2018 and 2019 BSCES AWARDS
AWARDS COMMITTEE RECOMMENDATIONS FOR BOARD CONSIDERATION
May 10, 2019

A. Individual Section Awards:

1. CITIZEN ENGINEER AWARD:
    a. Alyson Stuer, Alfred Benesch & Company – nomination submitted by Ron Burns, BSCES Vice President.
    - Recommend Award to Alyson Stuer for her service to the Future City competition including the Co-Coordinator for the New England Region and various other mentoring roles.

2. HORNE/GAYNOR PUBLIC SERVICE AWARD:
    a. David Westerling, PhD, Professor Emeritus, Merrimack College – nomination submitted by Ron Burns, BSCES Vice President.
    - Recommend Award to David Westerling for recognizing the need for and creating a Capital Planning Committee in his town of Berlin, MA and serving as chair of that committee.

3. 2018 GOVERNMENT CIVIL ENGINEER AWARD: Linda Hager – Approved by Board, June 2018

    2019 GOVERNMENT CIVIL ENGINEER AWARD:
    a. Alex Bardow, State Bridge Engineer, MassDOT – nomination submitted by Mike Cunningham, BSCES Vice President
    - Recommend Award to Alex Bardow for significant achievement and a dedicated career at a MA state agency.

4. CLEMENS HERSCHEL AWARD:
    a. Dr. Paul Kirshen, UMass Boston – nomination submitted by Bruce Jacobs, BSCES Sr. Vice President
    b. Mehrdad Sasani and Matthew Joyner - nomination submitted by Jerome F. Hajjar, CDM Smith Professor and Department Chair
    - Recommend Award to Sasani and Joyner:
        - Paper supports an immediate need and seems more readily useful to the industry than the Kirshen paper.
        - Paper was published in the ASCE Journal.
        - Supporting documentation provides more detail to support the above than the Kirshen nomination.

5. JOURNALISM AWARD:
    a. Adam Vacarro, Boston Globe – nomination submitted by Ron Burns, BSCES Vice President
    b. Beth McGinnis-Cavanaugh, Springfield Technical Community College – nomination submitted by Reed Brockman, AECOM
    - Recommend Award to Adam Vacarro for numerous news articles covering transportation issues in the Boston area to help raise awareness of the importance of the civil engineering industry. McGinnis-Cavanaugh nomination is for a single article

and does not contain supporting documentation to demonstrate a comparable level of accomplishments.

6. PRE-COLLEGE EDUCATOR AWARD:
    a. Alicia DiCecca, Stantec - nomination submitted by Michelle Cheung
    b. Suzanne Collins, Birchland Park Middle School - nomination submitted by Reed Brockman on behalf of the BSCES Public Awareness and Outreach Committee
    - Recommend Award to Alicia DiCecca for over 10-years of teaching youth about STEM through involvement with both the Future City Competition and the Model Bridge Competition: DiCecca appears to have a greater level of accomplishment.

7. COLLEGE EDUCATOR AWARD:
    a. James Kaklamanos, Merrimack College – nomination submitted by Leyna Tobey, Merrimack College
    b. Edward L. Hajduk, D.Eng, PE, University of Massachusetts Lowell - nomination submitted by Pradeep Kurup, UMass Lowell (received after deadline)
    - Recommend Award to James Kaklamanos for inspirational teaching of geotechnical engineering courses, mentorship, and other support of engineering students at a New England College. Hajduk nomination is quite worthy; however, it was received 4 days after the deadline while the Kaklamanos nomination was well before the deadline.

8. YOUNGER MEMBER AWARD:
    a. Gregory Mirliss, AECOM – 8 nominations submitted: Megan McMorris, AECOM; Sandra DiBacco; Carl Abramson; Melissa Ryan, AECOM; Rebecca Young, AECOM; Steve Marx, Linda Marx; Stephany Garza, Suffolk
    - Recommend Award to Greg Mirliss for his outstanding contributions to the engineering profession within BSCES, other member organizations, his workplace, and his community.

9. ENGINEER OF THE YEAR AWARD:
    a. Stephen Taylor, CBE – nomination submitted by Nate Rosencranz, TranSystems
    - Stephen Taylor is being recognized through a separate BSCES award this year; therefore, this nomination is not recommended.

10. PROJECT OF THE YEAR AWARD:
    a. Commonwealth Ave. Bridge – nomination submitted by Rich Maher, BSCES President Elect
    - Recommend Award jointly to MassDOT District 6 and Walsh Construction for the Commonwealth Avenue Bridge Replacement Project for innovation using an accelerated approach to successfully replace the eastbound side and westbound side of the bridge each in approx. 3 weeks to minimize disruption to traffic, improve pedestrian and bicycle accommodations, increase safety, and improve travel within the area.

B. <u>Employer Recognition Awards:</u>

11. SMALL EMPLOYER RECOGNITION AWARD:
    a. Nomination not submitted.

12. 2018 LARGE EMPLOYER RECOGNITION AWARD: GZA – Approved by Board, June 2018

    2019 LARGE EMPLOYER RECOGNITION AWARD:
    a. Kleinfelder – nomination submitted by Dan Dwyer, Kleinfelder

C. <u>Sustainability Awards as recommended by the Sustainability Committee:</u>

    1. Large Project – Boston Landing Station – nomination by Chris Hersey, BSCES Secretary.
    2. Small Project – Greenough Greenway – nomination by VHB.

Michael Cunningham

From: Ronald Burns <rburns@arcadia-tec.com>
Sent: Friday, April 19, 2019 1:25 PM
To: Michael Cunningham
Subject: Award Nomination for Alyson Stuer for Citizen Engineer Award
Attachments: 2019-BSCES-Individual-Section-Awards-Nomination-Astuer.pdf

External Email.

Mike,

Please find attached a copy of the Nomination form for Alyson Stuer to be awarded the Citizen Engineer Award for 2019.

The following is a summary the candidates qualifications:

Alyson began volunteering with BSCES Outreach in 2009. She has attended and led activities at STEM events across the state including but not limited to Construction Career Days, West End Children's Festival, Cambridge Science Festival, and Girl Scouts Geek is Glam. Alyson found her true passion in the Future City competition where she began volunteering as a mentor in 2011. Her first year she was thrilled her students went to nationals and that she was able to be part of something that truly introduced students to engineering early. Since then she has been involved in the competition day, judging, and overall logistics. Currently she is the Co-Coordinator for the New England Region working on growing the program to introduce more teachers and students to the resources of National Future City. In addition to her current Future City responsibilities she still makes time to seek out other outreach activities in particular with the Girl Scouts who work hard to introduce young females to engineering. Of most recent note she organized an all-female engineering volunteer group to teach girls about earthquakes through an Extreme Gingerbread House Design Challenge.

Ronald Burns, PE, LSP, LEED-AP
Principal Engineer
Arcadia Technology, Inc.
t: 617.202.6278
c: 508.561.1611
rburns@arcadia-tec.com
www.arcadia-tec.com

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2019 Individual Section Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

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The Nominations Deadline is **Monday, March 11, 2019**. The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 170th BSCES Annual Awards Dinner.

I would like to nominate Alyson Stuer For the:

X CITIZEN ENGINEER AWARD: This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

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Name and Company Address of Nominee(s)*:

Alyson Stuer

Alfred Benesch & Company

50 Redfield St., Suite 102 Boston, MA 02122

Is this a re-nomination? Yes ________ No ________

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Ronald Burns Daytime Telephone: 617-202-6278 Email: rburns@arcadia-tec.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

Michael Cunningham

From: Ronald Burns <rburns@arcadia-tec.com>
Sent: Friday, April 19, 2019 1:25 PM
To: Michael Cunningham
Subject: Nomination of D. Westerling for the Horne-Gaynor Award
Attachments: 2019-BSCES-Individual-Section-Awards-Nomination-DWesterling.pdf

External Email.

Mike,

Please find attached a copy of the Nomination form for Dave Westerling to be awarded the Horne-Gaynor Public Service Award for 2019.

The following is a summary the candidates qualifications:

a A few years ago his town voted down a warrant article to buy 12 acres of level land next to the elementary school for $285,000. No one had gotten an appraisal of the land. So He started a Capital Planning Committee in Berlin. Land,Buildings, fleet etc. So he is now Chair of that Committee.

Ronald Burns, PE, LSP, LEED-AP
Principal Engineer
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c: 508.561.1611
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I would like to nominate Dave Westerling For the:

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Name and Company Address of Nominee(s)*:

Dave Westerling, PhD

Retired

Is this a re-nomination? Yes ______ No X

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Ronald Burns Daytime Telephone: 617-202-6278 Email: rburns@arcadia-tec.com

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I would like to nominate Alex Bardow, MassDOT For the:

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Name and Company Address of Nominee(s)*:

Alexander Bardow, PE

State Bridge Engineer, MassDOT

10 Park Plaza, Boston, MA 02116

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Michael Cunningham, PE Daytime Telephone: 617-498-4773 Email: mcunningham@kleinfelder.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

2019 BSCES Government Civil Engineer Award:
Alexander Bardow, PE
State Bridge Engineer, MassDOT

I hereby nominate Alexander K. Bardow, PE for the 2019 BSCES Government Civil Engineer Award.

Mr. Bardow is the State Bridge Engineer for the Massachusetts Department of Transportation (MassDOT), a position he has held since 1995. Mr. Bardow is currently responsible for managing the Bridge Section, which consists of the Design and Preservation, Inspection, Ratings and Overloads, Metals Control, Geotechnical and Hydraulic Units. He has worked for MassDOT's Bridge Section in various positions since 1983.

As the State Bridge Engineer, he develops the MassDOT bridge design and rating policy, bridge construction standards and bridge inspection policy, and oversees the MassDOT Bridge Inspection Program and its compliance with the federal National Bridge Inspection Standards. Mr. Bardow is also responsible for developing the bridge program for the Massachusetts State Transportation Improvement Program (STIP) using the MassDOT Bridge Prioritization System, a risk-based, asset management system MassDOT developed to prioritize bridges for programming purposes.

Mr. Bardow has been demonstrating outstanding leadership as the State Bridge Engineer for over 23 years to ensure that the bridges of Massachusetts are safe, making final decisions on structural matters as they relate to MassDOT bridge policy. He also interfaces with the six MassDOT Districts regarding bridge related matters, provides structural advice to the MassDOT Construction Division and coordinates all federal aid activity with the Federal Highway Division Bridge Engineer. When the Central Artery Tunnel ceiling collapsed in 2006, Mr. Bardow was appointed by Secretary of Transportation John Cogliano to lead the design of the repairs and the remediation of the entire ceiling system in the I-90 Connector Tunnels.

Mr. Bardow is a voting member of the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Bridges and Structures (SCOBS) and serves on following SCOBS technical committees: Welding (Chair), Metals Fabrication (Chair), Timber (Vice Chair), Seismic Design, and Guard Rail and Bridge Rail. He has also been a member of the Precast/Prestresses Concrete Institute (PCI) New England Technical Committee since 1991. Mr. Bardow is a member of the American Society of Civil Engineers (ASCE) and the Boston Society of Civil Engineers Section of ASCE, and has served in several elected offices within BSCES, including as President in 2004-2005. He has received both his BSCE and MSCE degrees from the Massachusetts Institute of Technology.

Sincerely,

Michael R. Cunningham, PE

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I would like to nominate Paul Kirshen For the:

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Name and Company Address of Nominee(s)*:

Dr. Paul Kirshen, University of Massachusetts Boston,

100 William Morrissey Blvd., Boston, MA 02125

Is this a re-nomination? Yes ______ No x

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Bruce Jacobs Daytime Telephone: 617-308-7074 Email: sr.vp1@bsces.org

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

Nomination for 2019 BSCES Clemens Herschel Award

Nominee: Paul Kirshen, Professor, School for the Environment and Academic Director, Sustainable Solutions Lab at the University of Massachusetts Boston

Other authors:

- Arcadis - Kelli Thurson, Brett McMann, Carly Foster, Heather Sprague and Hugh Roberts
- UMass Boston School for the Environment - Mark Borrelli, Jarrett Byrnes, Robert Chen, Lucy Lockwood, Chris Watson
- UMass Boston Urban Harbors Institute - Kimberly Starbuck, Jack Wiggin, Allison Novelly, Kristin Uiterwyk
- Woods Hole Group - Kirk Bosma, Eric Holmes, Zach Stromer, Joe Famely, Alex Shaw, Brittany Hoffnagle
- Woods Hole Oceanographic Institute - Di Jin

Paper: Feasibility of Harbor-wide Barrier Systems: Preliminary Analysis for Boston Harbor

Date: May 2018

The report documents the results of a two-year effort by a multidisciplinary project team to assess the feasibility of a harbor-wide barrier to mitigate climate change induced increases in the frequency and height of shoreline flooding.

The investigation examined multiple barrier designs and configurations, while also considering impacts to shipping channels, other harbor uses, and water quality. Inner Harbor (airport to Seaport) and outer harbor (Winthrop to Hull) barriers were considered as the two most reasonable options. The considered systems were gated barriers that would close during periods of elevated storm surges. The frequency of operation is expected to increase with sea level rise, to a point 60 years out when the "barrier could no longer function as designed." Moreover, neither of the considered barrier designs are considered to be cost effective, on consideration of the higher anticipated cost-benefit ratio of shore-based climate change adaptation modifications.

The findings of the report are tremendously important in guiding the city's response to climate change induced shoreline flooding. They provide a scientifically based rationale for continued on-shore efforts. This puts to bed dreams of a simple barrier fix to the problem. While the principal findings are based on local conditions, the project provides a model approach for analysis of barriers at other coastal cities.

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I would like to nominate Mehrdad Sasani and Matthew Joyner For the:

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_______ PRE-COLLEGE EDUCATOR AWARD: This award is presented to a member of the K-12 educational community who integrates engineering topics, particularly civil engineering, in a manner that benefits the profession and may promote students to pursue an engineering career. The Public Awareness & Outreach Committee reviews these nominations and recommends the recipient to the Board.

_______ COLLEGE EDUCATOR AWARD: This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates should be actively teaching in a classroom setting at a college or university in New England.

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Multihazard Risk-Based Resilience Analysis of East and West Coast Buildings Designed to Current Codes
By: Matthew D. Joyner and Mehrdad Sasani
in *Journal of Structural Engineering, ASCE,* Vol. 144, No. 9 (04018156), pp. 1-16, 2018.

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2019 Individual Section Awards

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Name and Company Address of Nominee(s)*:

Professor Mehrdad Sasani and Ph.D. Candidate Michael Joyner, Department of Civil and Environmental Engineering, 400 Snell Engineering Center, 360 Huntington Avenue, Northeastern University, Boston, MA 02115

Is this a re-nomination? Yes _____ No x

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

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March 6, 2019

BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE
The Engineering Center, One Walnut Street, Boston, MA 02108-3616

To the BSCES Awards Committee:

I am pleased to write a letter in strong support for Prof. Mehrdad Sasani and his Ph.D. student, Matthew Joyner, to receive the 2019 Clemens Herschel Award for their paper entitled "Multihazard Risk-Based Resilience Analysis of East and West Coast Buildings Designed to Current Codes," published in the *Journal of Structural Engineering*, ASCE, in 2018.

This paper presents a methodology in which structural and nonstructural building damage and in turn building resilience under extreme events can be quantified for multiple hazards. This is important as we continue to need and develop methods that help communities bounce back more quickly from hazardous events. In this paper, a simplified method for evaluating seismic response of reinforced concrete structures under low-intensity ground motions (such as in Boston) is proposed that avoids the need for using of dynamic analyses from ground motion suites. This approach can then be used to help characterize the resilience of the structure and thus prioritize actions to enhance resilience. In addition, this work shows that after earthquakes, more than half of the building repair cost is associated with a lower level of performance than life-safety or collapse prevention, which suggests a need for explicitly accounting for such performance levels, in addition to life-safety and collapse prevention, in building design. As an example of this, about half of the loss of function is due to unrepairable damage caused by excessive permanent deformation, which suggests that, in order to improve building resilience, there is a need for explicit consideration of limiting permanent deformation of structures after seismic events.

This paper builds on the work the authors have been doing on developing overarching frameworks to establish resilience in structures. This is important work for our time. Prof. Sasani is a leading authority on resilience and progressive collapse of reinforced concrete and prestressed concrete structures. During the last decade he has published over 20 journal papers on this topic. He is currently a member of the ASCE Subcommittee for General Structural Requirements of ASCE-7; he is a member of ASCE Risk and Resilience Measurements Committee; he is an Associate Member of the ASCE-41 Committee on Seismic Retrofit of Existing Building Standards; he is a member of the SEI Disproportionate Collapse Mitigation of Building Structures Standard; he is the Chair of American Concrete Institute Committee 377 on Performance-Based Structural Integrity and Resilience of Concrete Structures; he has chaired the SEI Boston Chapter; he is one of the founding members and the current chair of the Structural Engineers Emergency Response program, and he is the chair of the Massachusetts Engineers and Architects Emergency Response Committee. Prof. Sasani has dedicated his research, teaching, and nationals service to these topics and, together with his students such as Mr. Joyner, he has made major contributions to our understanding of how to address resilience in reinforced concrete structures.

For all of these reasons, I am strongly supportive of Dr. Sasani and Mr. Joyner to receive the 2019 Clemens Herschel Award.

Sincerely,

Jerome F. Hajjar

Jerome F. Hajjar, Ph.D., P.E., F.ASCE, F.SEI
CDM Smith Professor and Department Chair

Multihazard Risk-Based Resilience Analysis of East and West Coast Buildings Designed to Current Codes

Matthew D. Joyner[1] and Mehrdad Sasani, F.ASCE[2]

Abstract: Resilience of buildings in the face of earthquakes and wind is not explicitly addressed by current building codes and standards, but the importance of a building's ability to bounce back in the face of these hazards and become functional soon after is gaining more interest. Given that the East and West Coasts of the United States pose different earthquake and wind hazards, evaluation of code-designed buildings in these two regions can provide much needed insight into the level of multihazard resilience they possess. This paper evaluates the resilience of two 7-story reinforced concrete moment frame buildings designed by current codes and standards in two cities: Boston and San Francisco. By employing new and existing models for hazard, demand, and capacity, and accounting for uncertainty, the cost and loss of function resulting from wind and earthquake hazards over the life of these two buildings are assessed. Deformation demand on structural framing, interior partitions, and the building envelope is evaluated using nonlinear time history analysis under a suite of ground motions in San Francisco and using a new approach based on modal analysis in Boston. Performance of envelope components under extreme wind conditions is evaluated by considering the effects of wind pressure as well as windborne debris impact. Building resilience is then assessed in terms of estimated repair cost and loss of function over the life of the building. It is discussed that unrepairable damage from permanent drift is an important factor for resilience because it contributes significantly to expected repair cost and loss of function. For wind hazard, it is shown that damage to flat roof covering is not a significant contributor to building resilience in either location. Furthermore, the need for having impact resistance design of glazing is discussed because the associated repair cost and loss of function are considerable. **DOI: 10.1061/(ASCE)ST.1943-541X.0002132.**

Author keywords: Multihazard; Risk analysis; Building resilience; Seismic; Wind.

Introduction

Disaster resilience is commonly defined as the ability to absorb the impact of, adapt to, and recover from hazards (National Academies 2012), with the primary objective of a resilient design strategy being the enhancement of these abilities. Current building codes, however, do not explicitly pursue this objective. Focusing on life safety and collapse prevention, while crucial, does not necessarily address building functionality in the aftermath of hazards, which involves repair of the resulting damage. Estimation of repair cost and the loss of function during repairs over the life of a building provides a measure of resilience that can be used to assess the efficacy and, more importantly, potential shortcomings of current codes so that targeted improvements can take place. Performance evaluation of buildings designed based on current codes provides the first step to measuring the resilience that they provide.

The seismic performance of RC buildings designed to current codes has previously been investigated by various researchers (Goulet and Haselton 2007; Haselton et al. 2011; Benavent-Climent et al. 2014; Sullivan et al. 2014). Performance of buildings during extreme wind events has also been investigated and documented for various hurricanes (FEMA 2005a, b, 2006, 2009) and models have been developed (Pita et al. 2009; Vickery et al. 2006a, b) for use in catastrophe modeling software such as FEMA's Hazus-MH software and the Florida Public Hurricane Loss Model (Gurley et al. 2005). Comparison of damage resulting from wind and earthquakes reveals a vast difference in the types of damage that they typically cause. While seismic events can produce damage to virtually all components of a building either by excessive transient drift, permanent drift, or acceleration, wind damage to RC buildings is primarily focused on the envelope and roof-covering components, breaching of which tends to be followed by water infiltration and damage to building contents. However, significant dynamic effects can occur in tall, slender buildings as a result of an extreme wind event, which can result in potentially damaging deformations and accelerations (Cui and Caracoglia 2015). Nevertheless, given the scope of the current evaluation (a 7-story structure) and based on various FEMA Mitigation Assessment Team postdisaster reports (FEMA 2005a, b, 2006, 2009) that provide no anecdotal evidence to support the possibility of structural damage to RC structures under wind loading, it is assumed that structural damage from extreme wind events can be ignored.

Calculation of the risks posed by these hazards and their relative severity on the East and West Coasts is critical for evaluating and improving multihazard resilience of buildings. The estimation of consequences of hazards requires knowledge of how a building performs during an event. Thus, multihazard performance assessment is the first step to calculating multihazard risk. Various researchers have applied the principles of performance-based engineering (PBE) to assess the performance of buildings under multiple hazards (Jaimes et al. 2015; Judd 2015; Unnikrishnan and Barbato 2016; Venanzi et al. 2016). One example of this is the development of a framework for multihazard risk assessment by Li and Ellingwood (2009) that uses the principles of PBE to develop a

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means of quantifying the probability of exceedance for various damage states. However, quantification of resilience requires not only estimation of damage probabilities, but also estimation of the consequences associated with damage.

In this paper, resilience of East and West Coast buildings designed based on current codes and standards is quantified in terms of the cost and loss of function resulting from earthquake and wind damage to the structure, interior partitions, envelope, and roof-covering systems. Performance evaluation of two 7-story RC moment frame office buildings, one designed for San Francisco and the other for Boston, is carried out to estimate the repair cost and repair time caused by seismic and wind events over the lifetime of each building. This evaluation employs new and existing models for estimation of hazard, demand, and fragility, while systematically accounting for uncertainties at each step. The results of this evaluation will be used to assess the level of resilience provided by current codes and standards in the two locations.

For both hazards, directionality is an important consideration in the amount of damage inflicted on the building. Windborne debris, for example, can inflict more damage if the wind is blowing toward the broad side of a building as compared to the narrow side because it presents a larger target. In order to more accurately estimate wind damage, both the probability distribution of the wind angle at the site of the building and building orientation would be needed. For seismic damage, the structure needs to be analyzed under bidirectional ground motions, which requires additional information in terms of the relationship between the severities of ground motion in two directions at the site. Because these considerations are beyond the scope of this paper, each hazard was assumed to act only in one direction: the direction that causes the maximum damage.

Building Design

Structural Layout and Design

For each city, a 7-story RC moment frame structure was designed, the plan view of which is shown in Fig. 1. The heights of the first story and stories above were 3.9 m (12 ft 8 in.) and 3.5 m (11 ft 6 in.), respectively. Member dimensions and steel reinforcement were designed per ASCE/SEI 7-10 (ASCE 2010) and ACI 318-14 (ACI 2014) based on analysis of an elastic structure using the finite-element software OpenSees. Site Class D soil was assumed in both cities. The building in San Francisco was designed as a special moment frame (SMF) structure and the building in Boston was designed as an intermediate moment frame (IMF) structure. The provisions in ASCE/SEI 7-10 would allow for a Risk Category II structure, such as the buildings considered here, to be designed as an ordinary moment frame (OMF) structure in Boston. However, the Massachusetts Building Code (MA Building Code 2010) prohibits the use of ordinary reinforced concrete moment frames for Seismic Design Category B, which is applicable in Boston. All elements were designed with 34-MPa (5-ksi) concrete and 413-MPa (60-ksi) steel.

Flat Roof Cover Design

There are two primary failure modes for flat roof covering: peeling and bubbling. The mean suction capacity for bubbling failure of a single-ply membrane roof cover is 1.5 times the mean suction capacity for peeling failure (FEMA 2012a). Furthermore, in agreement with Hazus, it is assumed that bubbling failure does not expose the underlying roof surface to rainwater and is thus not included as a source of damage. Therefore, areas of the roof that are not adjacent to the roof edge, and not exposed to peeling failure, were not considered in this study.

The International Building Code (ICC 2012) dictates that roof coverings be designed to resist wind suction in accordance with ASCE/SEI 7-10. Using this basic wind speed, wind suction demand on the edge and corner regions of the roof (i.e., those regions vulnerable to peeling failure) was calculated based on ASCE/SEI 7-10 using Exposure Category B for urban terrain. Beyond designing based on ASCE/SEI 7-10, a second roof cover design that would be insurable by FM Global was also considered. Insurability can be ensured by adhering to the design procedure in FM Global's Property Loss Prevention Data Sheet 1-28 (FM Global 2015). This results in the suction capacities for corner and edge zones [the boundaries of which are taken as those prescribed by ASCE/SEI 7-10 (ASCE 2010) for design] shown in Table 1 for both ASCE/SEI 7-10 and FM Global designs.

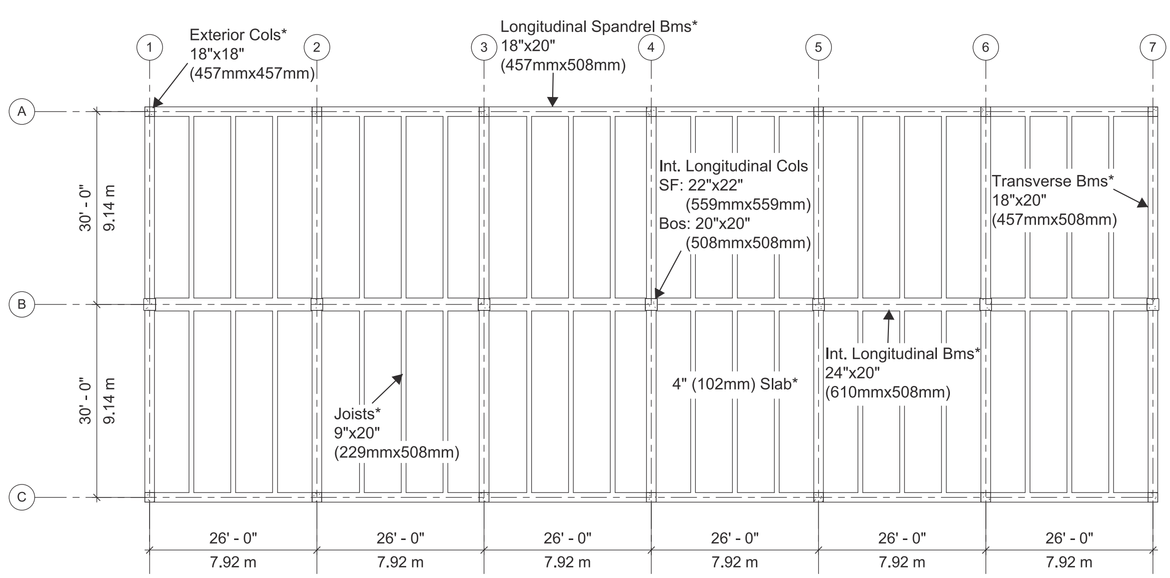

Fig. 1. Typical floor layout and member dimensions of buildings in Boston and San Francisco (* = dimensions are the same for Boston and San Francisco designs).

