The National Academies of
SCIENCES • ENGINEERING • MEDICINE

LABORATORY AND FIELD GEOTECHNICAL CHARACTERIZATION FOR IMPROVED STEEL CORROSION MODELING

A Virtual Workshop

BRIEFING BOOK

A workshop organized to inform the National Academies of Sciences, Engineering, and Medicine Committee on Corrosion of Buried Steel at New and In-Service Infrastructure

MARCH 9-10, 2021

WORKSHOP BACKGROUND

The National Academies of Sciences, Engineering, and Medicine (the National Academies) have been asked to prepare a peer reviewed consensus report that summarizes the primary mechanisms of the corrosion of bare or coated steel placed in earth materials (e.g., unconsolidated earth or rock in different geologic settings); the state of practice for characterizing earth materials for properties that influence corrosion and corrosion rates; and the use, efficacy, and uncertainties associated with methods to predict, identify, and monitor corrosion of steel in earth materials (see Box 1 for the full statement of task). An ad hoc committee of volunteer experts from relevant fields are considering the state of knowledge regarding, and technical issues associated with, the corrosion of steel used in earth applications (e.g., ground stabilization, pipelines, and infrastructure foundations). The committee will consider practices and research that might be implemented in the short- and long-terms to improve steel performance. As part of its information gathering efforts, the committee has organized this workshop to consider the field, laboratory, and modeling methods for characterizing the corrosion of steel in earth applications and environments.

Box 1. Corrosion of Buried Steel at New and In-service Infrastructure
Statement of Task

An ad hoc committee of the National Academies of Sciences, Engineering, and Medicine will conduct a study that will solicit input from the geotechnical and civil engineering and materials sciences technical communities to critically examine the state of knowledge and technical issues regarding the corrosion of steel used in earth applications (e.g., for ground stabilization, pipelines, and infrastructure foundations) and subsurface environments (e.g., unconsolidated earth or rock in different geologic settings). The study committee will

- Summarize the primary mechanisms for corrosion of bare or coated steel buried within earth materials under different geologic conditions;
- Assess the current state of practice for characterizing native and constructed earth and the subsurface environment for properties that contribute to or influence corrosion and corrosion rates; and
- Assess the use, efficacy, and uncertainties associated with methods for predicting, identifying, and monitoring corrosion of steel in earth materials for new and at in-service facilities.

The study will include a workshop on field, laboratory, and modeling methods for characterizing corrosion of steel buried in earth materials and new developments in the prediction and monitoring of corrosion of steel in earth applications and environments. The final report will identify gaps in knowledge and the short- and long-term research needed to improve the long-term performance of steel in earth applications.

Sponsors

Corrosion of Buried Steel at New and In-Service Infrastructure

Federal Highway Administration (FHWA)

National Science Foundation (NSF)

U.S. Army Corps of Engineers

Association for Mechanically Stabilized Earth (AMSE)

Geo-Institute, American Society of Civil Engineers

ADSC-International Association of Foundation Drilling

WORKSHOP ORGANIZATION

The study committee members, like the workshop participants, have expertise in geotechnical, civil, structural, and corrosion engineering, metallurgy, materials science, and other fields. With such a broad range of expertise, meaningful dialog is possible only if participants have some common knowledge of vocabulary and concepts. Workshop sessions are organized to provide basic information needed to inform dialog. Some of this information is provided through pre-recorded talks that participants are encouraged to view ahead of the workshop. The sessions are organized so that each informs the next:

- The first session identifies and describes current corrosion modeling approaches for improved understanding of corrosion potential (E_{corr}), rates, assessment and management;
- The second session focuses on how laboratory measurements are generated and used as model parameters.
- The third session focuses on field data generation and uncertainties, and how the data are and might be used to inform corrosion models; and
- The fourth session brings all the information together to consider how future lab and field characterization and corrosion modeling might be improved for better understanding of the corrosion of buried steel.

There 6 pre-recorded presentations availalble for prior viewing here: *https://www.nationalacademies.org/event/03-09-2021/laboratory-and-field-geotechnical-characterization-for-improved-steel-corrosion-modeling*

Predicting Corrosion in Soils for Infrastructure Applications: A Review and Recent Developments (35 Minutes)
Rob Melchers, University of Newcastle

Fundamentals in Geophysics for Assessing Corrosion (35 Minutes)
Mark Everett, Texas A&M University

How do we get valuable in situ field data regarding the extents, rates, and mechanisms of corrosion? (5 Minutes)
Khalid Farrag, Gas Technology Institute

In what ways are field tests and measurements relevant with respect to managing buried steel performance? (5 Minutes)
Kathryn Griswell, California Department of Transportation

What measurement technologies related to measuring corrosion of steel in reinforced concrete might be used in geotechnical applications? (5 Minutes)
Amir Poursaee, Clemson University

How are, and can, field data uncertainties be represented in corrosion models? (5 Minutes)
Naresh Samtani, NCS GeoResources

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AGENDA

SESSION 1 – Modeling
Identifying corrosion modeling approaches for improved understanding of corrosion potential (E_{corr}; see Box 2), rates, assessment, and management

SESSION OBJECTIVES

- Define common vocabulary for workshop participants.
- Describe current deterministic modeling approaches and their limitations.
- Identify emerging (non-deterministic) modeling approaches and challenges to their application.

Pre-recorded presentation for viewing prior to the workshop:
Predicting Corrosion in Soils for Infrastructure Applications: A Review and Recent Developments
Rob Melchers, University of Newcastle
https://www.nationalacademies.org/event/03-09-2021/laboratory-and-field-geotechnical-characterization-for-improved-steel-corrosion-modeling

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11:00 Welcome, Introductions, Discussion of Statement of Task, and Workshop Objectives
Scott Anderson, BGC Engineering Inc., Committee Chair

11:30 Presentation: Determinism in Science and Engineering
Digby Macdonald, University of California, Berkeley

12:00 Discussion with Digby Macdonald
Moderator: Homero Castaneda, Texas A&M University

12:30 Panel discussion on current approaches to modeling corrosion of steel in earth materials
Moderator: Homero Castaneda, Texas A&M University Greg Baecher, University of Maryland
Panelists:
Han-Ping Hong, Western University
Mark Orazem, University of Florida
Alberto Sagues, University of South Florida
Hui (Jack) Wang, University of Dayton

Each panelist will make a 5-minute presentation responding to the following prompting questions provided in advance of the workshop

- What do current deterministic models deliver, and with what kinds of limitations and uncertainties?
- Are there assumptions in deterministic corrosion models that are no longer needed or valid?
- What are the opportunities for improving deterministic models and what steps are needed to do so?
- What limitations and uncertainties in deterministic models can be addressed with non-deterministic models and what steps are needed to do so

