods for installing a new steel floor system.

Seawall Collapse: Investigated the failure of a seawall that reportedly occurred as a result of an incident involving a vessel fire and excessive loads introduced by emergency response vehicles and cranes. Assisted with evaluating the pre-incident condition of the seawall and determining the degree in which soil loss (undermining) due to erosion and concrete degradation factored into the wall's failure.

Steel Girder Failure: Investigated failure of built-up plate girders at a major transportation center. Exponent was tasked with opining on the root cause of the girder failures and opining on potential pre-damage repairs that could have prevented the girder damage and failures from occurring. Role consisted of reviewing a repository containing hundreds of thousands of documents and helping draft a report discussing the incident timeline, girder fabrication, structural loads, failure mechanisms, and potential repairs. Also assisted with drafting rebuttal reports to opposing experts, reviewing finite element models (SAP2000, ETABS, and RAM Structural Systems) of the transportation center, and preparing documents for trial.

Insurance Investigations

Storm Damage Assessments: Have performed investigations at multiple commercial (e.g., restaurants, office complexes, etc.) and residential properties to evaluate reported storm-related damage. Role consisted of performing site investigations, evaluating building components to determine the likely source of observed damage, performing engineering analyses, writing findings reports, and providing conceptual repairs.

Assessment of Structural Wood Deflections: Investigated reported issues with excessive floor deflections of a wood frame home undergoing construction. Role consisted of analyzing the wood floor system to identify if reported deflections exceeded code prescribed limits. Investigation also consisted of determining if reported deflections could be corrected or if they were permanent.

Post-Hurricane Damage Assessment: Performed investigations into damage to buildings during hurricanes, including distinguishing between damage caused by wind vs. water in residential structures, and distinguishing between new and pre-existing conditions.

Structural Design Review

Catwalk Structural Design: Tasked with investigating the existing structural design of a catwalk system installed on top of a high-rise structure in order to identify alternative layouts that avoided conflicts with existing building elements. Developed a finite element model (SAP2000 model) of the existing catwalk system and modified the layout to identify configurations that could utilize existing structural elements without exceeding the design capacity.

Historic Dam Analysis: Tasked with investigating if a historical steel dam structure could resist increased hydrostatic loads from a significant rain event. Role consisted of utilizing historical structural plans to develop a finite element model (SAP2000 model) of the entire dam's steel structure; the model was then subjected to increasing hydrostatic loads to determine if the structure could support reservoir storage up to a predetermined height. Investigation also consisted of identifying the forces being transferred to the dam's concrete piers and determining if the piers could also support the increased hydrostatic loads.

International Arbitration Support

Underground Metro Stations: Participated on a team investigating alleged civil and structural engineering design changes during a design-build project to construct underground metro stations. Role consisted of determining the percent completion of the design at the time instructions were given to modify the design, evaluating whether instructions led to changes to the technical scope, and evaluating the impact changes to the technical scope had on design level of effort. Also assisted with drafting multiple reports, participated in joint expert meetings, and provided virtual support during hearings.

Structural Health Monitoring and Vibration Studies

Racecar Vibration Investigation: Developed and executed vibration monitoring protocols in partnership with an international racing organization in order to evaluate the potential for high-speed vehicle induced vibrations to cause damage to street-adjacent structures. Vibration data was recorded on adjacent structures during high-speed vehicle pass-by events and then analyzed using novel filtering techniques and operational modal analysis procedures. The potential for damage was then determined by comparing the processed data against known thresholds for cosmetic damage discussed in various industry standards.

Peer Reviews

Journal of Bridge Engineering