Table 1. Suction capacity for roof covering systems for San Francisco and Boston

Zone	San Francisco ASCE/SEI 7-10	San Francisco FM Global (2015) (insurable)	Boston ASCE/SEI 7-10	Boston FM Global (2015) (insurable)
Corner	4.0 kPa (83 psf)	5.2 kPa (109 psf)	5.4 kPa (113 psf)	7.7 kPa (160 psf)
Edge	2.9 kPa (61 psf)	3.8 kPa (80 psf)	4.0 kPa (83 psf)	5.6 kPa (117 psf)

Roof covering systems with the precise capacities presented in Table 1 are unlikely to be found in practice. Instead, the FM Global approvals rating system can be used to select an appropriate roof covering wherein roof covering products are tested and given a rating starting at 2.9 kPa (60 psf) and increasing at increments of 0.7 kPa (15 psf). Based on this, the values in Table 1 are rounded up to the next 0.7 kPa (15 psf) to arrive at the final design capacity for the roof covering system.

Exterior Glazing Elements

Design for pressure resistance of vertical glazing elements was performed using the pressure demand obtained from ASCE/SEI 7-10 and the short-duration pressure capacities provided in ASTM E1300-16 (ASTM 2016), as required by the International Building Code (ICC 2012). For the building envelope, a curtain wall system was selected. The height of each glazing panel, center to center, was set equal to half of the story height, therefore the size of each glazing element was set at 1.52×1.75 m (5 ft $\times$ 5 ft 9 in.). Based on this information, it was concluded that a monolithic 6 mm (0.25 in.)–thick annealed glazing element is sufficient for pressure resistance in both Boston and San Francisco. However, exterior glazing is a key factor for energy as well as aesthetic concerns, so the final building design depends on more than just wind pressure resistance. The overall dimensions of glazing elements as well as the use of additional panes and/or laminate to provide thermal resistance are important architectural considerations when selecting an appropriate envelope system. Given these factors, a 25 mm (1 in.)–thick laminated dual-pane symmetric insulating glass curtain wall system with 6 mm (0.25 in.)–thick inner and outer panes was selected as the envelope system for both buildings.

ASCE/SEI 7-10 dictates that buildings located within 1.6 km (1 mi) of the coast with basic wind speed greater than 209 km/h (130 mi/h), or any building located where the basic wind speed is greater than 225 km/h (140 mi/h), must have proper protection of glazing elements against windborne debris. Since the basic wind speeds for Risk Category II buildings in both Boston and San Francisco are below 209 km/h (130 mi/h), this provision of ASCE/SEI 7-10 does not apply to either location. Therefore, the impact resistance of glazing was not considered in design. Furthermore, all curtain wall elements had sufficient clearance between the glass and the frame to accommodate seismic drift in compliance with ASCE/SEI 7-10.

Seismic Evaluation

Seismic Hazard

Hazard data from the 2008 national seismic hazard maps, which are used as the basis for the design ground motions in ASCE/SEI 7-10, were obtained from the USGS (Petersen et al. 2008) for performance evaluation. A piecewise linear function was utilized wherein discrete hazard data points were connected linearly in log-space to form a continuous representation of hazard. It was assumed that the buildings were constructed on Site Class D soils in both cities. In Boston, however, hazard data were not provided for Site Class D. Thus, the long-period site coefficient, F_v, was used to estimate hazard for Site Class D, given the hazard for the boundary between Site Classes B and C, which is provided by USGS. Given the piecewise linear curves for 1- and 2-s structures, linear interpolation (in log-space) was used to obtain the final hazard curves for the two buildings, which are shown in Fig. 2. The structures in San Francisco and Boston have fundamental periods, T, equal to 1.15 and 1.20 s, respectively.

Seismic Demand: San Francisco

Seismic demand on a structure can be estimated by subjecting a nonlinear model of the structure to earthquake ground motion records. Aleatoric demand uncertainty, or the intrinsic randomness in

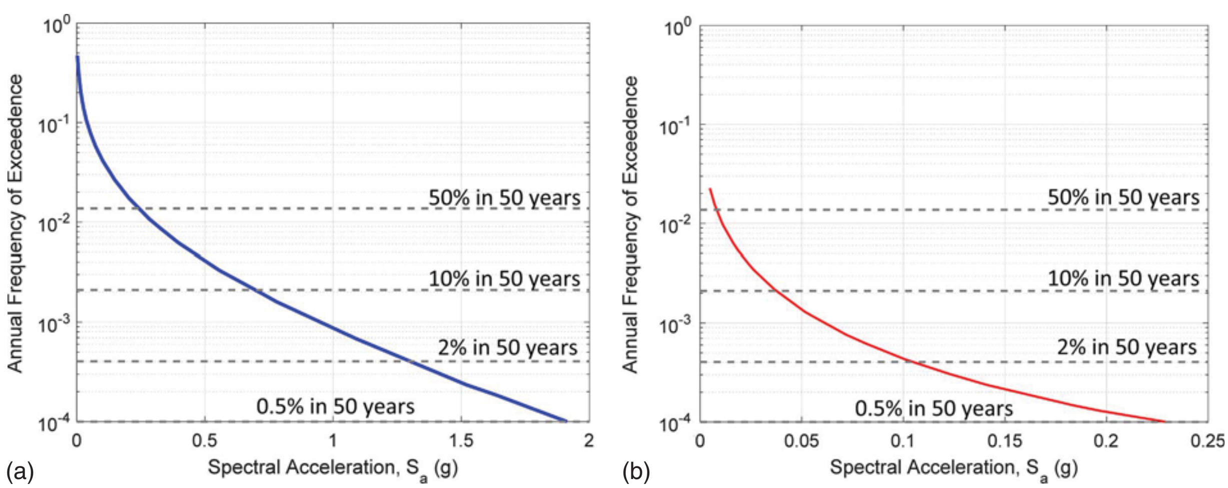

Fig. 2. Seismic hazard curves: (a) San Francisco ($T = 1.15$ s); and (b) Boston ($T = 1.20$ s).

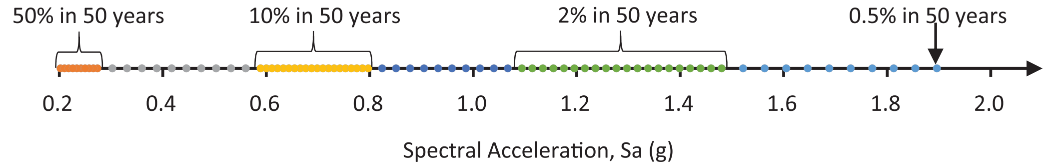

Fig. 3. Distribution of S_a for ground motion suite used for San Francisco building.

demand due to the arbitrary phasing and amplitude of chosen ground motion records (Li and Ellingwood 2007), was accounted for in San Francisco by selecting a suite of ground motion time histories from the Pacific Earthquake Engineering Research Center's (PEER's) NGA-West2 database (Ancheta et al. 2014). A list of the ground motions can be found in the Supplementary Data.

One approach to scaling ground motions for performance evaluation is to select a group of ground motions and scale the entire group to a specific spectral acceleration at the structure's fundamental period, S_a, associated with the performance level of interest. In this paper, however, in order to evaluate the performance, and in turn the expected damage for different levels of ground motion severity, the entire range of ground motion intensity was of interest. Thus, an alternative approach was adopted in order to provide continuous coverage over the entire domain.

In evaluating seismic response of structures, ground motions with 50, 10, and 2% probability of exceedance over 50 years (which correspond to return periods of 73, 475, and 2,476 years, respectively) can be commonly associated with immediate occupancy, life safety, and collapse prevention performance levels (ASCE 2013; FEMA 2000). Scaling of ground motion records such that their spectral acceleration at the structure's fundamental period cluster predominantly around spectral acceleration values (assumed here as $\pm 15\%$) for these three return periods increases the accuracy of their demand estimation. Fig. 3 shows the distribution of S_a among the selected suite of ground motions.

A three-dimensional nonlinear model of the structure utilizing fiber section elements with core concrete, cover concrete, and steel fibers was used to model the structure. Beam, column, and joist elements were modeled to include the effects of tensile strength and linear tension softening by use of the Concrete02 material in OpenSees. Concrete core confinement effects were accounted for using the modified Kent and Park model (Scott et al. 1982). Increased flexibility at beam ends due to bar slip was modeled by modifying the standard Gauss-Lobatto integration weights based on Murray et al. (2016).

For each story, the maximum transient interstory drift index ($\mathrm{IDI}_{\max,n}$), or the maximum relative displacement between the floor above and the floor below story n divided by the story height, was chosen for evaluating damage to drift-sensitive structural and nonstructural elements. Permanent interstory drift index (IDI_p), which is the largest value among all stories, was used for assessing repairability of a building after an earthquake. Demand uncertainty was accounted for by assuming a lognormal distribution of IDI given S_a (Cornell et al. 2002) with median $\widehat{\mathrm{IDI}}$ and logarithmic standard deviation $\beta_{IDI|S_a}$. The median of the IDI resulting from building response analysis can be modeled by

$$\widehat{\mathrm{IDI}} = \alpha (S_a)^{\gamma} \tag{1}$$

where $\widehat{\mathrm{IDI}}$ is either $\widehat{\mathrm{IDI}}_{\max,n}$ (for the maximum transient response of story n) or $\widehat{\mathrm{IDI}}_p$ (for the largest permanent value among all stories); S_a = spectral acceleration for 5% damping at the fundamental period of the structures; and α and γ = model parameters that are calculated in the vicinity (taken here as one order of magnitude in terms of return period) of S_a, where the contribution to the total probability integral is greatest (Kennedy and Short 1994; Cornell et al. 2002) along with the associated logarithmic standard deviation $\beta_{\mathrm{IDI}|S_a}$ for a heteroscedastic error term from regression analysis of IDI as a function of S_a. Three ground motions produced large IDI (>0.2) and were regarded as having led to collapse. For the purpose of finding the parameters of Eq. (1), the $\mathrm{IDI}_{\max}$ of the story that had large drift under these three ground motions was replaced by the $\mathrm{IDI}_{\max}$ value with a 1% probability of exceedance, associated with the S_a of the ground motion. This value was found based on the statistics derived from the building's response to the other ground motions within the vicinity of the S_a of the three ground motions. This resulted in $\mathrm{IDI}_{\max}$ of about 0.13 for the three records.

Seismic Demand: Boston

Given the low level of seismic hazard severity in Boston, first the level of nonlinearity of the structure response under the maximum considered earthquake ground motion (the most severe earthquake effects considered by ASCE/SEI 7-10) was evaluated. This was done by performing nonlinear time history analysis (NTHA) of the structure subjected to the Mineral, Virginia, earthquake of August 23, 2011, recorded at the Fredericksburg station, scaled to the 2,476-year return period $S_a = 0.105g$. The results showed slight nonlinearity in the response. Fig. 4 shows the second-story shear versus the story drift. This story had the largest drift response among all the stories. As discussed in the previous section, fiber section elements (with distributed plasticity) were used in the model where the concrete tensile strength was accounted for. As a result, Fig. 4 shows a change of slope of the backbone at the cracking shear, V_c, i.e., the shear force causing flexural cracking. Instead of fiber section elements, one could use elements with

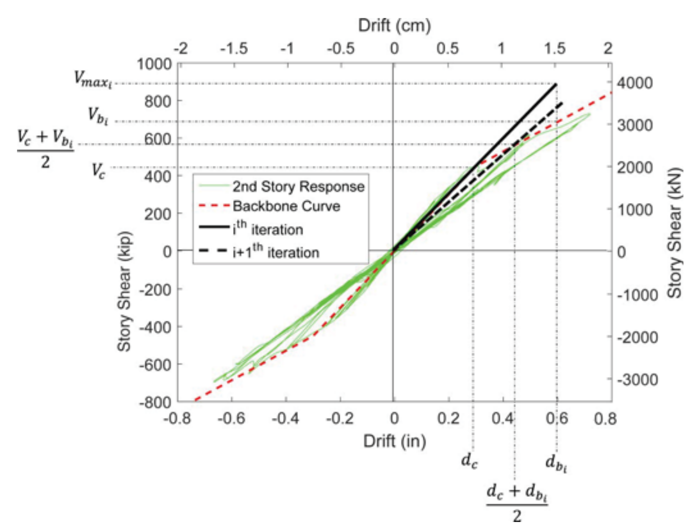

Fig. 4. Stiffness updating for iterative modal analysis for Mineral, Virginia, 2011 record.

reduced flexural stiffness with localized plasticity, requiring an estimation of reduced flexural stiffness.

Having obtained the backbone curve from a dynamic or a cyclic analysis, an iterative linear analysis is proposed here, referred to as iterative modal analysis (IMA), for estimating displacement demand for RC frame structures under low-intensity ground motions. IMA employs modal analysis with an iteratively updated stiffness matrix to avoid NTHA while still accounting for the nonlinearity in the response due to cracking.

The structure's response to the Mineral, Virginia, 2011 record was used here to define bilinear backbone curves for the shear-drift response of each story. A stick model was generated with a stiffness matrix based on the initial stiffness of these backbone curves. The model was then subjected to modal analysis under the hazard spectral acceleration to obtain the maximum shear and drift at each story. If the shear-drift combination for any story fell outside of the backbone curve, the story stiffness decreased (Fig. 4) based on the following equation:

$$K_{i+1} = \frac{V_c + V_{b_i}}{d_c + d_{b_i}} \tag{2}$$

where K_{i+1} = story stiffness in the next iteration; V_c and d_c = shear and drift at cracking; and V_{b_i} and d_{b_i} = backbone story shear and drift corresponding to $V_{\max_i}$ as shown in Fig. 4. That is, the next iteration's stiffness was defined based on the midpoint between the current iteration's backbone story shear and drift (i.e., V_{b_i} and d_{b_i}, respectively) and the cracking point of the bilinear backbone curve (i.e., V_c and d_c, respectively). This process was repeated until a given story's maximum drift converged to its final value, within a given level of accuracy. One important advantage of IMA is that it does not require time histories of seismic ground motions, which are scarce in eastern North America (ENA).

Table 2. Maximum, minimum, mean, and COV of the ratio of maximum drift from IMA to that of NTHA for ground motions clusters scaled for 475- and 2,476-year return periods

	475-year return period				2,476-year return period			
Story	Maximum	Minimum	Mean	COV	Maximum	Minimum	Mean	COV
1	1.12	0.68	0.90	0.16	1.27	0.89	1.02	0.10
2	1.21	0.78	1.03	0.12	1.18	0.84	1.08	0.09
3	1.14	0.79	0.98	0.11	1.14	0.76	1.00	0.13
4	1.28	0.80	0.97	0.16	1.11	0.75	0.96	0.12
5	1.12	0.78	0.97	0.14	1.17	0.81	0.99	0.14
6	1.23	0.74	0.94	0.15	1.26	0.80	1.02	0.14
7	1.39	0.80	1.04	0.18	1.21	0.86	1.05	0.12
		Mean	0.98	0.15		Mean	1.02	0.12

Validation of IMA

To validate this procedure, a comparison between the maximum drift from IMA and that of NTHA was carried out. The story-by-story maximum, minimum, and mean ratios of $\mathrm{IDI}_{\max}$ from IMA to that of NTHA, as well as the coefficient of variation (COV), are presented in Table 2 for 10 ENA ground motions (see Supplementary Data) scaled to represent clusters for 475- and 2,476-year return period hazard levels. Based on the fact that the error in mean for both return periods was only 2% and the COV was limited to 0.15, it was concluded that IMA is a good approximation of NTHA for seismic performance evaluation of an RC moment frame structure in Boston.

Capacity

FEMA document P-58-3, Performance Assessment Calculation Tool (PACT), provides element capacity data for structural and nonstructural elements based on prior experiments and research (FEMA 2012c). These data provide a relationship between IDI and general damage descriptions for each element by providing the statistics of capacity, expressed in terms of IDI, for various levels of damage, referred to as damage states. This allows quantification of damage, and therefore resilience, based on simulation of IDI. Table 3 shows the provided median capacity, $\widehat{\mathrm{IDI}}_{\mathrm{DS}}$, and logarithmic standard deviation, β_{DS}, for each structural and nonstructural damage state. Element capacity was assumed to be lognormally distributed (FEMA 2012b).

Repairable structural damage to the San Francisco building was based on sequential damage states for beam-column assemblies of SMF structures. For the Boston building, the damage was assessed for IMF structures instead. For the IMF structure, the nature and description of expected damage for each damage state (Table 3) was the same, but the median drift demand at which SDS2 and SDS3 occurred were lower due to the decreased ductility indicative of an IMF in comparison with an SMF.

Table 3. Capacity data obtained from PACT database for SMF and IMF

Component type	Damage state	$\widehat{IDI}_{\mathrm{DS}}$ (%)	β_{DS}	Description
Structural	SDS1	2	0.4	Beams or joints exhibit residual crack widths >0.15 cm (0.06 in.); no significant spalling; no fracture or buckling of reinforcing
	SDS2	2.75 (2.5[a])	0.3	Spalling of cover concrete exposes beam and joint transverse reinforcement but not longitudinal reinforcement; no fracture or buckling of reinforcing
	SDS3	5 (3.5[a])	0.3	Spalling of cover concrete exposes a significant length of beam longitudinal reinforcement; crushing of core concrete may occur; fracture or buckling of reinforcing requiring replacement may occur
Nonstructural	PDS1	0.5	0.4	Partitions: screw pop out, cracking of wall board, warping or cracking of tape, slight crushing of wall panel at corners
	PDS2	1	0.3	Partitions: moderate cracking or crushing of gypsum wall boards (typically in corners); moderate corner gap openings, bending of boundary studs
	PDS3	2.1	0.2	Partitions: buckling of studs and tearing of tracks; tearing or bending of top track; tearing at corners with transverse walls; large gap openings; walls displaced
	CDS1	2.7	0.3	Curtain wall: gasket seal failure
	CDS2	2.76	0.3	Curtain wall: glass cracking
	CDS3	3.03	0.3	Curtain wall: glass falls from frame

[a]For SDS2 and SDS3, the number in parenthesis corresponds to IMF.

In addition to those damage states presented in Table 3, this paper also considers unrepairability based on the permanent interstory drift index (largest among all stories), IDI_p. ASCE 41-13 discusses unrepairable damage as part of the collapse prevention performance level, which is associated with excessive permanent drift (ASCE 2013). However, a more quantitative indication of unrepairable damage in terms of permanent drift is included in FEMA 356 (FEMA 2000). FEMA 356 associates an IDI_p of 0.01 with the life safety structural performance level, which may lead to damage for which repair is not practical (FEMA 2000). Therefore, a median IDI_p of 1% is associated with total demolition and replacement of the building, referred to here as damage state RD_L (repairable damage limit).

Fragility

The seismic fragility of a structural or nonstructural system is defined as the conditional probability of failure of the system for a given intensity of the ground motion. In this paper, S_a was used as the intensity measure and, given that the model (epistemic) uncertainty was not accounted for, the mean fragility was evaluated (Sasani and Der Kiureghian 2001). Considering lognormal distributions of the interstory drift index capacity and demand, the mean fragility for a given DS can be calculated based on Ang and Cornell (1974) by

$$\bar{F}_{\mathrm{DS}_i|S_a} = P[\mathrm{IDI} > \mathrm{IDI}_{\mathrm{DS}_i}|S_a] = \Phi\left[\frac{\ln\left(\frac{\alpha S_a^{\gamma}}{\widehat{\mathrm{IDI}}_{\mathrm{DS}_i}}\right)}{\sqrt{\beta^2_{\mathrm{IDI}|S_a} + \beta^2_{\mathrm{DS}_i}}}\right] \tag{3}$$

where $\Phi[\cdot]$ = standard normal cumulative distribution function (CDF); $\mathrm{IDI}_{\mathrm{DS}_i}$ = capacity for damage state DS_i in terms of IDI; and $\widehat{\mathrm{IDI}}_{\mathrm{DS}_i}$ and β_{DS_i} = median and logarithmic standard deviation for that damage state's capacity.

Fig. 5 shows the mean fragilities for $\mathrm{IDI}_{\max,2}$ (maximum transient response of the second story, which has the highest fragility among all stories) for the San Francisco building failing to satisfy different damage state requirements as a function of S_a and the corresponding return period. The figure also shows IDI_p (maximum permanent response among all stories) failing to satisfy the repairability requirement. For the Boston building, the fragilities for PDS1 and PDS2 are shown in Fig. 6. All other damage states produce less than 0.1% probability of failure even at 2,500-year return period hazard.

Annual Probability of Failure

The annual probability of damage for the building is needed for resilience evaluation. Therefore, the annual probability of failure for each damage state was estimated by (Kennedy and Short 1994)

$$P_{f,\mathrm{DS}_i} = P[\mathrm{IDI} > \mathrm{IDI}_{\mathrm{DS}_i}] = \int_0^{\infty} \bar{F}_{\mathrm{DS}_i|S_a}\left|\frac{dH}{dS_a}\right| dS_a \tag{4}$$

where $\bar{F}_{\mathrm{DS}_i|S_a}$ = mean fragility for a given damage state DS_i; and $|dH/dS_a|$ = absolute value of the slope of the site hazard curve. The preceding integral was evaluated numerically over the range of S_a for which hazard, H, was available in order to arrive at the annual probability of failure for a given damage state at a given story, as

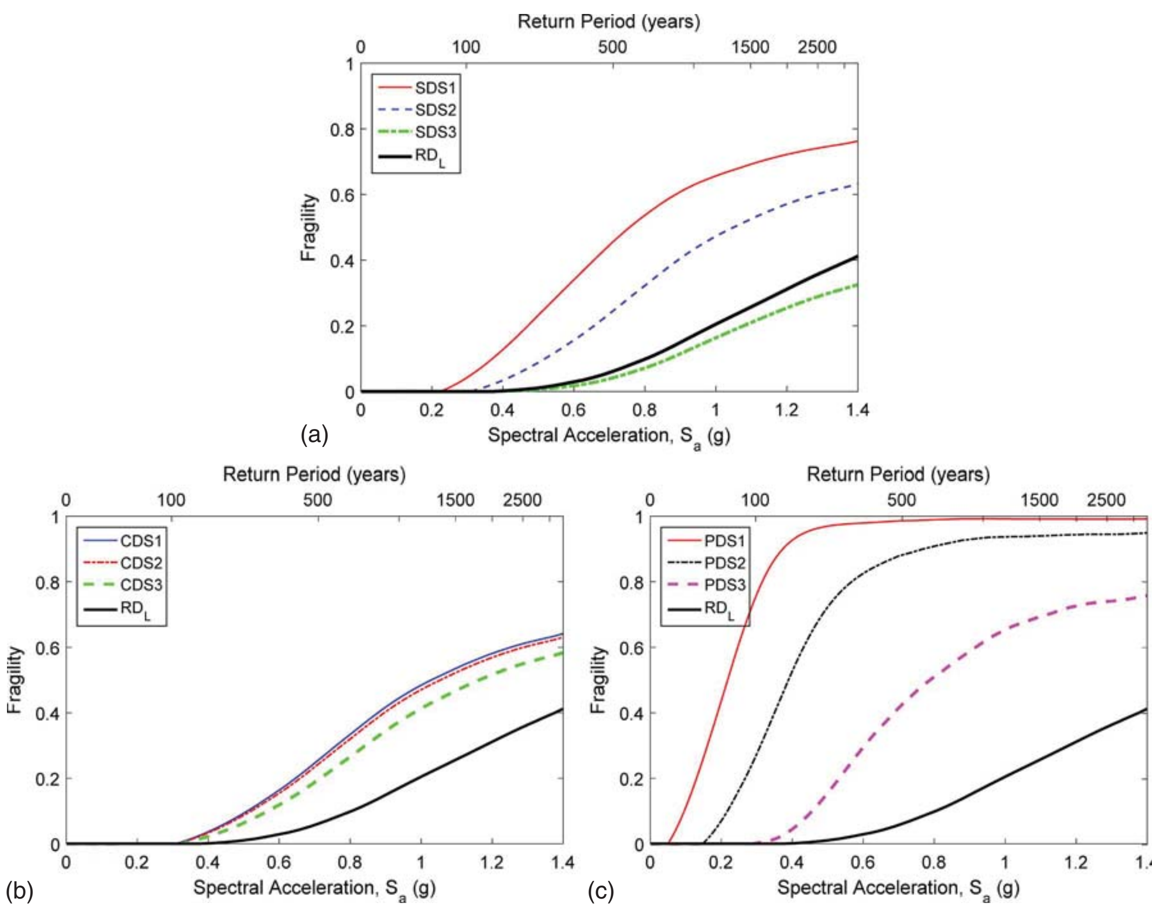

Fig. 5. Second-story mean fragility curves for (a) structural; (b) curtain wall; and (c) partition damage states for San Francisco.

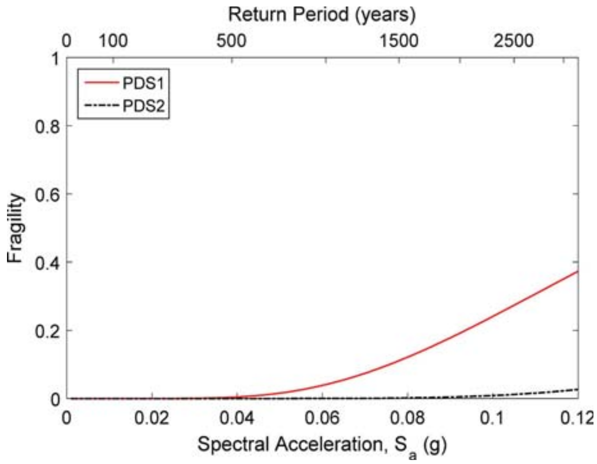

Fig. 6. Second-story mean fragility curves for partition damage states PDS1 and PDS2 for Boston.

shown in Fig. 7 for the San Francisco building. Fig. 8 shows the annual probability of failure for the first two nonstructural damage states for the Boston building.

Additionally, it was found that unrepairable damage had an annual probability of occurrence of 0.053% in San Francisco. It is opportune to point out that in addition to life safety and collapse prevention, which are the primary goals in building codes (ASCE/SEI 7-10), from a resilience point of view it is important to also account for repairability in design of structures.

Wind Evaluation

As previously mentioned, since the buildings in question were not slender enough for dynamic effects to become important and there was a lack of evidence for structural damage to RC buildings in postdisaster reports (FEMA 2005a, b, 2006, 2009), structural damage was excluded as a primary source of wind damage. The sources of building damage considered here include roof covering and exterior glazing.

Wind Hazard

Wind hazard maps, which provide maximum expected wind speeds for a range of return periods, were developed by Vickery et al. (2010) for use in ASCE/SEI 7-10. These maps provide the maximum 3-s gust wind speed at 10 m (33 ft) height in open terrain (Exposure Category C) for the entire United States from 10- to 1,700-year return periods. To provide a clear representation of the wind hazard applicable to each location (Fig. 9), the hazard curve for Exposure Category B at the same height (i.e., 10 m or 33 ft) is shown for both locations. These values were obtained by multiplying the square root of the velocity pressure exposure coefficient for Exposure B at 10 m (33 ft) by the mapped wind speeds.