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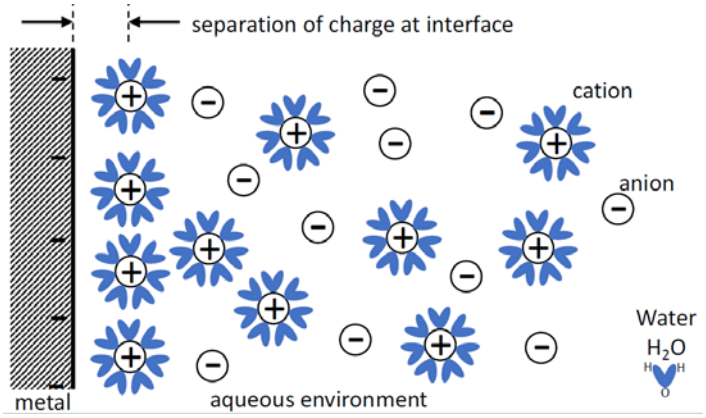
12:55 Panel discussion
Moderator: Homero Castaneda

2:15 Break

Box 2
"Corrosion Potential" versus "Potential for Corrosion"

The term "corrosion potential" is often confusing to novices in the field of corrosion because the first thought might be that it refers to the potential or possibility for corrosion to occur. Indeed, the likelihood of corrosion to occur will vary depending on the details of the material and the corrosivity of the environment to which it is exposed. However, in the field of corrosion, "corrosion potential" has a specific scientific meaning that is quite different than that of the potential for corrosion to occur, and it is important to understand this difference.

When a metal object is exposed to a corrosive environment, for instance an aqueous environment that contains dissolved ions, the region of the environment directly next to the metal is altered. Far from the metal, the water molecules and the ions, which are species with a net positive (cations) or negative (anions) electric charge, are randomly oriented and distributed. However, the water and ions next to the metal are rearranged, creating a separation of charge or a potential drop across this region. The extent to which this happens can be measured with a voltmeter and another special electrode, called a reference electrode. This voltage, or potential, is called the corrosion potential, E_{corr}. E_{corr} is an important parameter because this electrical potential is the driving force for corrosion. In a way, the corrosion potential is a measure of the potential for, or likelihood of, corrosion, but these concepts are not always directly related and should be kept distinct. In this workshop, the term corrosion potential will be reserved for the description of the potential drop at a metal surface, and not for the corrosivity of the environment.



Session 2 – Laboratory
Laboratory measurements as model parameters: past and future

SESSION OBJECTIVES

- Identify laboratory data that are supplied and used in modeling.
- Describe the limitations of laboratory methods for characterizing corrosivity observed in the field.
- Identify differences between laboratory data that are available versus data desired to better inform model inputs.
- Identify how laboratory practices might evolve to better meet modeling needs.

3:00 Description of session and session goals
Scott Anderson, BGC Engineering Inc., Committee Chair

Setting the Stage for Discussion: Prompts Provided to Speakers

With respect to characterizing corrosion rate of buried steel, describe (a) current laboratory practices, (b) opportunities for and evolution of practice to better meet needs, and (c) barriers to evolution for the following applications (as appropriate):

1. Characterizing spatial variability
2. Characterizing environmental variability
3. Replicating the as-built environment
4. Providing parameters for model input

Presentations

3:05 What do Model-Environments Encounter on Underground Pipelines?
John Beavers, DNV GL USA, Inc.

3:20 Laboratory Testing for Internal and External Corrosion of Buried Pipelines
Frank Cheng, University of Calgary

3:35 Laboratory Practices for Determination of Electrochemical Properties of Soil & Rock and Method Limitations
Karl Fletcher, Bowser-Morner, Inc.

3:50 Field Investigation of Corrosion of Buried Metallic Reinforcement Behind Retaining Walls
Bob Parsons, University of Kansas

4:05 Instruction for breakout discussions and transition time
Scott Anderson

4:10 Breakout discussions

Workshop participants will meet in one of five pre-assigned breakout groups to discuss a given theme:

- Characterizing spatial variability
- Characterizing environmental variability
- Replicating the as-built environment
- Providing parameters for model input

Each breakout room will include a committee member to moderate the session, and a second member who will serve as the group rapporteur to capture overarching themes to present in plenary.

Questions for breakout group discussion:

1. What are current laboratory practices with respect to the breakout theme?
2. What are the opportunities to better meet needs with respect to the breakout theme?
3. What are the barriers to making the above improvements?

5:00 Transition to Plenary

5:10 Plenary Session: summaries from breakout sessions
Moderator: Scott Anderson, BGC Engineering Inc., Committee Chair

6:00 Adjourn Day 1

Session 2
Breakout Room Assignments

Breakout Room Theme	#1 Characterizing spatial variability	#2 Characterizing environmental variability	#3 Replicating the as-built environment	#4 Providing parameters for model input	#5 Providing parameters for model input
Moderator:	**Stacey Kulesza**	**Susan Burns**	**Ken Fishman**	**Gerald Frankel**	**Aziz Asphahani**
Rapporteur:	**Brenda Little**	**Randall Poston**	**Liz Rutherford**	**Mersedeh Akhoondan**	**Homero Castaneda**
Participants:	Peter Anderson	Hans Arlt	Christopher Alexander	Giovanna Biscontin	Scott Anderson
	Arturo Bronson	Recep Avci	Michael Carey Brown	James Ellor	Greg Baecher
	Leonardo Caseres	Jon Bischoff	Craig Davis	Karl Fletcher	Vanessa Bateman
	Frank Cheng	Mark Everett	Khalid Farrag	Anand Govindasamy	John Beavers
	Jerry DiMaggio	Ray Fassett	Tom Hayden	Reggie Holt	Christine Beyzaei
	Peggy Haggerty Duffy	Marcus Galvan	Harold Hilfiker	Navid Jafari	Keith Brabant
	Mike Gomez	Robert Gladstone	Han-Ping Hong	Kingsley Lau	David Harris
	Erik Loehr	Kathryn Griswell	Burkan Isgor	Rob Melchers	Terry Holman
	Soheil Nazarian	Vincent Holohan	Brad Keelor	Naresh Samtani	Allen Marr
	Jennifer Nicks	Leszek Janusz	Silas Nichols	John Senko	Bob Parsons
	Amir Poursaee	Digby Macdonald	Mark Orazem	Narasi Sridhar	Joy Pauschke
	Matthew D. Smith	Jennifer McIntosh	Tom Schwerdt	Derek Soden	Kyle Rollins
	Pete Speier	Justin Ocel	Jeff Segar	Elizabeth Trillo	Preet Singh
	Joseph Turk	Larry Olsen	Leon Van Paassen	John Wolodko	Hui (Jack) Wang
	Kevin White	Alberto Sagues	Wenzing Zhou	Hui Yu	Zhongquan Zhou
		Mark Vessely			
Staff:	**Micah Himmel**	**Erik Svedberg**	**Liana Vaccari**	**Sammantha Magsino**	**Rachel Silvern**

Session 3- Field
Informing modeling through field characterization and performance monitoring data

SESSION OBJECTIVES

- Learn about current and emerging field methodologies and their uncertainties.
- Understand the utility of field data (e.g., modeling as direct input, as supplemental guide, or monitoring data?)
- Consider if and how field data uncertainties are represented in corrosion models.