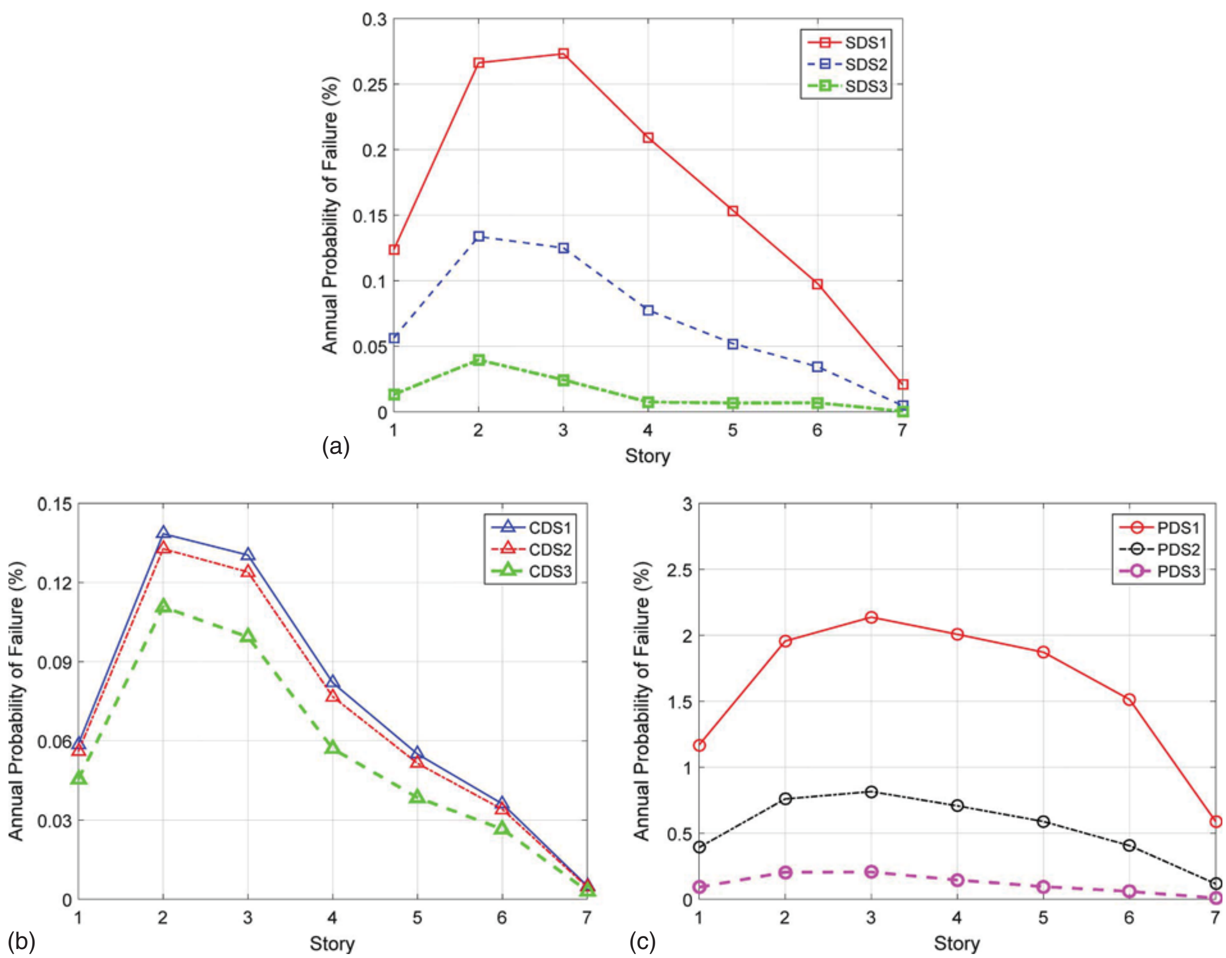

Fig. 7. Annual probability of failure for (a) structural; (b) curtain wall; and (c) partition damage states for each story of the San Francisco building.

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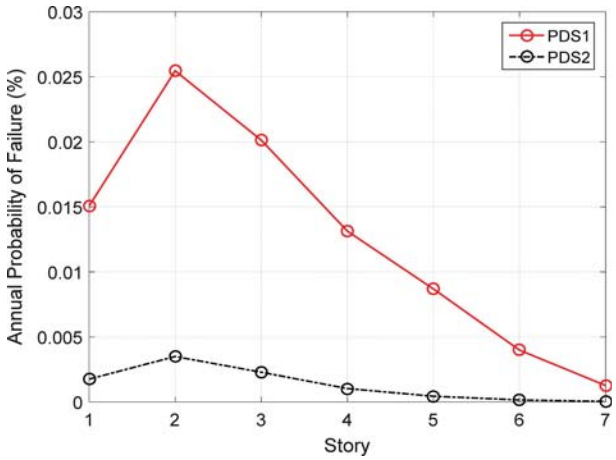

Fig. 8. Annual probability of failure for PDS1 and PDS2 for each story of the Boston building.

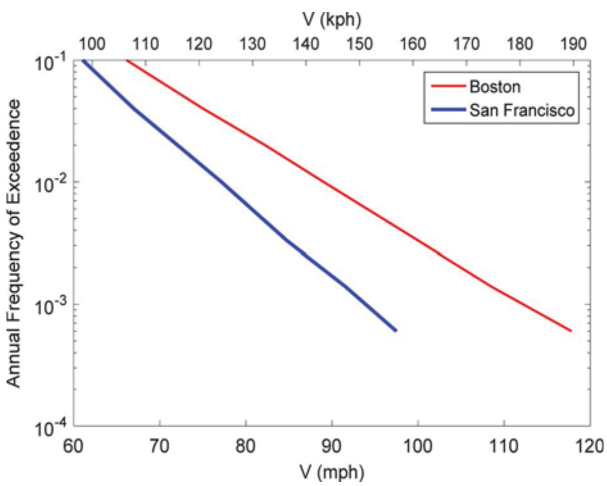

Fig. 9. Wind hazard curves at 10 m (33 ft) above ground in Exposure Category B for San Francisco and Boston. Values were obtained by multiplying square root of velocity pressure exposure coefficient by basic wind speeds.

Roof Cover

Wind Suction Demand

In order to develop fragility curves for flat roof covering systems, demand must be expressed in terms of the chosen intensity measure. For roof cover damage, the chosen intensity measure was maximum peak gust wind speed. Damage to roof covering systems requires translation of this peak gust wind speed into suction demand across the area of the roof. One option for accomplishing this translation is by using the components and cladding pressure distribution provided in ASCE/SEI 7-10. In ASCE/SEI 7-10, wind pressure demand on components and cladding is based on past wind tunnel tests that envelope the effects of wind angle, height above ground level, local geometric discontinuities, and location of the given element relative to the boundaries of the building surfaces (ASCE 2010). Since the effects of wind angle are enveloped in these tests, use of these distributions to evaluate damage at a given intensity level is equivalent to assuming that the peak gust blows in all directions simultaneously for any given event, an unrealistic assumption. Alternatively, wind pressure distribution can be estimated from wind tunnel tests performed on a scale model of the building. This approach allows for the estimation of suction distribution for a range of individual wind angles. While the assumption that wind only blows in one direction during a storm may also be unrealistic, given the previously mentioned approach of choosing the critical direction for each hazard, the peak gust during any given event was assumed to blow in the critical direction for damage. In lieu of performing wind tunnel tests for a specific building, it is possible to obtain wind tunnel test results from an online database such as Tokyo Polytechnic University's (TPU's) collection of data from wind tunnel tests performed on models with a range of aspect ratios and roof configurations (TPU 2007). The database provides the variation of pressure coefficient at a number of pressure taps uniformly distributed over the surface of the model roof for the duration of the wind tunnel test. The test was repeated for seven different wind angles from 0 to 90°. Among the available data in the TPU database, the results for the model with the closest aspect ratio to that of the two buildings were chosen to estimate wind pressure demand on the envelope. The velocity pressure exposure coefficient evaluated at mean roof height, K_h, was used to account for the height of the roof above ground.

Table 4. Comparison of wind tunnel pressure demand with ASCE/SEI 7-10

Region	ASCE $(GC_p)_{\mathrm{ASCE}}$	Wind tunnel $(GC_p)_{\mathrm{WT}}$	Ratio $(GC_P)_{\mathrm{WT}}/(GC_p)_{\mathrm{ASCE}}$
Corner	−2.85	−4.11	1.44
Edge	−1.85	−2.65	1.43

The selected model has an aspect ratio (breadth:depth:height) of 2:5:2, while the target aspect ratio is 2:5.2:2.7. Given the building's plan dimensions of 48×18 m (156×60 ft), the difference in breadth:depth ratio would correspond to a 1.8-m (6-ft, or 3.8%) difference in plan depth (i.e., if the building were 47×18 m in plan, the match would be exact). Since this variance is small in comparison to the overall depth, it was ignored in the analysis. The difference in breadth:height ratio, however, was more significant. The database model had a breadth:height ratio of 2:2, whereas our building had a ratio of 2:2.7, a 35% increase in height. For the purpose of calculating suction on the flat roof of our building, the effect of this height discrepancy can be assessed by evaluating the effect of the difference in turbulence intensity. Turbulence intensity, integral length scale of turbulence, and the turbulence intensity factor were all used to calculate the gust effect factor, G (ASCE 2010). By comparing the gust effect factor for both heights, we compared the effect of turbulence intensity and concluded that there was a 0.06% difference in gust effect factor as a result of the height difference. Thus, the TPU model results are considered acceptable for simulating wind suction demand on the building's roof covering system.

Extreme wind suction during hurricanes can cause significant damage to flat roof cover systems found on RC and steel buildings (FEMA 2005a, b, 2009). This in turn can cause water infiltration and costly damage to the interior of the building. Table 4 shows a comparison of the peak wind pressure coefficients for different regions of the roof with those used in ASCE/SEI 7-10. For comparison with the code-based pressure coefficients, peak values from the TPU database results were estimated for a given sample area based on Gierson et al. (2015), in which the Rice method (Sadek and Simiu 2002) was employed to estimate the CDF for the largest peaks of a given time interval [assumed to be 60 min, per Gierson et al. (2015)]. Weighted averaging within each sample area was used to account for spatial correlation of pressure demand. Due to the coarse resolution of pressure taps on the wind tunnel model, the corner zone, which was most strongly affected by the oncoming wind, only contained one pressure tap. Thus, spatial averaging for the corner region was not possible. Instead, a square sample area that fits inside the corner region was defined around the pressure tap and this area was used as the effective wind area for calculation of the ASCE/SEI 7-10 pressure coefficient. This was not needed for the edge zones because there were enough taps within each of these zones to allow for definition of sample areas that contain two pressure taps each, thereby allowing for weighted spatial averaging. After adjusting the peak values to account for a 3-s velocity pressure averaging time, the sample area with the maximum demand within each zone can be compared with the ASCE/SEI 7-10 demand for the same area and zone as seen in Table 4.

The comparison in Table 4 shows that the wind tunnel results from the TPU database were significantly higher than the ASCE/SEI 7-10 values. This finding is in agreement with Gierson et al. (2015), wherein the authors concluded that the pressure coefficients currently used by ASCE/SEI 7-10 for components and cladding are underconservative and thus are in need of updating.

Fragility

Wind suction demand was applied for each of seven wind angles to obtain the fragility for each sample area at a given wind speed. Sample areas were defined within edge and corner zones such that each contained at least two pressure taps, with the exception of the windward and leeward corner zones, which only contained one pressure tap each due to the coarse spacing, as previously mentioned. Upon evaluating damage at all seven wind angles, it was found that the 60° wind angle (measured with respect to the long axis of the building) produced the maximum amount of damage, and was thus used for resilience evaluation.

For fragility assessment of wind damage, demand uncertainty arises from the spatial and temporal variability of suction for a given wind speed. This uncertainty was accounted for by using wind tunnel test results along with methods described in Gierson et al. (2015) and Sadek and Simiu (2002) for estimating the statistics of suction demand assuming a Gumbel distribution. Capacity uncertainty was accounted for by using a COV of 0.15 for flat roof cover suction resistance (FEMA 2012a).

With the statistics of demand and capacity defined, the fragility of each sample area, A_i, can be estimated by the following equation:

$$\bar{F}_{A_i|V} = P[S_{D,A_i} > S_{C,A_i}|V] = \int_0^\infty [1 - F(s_{D,A_i})]\varphi\left[\frac{\ln(\frac{s_{D,A_i}}{\hat{S}_{C,A_i}})}{\beta_{C,A_i}}\right] ds_{D,A_i} \quad (5)$$

where S_{D,A_i} = peak suction demand; $F(\cdot)$ is its CDF conditioned on V, which has a Gumbel distribution, whose statistics were obtained from Sadek and Simiu (2002); S_{C,A_i} = suction capacity with median value $\hat{S}_{C,A_i}$ (taken as the design capacity) and logarithmic standard deviation β_{C,A_i}; and $\varphi[\cdot]$ is the standard normal probability density function (PDF). Fig. 10 shows the fragility of the most critical sample area (i.e., the sample area with the greatest fragility) within the corner and edge zones. Given the results, the roof damage was expected to initiate from the corner. Given the design level Exposure B wind speeds of 150 km/h (93 mi/h) and 175 km/h (109 mi/h) for San Francisco and Boston, respectively, it is seen in Fig. 10 that the FM Global design in San Francisco results in a 9% probability of initiating damage for the design wind speed. The ASCE/SEI 7-10 design, however, results in a 50% probability of initiating damage for the design level Exposure B wind speed. Similarly for Boston, design level Exposure B wind speeds result in 9 and 56% probabilities of initiating damage for FM Global and ASCE/SEI 7-10 designs, respectively.

Probability of Failure

Given the previously mentioned probabilities of damage initiation for San Francisco and Boston for Exposure B wind speed [150 km/h (93 mi/h) and 175 km/h (109 mi/h), respectively], it follows that the FM Global design results in roof covers that were only 18 and 16% as likely to be damaged as those designed

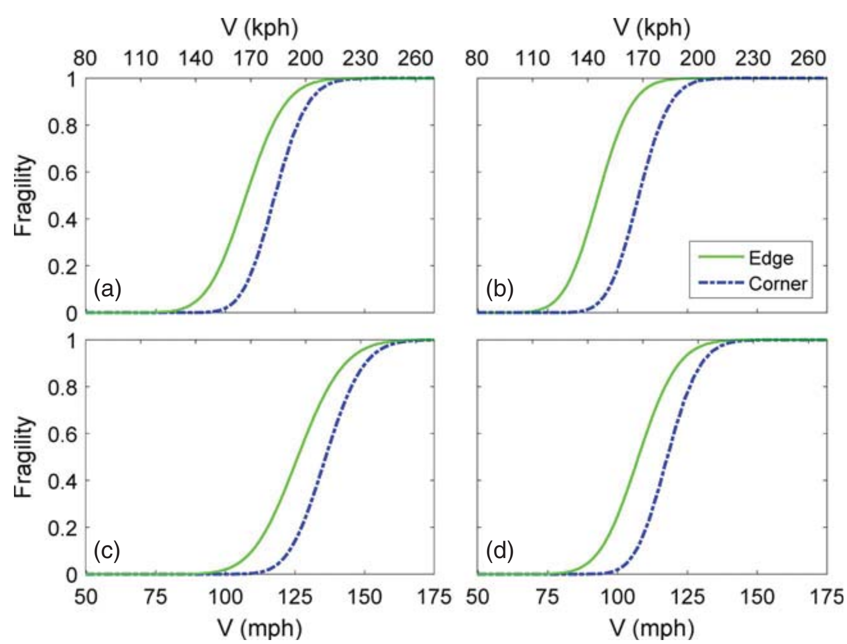

Fig. 10. Fragility curves for most critical area within each zone for San Francisco: (a) FM Global design; (b) ASCE/SEI 7-10 design; and for Boston: (c) FM Global design; and (d) ASCE 7-10 design.

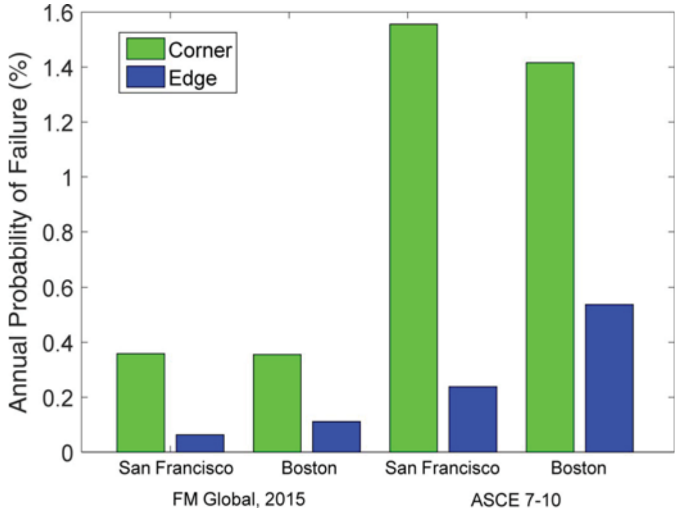

Fig. 11. Annual probability of failure for most critical area within each zone for both cities and both designs.

to the ASCE/SEI 7-10 requirements in San Francisco and Boston, respectively.

In order to assess the annual probability of sustaining wind damage to roof covering systems, it is first necessary to convolve the wind hazard relationship for the site with the fragility for each sample area using the same formulation as Eq. (4). The integral was evaluated numerically to obtain the annual probability of failure for both buildings as shown in Fig. 11 for the critical corner and edge areas for the ASCE/SEI 7-10 design as well as the FM Global design based on FM 1-28 (FM Global 2015). The failure probability for the edge zone showed a larger increase between the two cities than was observed for the corner zone. This is simply due to the fact that when rounding the suction resistance values (Table 1) for the edge zone up to the nearest 0.7 kPa (15 psf), the edge zone happened to result in a larger capacity increase than the corner zone.

Fig. 11 shows that the annual probabilities of damage for the corner zone in both cities were about four times higher for the ASCE/SEI 7-10 design than for the FM Global design. However, based on Fig. 10, when only considering the design level (Exposure B) wind speed, the two differ by a factor of about 6 in both cities. This demonstrates the importance of considering more than just one wind speed when comparing the resilience of flat roof cover systems. In order to facilitate a proper comparison that includes the contribution from all wind speeds, the convolution of fragility and hazard must be considered.

Glazing

Based on a survey of postdisaster assessments (FEMA 2005a, b, 2009), it was concluded that the majority of glazing damage to RC and steel buildings observed in hurricanes is due to windborne debris and failure due to extreme wind pressure alone is rare. Even though the design requirements for exterior glazing on a building in Occupancy Category II only require glazing to resist pressure from 700-year return period wind speeds (ASCE 2010), the final glazing design can resist significantly more than this due to consideration of energy efficiency and architectural matters. Since the design pressure resistance for the two buildings only requires a monolithic 6 mm (0.25 in.)–thick glazing unit and the final design was a dual-pane system with two 6 mm (0.25 in.)–thick panes, the short-duration pressure resistance of the final design was twice the required resistance (ASTM 2016). Therefore, given these considerations and the scarcity of anecdotal evidence for this type of failure, it was assumed that glazing damage due to wind pressure alone is unlikely and can therefore be ignored as a primary cause of wind damage in the present research.

Windborne Debris Damage

In urban settings, damage due to windborne debris can occur when gravel from the roof of a neighboring building (referred to as the source building) is lifted into the wind field and impacts the target building. If the debris has sufficient momentum upon impact, it can damage glazing elements and breach the target building envelope. Glazing damage from windborne debris can be extensive (FEMA 2009, 2012a), requiring not only replacement of glazing elements, but also costs for repair and loss of functionality due to water infiltration and wind damage to the target building interior that occurred after the envelope was breached. The scope of this paper, however, only includes glazing damage.

Models have been developed for estimating compact debris (i.e., gravel debris) trajectory in a wind field (Richards et al. 2008; Lin and Vanmarcke 2008, 2010; Moghim and Caracoglia 2012, 2014) as well as for estimating debris generation from a source building's roof (Karimpour and Kaye 2013). However, use of these models for damage evaluation would require further development. Such analyses require detailed information about the building's surroundings, such as the source building's location in relation to the target building, the height of the source roof, the dimensions of the source roof, as well as the angle of impact.

The approach developed by Hazus for estimating windborne debris damage suggests that these variables were accounted for by performing detailed numerical simulations for two source roof heights and two source roof areas (four cases total) representative of lower- and upper-end values typical of commercial buildings and estimating mean results. Based on the results of these detailed numerical simulations, a fast-running (simplified) model was developed (FEMA 2012a). The exposure used in these simulations was Category B, the applicable exposure for urban areas such as Boston and San Francisco (ASCE 2010). The fast-running model allows for estimation of the probability of damage to a glazing element within a short time interval T (a fraction of an hour) based on the following equation:

$$P_D = 1 - e^{-ATN[1-F_{M_D|V}(\hat{M}_C)]} \tag{6}$$

where A = area of the glazing element; N = expected number of impacts per unit area [for buildings up to 30 m (100 ft) tall], which is estimated based on the height of the glazing element above ground, the average center-to-center spacing of buildings in the area [taken here as 70 m (230 ft) based on observation of satellite imagery], and the peak gust wind speed in the given time interval (FEMA 2012a); and $F_{M_D|V}(\cdot)$ is the CDF of impact momentum demand as a function of the peak gust speed, V, which is provided in Hazus (FEMA 2012a). In Eq. (6), this CDF is evaluated at the median momentum capacity of the glazing element, $\hat{M}_C$. However, by assuming that impact momentum capacity takes its median value, this formulation neglects the uncertainty in the momentum capacity of the glass. In this paper, a modified version of the Hazus fast-running model was used in which the momentum capacity uncertainty can be accounted for by using the following probability to replace $F_{M_D|V}(\hat{M}_C)$ in Eq. (6):

$$P[M_D < M_C|V] = \int_0^\infty F_{M_D|V}(m_C)\varphi\left[\frac{\ln(\frac{m_C}{\hat{M}_C})}{\beta_{M_C}}\right]dm_c \tag{7}$$

where M_D and M_C = random variables describing the demand and capacity impact momentums, respectively. Given the assumed lognormal distribution for impact momentum capacity, the median impact momentum capacity, $\hat{M}_C$, was set equal to 0.05 kg-m/s (0.36 lbm-ft/s) for a 6 mm (0.25 in.)–thick annealed glazing element (FEMA 2012a). The logarithmic standard deviation, β_{M_C}, was found based on a COV of 0.12 (Harris 1978).

The probability of damage in the Hazus fast-running model is said to account for the number of gravel roofs in the surrounding area in an average sense by use of a source reduction factor, which is not disclosed (FEMA 2012a). Thus, in order to gain a sense of the relative exposure to gravel roofs between the two cities, satellite imagery was used to estimate the number of gravel roofs per unit area within the financial district of each city. This evaluation revealed approximately 0.43 gravel roofs per hectare (or 0.17 per acre) in San Francisco and 0.35 gravel roofs per hectare (or 0.14 per acre) in Boston. Using the Hazus fast-running model, this difference was not accounted for and it was further assumed that building surroundings in both cities have gravel roofs close to the average amount used in Hazus.

Fragility

Since curtain wall panels are placed at varying heights, while all other parameters are constant, it follows that each row of panels (i.e., those that are at the same height above ground) has a different probability of damage based on its height above ground. Thus, for a given time interval in a hurricane, the expected number of newly damaged glazing panels within a given row can be estimated by multiplying the damage probability [based on modified Eq. (6) as described previously] at that height by the number of previously undamaged panels in that row. This estimation was performed for each time step throughout the hurricane record, updating the number of previously undamaged panels in each row for each time interval based on the results of the previous time interval.

Demand uncertainty in the record-to-record variability for different hurricanes was accounted for by application of the modified Hazus fast-running model for eight hurricanes that made US landfall within the last 10 years. Data for the peak gust wind speed at 6-min intervals for these hurricanes were obtained from the National Data Buoy Center (NOAA n.d.). Traces for these storms are shown in the Supplemental Data.

Glazing damage was assessed by applying the modified Hazus fast-running model for each hurricane record scaled to cover the desired range of intensity. Assuming a lognormal distribution for the percentage of glazing damage (GD), its median, $\widehat{\mathrm{GD}}$, and logarithmic standard deviation, β_{GD}, were obtained from the damage results of eight records for each wind speed, V. Given that capacity uncertainty was already accounted for in the damage model, fragility can be estimated for a percent of glazing damage, gd, from

$$\bar{F}_{\mathrm{gd}|V} = P[\mathrm{GD} > \mathrm{gd}|V] = 1 - \Phi\left[\frac{\ln\left(\frac{\mathrm{gd}}{\widehat{\mathrm{GD}}}\right)}{\beta_{\mathrm{GD}|V}}\right] \tag{8}$$

Probability of Failure

The annual probability of failure for a given percentage of glazing damage due to windborne gravel debris was estimated by convolving the fragility with hazard, similarly to Eq. (4). The integral was evaluated numerically to obtain the annual probability of failure for glazing damage, which is shown in Fig. 12.

The lack of consideration of windborne debris hazard in building design is evident in Fig. 12. The annual probability for 5% glazing damage is nine times higher for Boston than it is for San Francisco. As damage increases, this difference increases significantly. The annual probability for 15% glazing damage is more than 19 times higher for Boston than for San Francisco.

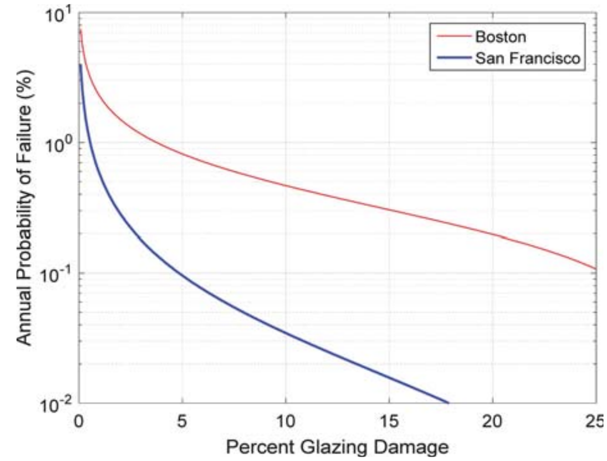

Fig. 12. Annual probability of glazing failure.

Cost and Resilience Evaluation

The results developed here represent damage to several key building components: structural framing, partitions, envelope, and roof covering. However, both earthquake and wind hazards can also cause costly damage to elements not considered here. The earthquake and wind hazards were assumed to be statistically independent. For earthquakes, acceleration-sensitive building components such as electrical, plumbing, and heating ventilation and air-conditioning (HVAC) systems were not considered. However, the framework developed here can easily be expanded to include any number of element types as well as the appropriate engineering demand parameters for evaluating damage to those element types. For wind, secondary damage such as water infiltration and wind damage to building contents (i.e., after the envelope has been breached) were not considered. Further research is required to incorporate these secondary damage sources into the cost and resilience evaluation framework.

Seismic Damage Costs

In evaluating the expected cost of damage, the life span of the buildings was assumed to be 50 years. Therefore, given the annual probability of failure [Eq. (4)], the probability of failure for damage state i over the life span of the building can be estimated, assuming independence of the probabilities from year to year, by

$$P_{f50,\mathrm{DS}_i} = 1 - (1 - P_{f,\mathrm{DS}_i})^{50} \tag{9}$$

where P_{f50,DS_i} = probability of failure for damage state DS_i over an assumed life span of the building of 50 years; and P_{f,DS_i} = annual probability of failure for damage state DS_i [Eq. (4)]. Although the assumption of independence of the probabilities from year to year may not be completely accurate (Der Kiureghian 2005), this assumption was used in development of the risk-targeted ground motion maps for ASCE/SEI 7-10 (Luco et al. 2007) in which a 1% probability of collapse over 50 years was used to provide uniform collapse risk (ASCE/SEI 7-10), as well as in this paper.

For sequential damage states such as the repairable damage states considered here, the probability associated with the repair costs and repair time for each damage state is its probability of

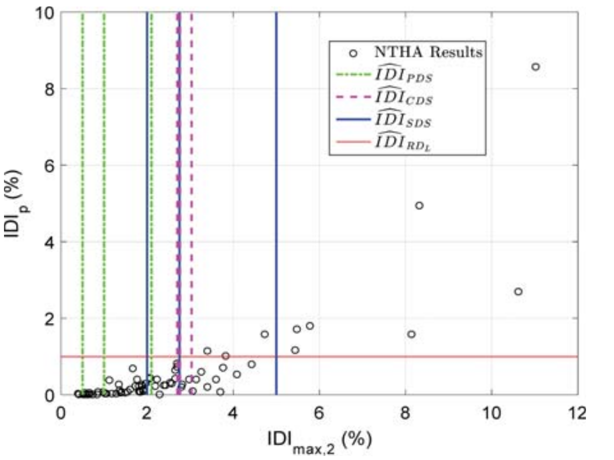

Fig. 13. IDI_p versus $IDI_{max,2}$ for San Francisco.

failure minus that of the next most severe damage state in the sequence. Furthermore, since the occurrence of unrepairable damage results in complete demolition of the building, it negates any repairable damage that may have occurred during an event. Therefore, for each damage state the probability of intersection of a sequential damage state and repairable damage must be considered in calculation of repair cost and repair time, as follows:

$$P[IDI_{DS_i} \le IDI_{max,n} \le IDI_{DS_{i+1}} \cap IDI_p < IDI_{RD_L}] \tag{10a}$$

which is equal to

$$P[IDI_p < IDI_{RD_L} | IDI_{DS_i} \le IDI_{max,n} \le IDI_{DS_{i+1}}] \times P[IDI_{DS_i} \le IDI_{max,n} \le IDI_{DS_{i+1}}] \tag{10b}$$

where IDI_{DS_i} = IDI capacity for damage state DS_i; and IDI_{RD_L} = IDI limit below which damage is repairable. The first term in Eq. (10*b*) can be approximately estimated using results similar to those shown in Fig. 13, in which IDI_p is given versus $IDI_{max,2}$. The conditional probability for structural and nonstructural damage states was estimated by dividing the number of ground motions that produce an $IDI_{max,n}$ between the median capacity values for DS_i and DS_{i+1} and an IDI_p smaller than the median capacity for repairable damage, by the total number of ground motions within the two subsequent damage states. For instance, for SDS2 and SDS3 (the two right solid vertical lines), except for three ground motions, the remaining ground motions led to repairable damage in terms of their IDI_p. Therefore, the first term in Eq. (10*b*) for the second story is $12/15 = 0.8$. The second term in Eq. (10*b*) can be calculated using the 50-year exceedance probabilities obtained from Eq. (9).

Because permanent drift is caused by excessive inelastic deformations, there is a positive correlation between IDI_p and $IDI_{max,n}$, as seen in Fig. 13. Thus, it follows that the first term in Eq. (10*b*), which is the conditional probability of repairability, can be expected to be smaller for more severe damage states. For the second story, for example, this conditional probability was estimated at zero for $IDI_{max,2} > \widehat{IDI}_{SDS3}$, which means that all ground motions causing response larger than that of $\widehat{IDI}_{SDS3}$ lead to unrepairable damage. Fig. 13 excludes three ground motions that produced large $IDI_{max,2}$ values signifying collapse of the structure. Therefore, as the conditional probability of repairability approaches zero, while increasing deformation capacity would help life safety and collapse prevention, it has little effect on building functionality after an earthquake. Thus, the relationship between transient and permanent drifts can have a significant effect on building resilience and should be considered accordingly.

To calculate expected cost (Table 5), the mean and COV for unit repair cost can be obtained from PACT for each damage state and then used along with the number of elements within each element type and the associated probability of damage for a given damage state [Eq. (10*b*)]. The cost of demolition and replacement (i.e., when $IDI_p > IDI_{RD_L}$) was calculated based on RSMeans data (2016) and the COV was assumed equal to the COV for unit repair cost of the most severe structural damage state, SDS3. Furthermore, all seismic damage repair costs have been adjusted from the 2011 Northern California values (provided in PACT) to location-appropriate 2016 costs using RSMeans historical indexes. Also, all costs were normalized by dividing them by the sum of replacement costs of all building components for which damage was considered.

Table 5 shows that the primary source of repair costs in San Francisco is repairable structural earthquake damage, which

Table 5. Estimated life span repair costs for earthquake and wind hazards in San Francisco and Boston as a percentage of building replacement cost for structure, partitions, curtain walls, and roof covering

			Structural		Nonstructural[a]		
City	Hazard	Type	Expected	COV	Expected	COV	Total expected cost
San Francisco	Earthquake	Repair	4.92%	0.36	2.64%	0.36	7.56%
		Demolition	0.83%	0.30	1.77%	0.30	2.60%
		Total	5.75%	—	4.41%	—	10.16%
	Wind	Roof cover	N/A	—	0%[b] (0.01%)[c]	(0.25)	0%[b] (0.01%)[c]
		Glazing	N/A	—	0.52%	0.12	0.52%
		Total	N/A	—	0.52%[b] (0.53%)[c]	—	0.52%[b] (0.53%)[c]
	Multihazard	**Total**	**5.75%**	—	**4.94%**[b] **(4.95%)**[c]	—	**10.69%**[b] **(10.70%)**[c]
Boston	Earthquake	Repair	0%	—	0.02%	0.47	0.02%
	Wind	Roof cover	N/A	—	0.01%[b] (0.02%)[c]	(0.25)	0.01%[b] (0.02%)[c]
		Glazing	N/A	—	3.21%	0.12	3.21%
		Total	N/A	—	3.22%[b] (3.23%)[c]	—	3.22%[b] (3.23%)[c]
	Multihazard	**Total**	**0%**	—	**3.24%**[b] **(3.25%)**[c]	—	**3.24%**[b] **(3.25%)**[c]

Note: Bold values indicate the multihazard total for each building. They are the addition of earthquake and wind damage.
[a]Partitions and curtain wall for earthquake damage and glazing and roof covering for wind damage.
[b]Value based on roof covering designed with FM Global (2015).
[c]Values based on roof covering designed for ASCE/SEI 7-10 demand.

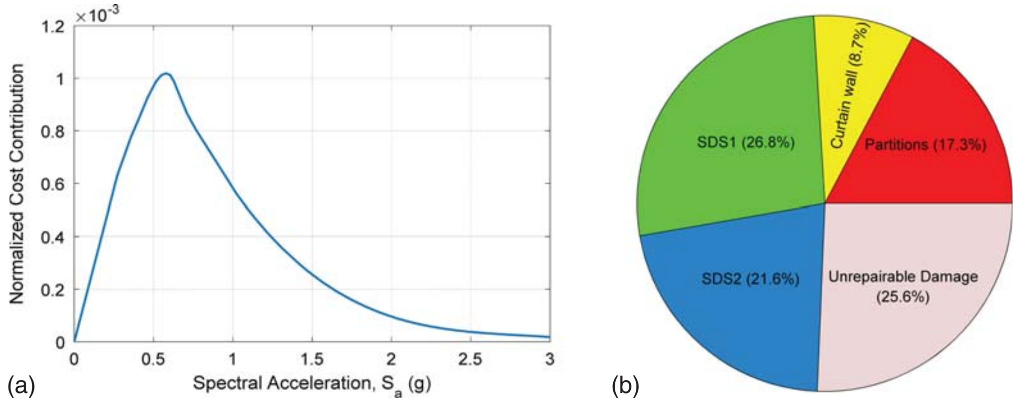

Fig. 14. (a) Normalized seismic cost contribution as a function of S_a; and (b) breakdown of contribution to cost for partition, curtain wall, structural repairs, and demolition for building in San Francisco.

constitutes 46% of the total expected multihazard repair cost. In Boston, on the other hand, earthquake damage (structural and nonstructural) contributes less than 1% to the total expected multihazard repair costs.

Fig. 14(a) shows the contribution to total expected seismic repair cost in San Francisco normalized with respect to the total (including all damage states) versus S_a. The design ground motion for the San Francisco building had a spectral acceleration of 0.56g. This is slightly less than the value for the maximum contribution to repair cost of 0.58g. The spectral acceleration for the ground motion at the site with 10% probability of exceedance in 50 years was 0.69g [Fig. 2(a)], larger than both the deterministic value of design spectral acceleration (based on ASCE/SEI 7-10) and the S_a with the maximum contribution to repair cost.

Fig. 14(b) shows the contributions of different types of seismic damage to the repair cost. As can be seen, more than half of the cost is associated with damage associated with partitions, curtain walls, and Structural Damage State 1 (SDS1). Given this high contribution to the cost of damage, it may be time to explicitly consider a lower level of performance (i.e., other than life safety and collapse prevention) in building design.

Wind Damage Costs

Expected repair costs from damage to roof covering systems over the life of the building are also presented in Table 5. Repair actions for roof cover damage are to remove and replace the damaged roof covering and perimeter flashing. The average unit repair cost for roof cover damage was estimated using RSMeans (2016) data. Uncertainty in repair costs was estimated using a web-based flat roof installation cost estimator (Roofing Prices Calculator n.d.) that provides high-end, midrange, and low-end cost estimates for installation of flat roof covering. High-end costs are quoted as being 25% higher than midrange costs, thus a COV of 0.25 was assumed for roof cover replacement costs. Glazing repair costs due to wind-borne debris are also presented in Table 5. The repair action for this type of damage is to replace the damaged glazing panel.

Resilience

Resilience of the two buildings was quantified in terms of the amount of time required for repairs and the amount of floor area that is unusable during those repairs (Table 6). The product of these two factors was taken as the primary resilience metric, loss of

Table 6. Estimated loss of function in day-m^2 (day-ft^2) and as a percentage of the total time-area associated with the life of the building for earthquake and wind hazards in Boston and San Francisco

			Structural		Nonstructural[a]		
City	Hazard	Cost type	Expected	COV	Expected	COV	Total expected LF
San Francisco	Earthquake	Repair	32,030 (344,730) 0.03%	0.44	7,870 (84,730) 0.01%	0.51	39,900 (429,460) 0.04%
		Demolition	12,150 (130,800) 0.01%	0.39	22,570 (242,910) 0.02%	0.39	34,720 (373,710) 0.03%
		Total	44,180 (475,530) 0.04%	—	30,440 (327,650) 0.03%	—	74,620 (803,180) 0.07%
	Wind	Glazing	N/A	—	470 (5,060) <0.01%	0.15	470 (5,060) <0.01%
	Multihazard	**Total**	**44,180 (475,530) 0.04%**	—	**30,910 (332,710) 0.03%**	—	**75,090 (808,240) 0.07%**
Boston	Earthquake	Repair	20 (230) <0.01%	0.46	80 (880) <0.01%	0.52	100 (1,110) <0.01%
	Wind	Glazing	N/A	—	2,760 (29,710) <0.01%	0.28	2,760 (29,710) <0.01%
	Multihazard	**Total**	**20 (230) <0.01%**	—	**2,840 (30,590) <0.01%**	—	**2,860 (30,820) <0.01%**

Note: Bold values indicate the multihazard total for each building. They are the addition of earthquake and wind damage.
[a]Partitions and curtain wall for earthquake damage and glazing, and roof covering for wind damage.

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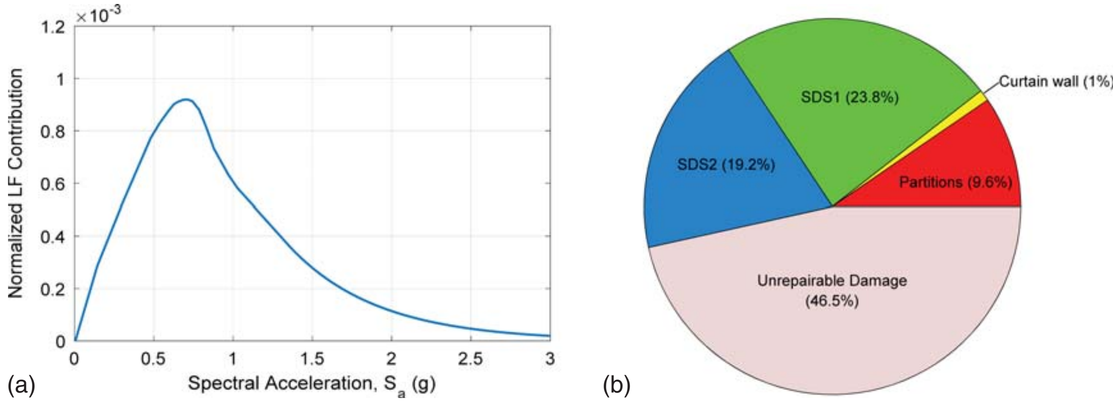

Fig. 15. (a) Normalized LF contribution as a function of S_a; and (b) breakdown of contribution to LF for partition, curtain wall, structural repairs, and demolition for building in San Francisco.

function (LF). Values for loss of function were normalized by dividing them by the total time-area associated with the life of the building. Given that the repair actions for roof cover loss only involve work on the exterior of the building, loss of function of the interior of the building was not anticipated. Repair actions for earthquake and windborne debris damage, however, disrupt the occupants of the building and therefore contribute to the overall loss of functionality for the building after an event. To estimate the loss of function, the mean and COV of unit repair time was obtained from PACT for all earthquake damage states as well as for glazing damage (since the repair actions are the same as for CDS3).

Fig. 15(a) shows the contribution from each value of S_a to the total loss of function for the San Francisco building, normalized with respect to the total. The maximum contribution occurs at $0.70g$, which is 25% larger than the design spectral acceleration. The S_a with the maximum contribution to loss of function was close to the $0.69g$ spectral acceleration for the ground motion at the site with 10% probability of exceedance in 50 years [Fig. 2(a)].

Fig. 15(b) shows the contributions of different types of seismic damage to LF. As can be seen, more than half of the LF was associated with unrepairable damage due to excessive permanent deformation. Therefore, in addition to the effort made by researchers and engineers to enhance deformation capacity of structures for improving life safety and collapse prevention performance, there is a need for reducing permanent deformation of structures to better control and limit loss of function and in turn increase building resilience.

Conclusions

The resilience of two 7-story RC moment frame structures with the same floor plan was evaluated under seismic and wind hazards in San Francisco and Boston, which were designed as SMF and IMF, respectively. For seismic evaluation, the performance of the structure, the envelope (curtain walls), and partitions were considered. For wind hazard it was concluded that structural damage was not likely and instead damage to the roof cover and glazing were considered.

It was concluded that for the building in Boston, even under the maximum considered earthquake ground motion, the structure experienced limited yielding. Therefore a new method, called IMA, was proposed for estimating structural response under earthquake effects, which iteratively accounts for stiffness reduction due to section flexural cracking. It was shown that compared with nonlinear dynamic analysis, this method reliably estimates building response. That is, the maximum interstory drift calculated for 10 ground motions scaled in the neighborhood of hazard for 475- and 2,476-year return periods had about 2% error in the mean, with a maximum COV of 0.15. An important advantage of IMA is that it does not require time histories of seismic ground motions, which for high-intensity events are scarce in ENA.

In Boston, wind hazard produces the most damage, whereas the expected seismic damage is minimal. Despite a low seismic risk in Boston, the Massachusetts Building Code (MA Building Code 2010) includes an amendment to ASCE/SEI 7-10 prohibiting the use of RC OMF systems for Seismic Design Category B, which is the seismic design category for the building in Boston, suggesting that RC structures designed in Boston require enhanced ductility in comparison with the ASCE/SEI 7-10 code-minimum requirement. The difference between the performance of IMF versus OMF is more pronounced in terms of life safety and collapse resistance, which were not a focus of this paper. However, the findings of this study on performance of two RC buildings suggest that this prohibition may be relaxed because the expected damage due to seismic drift over the life of the building in Boston is minimal.

For the San Francisco building, the seismic damage was much greater, given that spectral acceleration was more than one order of magnitude greater there than that in Boston for 50, 10, and 2% probability of exceedance in 50 years. In quantifying building damage due to seismic actions, in addition to maximum interstory drift index of each story ($\mathrm{IDI}_{\max,n}$), the largest permanent IDI among all the stories was also considered (IDI_p). In order to evaluate the probability of occurrence of each damage state in terms of $\mathrm{IDI}_{\max,n}$ over the life of the building, and in turn the repair cost and recovery time, a method was developed to exclude the conditions in which the value of IDI_p rendered the building unrepairable. The results show that for the building in San Francisco

1. More than half of the building repair cost is associated with partition and curtain wall damage as well as Structural Damage State 1 (SDS1), which suggests a need for explicitly accounting for such performance levels, in addition to life safety and collapse prevention, in building design.
2. About half of the LF is due to unrepairable damage caused by excessive permanent deformation, which suggests a need for explicit consideration of limiting permanent deformation of structures after seismic events to better control and limit loss of function and in turn build resilience.

In other words, in terms of repair cost and repair time, the controlling factors are minor-to-moderate repairable damage from transient drift and unrepairable damage from permanent drift,

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respectively. Furthermore, while $S_a = 0.58g$ (which is close to the design $S_a = 0.56g$) is associated with the maximum contribution to the cost, the S_a that corresponds to the maximum contribution to the loss of function has a somewhat larger value of $0.70g$. This shift from 0.58 to $0.70g$ can be explained by the fact that the cost is significantly affected by lower performance levels (caused by less severe ground motions) and the loss of function is mainly affected by unrepairable damage (caused by more severe ground motions).

For wind damage to roof covering systems, it was shown that the FM Global design, which requires higher demand and a larger safety factor, results in negligible repair costs over the life of the San Francisco building and only 0.01% for the Boston building. The ASCE/SEI 7-10 design, however, does produce more significant expected repair costs but still only accounts for 0.6% of the total multihazard repair costs in Boston and less than 0.1% in San Francisco. Thus, wind damage to roof covering systems is deemed not to be an immediate concern in terms of the resilience provided by current codes. As a side conclusion, it is shown that the ASCE/SEI 7-10 component roof suction may underestimate peak values calculated based on wind tunnel test results by about 40%.

Glazing damage from windborne debris is expected to result in more than six times more repair costs in Boston than in San Francisco. This is based on the assumption that the percentage of existing gravel roof buildings in Boston and San Francisco (which is about 0.4 gravel roofs per hectare or 0.16 per acre) is in fact close to the percentage considered in Hazus. Given that neither building is located within the windborne debris regions defined by ASCE/SEI 7-10 (ASCE 2010), the impact capacities of glazing on the two buildings are the same. Considering the higher wind hazard in Boston than in San Francisco, it was shown that the annual probability of failure for glazing damage is much higher (more than 19 times higher for 15% glazing damage) in Boston than it is in San Francisco. Perhaps risk of damage due to windborne gravel debris needs to be considered in design.

Based on the results presented in this paper and in terms of building resilience, the duration of loss of functionality of the building in San Francisco is expected to be equivalent to about 2 weeks of the entire building being out of service over its life span. It is important to note the assumptions that led to this outcome. One is that only damage imposed to the structure, envelope, partitions, and roof were considered in this paper. These components account for slightly less than half of the total cost of a building construction. Obviously, considering damage to other nonstructural components, particularly under seismic ground motions, as well as damage to the building interior following glazing damage under hurricanes can significantly increase the repair time (and cost). Also, damage due to hazard events was considered in only one direction (the direction that causes the most damage) and damage in the other directions would increase the repair time. Finally, the loss of lives, the minimizing of which is the main objective of building codes and standards, and obviously an important measure of building resilience, was not discussed in this paper.

Acknowledgments

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Supplemental Data

Tables S1–S7 and Fig. S1 are available online in the ASCE Library (www.ascelibrary.org).

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2019 Individual Section Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

Each year, BSCES presents awards to deserving individuals in the Section or in the community who are nominated by their peers in recognition of their service. Here is your opportunity to nominate a co-worker, friend, or someone who you think deserves special recognition. Please see the following awards descriptions and page 2 of this form for nomination instructions.

The Nominations Deadline is **Monday, March 11, 2019**. The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 170th BSCES Annual Awards Dinner.

I would like to nominate Adam Vaccaro For the:

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_______ HORNE/GAYNOR PUBLIC SERVICE AWARD: This award is presented to a BSCES member or registered professional engineer for unpaid public service in a municipal, state or federal-elected or appointed post for philanthropic activities in the public interest.

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X JOURNALISM AWARD: This award is presented to a journalist or other author who has published one or more articles, papers, books, social media blogs, or films for a non-technical audience that raises awareness of the contributions of the civil engineering profession.

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_______ COLLEGE EDUCATOR AWARD: This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates should be actively teaching in a classroom setting at a college or university in New England.

_______ YOUNGER MEMBER AWARD: This award is intended to recognize a BSCES member, 35 years of age or younger on February 1 in the year of the award, who has made an outstanding contribution to BSCES and/or the civil engineering profession.

_______ ENGINEER OF THE YEAR AWARD: This award is presented to a BSCES member, with 15 years or more professional experience, who has exhibited extraordinary leadership in the form of managerial leadership, technical excellence, professional integrity, and mentorship of other engineers.

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2019 Individual Section Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

To submit a nomination, complete this form and return it by the nomination deadline via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, The Engineering Center, One Walnut Street, Boston, MA 02108-3616, respectively.

Name and Company Address of Nominee(s)*:

Adam Vaccaro, Reporter

Boston Globe - 1 Exchange Place Boston, MA 02109

Is this a re-nomination? Yes ______ No X

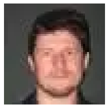
**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Ron Burns Daytime Telephone: 617-202-6278(dir) Email: rburns@arcadia-tec.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

BACK TO STAFF LIST



REPORTER

Adam Vaccaro

ON THE WEB

adamtvaccaro

E-MAIL

adam.vaccaro@globe.com

PHONE

617-929-7015

Adam Vaccaro covers transportation, infrastructure, and commuter issues for the Globe. Adam commutes mostly by bike and subway, though he shares a car with his wife. A native of Massachusetts, he has previously written for Boston.com, Inc. magazine, and the Patriot Ledger.

Latest stories

With traffic so bad, is it really the time to raise T fares?

BY ADAM VACCARO , GLOBE STAFF

Transit specialists say another fare hike could lead to a drop in the number of people who take the bus, train, and subway.

Mass. still short on transportation funding, report says

BY ADAM VACCARO , GLOBE STAFF

The state's highways, roads, and bridges — along with the MBTA — are facing a big funding gap over the next decade, according to a report from a business group.

Cambridge wanted a big drop in car ownership by 2020. That hasn't exactly happened

BY ADAM VACCARO , GLOBE STAFF

Even Cambridge — which took up the anticar cause decades ago — can't get more residents to give up their vehicles.

The global trade war makes a local stop: Springfield

BY ADAM VACCARO , GLOBE STAFF

The Chinese government-backed rail car company building cars for the MBTA's Orange and Red lines won't get any tariff relief, even though the cars are being assembled in Massachusetts.

The next Hub of cycling? Everett

BY *ADAM VACCARO* , GLOBE STAFF

The worst gridlock in the US is right here in Boston

BY *ADAM VACCARO* , GLOBE STAFF

MBTA says eliminating North Shore express routes will improve bus service

BY *ADAM VACCARO* , GLOBE STAFF

Ridership on commuter rail exploding with fans for Patriots rally

BY *ADAM VACCARO*, *MARK ARSENAULT* AND MEGHAN BARR , GLOBE STAFF

MBTA commits to linking Red and Blue lines — eventually

BY *ADAM VACCARO* , GLOBE STAFF

Is the future of the Mattapan line more trolleys, or buses?

BY *ADAM VACCARO* , GLOBE STAFF

How the T's proposed fare hike stacks up against other cities

BY *ADAM VACCARO* , GLOBE STAFF

See how much more riding the MBTA would cost under proposed fare hike

BY *MATT ROCHELEAU* AND *ADAM VACCARO* , GLOBE STAFF

FEWER STORIES ▲

From: Geoffrey Schwartz <Geoffrey.Schwartz@gza.com>
Sent: Sunday, March 17, 2019 5:10 PM
To: Michael Cunningham
Cc: Reed Brockman
Subject: Fwd: [Tiny Scanner] Doc Mar 17, 2019, 16:58
Attachments: Doc Mar 17, 2019, 1658.pdf; ATT00001.htm

External Email.