The following pre-recorded presentations for viewing prior to the workshop are available here: *https://www.nationalacademies.org/event/03-09-2021/laboratory-and-field-geotechnical-characterization-for-improved-steel-corrosion-modeling*

Fundamentals in Geophysics for Assessing Corrosion (36 minutes)
Mark Everett, Texas A&M University

How do we get valuable in situ field data regarding the extents, rates, and mechanisms of corrosion?
Khalid Farrag, Gas Technology Institute

How do we get valuable in situ field data regarding the extents, rates, and mechanisms of corrosion?
Kathryn Griswell, California Department of Transportation

What measurement technologies related to measuring corrosion of steel in reinforced concrete might be used in geotechnical applications?
Amir Poursaee, Clemson University

How are, and can, field data uncertainties be represented in corrosion models?
Naresh Samtani, NCS GeoResources

11:00 Welcome, Objectives of Day 2,
Scott Anderson, Committee Chair

11:20 5-min recap of pre-recorded presentation,
Mark Everett, Texas A&M University

11:25 Clarifying questions from committee for Mark Everett
Moderator: Stacey Kulesza, Kansas State University

11:35 Presentation: State of Field Monitoring and Characterization for Estimating Corrosion- Related Indicators and Parameters
Soheil Nazarian, University of Texas at El Paso

11:55 Clarifying questions from committee for Soheil Nazarian
Moderator: Stacey Kulesza, Kansas State University

12:05 Presentation: Field Characterization of Dynamic Hydrogeologic, Geochemical and Microbial Conditions that Affect Corrosion,
Jennifer McIntosh, University of Arizona

12:25 Clarifying questions from committee for Jennifer McIntosh
Moderator: Stacey Kulesza, Kansas State University

12:35 Introduction for panelists and panel discussion: State of practice for field monitoring across different industries: current limitations and uncertainties in assumptions
Moderator: Stacey Kulesza, Kansas State University
Panelists:
Khalid Farrag, Gas T0echnology Institute
Kathryn Griswell, California Department of Transportation Amir Poursaee, Clemson University
Naresh Samtani, NCS GeoResources
Mark Everett, Texas A&M University
Soheil Nazarian, University of Texas at El Paso Jennifer McIntosh, University of Arizona

1:35 Summarize important points from session,
Ken Fishman, McMahon and Mann Consulting Engineers

1:45 Break

Session 4 – The Future
Future Modeling and Laboratory and Field Geotechnical Characterization for Improved Understanding of Buried Steel Corrosion

SESSION OBJECTIVES

- Explore how existing lab and field techniques might be refined to improve modeling.
- Explore how to refine modeling to better constrain uncertainties.

2:45 Introduction to session objectives,
Scott Anderson, BGC Engineering Inc., Committee Chair

2:50 Flash talks on emerging approaches to improve corrosion modeling
Moderator: Scott Anderson, BGC Engineering Inc., Committee Chair
Panelists:
Arturo Bronson, University of Texas at El Paso Han-Ping Hong, Western University
Burkan Isgor, Oregon State University
Erik Loehr, University of Missouri Wenxing Zhou, Western University

3:20 Discussion with flash talk speakers
Moderator: Ken Fishman, McMahon and Mann Consulting Engineers

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Prompting Questions for Discussion:

1. How might work practices for characterization of earth materials or for long-term management of buried steel be modified based on what has been discussed during this workshop?

2. What developments in modeling, laboratory, or field work might lead to improved understanding of corrosion potential, rates, assessment, and management?

4:20 Summary discussion from previous sessions
Moderator: Susan Burns, Georgia Institute of Technology)
Session 1: *Homero Castaneda, Texas A&M University*
Session 2: *Scott Anderson, BGC Engineering Inc., Committee Chair*
Session 3: *Stacey Kulesza, Kansas State University*

5:05 Open microphone: what would you like to say that you haven't heard at the workshop?
Moderator: Scott Anderson, BGC Engineering Inc., Committee Chair

5:20 Closing remarks
Scott Anderson, BGC Engineering Inc., Committee Chair

5:25 Workshop Adjourns

Workshop Speaker and Participant List

Speakers

John Beavers, DNV GL

Arturo Bronson, The University of Newcastle, Australia

Greg Beacher, The University of Maryland

Frank Cheng, The University of Calgary

Mark Everett, Texas A&M University

Khalid Farrag, Gas Technology Institute

Karl Fletcher, Bowser Morner

Kathryn Griswell, Department of Transportation

Han-Ping Hong, The University of Wisconsin

Burkan Isgor, The Oregon State University

Erik Loehr, The University of Missouri

Digby MacDonald, The University of California, Berkeley

Robert Melchers, The University of Newcastle, Australia

Jennifer McIntosh, The University of Arizona

Soheil Nazarian, The Univeristy of Texas, El Paso

Mark Orazem, The University of Florida

Bob Parsons, University of Kansas

Amir Poursaee, Clemson University

Alberto Saques, The University of South Florida

Naresh Samtani, NCS GeoResources, LLC

Hui (Jack) Wang, The University of Dayton

Wenxing Zhou, University of Western Ontario in London

Participants

As of March 1st

Mersedeh Akhoondan, HDR Engineering

Christopher Alexander, University of South Florida

Peter Anderson, Reinforced Earth

Scott A. Anderson, BGC Engineering

Hans Arlt, U.S. Nuclear Regulatory Commission

Aziz Asphahani, QuesTek Innovations

Recap Avci, Montana State University

Vanessa C. Bateman, United States Army Corps of Engineers

Christine Beyzaei, Exponent

Jon Bischoff, Utah DOT

Giovanna Biscontin, National Science Foundation

Keith Brabant, Reinforced Earth

Michael Carey Brown, WSP USA

Susan E. Burns, Georgia Institute of Technology

Leonardo Caseres, Southwest Research Institute

Homero Castaneda, National Corrosion and Materials Reliability Laboratory

Craig Davis, Los Angeles Department of Water and Power (Retired)

Jerry DiMaggio, Applied Research Associates

Peggy Haggerty Duffy, Hagerty Engineering Inc.

James Ellor, Elzly Technology Corporation

Ray Fassett, Condon-Johnson & Associates

Kenneth L. Fishman, McMahon and Mann Consulting Engineers P.C.