Mike,

FYI - nomination from Reed

Geoff

Sent from my iPhone

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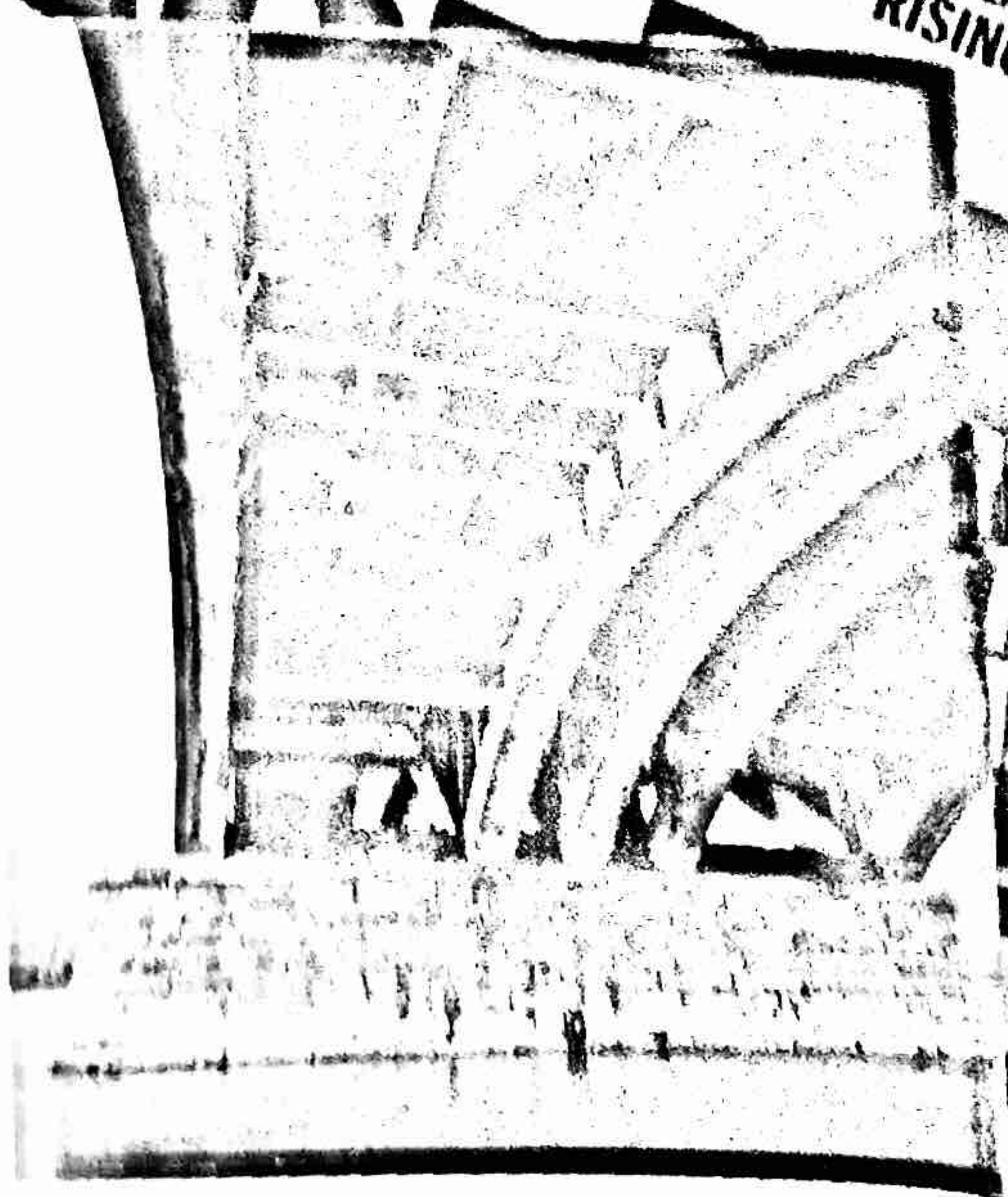
historic
STRUCTURES

"Here…is the gateway to Springfield and the towns to the east for almost an entire nation," proclaimed Massachusetts Governor Channing Cox on August 2, 1922. It was Dedication Day for the new Hampden County Memorial Bridge, which spans the Connecticut River between the City of Springfield and Town of West Springfield in Western Massachusetts. Boston engineers Fay, Spofford & Thorndike, with architects Haven & Hoyt, designed the bridge, deemed a "finely-engineered example of a rare self-supporting arch rib reinforcement technique derived from the Melan tradition" [HAER Ma-114]. Builder H. P. Converse & Co. of Boston completed the bridge ahead of schedule on July 31, 1922, after 28 months of construction. At 1,515 feet long and 80 feet wide, it was designed to support pedestrian, vehicular, street rail, and heavy armament traffic. A bridge big in size and cost ($4 million) for its time, it remains the longest reinforced concrete deck arch span in Massachusetts.



Looking east, showing piers and arches. Retrieved from the Library of Congress.

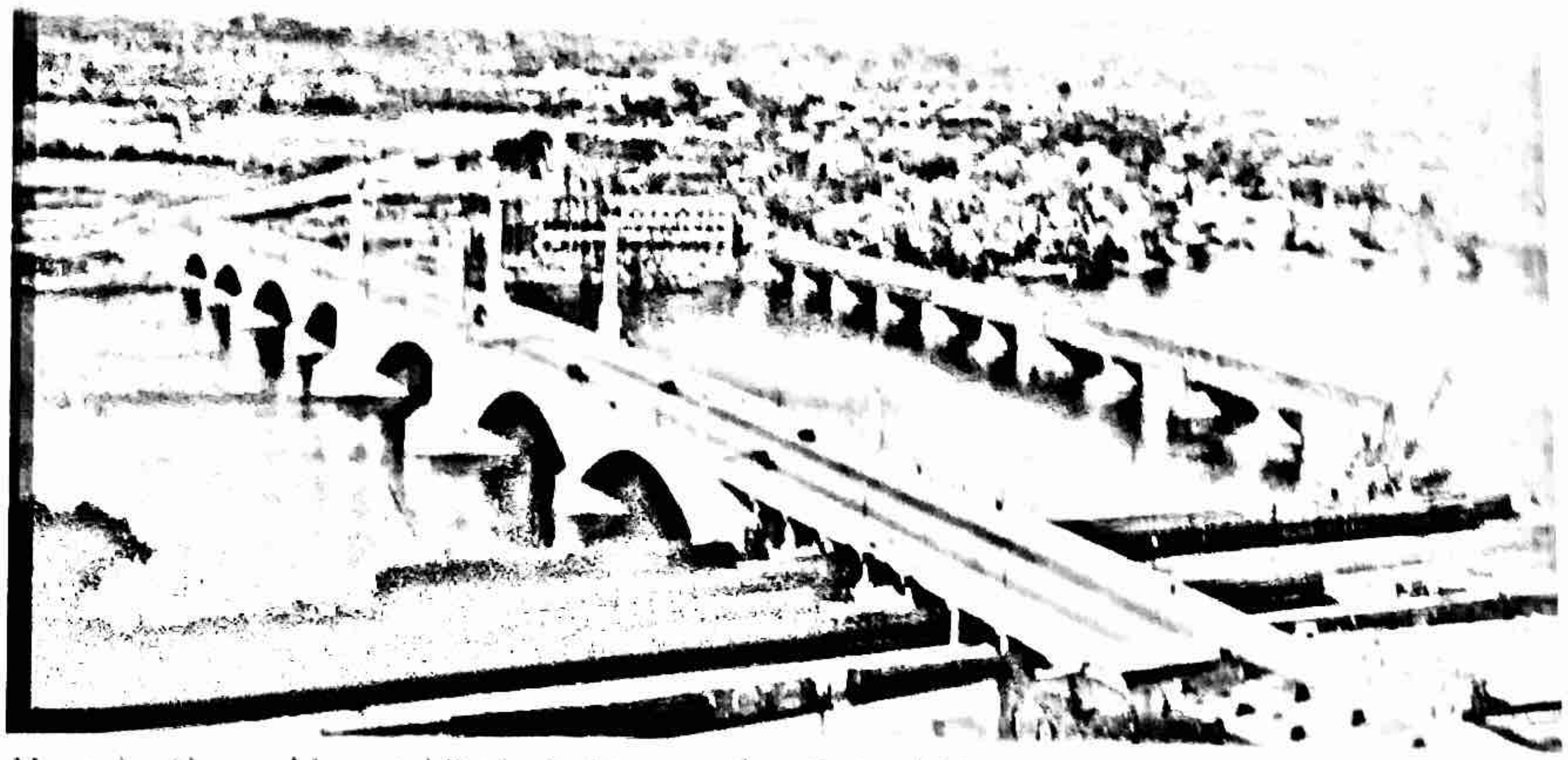
Springfield's Great Bridge Salutes History

By Beth McGinnis-Cavanaugh, MSCE

Beth McGinnis-Cavanaugh is a Professor at Springfield Technical Community College in Springfield, Massachusetts, where she teaches courses in physics, engineering mechanics, and structures. She is particularly interested in the engineering and social significance of historic structures.

(bmcginnis-cavanaugh@stcc.edu)

The Memorial Bridge sits at the nexus of three rivers: the 410-mile north-south Connecticut River, New England's longest, and major east and west tributaries Chicopee and Westfield Rivers. With river access to New York and Canada and the rich soil of the Connecticut River Valley, Springfield was founded as a trading and farming community when Puritan William Pynchon purchased land from the Agawam Indians in 1636. The river was not bridged until 1805 when a wooden toll bridge was built. A covered wooden toll bridge followed in 1816, but the motorized cars and trucks of the 20th century and a burgeoning Springfield population made a new bridge imperative in the early 1900s.



Hampden County Memorial Bridge looking west from Springfield, August 1922. Springfield viaduct in the foreground. 1816 covered wooden toll bridge upstream, in the process of deconstruction. A segment of railroad bridge is visible beyond. Courtesy of the Lyman and Merrie Wood Museum of Springfield History.

Years of dispute forced the Commonwealth to appoint an independent commission to finalize its design and location. The Connecticut's soft riverbed precluded solid concrete and masonry structures, and exposed steel arches were deemed unpleasing for what principal Charles M. Spofford called "this important new artery of commerce spanning a great New England river." In 1919, commissioners selected a reinforced concrete deck arch bridge named to honor "those who had died as pioneers, and soldiers in the Revolutionary, Civil and Foreign Wars." The bridge, designed in the Beaux-Arts style, boasted seven parabolic concreted rib arches on six piers and two abutments that spanned 1,200 feet across the river. A nine-span viaduct of 314 feet over railroad tracks on the Springfield (east) side formed the Springfield approach. The bridge was located 400 feet downstream of the 1816 covered bridge at right angles to the river – just north of the river's widest point.

The Memorial Bridge opened to great fanfare in 1922, "beautiful in the sweep of its lines, the last word in engineering science…a symbol of that progressiveness that has been characteristic of the valley" [*Springfield Republican*, July 1922]. Springfield had shed its colonial past, surpassing neighboring Hartford in size and status and emerging as a hub of industry, innovation, and intellect. General George Washington had established the Springfield Armory in 1777, where the first American musket and famous Springfield rifle were produced. After the War of 1812, the Armory pioneered the use of interchangeable parts and assembly line production, making Springfield the nation's epicenter of precision manufacturing – the "Silicon Valley of the 19th century." This catalyzed industry of all types. Springfield was the birthplace of the Duryea car, America's first gas-powered automobile, and the Indian motorcycle. The "City of Firsts" was home to Knox fire engines, Wason railroad cars, Goodyear vulcanized rubber, Rolls Royce automobiles, Smith and Wesson firearms, and Merriam-Webster's dictionary, among many other firsts. Naismith's game of basketball, Milton Bradley board games, four Carnegie libraries, renowned museums, and a young Dr. Seuss also called Springfield home in 1922.

Thus, upon its opening, the Memorial Bridge was more than it appeared – much more than just a river crossing. It was an announcement. The frontispiece of a confident city, the bridge exuded strength, permanence, and promise. It was the very embodiment of Springfield in 1922. Like the City, it was "practically imperishable" according to H. P. Converse, who stated, "I can't think of anything that will prevent the bridge from standing as firmly 500 or a thousand years from now as it does today" [*Springfield Republican*, July 1922].

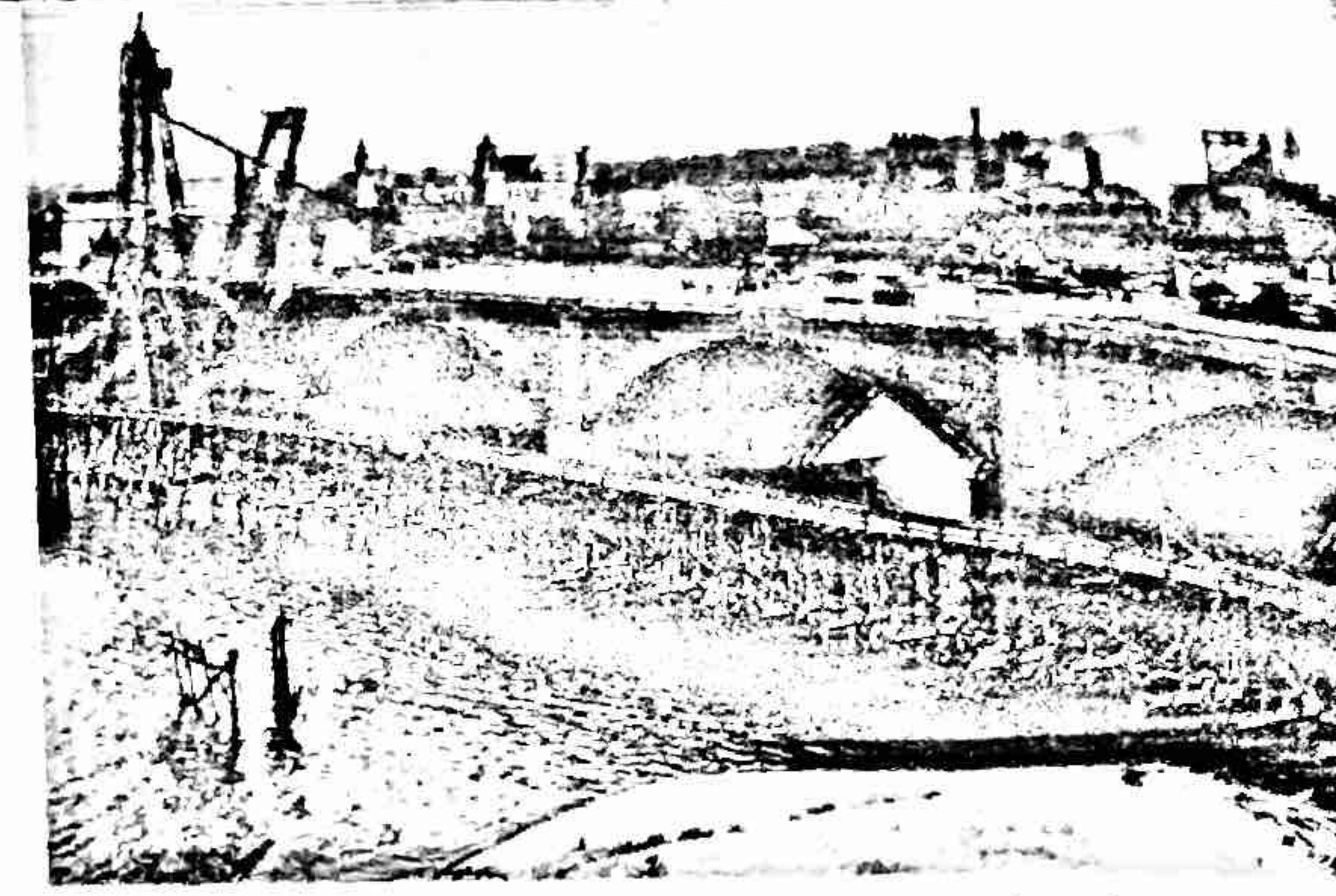
The Melan System

The introduction of the Melan system spurred the construction of reinforced concrete bridges in the U.S. in the late 1800s and early 1900s. The system called for parallel, self-supporting steel arch ribs – curved I-beams – encased in concrete to support traditionally reinforced superstructures. Ribs were placed along the centerline of the arches, not where tensile stresses occurred as would be typical with traditional reinforced concrete. Steel and concrete were used in parallel to support loads but did not act as a composite material. By 1924, over 5,000 Melan or Melan-style bridges had been built in the U.S.

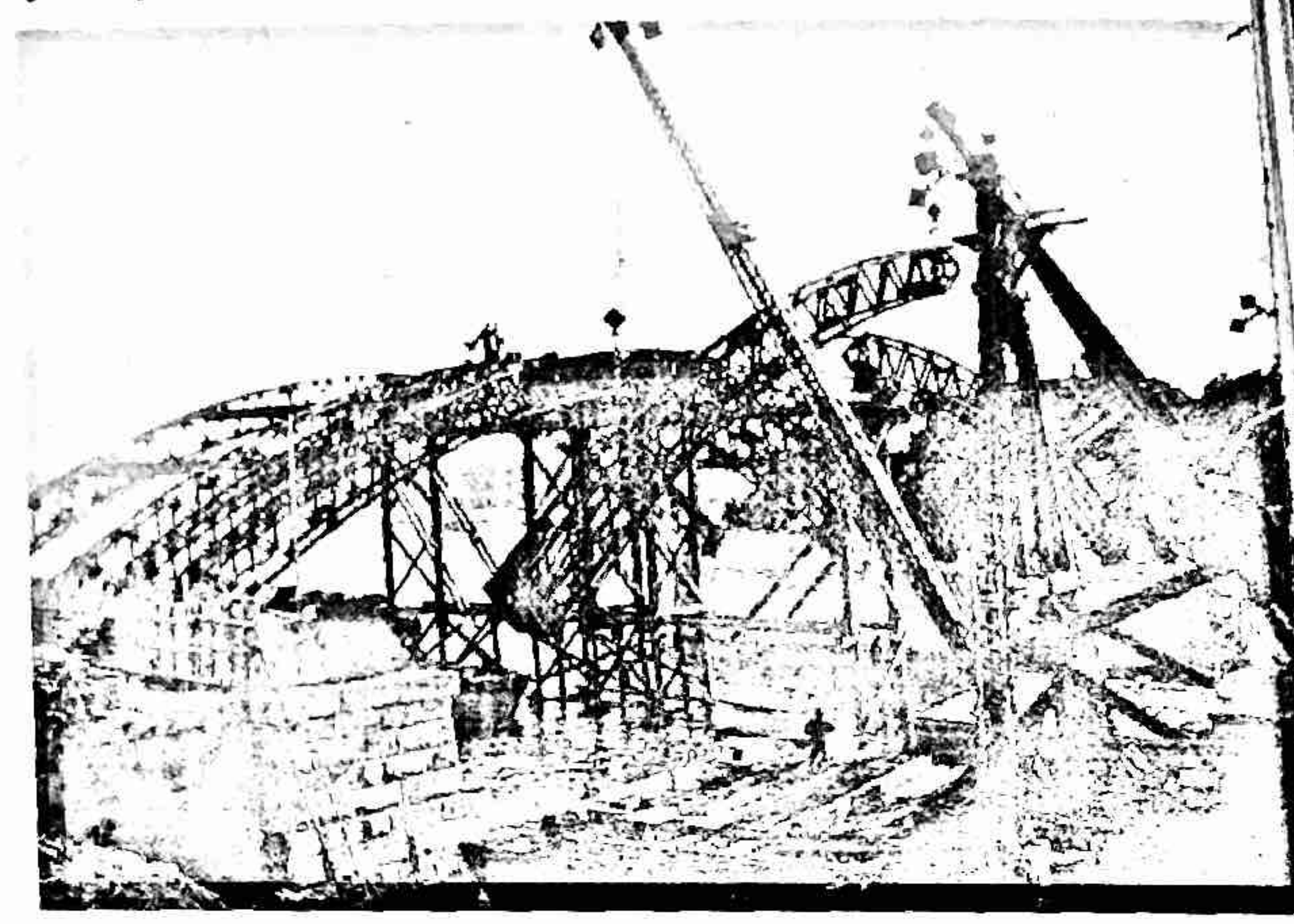
Patented by Austrian engineer Josef Melan (1854-1941) in 1893 in the U.S., the Melan system was originally a design for suspended floors and roofs in warehouses and other large span buildings. Melan, a renowned bridge engineer and professor of structural mechanics, adapted it for bridge use after testing showed that it was 3 to 4 times stronger than other bridge designs, including those using Monier's wire mesh. The system was championed in the U.S. by former Melan student Fritz von Emperger, who patented several variations, including the use of lighter latticed (trussed) ribs instead of I-beams.

Longer and wider spans, greater loads, ease and speed of construction, and economy made the Melan system popular in the U.S. The use of steel arch ribs minimized the use of concrete or masonry as in barrel arches, which reduced dead load. Concreting of the ribs added strength and stiffness. This permitted longer spans with fewer piers, and greater live loads. Further, the use of ribs to support formwork and concrete induced stresses in the ribs that allowed the more efficient use of the steel and maximized the steel's strength. With traditional reinforcement, the capacity of the steel was limited by the concrete modulus, which was typically 10 to 15 times less than that of steel.

The Melan system promoted ease and speed of construction, which meant fewer laborers, less skilled labor, and less time. Unlike concrete or masonry arches that could not be prefabricated or labor-intensive bar reinforcement, arch ribs were delivered in two or four sections ready for erection. The ribs were stable during erection with minimal support and equipment and designed to support the formwork for concrete, which was hung on the ribs. This eliminated vast amounts of falsework, which minimized the use of timber and simplified construction over terrain that threatened the stability of the falsework. Further, the system allowed multiple facets of construction to be done simultaneously; for example, ribs in one span could be concreted while ribs in another span were erected.



Bridge construction. Concrete hoisting tower (130 feet) shown. Concrete was transported from mixing plant on West Springfield side along a temporary wood trestle 70 feet upstream. Courtesy of the Lyman and Merrie Wood Museum of Springfield History.



Arch erection in span 7, Springfield side. Courtesy of the Lyman and Merrie Wood Museum of Springfield History.

As spans lengthened and live loads increased due to the growth of vehicular and street rail traffic, larger rib sections were required. To reduce increasing amounts of steel and dead load as well as pier size, I-beams were replaced with lighter latticed or trussed hinged ribs. Often, these ribs were reinforced with hoops and traditional bars. The use of hinges minimized bending stresses, temperature stresses, and stresses due to shrinkage of concrete, and made for more straightforward analysis. Crown hinges were fixed during concreting, reducing deflections of the arches.

The Melan system was an alternative to traditional reinforcement and the prevailing uncertainty about composite action, concrete quality, and construction methods. Swiss bridge engineer Robert Maillart criticized the system because the design could not rely on the bond between concrete and ribs. Maillart believed the lack of bonding would lead to separation and ultimate corrosion of steel. Moreover, as Melan bridges were overbuilt to inspire confidence, the system was surely an affront to the efficiency and elegance of Maillart's three-hinged deck-stiffened concrete arches. Also problematic was the concrete encasement of the steel, which prevented proper drainage and led to corrosion.

The Bridge

"No other bridge in the country is just like it…" boasted the bridge souvenir edition of the *Springfield Republican* in July 1922, adding "the structure will long be of interest to engineers." The bridge was "structurally and architecturally significant" and the engineering "sophisticated" [HAER MA-114].

A total of 10,500 pine piles, 20 to 40 feet in height and spaced 20 feet on center on hard clay, form the foundation for six river piers and two abutments. Under the channel span piers, there are 2,263 piles; under the smallest pier on the West Springfield (west) shore, there are 700. An average of 110 piles per day were placed with two steam-powered pile drivers. Concrete piles were used for the viaduct spans.

The hollow concrete piers support 5 arches per span. The piers, constructed using cofferdams, vary in size. The channel span piers, designed to accommodate a potential draw span per order of the Army Corps of Engineers, are the largest at 65 feet by 179 feet. Each pier has ten skewbacks – two for each arch – and does not extend above the springing. All are faced with 10 courses of cut granite from just below the water level that protects the piers from river current and winter ice flows. Dredging was done to maintain the natural flow of the river.

The arch span lengths vary from 110 to 209 feet; the span rises from 19.1 to 29.7 feet. Marked by four 80-foot beacon towers, the channel span is 176 feet in width and 40 feet above low water over 60 feet, "fixed in accordance with the requirements of the War Department" [ENR 88, 13] for all "navigation necessities" [ENR 88, 13]. The bridge is asymmetric on the river to follow deep water; that is, the channel span is the third span from the Springfield side. The two spans that flank the channel span on either side, 154 feet and 146 feet in length, are sized to give the bridge symmetry. Smaller beacon towers embellish these spans, which furthers the illusion of symmetry. The remaining two smaller spans on the West Springfield side balance the Springfield viaduct. The nine viaduct spans are equal in width.

In all arch spans, there are five parallel arches: two exterior and three interior arches, which are centered under the critical street rail load in the middle of the road deck. Each arch is a steel arched Warren truss rib encased in concrete. All arches are 5.5 feet wide but vary in height with span length, ranging from 4 feet 9 inches to 7 feet. The arches support a traditionally reinforced concrete deck on reinforced columns. The inner arches are not filled, and exterior spandrel walls hide the arches and columns to give the bridge the appearance of solid masonry.

All of the 35 steel arch ribs, each weighing between 20 and 70 tons, were initially three-hinged, transported in four sections. They were erected in only 10 days with an erection sequence designed to ensure the stability of the piers. Falsework was used to support the arches at the crowns and quarter points on the four larger spans during erection. The ribs were encased in 593 psi concrete, as compared to a working stress of 16,000 psi for the rib steel. The crown hinges were fixed after concreting, leaving the ribs as two-hinged. On the outer arches, the crown hinges were fixed before concreting; the interior crown hinges were fixed after the roadway deck was placed to offset deformations due to dead load and shrinkage. Within each span, the ribs are connected with wind bracing and reinforced with traditional bars along the arch and hoops around the rib.

Conclusion

The Melan system fell out of favor in part as steel became more expensive and less available. More so, a better understanding of cement and concrete technologies, composite behavior, and the development of uniform codes and construction methods moved structures towards more efficient and economical bar reinforcement. The system experienced a rebirth in the 1970s which continues in Japan and China, where self-supporting arches are used to construct bridge spans in mountainous regions.

As a structure, then, the Memorial Bridge was technically obsolete almost upon its execution – a harbinger of things to come for Springfield. Alterations to the bridge were made in 1950 and 1966, and it was obfuscated by the opening of an elevated viaduct in 1970. A complete rebuilding of the superstructure was completed in 1996 after extensive corrosion was discovered. An EF3 tornado rendered it unscathed in 2011, yet the recent construction of a downtown casino has cast further shadow. But the bridge will not be denied. Transcendent, it remains a vital channel and landmark in Western Massachusetts. As it nears its 100th year, it continues a touchstone for a City struggling to reclaim itself and persists in bearing witness to Springfield's illustrious past.▪

From: Brockman, Reed <Reed.Brockman@aecom.com>
Sent: Monday, March 25, 2019 5:44 PM
To: Michael Cunningham
Cc: Geoffrey Schwartz
Subject: Re: [Tiny Scanner] Doc Mar 17, 2019, 16:58

External Email.

Thanks,
Reed

Reed Brockman, PE
Associate Vice President / Senior Structural Engineer
New England Transportation
Manager & Team Leader, Bridge & Tunnel Inspections
Cell +1-617-240-7979

reed.brockman@aecom.com

AECOM
One Federal Street
Boston, MA 02110, USA
T +1-617-723-1700
AECOM.com

Built to deliver a better world

Begin forwarded message:

> From: Michelle Cheung <michelle.ann.cheung@gmail.com>
> Date: March 22, 2019 at 10:50:58 AM EDT
> To: "Brockman, Reed" <reed.brockman@aecom.com>
> Subject: Alicia DiCecca

Over more than ten years, Alicia has shown dedication towards helping youth understand and experience the world of STEM.
For the Future City Competition, Alicia has been heavily involved in the planning of the event and has held active roles on Competition Day. She's shown true dedication and reliability through her efforts from coordinating judges, scoring, to overall set-up of the day-long Competition.
For the Model Bridge Competition, every year Alicia has enthusiastically helped students prepare themselves as they compete to show off their model bridges. Similar to her commitment to Future City, she has devoted herself to making sure young students enjoy their exposure to real engineers from the community.
Alicia demonstrates genuine character in helping young students see what engineering does for our world, as well as ensures they feel welcomed to world they may be interested in.

THANK YOU, ALICIA!

Thanks,
Reed

Reed Brockman, PE
Associate Vice President / Senior Structural Engineer
New England Transportation
Manager & Team Leader, Bridge & Tunnel Inspections
Cell +1-617-240-7979

reed.brockman@aecom.com

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Built to deliver a better world

On Mar 18, 2019, at 8:14 AM, Michael Cunningham <MCunningham@kleinfelder.com> wrote:

Thanks Geoff!