Gerald S. Frankel, The Ohio State University

Marcus Galvan, Foresight Planning and Engineering Service

Robert Gladstone, Association for Mechanically Stabilized Earth

Mike Gomez, The University of Washington

Anand Govinasamy, Geosyntec Boston

David Harris, Integral Engineering Co.

Tom Hayden, Engineering Director Inc.

Harold Hilfiker, Hilfiker Retaining Walls

Reggie Holt, Department of Transportation

Terry Holman, Geosyntec Consultants

Navid Jafari, Louisiana State University

Leszek Janusz, ViaCon Polska

Brad Keelor, Association for Mechanically Stabilized Earth

Stacey Kulesza, Kansas State University

Kingsley Lau, Florida International University

Daryl Little, Bureau of Reclamation

Brenda J. Little, B.J. Little Corrosion Consulting LLC

Allen Marr, Geocomp

Robert D. Moser, United States Army Corps of Engineers

Silas Nichols, Department of Transportation

Jennifer Nicks, Department of Transportation

Justin Ocel, Department of Transportation

Larry Olsen, Olsen Engineering Inc.

Joy Pauschke, National Science Foundation

Randall Poston, Pivot Engineers

Kyle Rollins, Brigham Young University

Elizabeth Rutherford, Energy Transfer

Jeff Segar, Braun Intertec Corporation

Derek Soden, Department of transportation

Pete Speier, Williams Form Engineering Corp

Tom Schwerdt, Texas Department of Transportation

John Senko, The University of Akron

Preet Singh, Georgia Institute of Technology

Narasi Sridhar, MC Consult LLC

Mathew D. Smith, United States Army Corps of Engineers

Elizabeth Trillo, Southwest Research Institute

Joseph Turk, Tennessee Valley Authority

Leon VanPaassen, Arizona State University

Mark Vessely, BGC Engineering

Kevin White, E.L. Robinson Engineering

John Wolodko, The University of Alberta

Hui Yu, TRC Companies Inc.

Speaker Biographies

Arturo Bronson has focused his teaching and research on the effect of chemical interactions on and near interfaces for high temperature materials and corrosion of materials. Investigations have centered in the area of ceramic composites and metals by linking microstructure developed during processing or synthesis with performance. Current research topics include the processing and oxidation of ceramic composites at temperatures greater than 2000 K, high temperature oxidation (800-1300 K) of metals and aqueous corrosion of metals embedded in soils.

Gregory B. Baecher PhD is a Glenn L Martin Institute Professor of Engineering at the University of Maryland. He is a geotechnical engineer specializing in risk, reliability, and statistical issues of water resource development, dam and levee safety, hydropower, and navigation. He is the author of five books on risk, safety, and the protection of civil infrastructure; and 250+ technical publications.

John Beavers is a Vice President and a Senior Principal Engineering DNV GL's Pipeline Services Department, Energy Systems. He has directed and contributed to numerous research and engineering programs on corrosion and cracking behavior of underground pipelines. These programs have included failure analyses, critical literature reviews, and laboratory and field evaluations. The research has been directed toward assisting pipeline operators in developing data to enhance their integrity management programs. For example, Dr. Beavers has developed test techniques to measure realistic growth rates for stress corrosion cracks and corrosion fatigue cracks in pipelines. Data from such tests are used to optimize hydrostatic retest and in-line inspection frequencies for pipelines containing these defects. Currently, Dr. Beavers works in the Incident Investigation Section (failure analyses, root cause analyses, and litigation support), which he previously managed for 11 years.

O. Burkan Isgor is a Professor of Civil Engineering and Materials Science at Oregon State University, Corvallis, Oregon. He has over 20 years of experience in the cement and concrete research, corrosion, electrochemistry, surface science, and computational materials science. He is the current Chair of the American Concrete Institute's (ACI) Committee 222 on Corrosion of Metals in Concrete. A professional Engineering Ontario, Canada, Dr. Isgor served as the Vice President of the Canadian Society for Civil Engineering (CSCE) between 2009 and 2011 and was in charge of the technical divisions of the Society. He is an active member of RILEM (TC 262- SCI), ACI (Committees 236 on Materials Science and 365 on Service Life Prediction), and CSCE (Committee on Mechanics and Materials). Dr. Isgor is a Fellow of ACI and CSCE.

Frank Cheng is a Professor and Canada Research Chair in Pipeline Engineering at the University of Calgary. His research interests span a wide spectrum of corrosion and its control of oil/gas pipelines. Frank has authored 3 books (*Stress Corrosion Cracking of Pipelines*, Wiley, 2013; *Pipeline Coatings*, NACE, 2017; *AC Corrosion of Pipelines*, NACE, in press) and 240 journal articles, with total citations of 10,400+ and the H-index of 65. Frank is an elected Fellow of NACE International. He is the recipient of 2014 Uhlig Award and 2021 Technical Achievement Award of NACE; 2017 Metal Chemistry Award and 2019 Distinguished Materials Scientist Award of Canadian Metallurgy and Materials Society; and 2015, 2018, 2019 and 2020 Engineering Research Achievement Award of the University of Calgary. Frank is serving as the Editor-in-Chief of *Journal of Pipeline Science and Engineering*. Frank obtained his Ph.D. in Materials Engineering at the University of Alberta in 2000.

Mark Everett is a professor of geophysics at Texas A&M University since 1995 specializing in near- surface electromagnetic, electrical and magnetic techniques with applications to subsurface imaging of buried infrastructure and cultural heritage as well as environmental problems related to water resources, agriculture, and ecosystems. He received the PhD in 1991 from University of Toronto and has worked as a postdoc at Scripps Institution of Oceanography, and University of Cambridge, and was a visiting professor at ETH Zurich and Khon Kaen University in Thailand. Dr. Everett authored the 2013 textbook "Near-Surface Applied Geophysics" and is State of Texas Professional Geoscientist #5141. He was awarded, along with co-author Alan Chave, the 2019 Best Paper in the SEG journal "Geophysics" and currently serves as co-Editor-in-Chief for Journal of Applied Geophysics.

Khalid Farrag's work focuses on research and development programs to help improve the performance, increase safety, and reduce the costs associated with infrastructure construction and maintenance activities. He has performed and managed various projects on pipeline excavation damage, corrosion and other pipeline threats, pipeline integrity, composite pipes, soil-pipe interaction, utility installation, and quantifying gas emissions. Prior to joining GTI in 2001, Dr. Farrag worked as the Research Coordinator at the Louisiana Transportation Research Center at LA-DOT for 10 years. There, he was the project manager of several research programs on soil stabilization, evaluation of highway materials, and soil-structure interaction. Dr. Farrag holds Ph.D. and M.Sc. degrees in Civil Engineering from Louisiana State University. He is a registered Professional Engineer(P.E.) in Louisiana and Florida and he is a registered Project Management Professional (PMP). He is a member in the Transportation Research Board (TRB) on Transportation of Hazardous Materials (AT040), the American Society of Civil Engineering (ASCE), American Society of Mechanical Engineering (ASME) Committee PCC-2 on Composite Repair, and the American Society for Testing and Materials (ASTM) Committee D18 on Soils and Rocks.

Karl Fletcher is the Vice President and Assistant Director of Bowser-Morner's Construction Materials and Geotechnical Laboratories headquartered in Dayton, OH. Karl has more than 23 years of experience in laboratory testing of such materials as soils, aggregate, concrete, cement, masonry, asphalt, proppants, and filter media. He is responsible for oversight of technical matters, scheduling and completion of work, approval of laboratory reports, budgets and sales, customer satisfaction and other quality related issues. He is responsible for ensuring compliance with the company's quality management system including training, equipment maintenance, audits, and accreditation programs such as ISO 17025, AASHTO R18, USACE Validation. Karl is also responsible for technical and operational oversight of satellite laboratories located in Springfield, IL, Birmingham, AL, and Toledo, OH. Karl is an active member of ASTM Committee D18 on Soil & Rock, Transportation Research Board Committee AKG50 Transportation Earthworks, NSSGA Engineering & Technical and Young Leaders Committees, and numerous state aggregate association technical committees.

Kathryn Griswell has over 30 years of engineering experience with the State of California. She has experience in highway construction and design, geotechnical field investigation, storm damage assessments, landslide remediation, as well as earth retaining system design and construction. She has developed specifications and design guidance for Caltrans and participated in the same with FHWA, TRB, and AASHTO. She has researched earth retaining system performance, unique designs and experimental backfills, in California, on NCHRP and in pool fund studies with other DOT's. She is currently working for the State Bridge Engineer at Caltrans as a subject matter expert in earth retaining systems. She received her BS in geological engineering from New Mexico Institute of Mining and Technology, and her MS in civil engineering from California State University in Sacramento

Hanping Hong is a professor in the Department of Civil and Environmental Engineering at the University of Western Ontario. Before joining the department in 1996, he worked more than six years as a research scientist in the oil and gas industry concentrated on the optimum maintenance strategies of oil and gas pipelines under corrosion. Dr. Hong has expertise in the areas of application of probabilistic analysis, reliability and risk assessment, natural hazard modeling, and design code calibration. He has contributed to the reliability-based and economic efficient structural design code development and infrastructure retrofit. He is actively participating in several design codification and standard committees, including the National Building Code of Canada, Canadian Highway Bridge Design Code, Strength design in aluminum; and Engineering Design in Wood. He is a prolific researcher and authored/co-authored more than 180 peer-reviewed journal papers. He received several awards and prizes for his research contributions. He is a member of The Mexican Academy of Engineering, and a fellow of Canadian Society of Civil Engineering.

Erik Loehr is Associate Professor and Logan Professor in the College of Engineering at the University of Missouri and Senior Principal Engineer with Dan Brown and Associates. He received his B.S., M.S., and Ph.D. degrees from The University of Texas at Austin. Professor Loehr specializes in research and professional practice associated with complex soil-structure interaction problems and with development of methods for practical implementation of reliability-based design, risk assessment, and asset management concepts. He is currently serving as Principal Investigator for projects addressing design of micropiles for the Transportation Research Board, design of drilled shafts in weak rock for the Oklahoma Department of Transportation, and post-grouted drilled shafts for Caltrans, in addition to recent work for FHWA addressing durability of reinforced concrete foundation elements. Dr. Loehr is active in professional organizations including the Deep Foundations Institute (DFI), the ASCEGeo- Institute (G-I), the International Association of Foundation Drilling (ADSC), and the Transportation Research Board (TRB). He is a recipient of the ADSC Outstanding Service Award, the K.B. Woods Award from TRB, an NSF CAREER Award, and the Harry Schnabel Jr. Award from the ASCE Geo- Institute among other honors. He is a registered Professional Engineer in the State of Missouri.

Digby D. Macdonald is a native of New Zealand, a naturalized US citizen, and is a Professor in Residence (semi-retired) in the Departments of Nuclear Engineering and Materials Science and Engineering at the University of California at Berkeley. He specializes in the growth and point defect structures of thin oxide films on metal surfaces under extreme environmental conditions and developed the Point Defect Model for describing the physico-electrochemistry of such systems. He has also developed the modern theory of stress corrosion cracking, corrosion fatigue, and pitting corrosion in terms of the deterministic Coupled Environment Models and is a pioneer in the modern form of Electrochemical Impedance Spectroscopy. One of his major activities has been the modeling of the electrochemical and corrosion properties of structural materials in the coolant circuits of operating, water-cooled nuclear power reactors and recently modeled for DOE the coolant circuit of the ITER that is currently being built in Cadarache, France. ITER is the World's first fusion technology demonstration reactor. He has also contributed to developing the science base for the disposal of High-Level Nuclear Waste in the US (Yucca Mountain), Belgium, and Sweden. Prof. Macdonald has published more than 1000 papers in peer-reviewed journals and conference proceedings, is a Fellow of the Royal Society of Canada, the Royal Society of New Zealand (the "National Academies" of those countries, and is a Member of the EU Academy of Sciences. He enjoys a H-index of 77 and his papers have been cited about 30,000 times.

Robert E Melchers is Professor of Civil Engineering at The University of Newcastle, Australia. During 2014-2016 he was concurrently an Australian Research Council DORA Research Fellow and prior to that an Australian Research Council Professorial Fellow [2004-8 and 2009-13]. He holds a BE and M Eng Sc from Monash University and a PhD from the University of Cambridge, UK. He is a Fellow of the Australian Academy of Technological Sciences and Engineering and an Honorary Fellow of The Institution of Engineers Australia. His awards include the 2009 ACA Corrosion Medal, the 2012 Jin S Chung Award (International Society of Offshore and Polar Engineers) and the 2013 John Connell Gold Medal (The Institution of Engineers, Australia). He was the 2014 Eminent Speaker for the College of Structural Engineers, The Institution of Engineers, Australia. He was the PF Thompson Memorial Lecture in 2009 and has received the ACA's Marshal Fordham Research Award multiple times, and also the Guy Bengough Award 2007 and 2018, Institute Materials, Minerals and Mining, UK.