From: Geoffrey Schwartz <Geoffrey.Schwartz@gza.com>
Sent: Sunday, March 17, 2019 5:10 PM
To: Michael Cunningham <MCunningham@kleinfelder.com>
Cc: Reed Brockman <Reed.Brockman@aecom.com>
Subject: Fwd: [Tiny Scanner] Doc Mar 17, 2019, 16:58

External Email.

Mike,

FYI - nomination from Reed

Geoff

Sent from my iPhone

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> I would like to nominate Beth McGinnis-Cavanaugh from STCC in Springfield for the BSCES Journalism Award. Is it too late?

Michael Cunningham

From: Brockman, Reed <Reed.Brockman@aecom.com>
Sent: Monday, March 25, 2019 6:09 PM
To: Michael Cunningham
Cc: Geoffrey Schwartz
Subject: Re: [Tiny Scanner] Doc Mar 17, 2019, 16:58

External Email.

The BSCES Public Awareness and Outreach Committee proudly nominates Suzanne Collins. Suzanne teaches at Birchland Park Middle School and has led teams in Future City since before BSCES involvement with the group. Over these years, many of her students have been part of a gifted and talented program. Suzanne has also helped other teams get involved in Future City and has invited the BSCES Outreach program into her classroom. Beyond this work, Suzanne was for years a lead organizer of First Night in Boston.

Thanks,
Reed

Reed Brockman, PE
Associate Vice President / Senior Structural Engineer
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BSCES
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2019 Individual Section Awards

Each year, BSCES presents awards to deserving individuals in the Section or in the community who are nominated by their peers in recognition of their service. Here is your opportunity to nominate a co-worker, friend, or someone who you think deserves special recognition. Please see the following awards descriptions and page 2 of this form for nomination instructions.

The Nominations Deadline is **Monday, March 11, 2019**. The Awards Committee will review all nominations and present a list of candidates for selection by the Board of Government. Awards will be presented at the 170th BSCES Annual Awards Dinner.

I would like to nominate James Kaklamanos For the:

_______ CITIZEN ENGINEER AWARD: This award is presented to a BSCES member or registered professional engineer for outstanding public involvement in local or national legislation, education (at any level), non-profit volunteer organizations, community activities, or similar activities improving the image of ASCE, BSCES and the civil engineering profession.

_______ HORNE/GAYNOR PUBLIC SERVICE AWARD: This award is presented to a BSCES member or registered professional engineer for unpaid public service in a municipal, state or federal-elected or appointed post for philanthropic activities in the public interest.

_______ GOVERNMENT CIVIL ENGINEER AWARD: This award is presented to a BSCES member who is serving as a paid public sector engineer at a federal, state, or municipal agency, department, or authority in Massachusetts.

_______ CLEMENS HERSCHEL AWARD: This award recognizes an individual who has published a paper, not necessarily published in the BSCES Journal, that has been useful, commendable, and worthy of grateful acknowledgment. If nominating for the Clemens Herschel Award, please attach the name of the paper and names of all authors, if co-authored.

_______ JOURNALISM AWARD: This award is presented to a journalist or other author who has published one or more articles, papers, books, social media blogs, or films for a non-technical audience that raises awareness of the contributions of the civil engineering profession.

_______ PRE-COLLEGE EDUCATOR AWARD: This award is presented to a member of the K-12 educational community who integrates engineering topics, particularly civil engineering, in a manner that benefits the profession and may promote students to pursue an engineering career. The Public Awareness & Outreach Committee reviews these nominations and recommends the recipient to the Board.

X COLLEGE EDUCATOR AWARD: This award is presented to a member of the academic community who inspires and encourages civil engineering students through exceptional teaching and mentorship. Educators empower students to realize full potential and exemplify the profession in their classroom. Candidates should be actively teaching in a classroom setting at a college or university in New England.

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To submit a nomination, complete this form and return it by the nomination deadline via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, The Engineering Center, One Walnut Street, Boston, MA 02108-3616, respectively.

Name and Company Address of Nominee(s)*:

James Kaklamanos - Merrimack College

315 Turnpike Street

North Andover, MA 01845

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Leyna Tobey Daytime Telephone: 207-680-0945 Email: leyna.tobey@gmail.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

Nomination Statement for Professor James Kaklamanos, Merrimack College
BSCES College Educator Award
By: Leyna Tobey, Staff Engineer, GEI Consultants; Merrimack College BSCE 2017

I enthusiastically nominate Professor Jim Kaklamanos for the BSCES College Educator Award. Professor Kaklamanos joined the faculty of the Department of Civil Engineering at Merrimack College in fall 2012, after obtaining his BSCE, M.S., and Ph.D. at Tufts University. He specializes in geotechnical engineering, and his research focuses in the area of geotechnical earthquake engineering, specifically on the improvement of models for predicting earthquake-induced ground motions. At Merrimack, Professor Kaklamanos has taught courses in geotechnical engineering, foundation engineering, earth slopes and retaining structures, seismology and earthquake engineering, mechanics of materials, and engineering probability and statistics; I had the privilege of completing three courses with him during my undergraduate career. During his first six years at Merrimack, Professor Kaklamanos served as the faculty advisor for our ASCE student chapter (for which I served as President for two years). In all these endeavors, he challenges students to realize their full potential, think like engineers, and comprehend the importance of the engineering profession. Professor Kaklamanos' teaching and mentorship has had a profound impact on my development as an engineering professional, and I offer him my strongest possible recommendation for this award.

In his courses, Professor Kaklamanos exhibits a challenging, engaging, organized teaching style in which he brings his engineering research and professional experience to his courses. He promotes a high level of student-faculty interaction inside and outside the classroom, in which he not only serves as a course instructor, but also as a laboratory instructor and grader at nearly all levels. A Kaklamanos class is never easy, but every minute of effort is worthwhile – you truly *learn*. He believes that students must understand the broader significance of the course context in order for them to retain and appreciate the material, and he often uses historical or current events to illustrate engineering concepts (for example, linking various curricular topics in his introductory geotechnical engineering course to the Hurricane Katrina levee failures). To introduce his students to real-world infrastructure projects, he organizes field trips whenever possible; for example, to a high-rise construction project in Cambridge, a highway bridge construction project on I-95 in Amesbury, and a seismic velocity field test in Providence. Above all, Professor Kaklamanos places a strong emphasis on getting to know his students, helping them discover their passions, and on making learning fun. I doubt there are many other professors who incorporate a geotechnical engineering mascot ("Soil Man") into their classes, or who teach their students a dance to learn the differences between various lateral earth pressure theories. In recognition of his dedication to engineering education, Professor Kaklamanos was named as one of the 2017 Top Ten New Faces of Civil Engineering by ASCE, and also received the ASCE ExCEEd New Faculty Excellence in Teaching Award that year.

For the past six years, Professor Kaklamanos has been my go-to for help with everything from running Merrimack's ASCE student chapter, to academic, internship, career, and graduate school advice, to writing letters of recommendation, and anything else I have ever needed. I know he has played the same role in the lives of many of his other students as well. Professor Kaklamanos is the most passionate professor I have ever had, both inside and outside of the classroom, and is truly an advocate for each of his students. For all of the reasons outlined in this letter, I believe Professor Kaklamanos is truly deserving of the BSCES College Educator Award.

Please feel free to contact me if you have any questions. Thank you for your time and consideration.

Sincerely,

Leyna Tobey

Boston Society of Civil Engineers Section
American Society of Civil Engineers

2019 Individual Section Awards

Each year, BSCES presents awards to deserving individuals in the Section or in the community who are nominated by their peers in recognition of their service. Here is your opportunity to nominate a co-worker, friend, or someone who you think deserves special recognition. Please see the following awards descriptions and page 2 of this form for nomination instructions.

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I would like to nominate Edward L. Hajduk, D.Eng, PE For the:

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BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

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Name and Company Address of Nominee(s)*:

Edward L. Hajduk, D.Eng, PE

Department of Civil and Environmental Engineering, Univeristy of Massachusetts Lowell

1 University Avenue, Lowell, MA 01854

Is this a re-nomination? Yes ____ No X

Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.

Your Name: Prade Kurup Daytime Telephone: 978-934-22 Email: Pradeep_Kurup@um

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

University of Massachusetts Lowell
Dept. of Civil & Environmental Engineering
One University Avenue
Lowell, MA 01854

Pradeep U. Kurup, Ph.D., P.E., D.GE
University Professor and Chair
Phone/Fax: (978) 934-2278 / 934-3052
E-mail: Pradeep_Kurup@uml.edu

To: The BSCES Awards Committee Date: March 15, 2019

I would like to nominate Edward L. Hajduk, D.Eng, PE, Associate Teaching Professor and an Associate Chair for Undergraduate Studies in the Civil and Environmental Engineering Department at the University of Massachusetts Lowell, for the BSCES 2019 College Educator Award. Since joining our faculty in the Spring 2011 semester, Ed has educated students by incorporating active learning, problem-based learning, technology, state of the practice engineering knowledge, and "real world" case history data into his courses. Coupled with a commitment to service learning, Ed prepares UMass Lowell civil engineering students to make a difference in the world.

Ed has been recognized for his pedagogy by both students and faculty five (5) times during his time at UMass Lowell. The Civil and Environmental Engineering Department awarded Ed their Teaching Excellence Award for both the 2010-2011 and 2014-2015 academic years. Ed was awarded the Innovations in Teaching (Service Learning) Award by the University in November 2013. Students have recognized Ed three (3) times for his teaching and mentoring efforts. Ed was awarded with both the Donald G. Leitch Award for Excellence in Teaching by the UMass Lowell American Society of Civil Engineers (ASCE) Student Chapter and the UMass Lowell Student Government Association (SGA) Exceeding Excellence Teacher Award for the College of Engineering for the 2012-2013 academic year. Ed was also awarded the University of Massachusetts Lowell Tau Beta Pi/Chi Epsilon Faculty Mentorship Award in the Spring of 2014. Students appreciate that he has weekly one (1) hour "extra study sessions" for his courses every semester.

President Theodore Roosevelt once said "Every man owes a portion of his time and his income to the business or industry in which he earns his living." Ed personifies this statement by incorporating service-learning assignments and projects into his courses and developing engineering service projects for the UMass Lowell ASCE Student Chapter. Ed worked with a UMass Lowell alumnus and the UMass Lowell College of Engineering Service Learning Coordinator to develop a service learning senior level Capstone Design course in 2013. Since then, students in Ed's S-L Capstone Design course worked with community partners to solve various problems. Projects in his Capstone Design courses have included analyzing a flooded intersection in Les Cayes, Haiti; developed preliminary designs for a 9/11 Memorial for the Massachusetts State Police; and preparing preliminary designs for a Public Safety Building for the Town of Dunstable.

Ed has used his knowledge and industry contacts to develop engineering service projects for the UMass Lowell ASCE Student Chapter. For example, Ed teamed with the Town Engineer of Lexington, Mr. John Livsey, PE, to develop the Lexington Stream Team. For this engineering service project, students are trained by Town of Lexington Engineers to sample and test stormwater outfalls throughout the town and analyze the data. This project won a 2015 New England Stormwater Collaborative "STORMY" Award. This project was so successful that the neighboring City of Woburn asked for a similar student team. Both the Lexington and Woburn projects are ongoing. Other current UMass Lowell ASCE engineering service projects include analyzing playground flooding for the Brackett Elementary School in Arlington; conducting intersection analysis for the Town of Tewksbury; and teaching engineering to the Greater Lowell Boys and Girls Club. Ed's community service work led to him being awarded the 2015 BSCES Citizen Engineer Award. The UMass Lowell ASCE Student Chapter, to which Ed is the faculty advisor, has been recognized with Letters of Recognition for Community Service from ASCE in 2017 and 2018. Ed is firmly committed to involvement with students outside the classroom, as he believes that extracurricular activities reinforce engineering knowledge while providing opportunities to acquire or enhance soft skills not traditionally developed within the classroom environment.

Ed's dedication to educating his students by having them assist their community through applied engineering is exemplary. This devotion reflects distinct credit on him, the University of Massachusetts Lowell, and the Civil Engineering Profession. In my opinion, Ed is an excellent candidate to 2019 Boston Society of Civil Engineers Section (BSCES) College Educator Award. If you need further information, please feel free to contact me by email or at the address and phone number listed above.

Sincerely yours,

UPK Pradeep Kurup

Dr. Pradeep U. Kurup, Ph.D., P.E., D.GE
Professor and Chairman of Civil and Environmental Engineering & Distinguished University Professor

2019 Individual Section Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

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Name and Company Address of Nominee(s)*:

Gregory Mirliss, AECOM
One Federal St, 8th Floor
Boston, MA 02110

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Megan McMorris Daytime Telephone: 857-383-3837 Email: megan.mcmorris@aecom.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

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Name and Company Address of Nominee(s)*:

Gregory Mirliss

AECOM's Bridge and Tunnel Inspection Team

1 Federal Street, Boston, MA 02110

Is this a re-nomination? Yes ______ No X

***Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.**

Your Name: Sandra DiBacco Daytime Telephone: 508-498-6011 Email: sandydibacco@yahoo.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

Sandra DiBacco
51 Cleveland Street
Norfolk, MA 02056
508-498-6011

March 7, 2019

BSCES Awards Committee
Boston Society of Civil Engineers Section/ASCE
The Engineering Center
One Walnut Street
Boston, MA 02108-3616

RE: GREGORY MIRLISS

To Whom It May Concern:

I am nominating Gregory Mirliss for the following reasons:

Gregory Mirliss is a Deputy Project Manager and Coordinating Team Leader for AECOM's Bridge and Tunnel Inspection Team and the Boston Office Safety Representative. He has been inspecting the infrastructure of Boston and beyond since graduating from Wentworth Institute of Technology in 2007. As a member of AECOM's inspection program, Gregory handles all logistics and coordination efforts in ensuring the bridges and tunnels are inspected effectively and efficiently. Gregory also recently completed his MBA at Suffolk University.

Since 2013, Gregory has been an active member of BSCES serving in multiple positions and actively working to grow and improve BSCES. He was instrumental in bringing structure and fiscal responsibility to the Public Awareness and Outreach (PA&O) Committee. While continuing to serve as the treasure of the PA&O committee, Gregory took on the added responsibility of serving as BSCES Assistant Treasurer (AT). As AT he worked on reviewing all expenses and ensuring that BSCES financial policies were being followed. Additionally, he was an active member of the Board and Ex-Com, working on several initiatives.

After serving as AT for three years he ascended to the position of Treasure. Since taking the role, Gregory has been active in working to address short comings in the financial policies and by-laws. In addition to BSCES, Gregory has been an active member of MEARE/MA AEER since its inception in 2013 with its initiative to have the Good Samaritan Law passed, then working to build a relationship with MEMA.

Beyond his work with AECOM and BSCES, Gregory is active in the community, serving at different time on committees and in leadership positions with the Boy Scout of America, Town Government, at his alma mater's, and with his own foundation in memory of his late father Gary Mirliss.

I truly believed that Greg Mirliss would be the best nominee for this award.

Thank you for your consideration. If you have any further questions, please do not hesitate to contact me.

Very truly yours,

Sandra M. DiBacco

Sandra M. DiBacco

BSCES Leadership Positions Held:
June 2013-June 2018 – Treasure of the Public Awareness and Outreach Committee
June 2015- June 2018 – Assistant Treasure
June 2018 - Present – Treasure

Active Participation with BSCES Committees/Groups:
Public Awareness and Outreach Committee 2011-Present
Engineering Management Group 2017-Present
Government Affairs and Professional Practice Committee 2011-2018

Honors:
- December 2000 - Eagle Scout
- 2018 AECOM Making A Difference Pinnacle Award - for contributions to the New England Structural Department
- 2018 AECOM Making a Difference – for contributions to the Northeast Safety, Health, and Environment Team
- 2016 ASCE Thank a Volunteer, Boston Section recipient "Engineers Make a World of Difference" Recognition
- 2015 AECOM Making a Difference – for contribution to the New England Bridge Inspection Practice
- 2015 ACEC Nominee for Young Professional of the Year Award
- 2013 AECOM Citizen of the Year – for taking initiative in leading and organizing a blood drive following the Boston Marathon Bombing

Community Involvement:
- Troop 80 Trust, Board Member, Fall 2016 - Present
- Troop 80 Assistant Scout Master and Eagle Scout Coordinator, 2008 - 2014
- Sever Rivers District, Old Colony Council, BSA, Unit Commissioner, 2009-2015
- Suffolk University Graduate Business Association, President April 17- May 18; Past President May 18-Dec. 18; Lunch with a Leader Coordinator Jan. 17 – May 18
- Wentworth Institute of Technology, CEPAC, Member Oct. 2016 – Pres.
- American Corporate Partners (ACP) Mentor 2015-2016
- Norfolk Public Safety Building Committee 2009- Present
- Norfolk Planning Board, Associate Member June 2009- June 2011 & May 2012 - Jan. 2014, Clerk – June 2011- May 2012
- Norfolk Economic Development Committee (EDC) Sept. 2008 – Jan. 2014
- Norfolk, MA 9/11 10th Anniversary Memorial Service and Dedication, Program Director
- Gary Mirliss Memorial Foundation, Vice Chairman and Co-Founder 2004 – Present

March 11, 2019

Board of Governors
BSCES
Via e-mail :bsces@engineers.org

YOUNGER MEMBER AWARD NOMINATION FOR GREGORY MIRLISS

I would like to nominate a friend whom I believe meets - and likely exceeds - requirement s, and deserves special recognition for your BSCES Younger Member Award.

Gregory Mirliss is an exceptional young man. He is a talented and dedicated civil engineering professional who has been extremely active in all phases of his career. While working long full-time hours, he advanced his outstanding academic achievements and obtained his MBA; served on a variety of professional, charitable and municipal committees; and for the last 15 years has successfully managed a foundation in memory of his father, who died at a very early age.

Although I am not a member of the engineering profession, I know Gregory has been extremely active by serving on many boards and committees of many professional organizations, including BSCES. I've known him his whole life and I know how committed he is and how much time and effort he puts forth into each of these committee opportunities. I trust his resume will outline specifics of the many professional organizations and committees to which he has provided his time and expertise. Gregory has also received a number of special honors during the last five years, most of which fall under the purview of engineering related activities. I cannot imagine that many of his colleagues have earned such recognition so early in their careers.

As a teenager, Gregory earned his Eagle Scout designation. That tells us that his commitment and dedication to excellence started at a very early age – and it continues today. It was a terrific stepping stone. He also has not been shy about lending his expertise to a variety of his hometown municipal committees, including public safety, planning board, end economic development.

Gregory is proud to be a member of the engineering profession. I can attest that, even in social situations, he extolls on the satisfaction he receives from his daily work, efforts that he knows contribute toward the improvement of the Boston and surrounding areas' infrastructure, resulting in a safer environment for us all.

Gregory is intelligent, talented, high-energy and a "good guy". I cannot imagine anyone being more deserving of such an award sponsored by the profession about which he is so passionate.

Please do not hesitate to contact me with any follow-up questions you may have.

Sincerely,

Carl R. Abramson
339-364-0307 (cell)
crabramson@gmail.com

Boston Society of Civil Engineers Section
American Society of Civil Engineers

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Name and Company Address of Nominee(s)*:

Gregory Mirliss, AECOM

One Federal St, 8th Floor

Boston, MA 02110

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Megan McMorris Daytime Telephone: 857-383-3837 Email: megan.mcmorris@aecom.com

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Gregory is a deserving young member of BSCES. He is very engaging and cares about the activities that he becomes involved in. He is always willing to help no matter what the task is and will see the task through to completion. His passion for engineering is seen throughout his daily work at AECOM where he strives to succeed. In addition to engineering, Gregory has taken the initiative to learn all aspects of the business including finance, marketing and project management. In addition to his success at AECOM, he is using his talents to make a difference in his community by serving on multiple boards and commissions. For these reasons, I am nominating Gregory for the young member award in recognition of his contribution to engineering and outstanding leadership.

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BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

2019 Individual Section Awards

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Name and Company Address of Nominee(s)*:

Gregory Mirliss, AECOM
One Federal St, 8th Floor
Boston, MA 02110

Is this a re-nomination? Yes ________ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Megan McMorris Daytime Telephone: 857-383-3837 Email: megan.mcmorris@aecom.com

NOTE: *If you nominated someone last year who was not selected, you may re-nominate the individual(s).*

QUESTIONS: *Contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.*

Gregory Mirliss' Qualifications for Nomination

Gregory Mirliss is one of the hardest working coworkers I have at AECOM. Gregory is a Deputy Project Manager and Coordinating Team Leader for AECOM's Bridge and Tunnel Inspection Team and our local offices Safety Representative. He has had 12 years of experience inspecting infrastructure of Boston and beyond since graduating Wentworth in 2007. In addition to the amount of work he does in our office Gregory also recently completed his MBA at Suffolk University.

Gregory has been an active leader at AECOM as well as an active member of the BSCES. He has served multiple positions within BSCES, including treasure of the PA&O committee, BSCES Assistant Treasurer, and then BSCES Treasurer. In addition to BSCES, Gregory has been an active member of MEARE/MA AEER since its inception in 2013 with its initiative to have the Good Samaritan Law passed, then working to build a relationship with MEMA.

Beyond his involvement with the BSCES and AECOM he is also active in the community, serving at different times on committees and in leadership positions with the Boy Scout of America, Norfolk Town Government, and with his own foundation in memory of his late father Gary Mirliss.

Below are some of some of Gregory's additional community involvement:

- Troop 80 Trust, Board Member, Fall 2016 - Present
- Troop 80 Assistant Scout Master and Eagle Scout Coordinator, 2008 - 2014
- Sever Rivers District, Old Colony Council, BSA, Unit Commissioner, 2009-2015
- Suffolk University Graduate Business Association, President April 17- May 18; Past President May 18-Dec. 18; Lunch with a Leader Coordinator Jan. 17 – May 18
- Wentworth Institute of Technology, CEPAC, Member Oct. 2016 – Pres.
- American Corporate Partners (ACP) Mentor 2015-2016
- Norfolk Public Safety Building Committee 2009- Present
- Norfolk Planning Board, Associate Member June 2009- June 2011 & May 2012 - Jan. 2014, Clerk – June 2011- May 2012
- Norfolk Economic Development Committee (EDC) Sept. 2008 – Jan. 2014
- Norfolk, MA 9/11 10th Anniversary Memorial Service and Dedication, Program Director
- Gary Mirliss Memorial Foundation, Vice Chairman and Co-Founder 2004 - Present

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Name and Company Address of Nominee(s)*:

Gregory Mirliss, AECOM
One Federal St, 8th Floor
Boston, MA 02110

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Megan McMorris Daytime Telephone: 857-383-3837 Email: megan.mcmorris@aecom.com

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Name and Company Address of Nominee(s)*:

Mott MacDonald

400 Blue Hill Drive, Suite 100 (North Lobby)

Westwood, MA, 02090

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Nate Rosencranz Daytime Telephone: 203 451 6892 Email: nlrosencranz@transystems.com

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Stephen Taylor CBE

On January 12th 2019 SEI Boston lost one of its longtime members. Steve Taylor had been a dedicated volunteer for SEI Boston (formerly the BSCES Structural Group) for the past 15 years including serving as the Committee's Clerk, Vice Chair and Chair. He continued being an active member on the Committee up until his passing where he was always regarded as a leader, friend, and mentor.

Steve was greatly appreciated for his commitment, technical excellence, high energy, and very dry wit, always delivered in his low-key British way. He was a highly regarded colleague to everyone and his participation was greatly appreciated at meetings and in all of the volunteer work he did.

Steve also volunteered for ACEC, serving as a long time member and Chair of ACEC/MA's Engineering Excellence Awards Committee. Having served for so long, the Committee granted him the title Chair Emeritus.

Outside of volunteering, Steve was a Senior Vice President for Mott MacDonald working out of their Boston office. One of Steve's most notable contributions to the profession included managing the Central Artery Project (The Big Dig) for Mott MacDonald, which won many awards and contributed to Steve being awarded a CBE (Commander of the British Empire).

Steve is survived by his wife Marijke, his daughters Jennifer, Stephanie, and Katie, his son Antony, and his grandson Nate. Steve will be greatly missed by all that knew him.

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Name and Company Address of Nominee(s)*:

Walsh Construction Company - Sr PM Vincent Alley (312) 656-1285

100 River Ridge Drive

Norwood MA 02062-5030

Is this a re-nomination? Yes ______ No X

**Please attach a brief (no more than one page) explanation of the candidate's qualifications for nomination.*

Your Name: Rich Maher Daytime Telephone: 617-974-88 Email: rich@perryassociate

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COMM AVE BRIDGE

REPLACEMENT PROJECT

massDOT
Massachusetts Department of Transportation

Legislative Briefing

April 24, 2018

massDOT
Massachusetts Department of Transportation

Agenda

- Introduction to Project Team
- Project Description
- Schedule
- Impacts
- Communication/Public Outreach

COMM AVE BRIDGE REPLACEMENT PROJECT

Project Team

Contractor

- Walsh Construction

Design Team

- HDR – Lead
- City Point Partners, LLC
- Fort Hill Infrastructure Services, LLC
- Harris Miller Miller & Hanson, Inc.
- Kleinfelder, Inc.
- LTK Engineering Services
- McMahon Associates Inc.
- Nitsch Engineering, Inc.
- Regina Villa Associates, Inc.
- RM Engineering, Inc.

MassDOT Highway Division

- District 6 Construction
- Traffic/Safety

MBTA

- Subway, Bus, and Railroad Operations
- Power Department
- Track Department
- Safety Department
- Police
- Capital Delivery
- Keolis

massDOT Massachusetts Department of Transportation

Project Location

Background

- The bridge carries traffic on Commonwealth Avenue and the MBTA's Green Line over I-90 as well as the MBTA Commuter Rail and Amtrak train tracks in Boston.
- The bridge was originally constructed in 1965 and is structurally deficient.
- The eastbound side of the bridge was replaced during the summer of 2017.
- The westbound side of the bridge will be replaced this summer.

About the Project

- $110 million project that is scheduled to be fully completed in the spring of 2019.

- The project uses **Accelerated Bridge Construction (ABC)** to replace the superstructure over two intensive construction windows:
  - **Summer 2017** (eastbound portion of the bridge) - ***complete***
  - **Summer 2018** (westbound portion of the bridge)

The Summer 2018 construction window will occur from **July 26 – August 11** (15 ½ days).