Jennifer McIntosh is Professor and University Distinguished Scholar in the Department of Hydrology and Atmospheric Sciences at the University of Arizona (UA), and a Joint Faculty member in the UA Geosciences Department. She also held an Adjunct Research Geologist position with the United States Geological Survey from 2007-2017, and is currently an Adjunct Professor at the University of Saskatchewan in the Department of Civil and Geological Engineering. McIntosh is a fellow of the Geological Society of America and the Canadian Institute for Advanced Research (CIFAR) Earth 4D: Subsurface Science and Exploration Program. McIntosh received a BA in geology-chemistry from Whitman College, a MS and a PhD in Geology from the University of Michigan (2004), and the Morton K. and Jane Blaustein Postdoctoral Fellowship at Johns Hopkins University in Earth and Planetary Sciences. McIntosh is a hydrogeochemist who works at the interface of hydrology, geochemistry, and microbiology to understand micro (pore) to macro (continental scale) processes from the surface to several kilometers in the earth's crust. She has received numerous awards for her research, teaching, and student mentoring, including the USGS Star Award, UA Distinguished Scholar Award, and Blitzer (teaching) Award for physics-related sciences. She regularly serves as a technical expert for the US EPA, National Academies of Sciences and Engineering, and Nuclear Waste Technical Review Board. Her students and postdoctoral scholars have gone on to positions in academia, government agencies and environmental consulting.

Soheil Nazarian is the McIntosh Murchison Chair Professor of Civil Engineering at The University of Texas at El Paso (UTEP) where he serves as the Director of the Center for Transportation Infrastructure Systems and the Campus Director of the newly-established Engineering Research Center entitled "Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE)" funded by the National Science Foundation. Dr. Nazarian has more than 40 years of experience in the areas of design, evaluation, and nondestructive testing of geotechnical and transportation infrastructure and lifeline. He has been instrumental in the development and improvement of the nondestructive testing methods in infrastructure assessment, and he has significantly contributed to the bosoheildy of knowledge in construction, quality management, and mechanistic characterization of earthwork using innovative technologies. He currently chairs the Geotechnical Instrumentation and Modeling Committee of the Transportation Research Board.

Mark Orazem obtained his BS and MS degrees from Kansas State University and his doctorate in 1983 from the University of California, Berkeley. In 1988 he joined the faculty of the University of Florida, where he is a Distinguished Professor of Chemical Engineering and holds the Dr. and Mrs. Frederick C. Edie, University of Florida Foundation Preeminence, and University of Florida term professorships. Prof. Orazem is a Fellow of both the Electrochemical Society and the International Society of Electrochemistry, and he served as President of the International Society of Electrochemistry in 2011-2013. He has over 210 refereed publications and has co-authored, with Bernard Tribollet of the CNRS in Paris, a textbook entitled *Electrochemical Impedance Spectroscopy*. This book, published by Wiley in 2008, was translated into Chinese and published by Chemical Industry Press in 2014. The second edition was published in 2017, and the Chinese translation is in preparation. His edited book on *Underground Pipeline Corrosion* was published by Woodhead Publishing in 2014. Prof. Orazem and his student Douglas Riemer developed a boundary-element model for the cathodic protection of pipelines that can account for interactions between pipelines and CP systems. Prof. Orazem and his student Christopher Alexander explored the use of indirect impedance measurements to detect corrosion of post- tensioned tendons in segmentally constructed bridges. In 2012, Prof. Orazem received the Henry B. Linford Award of the Electrochemical Society. With his co-author Bernard Tribollet, Prof. Orazem is a 2019 recipient of the Claude Gabrielli Award for contributions to electrochemical impedance spectroscopy.

Robert (Bob) Parsons is a Professor in the Civil, Environmental, and Architectural Engineering Department at the University of Kansas. He came to KU in 1998 after finishing his PhD in Civil Engineering at the Georgia Institute of Technology with an emphasis in geotechnical engineering. In addition to teaching at the graduate and undergraduate level, Dr. Parsons has an active research program with emphases on mechanically stabilized earth, soil stabilization, aggregate testing, deep foundations, and railroad ballast characterization and improvement. He is an author of more than 100 publications. He has been working for several years on the relationship between backfill resistivity and corrosion of metallic reinforcement within the backfill behind retaining walls.

Amir Poursaee is an associate professor in Glenn Department of Civil Engineering and Materials Science & Engineering at Clemson University. His primary area of research is corrosion. Prior to joining Clemson University, Dr. Poursaee worked as a research assistant professor at Purdue University for three years and as a senior engineer for more than ten years in different fields of materials engineering including corrosion, quality control, non-destructive evaluation, and failure analysis. Dr. Poursaee is the editor of a book entitled: “Corrosion of Steel in Concrete Structures”. In 2018, he received the prestigious and competitive Humboldt fellowship for experienced researchers in recognition of his scientific work. This fellowship allowed him to carry out thirteen months of research at the Max-Planck-Institut für Eisenforschung GmbH (MPIE) in Dusseldorf, Germany. Dr. Poursaee was also awarded the Clemson University Research, Scholarship, and Artistic Achievement Award that recognizes Clemson University faculty who have achieved the highest levels of national and international recognition and the faculty selected for this award recognition are lifetime appointees. He is a registered professional engineering Ontario, Canada, and serves as a member of the editorial board of the Advances in Civil Engineering Materials (ACEM) Journal, published by the ASTM.

Alberto A. Sagüés is Distinguished University Professor Emeritus at the Department of Civil and Environmental Engineering, University of South Florida. He has a Ph.D. in Metallurgy from Case Western Reserve University, is a registered professional engineer in Florida and has formerly served at the University of Kentucky, Argonne National Laboratory, Juelich Nuclear Research Center in Germany, and as Member of the U.S. Nuclear Waste Technical Review Board. He has contributed extensively to the literature of corrosion science and engineering in reinforced concrete, soil and other infrastructure, advanced durability forecasting models and nondestructive diagnostic techniques, and materials for nuclear and other energy systems. Current work includes patented technology for diagnostic imaging of post tensioned tendons, contactless corrosion diagnostic of reinforced concrete and buried metal, and next generation modeling of reinforced concrete damage functions.

Naresh Samtani, Ph.D., P.E., D.GE, F.ASCE, is the owner and President of NCS GeoResources, LLC, a geotechnical firm located in Tucson, Arizona, and has more than 35 years of experience. He has worked on major infrastructure facilities in many parts of the country including hundreds of bridges and retaining walls, as well as several ground improvements projects. He has authored or co-authored over 15 manuals for agencies such as the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), research reports for National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board (TRB), 20 webinars and 2 virtual workshops for ASCE's Geo- Institute, as well as self-paced web-based training for FHWA. He helped calibrate the fully probabilistic *fib* model for corrosion of buried structures as part of the overall work that led to the 2020 AASHTO Guide Specification for Service Life Design of Highway Bridges. He has helped develop implementation processes and comprehensive design policies for a variety of topics related to bridges, walls, pavements, and scour for several agencies with emphasis on multi- disciplinary interaction between geotechnical, structural, drainage, roadway, and construction specialists. Currently, Naresh concentrates on forensics, expert consultation, education, research, and training services.

Jack (Hui) Wang joined the University of Dayton in 2018 as an assistant professor with the Department of Civil and Environmental Engineering. He received his Ph.D. at the University of Akron on pipeline external corrosion and had three years of research experiences on machine learning and computational geosciences at the RWTH Aachen University in Germany. His research focuses on the opportunities in the multidisciplinary fields spanning machine learning, subsurface modeling, infrastructure reliability & risk assessment. Several finished research projects include a predictive model of tunnel structure deformation, soil corrosivity assessment and underground pipeline integrity management, three-dimensional ground modeling and large-scale soil pattern recognition using remote sensing and geophysical measurements. He is currently the technical committee member of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) Technical committee: Engineering Practice of Risk Assessment and Management, and ASCE\Geo-Institute Technical committee: Risk Assessment and Management. He is the invited reviewer for all major international journals of geotechnical engineering, civil and infrastructure engineering, and engineering geology. He is also on the editorial board of the Journal of Pipeline Science and Engineering.

Wenxing Zhou is an Associate Professor in the Department of Civil & Environmental Engineering at the University of Western Ontario in London, Ontario, Canada. Dr. Zhou is an expert in the reliability-based structural integrity management of oil and gas pipelines under various threats such as corrosion, mechanical damage, fracture and fatigue. He has published extensively on the development of probabilistic models for corrosion in buried oil and gas pipelines based on inspection data. He is a Vice Chair of the Technical Committee for the Canadian Standards Association (CSA) standard CSA Z260 – Pipeline system safety metrics, and also a member of the Risk Management Task Force under the Technical Committee for the CSA standard CSA Z662 – Oil and gas pipeline systems.

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Committee Biographies

SCOTT A. ANDERSON is a principal geotechnical engineer at BGC Engineering in Golden, Colorado. He has wide ranging geotechnical design and construction experience in the transportation, water resources, mining, and pipeline industries. His experience includes earthwork—retaining structures, foundation design and construction, and ground modification techniques. He is experienced in remote sensing, geophysical and drilling site characterization, and the determination of soil and rock properties and design parameters. He has provided oversight and review of design and construction as well as contributed to research and deployment of training and new technology in many areas of practice. Prior to joining BGC Engineering, Dr. Anderson was the geotechnical services team leader for the Federal Highway Administration (FHWA) Resource Center from 2008 to 2017; and prior to that, he held geotechnical leadership roles for the Federal Lands Highway Division of FHWA for 6 years. He was awarded the FHWA Engineer of the Year in 2014, he was the recipient of the K.B. Woods Award in 2016 from the Transportation Research Board (TRB) for contribution to the design and construction of transportation facilities, and he served as the 2017 Jahns Distinguished Lecturer for the Association of Engineering Geologists and the Geological Society of America. Dr. Anderson holds a B.A. and M.S. in engineering geology from the University of Colorado, Boulder and Colorado State University, respectively. He received an M.S. and Ph.D. in civil engineering from the University of California, Berkeley.

MERSEDEH AKHOONDAN has over 15 years of experience in condition assessment and rehabilitation of metallic and reinforced concrete infrastructures, specializing in service life modeling of different types of infrastructure. She has designed and managed corrosion testing programs, developed rehabilitation plans and specifications for corrosion control systems, performed failure analysis and metallographic evaluations of field coupons, and conducted soil corrosivity studies. Dr. Akhoondan is a registered civil engineer in the states of Florida and Texas. She has authored or co-authored over 30 technical publications. She currently serves as the chair of HDR's Condition Assessment Practice Group and the vice-chair of the NACE San Diego section. Dr. Akhoondan received her B.S. and M.S. in civil engineering and her Ph.D. in corrosion engineering from the University of South Florida.

AZIZ I. ASPHAHANI (NAE) is chairman and chief executive officer of QuesTek Innovations, LLC. As a distinguished engineer specializing in the advancement of materials, reliability, alloy development, and corrosion control, he is internationally recognized for his work in the field. His early research activities were focused on identifying the parameters affecting alloys resistance to stress corrosion cracking (SCC), pitting/crevice corrosion, and corrosion fatigue. His research involved assessing the mechanisms of hydrogen embrittlement and its impact on the SCC of corrosion-resistant alloys (CRA). Furthermore, he identified the roles of key alloying elements that were used to develop CRA with improved resistance to corrosion and wear. Later, he led a company focused on water treatment, air purification, and site remediation. Presently, he manages QuesTek Innovations, a leader in developing and deploying best-in-class materials (addressing priorities outlined in the U.S. Materials Genome Initiative), based on its integrated computational materials engineering technologies and its materials by design methodology, using genomic data, and science based modeling. He holds eight patents. In 2017, Dr. Asphahani was elected to the U.S. National Academy of Engineering "for executive leadership in STEM education, integrated computer design of materials, and innovation and production of corrosion-resistant alloys." Dr. Asphahani is a past president of ASM International and past chair of its educational foundations. Dr. Asphahani's degrees include diplome ingenieur-physics from École Centrale de Paris and a Ph.D. in materials science from MIT.

SUSAN E. BURNS is a professor of geosystems engineering and associate chair for administration and finance in the School of Civil and Environmental Engineering at the Georgia Institute of Technology. Dr. Burns' research focuses on applications in geoenvironmental engineering with particular emphasis on the beneficial use of waste materials including dredged sediments, fly ash, and biomass fly ash; treatment of highway stormwater runoff using engineered materials; erosion control of soils on highway rights-of-way; interfacial behavior of organic- and inorganic-coated soils; the transport and behavior of microbubbles in otherwise saturated porous media; and the hydraulic conductivity and consolidation properties of fine-grained soils using seismic piezocone penetration testing (SPCPT). Dr. Burns is a recipient of the National Science Foundation CAREER Award, a fellow of the American Society of Civil Engineers, and she was named the 2020 Engineer of the Year by the Georgia Society of

Professional Engineers. Dr. Burns earned a B.C.E. (1990) and M.S. in civil engineering (geotechnical) (1996), M.S. in environmental engineering (1996), and Ph.D. in civil engineering (1997), all from Georgia Tech.

HOMERO CASTANEDA is an associate professor and director at the National Corrosion and Materials Reliability Laboratory within Texas A&M University (TAMU). He is also the instructor for NACE certifications. Dr. Castaneda has 19 years of experience using electrochemical and nondestructive techniques to monitor interfacial phenomena in materials and theoretical modeling of corrosion science and engineering, energy generation and storage, and electrochemical processes for different industries. He has been the PI for multiple projects on corrosion science and engineering for the DOE, DOD, DOT, and several Fortune 500 companies. Before joining TAMU, he worked for five years at The University of Akron (2011 to 2015) as an assistant professor and before that at Battelle Memorial Institute as a senior scientist (2006-2010) in the Advanced Materials and Energy Systems in Columbus, Ohio. Before Battelle, he was the technical director of the Corrosion, Materials and Pipelines in the Mexican Petroleum Institute for five years. He has authored over 100 peer-reviewed papers in the areas of corrosion science and engineering, coatings degradation and reliability, materials characterization, and electrochemical impedance spectroscopy. He holds ten patents and copyrights. He received the H.H. Uhlig award from NACE International in 2018. He was awarded to be the NACE Fellow of Class 2019. He is the editor of three journals related to electrochemistry, corrosion, and pipelines. He received his B.S. in chemical metallurgical engineering (1994) and M.S. in materials science (1997) from the Universida Nacional Autónoma de México and his Ph.D. in materials science and engineering from Penn State University in 2001.