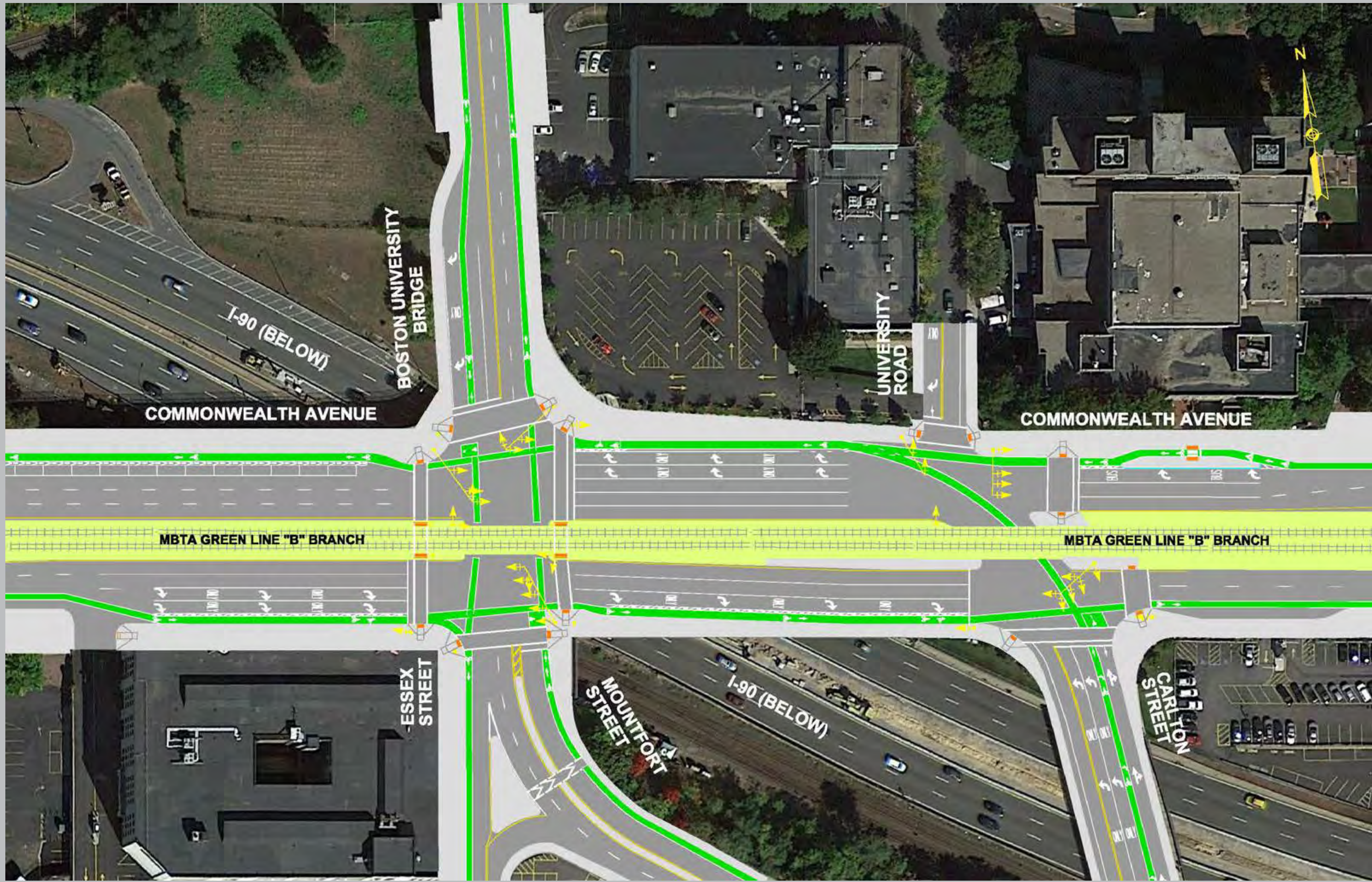
Benefits of Time Period

- Traffic volumes on I-90 are lowest during late July/early August.
- Green Line ridership is at its lowest in late July/early August.
- This construction window impacts the same number of Red Sox games as last year – and these impacts were well managed as a result of coordination with the MBTA and public outreach.
- I-90 at full capacity during July 4 celebrations and will be re-opened to full capacity prior to Labor Day.

COMM AVE BRIDGE REPLACEMENT PROJECT

Project Benefits

- New bridge that is expected to last approximately 75 years
- New bicycle and pedestrian accommodations, including bicycle lanes and dedicated traffic signals
- Increased safety and improved travel throughout this intersection and the local area
- New MBTA Green Line tracks



massDOT Massachusetts Department of Transportation

COMM AVE BRIDGE REPLACEMENT PROJECT

Summer 2017 Highlights

- Successfully replaced the eastbound side of the bridge in approximately 3 weeks.
- Managed impacts to local community and the region.
- Traveling public made smart decisions.

massDOT
Massachusetts Department of Transportation

Summer 2018 Construction

- In 15 ½ days, crews will replace the westbound side of the Commonwealth Avenue Bridge.
- Over 200 workers are expected to work around the clock.
- Crews will utilize three 600-ton cranes.
- The westbound side of the bridge will be constructed with 45 steel beams and 214 pre-fabricated concrete deck panels.

COMM AVE BRIDGE REPLACEMENT PROJECT

2018 Project Schedule

July 26 – August 11

Facility	Impacts	Notes
Commonwealth Avenue (Packard's Corner to Kenmore)	Closed to through motor vehicles for 15½ days	*Two-way access will be maintained for local businesses and residents, MBTA buses, emergency services, pedestrians, and bicyclists. There will be no access for private vehicles between St. Paul and St. Mary's Streets.*
Boston University (BU) Bridge	Closed to motor vehicles and buses for 15½ days	*Two-way access will be maintained for pedestrians and bicyclists.*
MBTA Bus Routes (CT2 and 47)	Detoured from normal routes for 15½ days	*Detour maps are available on the project website.*
MBTA Green "B" Line (Blandford St. to Babcock St.)	Closed from Blandford St. to Babcock St. for 15 days	*Shuttle bus service will run between Blandford St. and Babcock St.*
I-90 (Mass Turnpike)	Lane reductions and ramp closures for 9½ days	*Two lanes in each direction during peak periods. The I-90 Eastbound on-ramp from Cambridge Street/Soldiers Field Road will be closed during this entire period. The I-90 Westbound Exit 20 off-ramp to Brighton/Cambridge will also be closed intermittently.*
MBTA Commuter Rail (Framingham/Worcester Line)	Service impacts for two weekends: July 28-29 and August 4-5	*Shuttle bus service will replace trains on weekends. Details regarding bus diversions are being finalized.*
Amtrak (Lake Shore Limited Line)	Service impacts for two weekends: July 28-29 and August 4-5	*Shuttle bus service from Albany, NY to Boston.*

massDOT Massachusetts Department of Transportation

COMM AVE BRIDGE
REPLACEMENT PROJECT

2018 vs. 2017

Facility	2018 Impacts	2017 Impacts
Commonwealth Avenue	Closed to vehicles for 15 ½ days (July 26th 7 p.m. – Aug 11th 5 a.m.)	*Closed to vehicles for 20 days*
BU Bridge	Closed to vehicles for 15 ½ days (July 26th 7 p.m. – Aug 11th 5 a.m.)	*Closed to vehicles for 20 days*
I-90	Traffic Shifted for 9 ½ days (July 27th 9 p.m. – Aug 6th 5 a.m.)	*Traffic shifted for 9 ½ days*
MBTA Green Line B-Branch	Bus diversions for 15 days (July 27th 5 a.m. – Aug 11th 5 a.m.)	*Bus diversions for 20 days*
MBTA Commuter Rail (Worcester Line)	Bus diversions on 2 weekends (Jul 28– Jul 29 and Aug 4 – Aug 5)	*Bus diversions on 2 weekends*
MBTA Bus Service	Expanded detours to the CT2 and 47 routes for 15 ½ days (July 26th 7 p.m. – Aug 11th 5 a.m.)	*Bus detours for 20 days*
Amtrak Train Service	Bus diversions on 2 weekends (Jul 28th – Jul 29th and Aug 4th – Aug 5th)	*Bus diversions on 2 weekends*

What's different in 2018?

- 15 ½ days of intensive work compared to 20 days in 2017
- I-90 will not be reduced from 4 to 3 lanes throughout the month of July
- The BU Bridge will be closed to all vehicular traffic including MBTA buses meaning expanded detours
- There will be minimal MBTA track work

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COMM AVE BRIDGE
REPLACEMENT PROJECT

2018 Project Schedule

	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
	July 26	July 27	July 28	July 29	July 30	July 31	Aug 1	Aug 2	Aug 3	Aug 4	Aug 5	Aug 6	Aug 7	Aug 8	Aug 9	Aug 10	Aug 11
Comm Ave CLOSED to through motor vehicles	7:00 PM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5:00 AM
BU Bridge CLOSED to motor vehicles	7:00 PM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5:00 AM
MBTA CT2 & 47 Detours	7:00 PM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5:00 AM
MBTA Green B Line Bus Diversion		5:00 AM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5:00 AM
I-90 Lane Restrictions		9:00 PM	X	X	X	X	X	X	X	X	X	5:00 AM					
Commuter Rail Bus Diversion			X	X						X	X						

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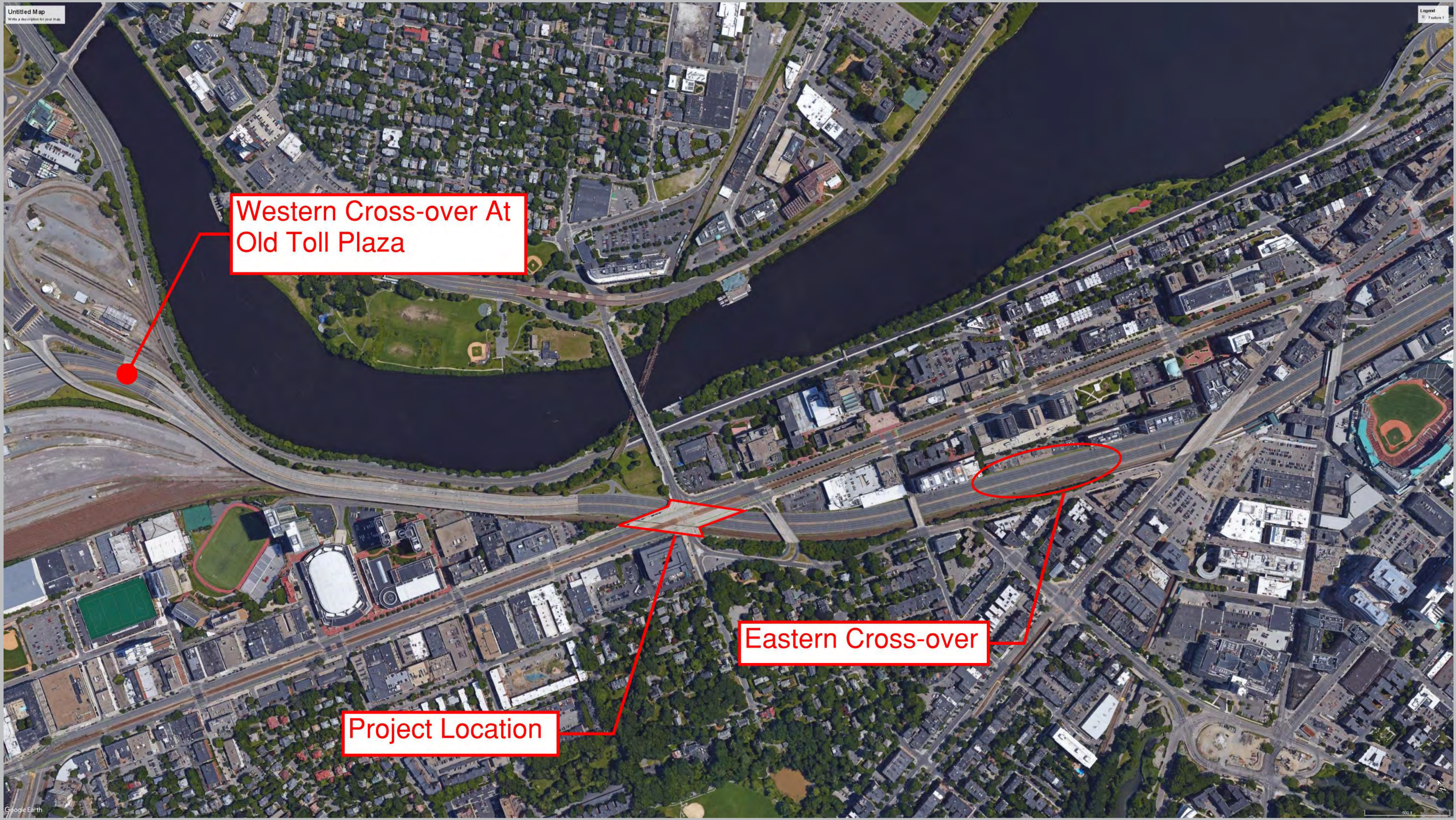
COMM AVE BRIDGE REPLACEMENT PROJECT

I-90 Impacts

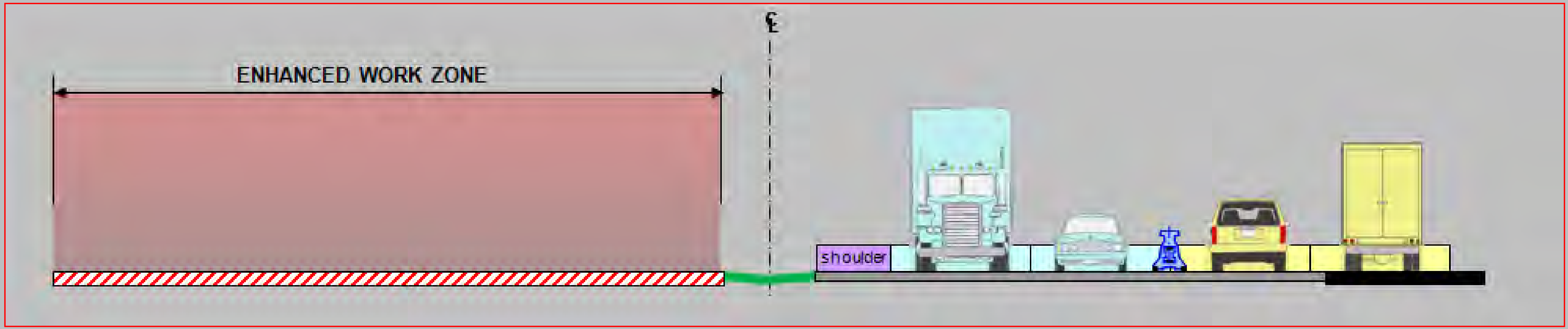
I-90 Crossover



Limits of the crossover are Allston/Brighton Toll Plaza and Beacon Street Overpass (~6600 feet)

Use of Movable Barrier

- Similar to the HOV Zipper Lane on I-93



COMM AVE BRIDGE
REPLACEMENT PROJECT

I-90 Dry Run (Weekend of June 1)

- I-90 will be restricted from 4 lanes to 2 lanes in each direction beginning 9:00 PM on Friday, June 1
- The I-90 Eastbound on-ramp from Cambridge Street/Soldiers Field Road will be closed during this entire period
- The I-90 Westbound Exit 20 off-ramp to Brighton/Cambridge will be closed intermittently
- I-90 will reopen to 4 lanes by 5:00 AM on Sunday, June 3

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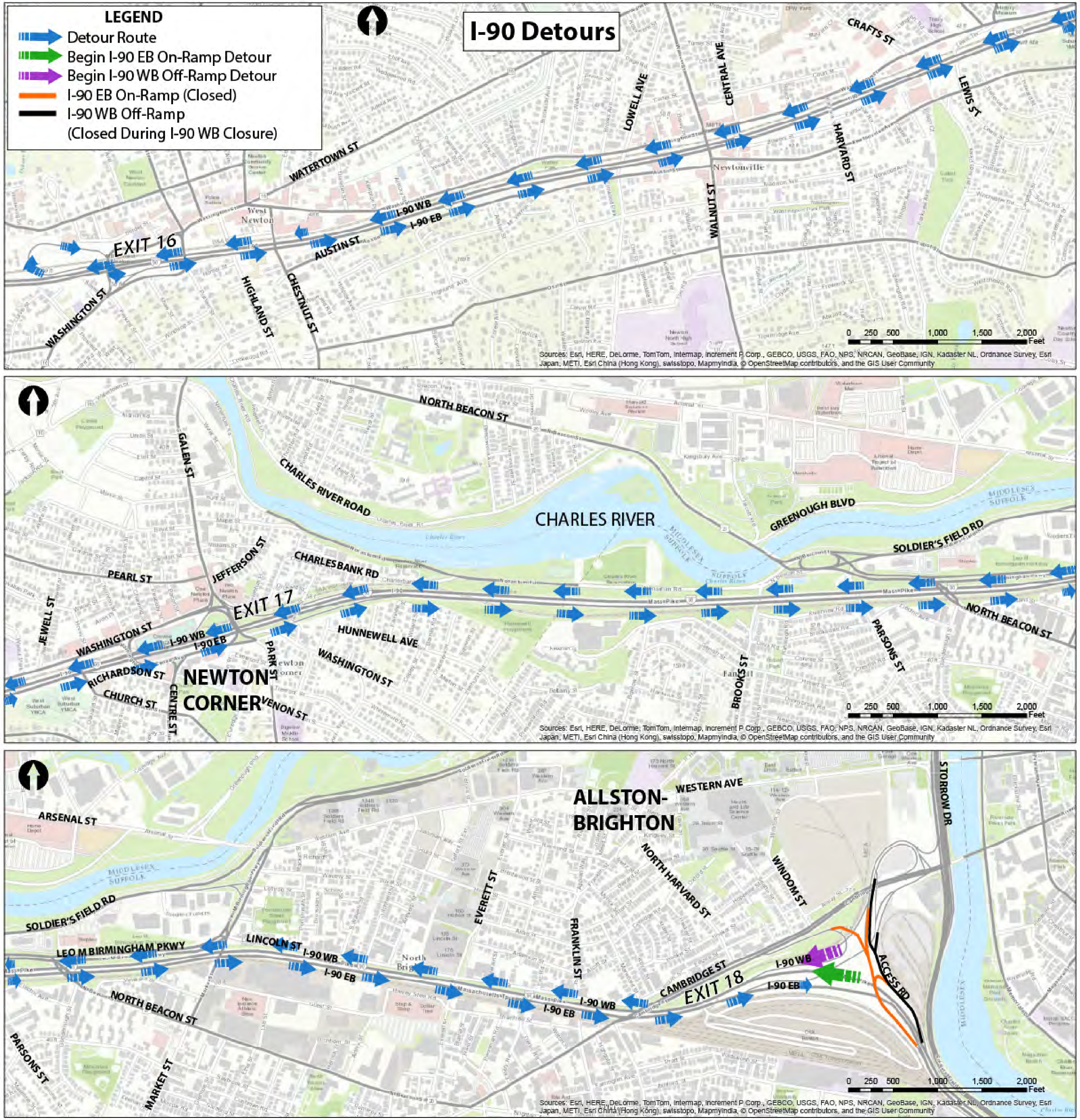
I-90 Impacts During Shutdown

State troopers escorting contraflow traffic during Dry Run

- I-90 will be reduced to 2 lanes in both directions **from 9:00 PM on July 27 to 5:00 AM on August 6** (*with additional lane closures during off-peak hours)*
- The **I-90 Eastbound on-ramp from Cambridge Street/Soldiers Field Road** will be closed during this entire period and the **I-90 Westbound Exit 20 off-ramp to Brighton/Cambridge** will also be closed intermittently during this timeframe
- The eastbound lane reductions will begin in advance of the Allston Interchange
- Westbound lane reductions will begin at the on-ramp from Mass Ave

COMM AVE BRIDGE
REPLACEMENT PROJECT



I-90 Ramp Closures Detour

In effect from 9:00 PM on July 27 to 5:00 AM on August 6

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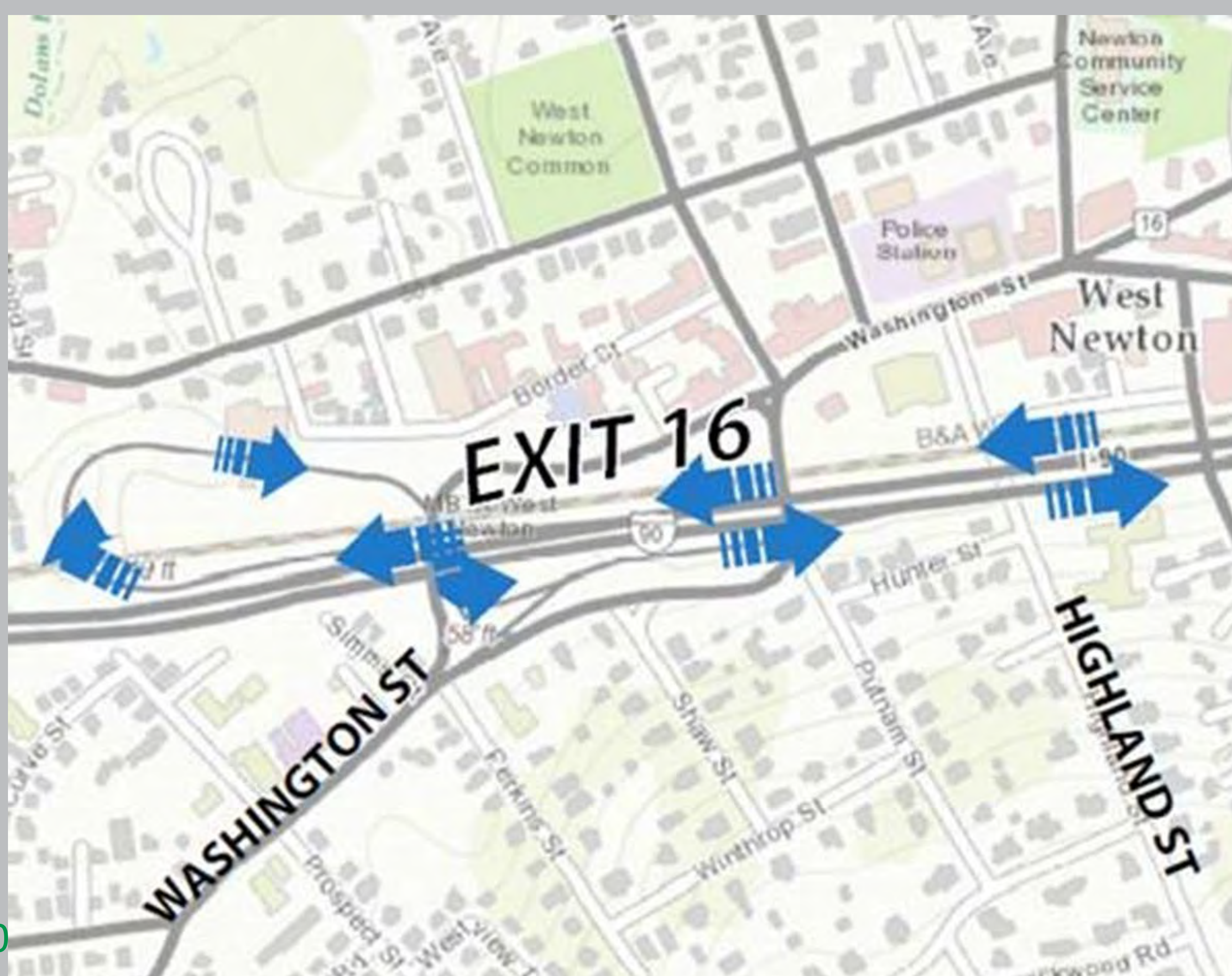
I-90 Ramp Closures Detour



I-90 Eastbound On-Ramp from Cambridge Street Closure:
Use the I-90 westbound on-ramp to continue onto I-90 westbound. Take Exit 16 (Route 16 West Newton/Wellesley) and follow signs to access I-90 eastbound.

I-90 Westbound Exit 20 Closure:
From I-90 westbound, continue to Exit 16 (Route 16 West Newton/Wellesley) and follow signs to access I-90 eastbound. Continue on I-90 eastbound to Exit 18 (Brighton/Cambridge) and use the eastbound off-ramp to exit onto Cambridge Street.