KENNETH L. FISHMAN is a principal at McMahon and Mann Consulting Engineers, P.C. and is the leader of their Earth Reinforcement Testing Division. He has 40 years of combined experience in civil/geotechnical engineering that includes teaching, research, and consulting and is an expert on state-of-the-art techniques for performance monitoring, characterization of corrosion potential, and service-life modeling for mechanically stabilized earth (MSE) walls and other geotechnical applications. He has been a consultant, co-PI, or PI on various projects sponsored by the National Cooperative Highway Research Program (NCHRP), FHWA, MCEER and various state departments of transportation on projects related to service-life design, condition assessment, corrosion monitoring, and durability studies for buried steel including MSE structures, elements of deep foundation systems, and pipelines. These projects include research, implementations of research results, training, and applications of the state of the art techniques for performance monitoring and characterization of corrosion potential. He is author of over 50 publications in the area of geotechnical engineering including FHWA-HRT-05-067, NCHRP Report 477, FHWA-NHI-09-087, NCHRP Report 675, several comprehensive reports describing results from FHWA/state DOT sponsored demonstration projects, and pooled-fund studies. He has participated in numerous workshops and webinars sponsored by NCHRP, FHWA, the American Association of State Highway Transportation Officials (AASHTO), TRB and others including two recent webinars related to asset management and performance modeling sponsored by the FHWA Office of Asset Management and Resource Center, AASHTO and TRB. Dr. Fishman earned his Ph.D. for his work in geotechnical engineering from the University of Arizona in 1988.

GERALD S. FRANKEL is distinguished professor of engineering, professor of materials science and engineering, and director of the Fontana Corrosion Center at The Ohio State University (OSU). Prior to joining OSU in 1995, he was a post-doctoral researcher at the Swiss Federal Technical Institute in Zurich and then a research staff member at the IBM Watson Research Center in Yorktown Heights, NY. His primary research interests are in the passivation and localized corrosion of metals and alloys, corrosion inhibition, protective coatings, and atmospheric corrosion. He has authored almost 300 papers in peer reviewed journals. He is a member of the editorial board of The Journal of the Electrochemical Society and Corrosion and a fellow of NACE International, The Electrochemical Society, and ASM International. He received the W.R. Whitney Award from NACE International in 2015, the U.R. Evans Award from the U.K. Institute of Corrosion in 2011, the OSU Distinguished Scholar Award in 2010, the 2010 Electrochemical Society's Corrosion Division H.H. Uhlig Award, and the Alexander von Humboldt Foundation Research Award for Senior U.S. Scientists in 2004. From 2012-2016, he served as a member of the Nuclear Waste Technical Review Board after being appointed by President Obama. In 2016, he became the director of a DOEfunded Engineering Frontier Research Center focused on the performance of nuclear waste forms. He earned his Sc.B. in materials science engineering from Brown University and his Sc.D. in materials science and engineering from MIT.

STACEY KULESZA is an associate professor in civil engineering at Kansas State University where her research focuses on anthropogenic impacts on soil properties, applied near-surface geophysics, characterizing infrastructure deterioration, and soil erosion potential. Her research group seeks to understand the in situ integrity of natural materials and aging infrastructure to support the global initiative of sustainability and resiliency.She is also interested in engineering education and broadening pathways to and through engineering degrees. She currently serves on two technical committees of the TRB and the American Society of Civil Engineers (ASCE) Geo-Institute including serving as the chair for the ASCE Geo-Institute Outreach and Engagement Committee. She is a registered professional engineer in the state of Kansas. She received her B.S., M.E., and Ph.D. in civil engineering with a focus in geotechnical engineering from Texas A&M University.

BRENDA J. LITTLE retired in January 2018 from the Naval Research Laboratory, Stennis Space Center, where she served as a senior scientist. Her career has focused on the investigation of microorganism/material interactions including biodeterioration, biodegradation, and bioremediation (i.e., chemistries produced by microorganisms). Her publications include 2 co-authored books and over 100 peer-reviewed journal articles on these topics. Dr. Little is now an independent consultant and the sole proprietor of B.J. Little Corrosion Consulting, LLC, and she serves as the current president of the International Biodeterioration and Biodegradation Society (IBBS). Dr. Little is a fellow for the NACE-International and on the editorial board for International Biodeterioration and Biodegradation, the official journal for the IBBS. Dr. Little received her Ph.D. in chemistry from Tulane University.

RANDALL W. POSTON, NAE, is a Sr. Principal at Pivot Engineers, a structural engineering consulting firm in Austin, TX. He is also a Neil Armstrong Distinguished Visiting Fellow at Purdue University College of Engineering. He is the Immediate Past President of the American Concrete Institute (ACI). For the past 35 years, Poston has been engaged in the evaluation, repair, strengthening and design of more than 700 structures. His expertise includes investigation of structural failures, evaluation of corrosion of steel in concrete, structural concrete repair and strengthening design, and nondestructive testing of concrete structures. He has been elected a Fellow of ACI, ASCE, PTI and IABSE and is an active member of numerous national and international technical committees including being a current member of ACI Committee 318 – Structural Concrete Building Code, and was the Chair of Committee 318 during the 2014 code cycle. Poston was elected to the U.S. National Academy of Engineering in 2017. He received BS, MS and PhD degrees in Civil Engineering from the University of Texas at Austin.

ELIZABETH RUTHERFORD is a senior metallurgical engineer at Energy Transfer with over 10 years of experience in pipeline integrity, failure investigation, root cause analysis, and quality assurance. She has worked on pipeline failures in a variety of terrains in the U.S. in addition to numerous preventative inspections and repairs. She is actively involved in both Pipeline Research Council Internationaland Joint Industry Projects addressing research gaps and identifying technologies to move the industry forward safely. For the past year, her focus has been on the quality assurance side of the business monitoring the acquisition and production of pipe for new construction projects. Prior to joining Energy Transfer, Ms. Rutherford spent three years with the Nuclear Regulatory Commission as a reactor inspector with special emphasis on in-service inspection. Ms. Rutherford received her B.S. in metallurgical engineering in 2004 from the University of Missouri-Rolla (now Missouri University of Science and Technology).