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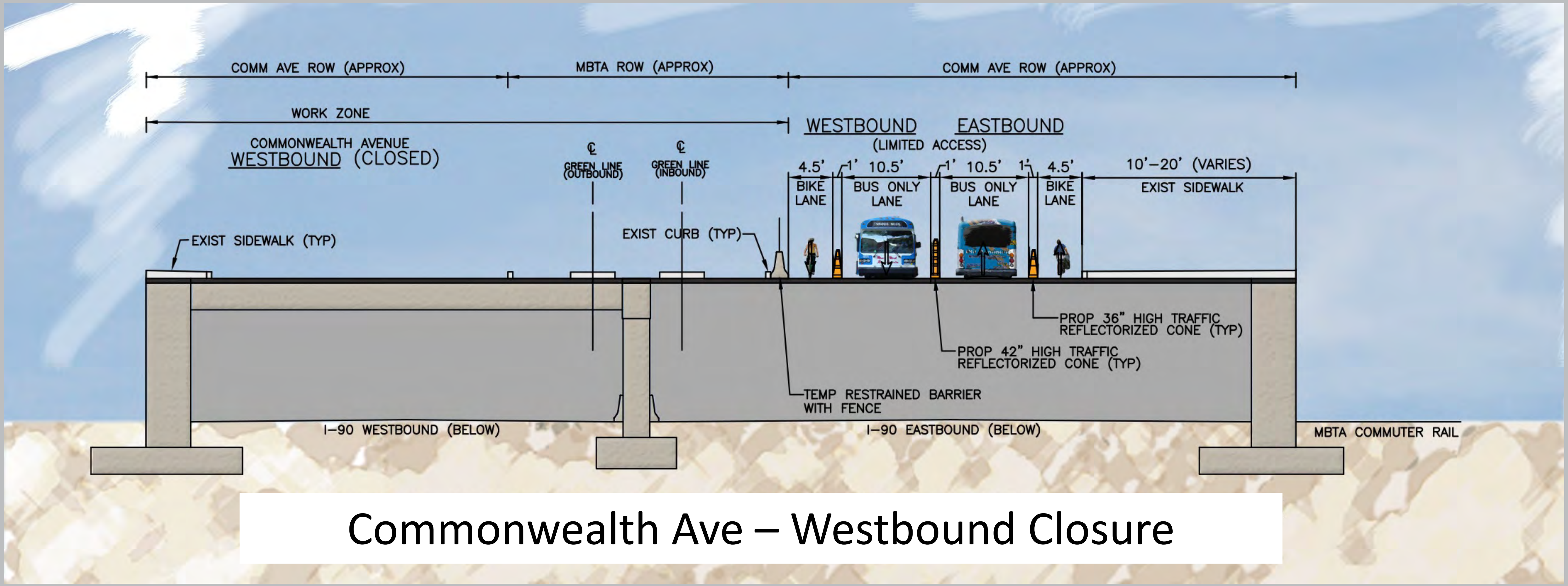
Commonwealth Avenue/ BU Bridge Impacts

COMM AVE BRIDGE
REPLACEMENT PROJECT

Commonwealth Ave

Restricted access from Packard’s Corner to Kenmore Square

- Maintain access in two-directions for buses/emergency vehicles
- Maintain access for pedestrians, bicycles, abutters, local business



Commonwealth Ave – Westbound Closure

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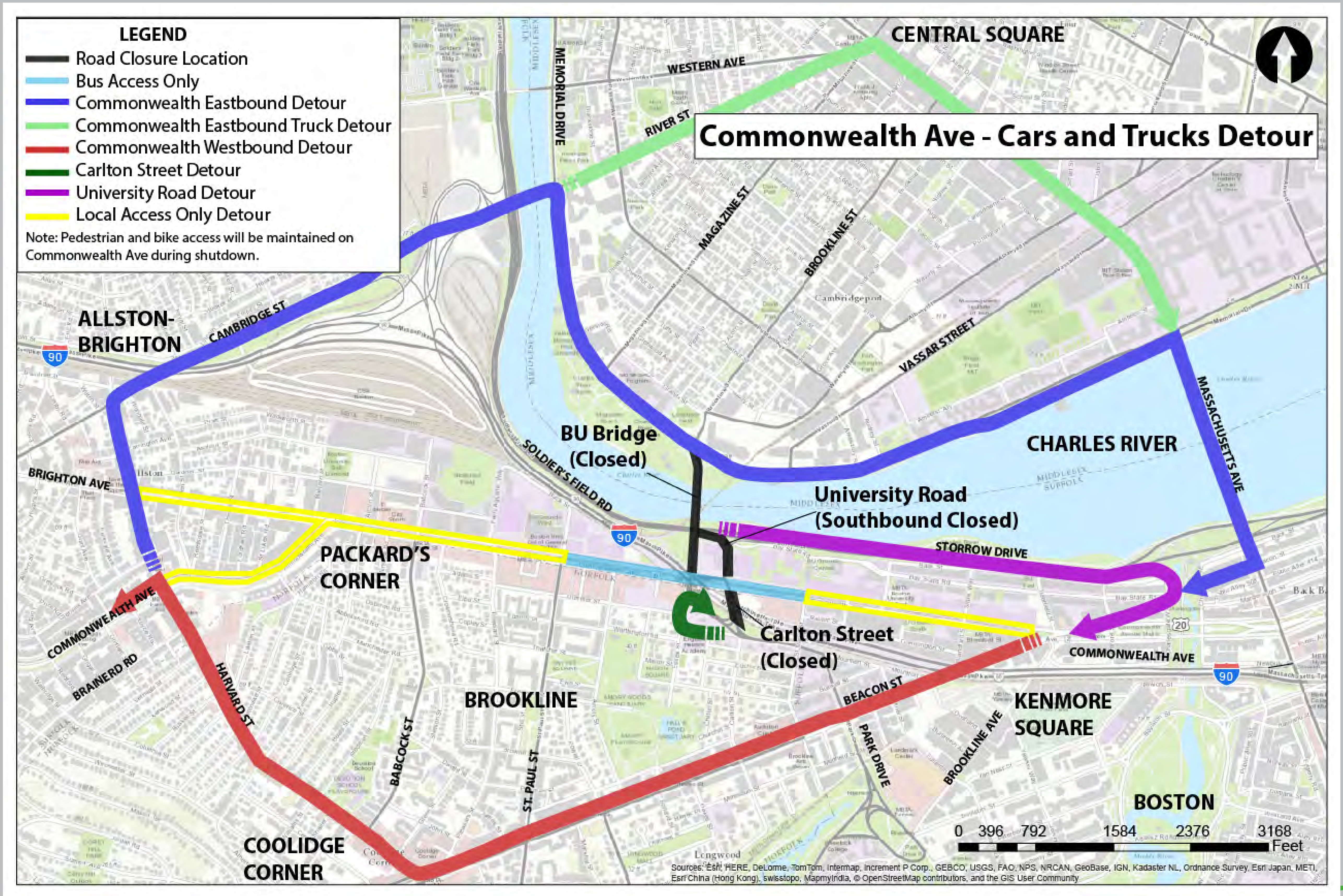
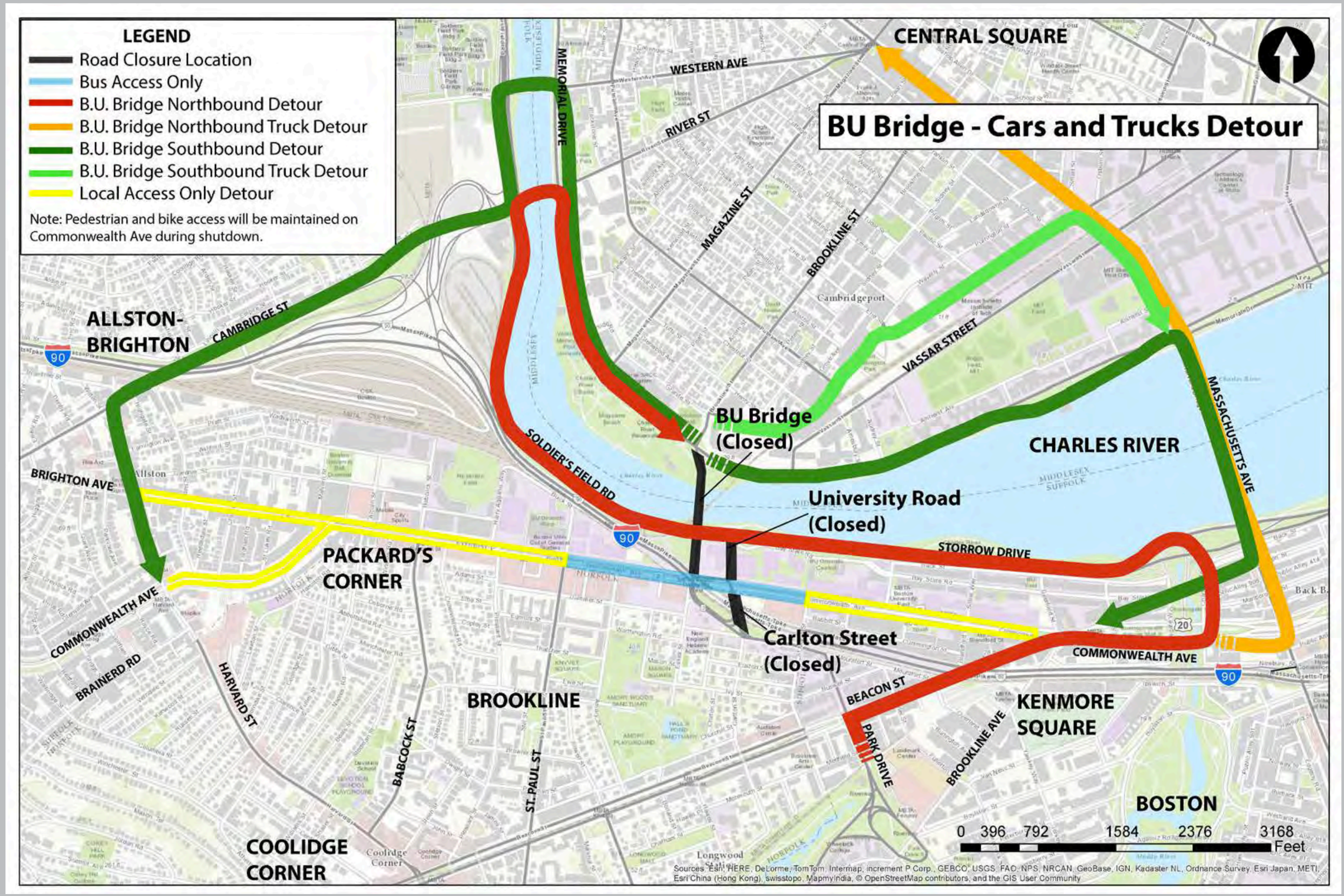
Vehicle Detours



BU Bridge

Beginning Thursday, July 25 at 7:00 PM:

- Closed to vehicles
- Access is restricted to only pedestrians and bicycles



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Encouraging Walking/Biking

- MassDOT/MBTA plans to utilize pedestrian and bicycle wayfinding signage to encourage active transportation, especially for short trips
- This will help optimize shuttle bus operations by shortening bus wait times and headways
- The Project Team is also partnering with Hubway to provide additional bike service along Comm Ave

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COMM AVE BRIDGE
REPLACEMENT PROJECT

MBTA Service Impacts

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Green Line – B Line Service

Beginning Fri, July 27 at 5:00 AM for 15 days

- Light Rail Service terminates at Babcock Street Station and Blandford Street Station
- Replacement shuttle bus service
- Police details and Customer Service personnel at stations
- Route 57 bus will make most of the same stops

Regular light rail service commences at 5:00 AM on Saturday, August 11 - BACK ON TRACK

Goal: Provide the best possible transportation options during the construction period

MBTA Commuter Rail Framingham/Worcester Line

Service impacts for two weekends: **July 28-29** and **August 4-5**

- Normal weekday operations (maximum capacity) under flag operations
- Details regarding bus diversions are being finalized.

Amtrak Lakeshore Line:

- No service disruptions on weekdays.
- Two weekends: July 28-29 and August 4-5. Shuttle bus service will run between South Station and Albany, NY.

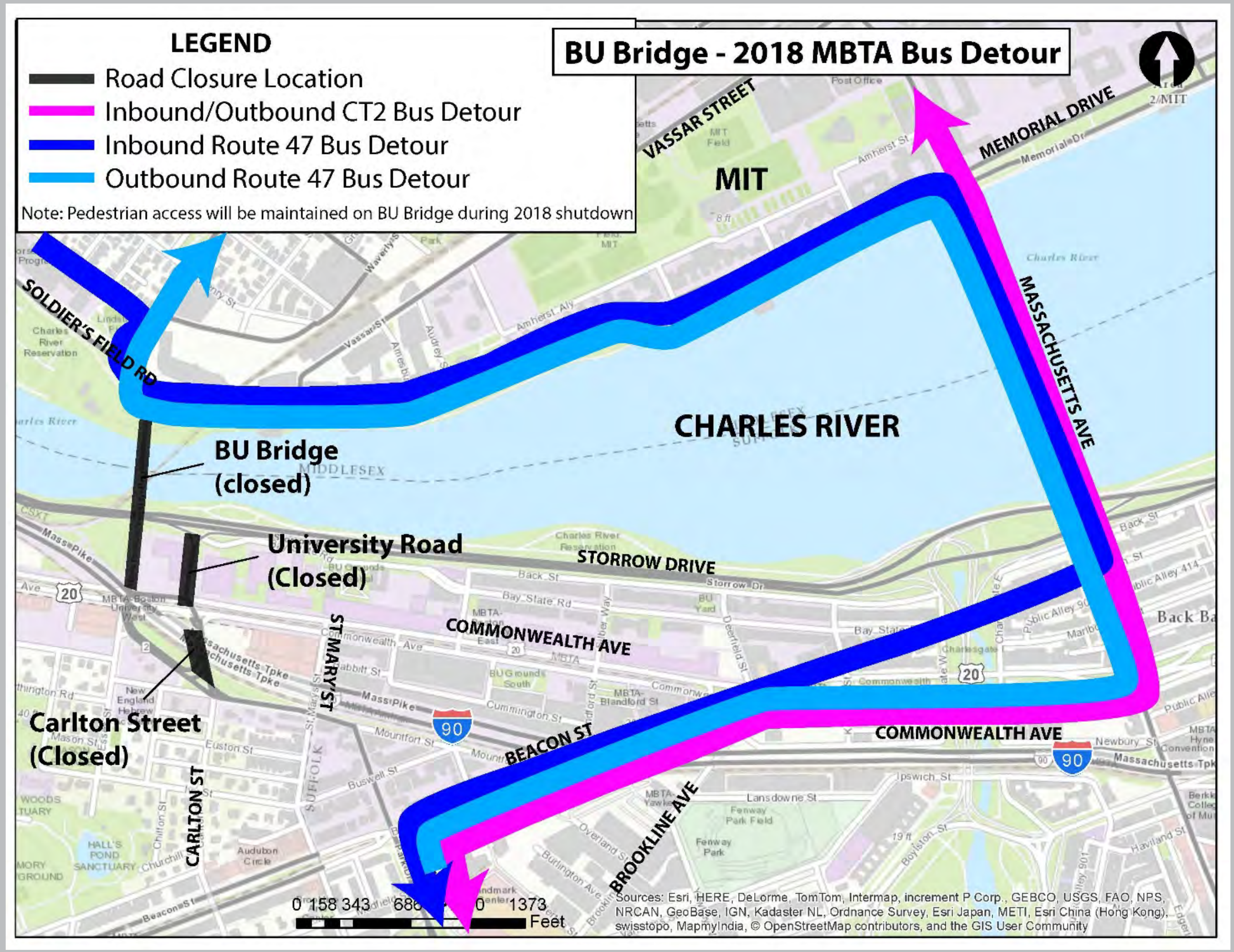
Parking lots at stations near full capacity.

Plan ahead, car pool, seek alternate routes, etc.

MBTA Bus Service

Beginning Thursday, July 27 at 7:00 PM:

- MBTA Bus Routes CT2 and 47 will be detoured from normal route
- Route 57 bus will continue to run and make most of regular stops



COMM AVE BRIDGE REPLACEMENT PROJECT

Tips for the Public

- **Reduce**
  - Avoid unnecessary travel if possible.
  - Plan ahead- take your summer vacation during this time.
- **Reroute**
  - Recognize that Commonwealth Avenue will be closed to vehicles and I-90 will have reduced capacity.
  - Use alternate routes to reach destinations throughout the region.
- **Re-mode**
  - Shift to active transportation including walking and biking
  - Take public transportation such as the MBTA Commuter Rail Worcester/Framingham line.

Public Outreach and Communication

COMM AVE BRIDGE REPLACEMENT PROJECT

Outreach Next Steps

- Public meetings beginning in May and briefings for stakeholders
- Door-to-door business outreach and Business Working Group
- Media briefings and interviews
- Project website and email alerts (currently over 2200 subscribers)
- Email to E-Z Pass users and letters to Pay-by-Plate customers
- Printed materials (brochures, flyers) available in multiple languages
- Red Sox advertisements and outreach

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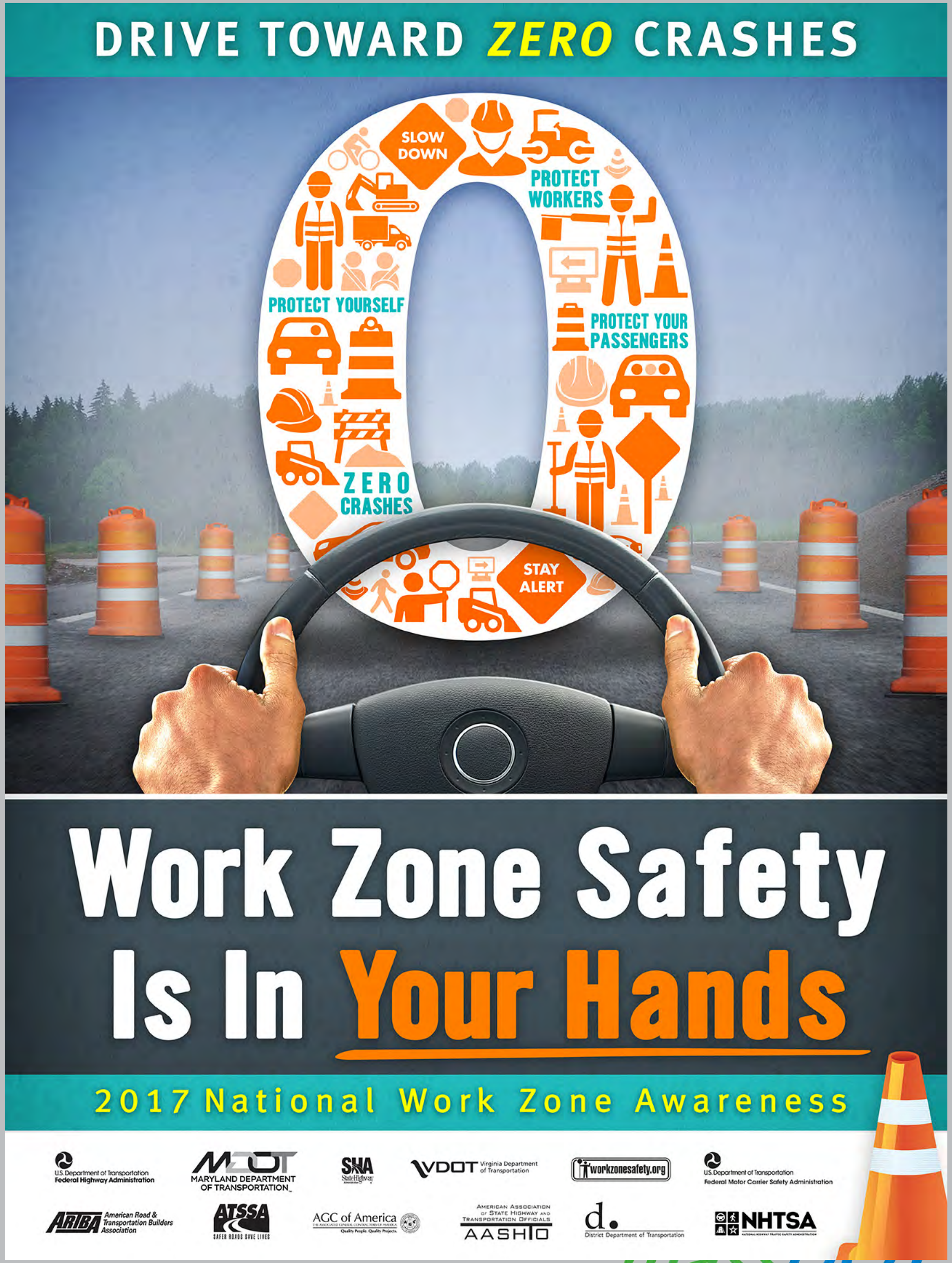
Project Website

www.mass.gov/massdot/CommAveBridge

- Sign up for email construction updates and traffic alerts
- View a detailed project schedule, including temporary traffic impacts
- Download maps of detour routes
- Learn more about traffic options in your area
- View project documents and presentations
- Find out about upcoming meetings

Work Zone Safety Message

- Be Patient
- Minimize Distractions
- Give your full attention to navigating through the work zone
- This is not the time to talk on a cellphone, text, or change the radio station



Massachusetts Department of Transportation

Contact Us

Sign up for email alerts!

www.mass.gov/massdot/CommAveBridge

Questions? Email us at

CommAveBridge@dot.state.ma.us

2018 Shutdown Construction Animation

- https://www.youtube.com/watch?v=QiGoPf8-3-Q

2019 Employer Recognition Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

The Boston Society of Civil Engineers Section of the American Society of Civil Engineers Awards Committee invites you to nominate an organization to receive the Small Employer Recognition Award *or the* Large Employer Recognition Award*. Please see the following awards description and page 2 of this form for nomination instructions. To be eligible to receive this award your award nomination must be received by the BSCES Awards Committee no later than* ***Monday, March 11, 2019****.*

As a means of fostering the members of the civil engineering profession, the Boston Society of Civil Engineers Section/ASCE has established an award to recognize those employers who commit to providing exceptional opportunities to their engineers. Special recognition will go to those organizations who exhibit exemplary support as evidenced by:

1. Encouraging technical and professional growth through continuing education, training, mentoring, project experience, participation in development of technical papers or presentations, and other means.
2. Tackling staff quality-of-life issues in the modern workplace.
3. Contributing to the community to make a positive impact.
4. Encouraging active participation in professional societies such as ASCE/BSCES.

Members who want an organization to be considered for recognition should provide a letter demonstrating the firm's commitment to its engineers. Firms nominated shall be actively participating in BSCES via sponsorship, employee membership, contributions to the newsletter, etc. Letters shall include the total number of employees in the firm, number of BSCES members, and cite specific examples of its employees being actively involved in BSCES.

The awards committee will review the nominations and select an exemplary small employer and a large employer in the Section. Organizations with less than 50 employees are eligible for the Small Employer Award. Awards will be presented at the 170th BSCES Annual Awards Dinner. Successful recipients will be considered for endorsement as potential (future) applicants for the ASCE Employer Recognition Award. No organization will be eligible to receive the award in consecutive years.

Name of Organization: Kleinfelder

2019 Employer Recognition Awards

BSCES
Boston Society of Civil Engineers Section
American Society of Civil Engineers

Complete and return this nomination form and attachment to the BSCES Awards Committee no later than Monday, March 11, 2019 to be eligible for the award.

Nominator/Title:	Daniel Dwyer / Project Professional Geotechnical Team		
Address:	8 Davis Road, Beverly MA, 01915		
Telephone:	508-423-0721	Email:	ddwyer@kleinfelder.com
Signature:	Daniel Dwyer	Date:	3/11/19
Organization:	Kleinfelder		
Contact Person:	Daniel Dwyer		
Title:	Project Professional		
Office Address:	One Beacon Street, Suite 8100, Boston, MA 02108	Website:	www.kleinfelder.com
Telephone:	617-497-7800	Email:	ddwyer@kleinfelder.com

Please attach a brief (no more than two pages) narrative describing why the organization meets the criteria described in this nomination form.

Please complete this form and the additional pages and return it via email, fax, or mail to bsces@engineers.org, 617/227-6783, or BSCES Awards Committee, Boston Society of Civil Engineers Section/ASCE, The Engineering Center, One Walnut Street, Boston, MA 02108-3616, respectively. For questions, contact BSCES Awards Committee Chair Michael Cunningham at 617/498-4773 or Vice.President2@BSCES.org.

Thank you for your continued support of ASCE and BSCES.

March 11, 2019

BSCES Awards Committee
Boston Society of Civil Engineers
The Engineering Center
One Walnut Street
Boston, MA 02108-3616

SUBJECT: BSCES Large Employer Recognition Award

To Whom It May Concern:

It is with great pleasure that I write this letter nominating Kleinfelder (KLF) for the 2019 BSCES Large Employer Recognition Award. KLF has approximately 1700 employees nationwide and about 100 employees combined in the two Massachusetts offices in Westborough and Boston with 24 active ASCE/BSCES members. The Boston office is one of KLF's design centers meaning that it supports multiple design groups including architects, water resource engineers, geotechnical engineers, environmental engineers, structural engineers, civil engineers, and climate change engineers.

I joined KLF as a Geotechnical Engineer for the Geo/Environmental Team in February of 2018 and am currently employed there. Upon arriving at KLF, the company's extensive involvement in ASCE, BSCES and other professional organizations was immediately apparent. Even before joining KLF, I had been made aware of their support and involvement as I had met many KLF staff at prior ASCE/BSCES events.

The level of involvement from the staff to management level across the KLF engineering design groups is impressive. Each group contains at least one BSCES member and some have distinguished themselves in terms of contributions to BSCES. Some of the notable contributions by KLF staff include:

- <u>Michael Cunningham P.E.</u>, Program Manager for the **Water Resources Group**
  - BSCES Vice President since 2018
  - Chair of Awards Committee
  - Member of BSCES Newsletter Editorial Board since 2008 and Chair from 2014-2017
- <u>James Turnbull P.E.</u>, Civil Engineer in the **Civil/Site Design Group**
  - Vice Chair for the Transportation & Development Institute chapter of BSCES
  - Currently planning the yearly Bertram Berger Seminar
- <u>Nasser Brahim</u>, Senior Climate Change Planner in the **Climate Change Group**
  - Authored the article, *Climate Ready East Boston and Charlestown* which was published in the October 2018 BSCES Newsletter
  - Authored the article, *Municipal Vulnerability Preparedness Program: From Planning to Action,* which was published in the June 2018 BSCES Newsletter
- <u>Kirsten Ryan P.G.,</u> Principal Hydrogeologist and Massachusetts Drinking Water Practice Leader in the **Water Resources Group.**
  - Authored the article, *Update on PFAS and Massachusetts Drinking Water* in the January 2019 BSCES Newsletter
- <u>Dan Dwyer P.E.</u>, Geotechnical Engineer in the **Geo/Environmental Group**
  - Vice Chair of the Engineering Management Group (EMG) chapter of BSCES.
  - Currently planning the yearly Joseph C. Lawler Lecture

Apart from these individual contributions, KLF staff involvement with BSCES organized events is frequent and always supported and encouraged by KLF management. Throughout the past year, BSCES events attended by KLF staff include but are not limited to the following:

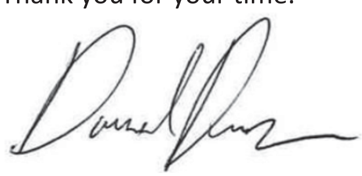
- February 2019 – Building New Solution to Old Problem: *A guide to Utilizing Green Stormwater Infrastructure and Maximizing Environmental Benefits.*
- November 2018 – Committee on Sustainability and Younger Member Group: *Alewife Wetland Tour & Networking Social.*
- October 2018 – Lunchtime Transportation Webinar Series: *Complete Street Design*
- October 2018 – Geo-institute and Engineering Management Group Social at Slumbrew sponsored by the **Geo-Institute and the EMG**
- August 2018 – Civil Engineering Trivia Night sponsored by the **Younger Members Group.**
- May 2018 – Joseph C. Lawler Lecture: *Megaprojects and Risk* sponsored by the **EMG.**
- April 2018 – John R. Freeman Lecture - *Water, Sanitation, Hygiene and Engineering in International Humanitarian Response: Lessons from Haiti and Worldwide* Sponsored by the **Environmental & Water Resources Institute Boston Chapter.**
- February 2018 – Somerville Infrastructure Program Presentation sponsored by the **EMG.**

Participation in these events and organizations is made possible by the professional encouragement and financial backing of KLF who continues to demonstrate commitment to its engineering staff and BSCES by:

- Sponsoring BSCES in 2018 and 2019;
- Developing a points-based evaluation system as part of the yearly review process where staff are rewarded for participating in external professional organizations like BSCES;
- Reimbursing for ASCES/BSCES dues and other continuing education courses offered by BSCES;
- Encouraging and allocating budget for staff to develop and submit technical papers like the ones referenced in this letter.

Given my first-hand experience and the examples provided in this letter, I believe that Kleinfelder should be recognized for the on-going encouragement and support of their staff and BSCES and should be awarded the 2019 Large Employer Recognition Award.

Thank you for your time.



Daniel Dwyer
Geotechnical Engineer, Geo/Environmental Team
Kleinfelder

BSCES
Boston Society of Civil Engineers Section

SUSTAINABILITY IN CIVIL ENGINEERING AWARD
ENTRY FORM

PROJECT INFORMATION

PROJECT NAME: Boston Landing Station

PROJECT LOCATION: Brighton, MA

DATE OF COMPLETION: April 1, 2017

PROJECT OWNER
Agency / Corporation: NB Development Group
Contact Name: Keith Craig
Contact Phone Number: (617)987-2523
Contact Email: kcraig@nbdevelopment.com

PROJECT ENGINEER/DESIGNER (list design team members if multiple companies involved)
Company Name: STV
Contact Name: Kristine Gorman
Contact Phone Number: (617)482-7298
Contact Email: kristine.gorman@stvinc.com

BSCES NOMINATING MEMBER (if applicable, not required)
Company Name: Skanska
Contact Name: Chris Hersey
Contact Phone Number: (617)218-5900
Contact Email: christopher.hersey@skanska.com

ENVISION™ PROJECT RATING
Envision Sustainable Professional (ENV SP)
Company Name: Skanska
Contact Name: Chris Frano, ENV SP
Contact Phone Number: (617)218-5883
Contact Email: chris.frano@skanska.com

PROJECT MERITS

Please provide a brief description of the project.

See attached.

Please describe the extent to which the projects innovative design exemplifies the economic, social and environmental principles of sustainability as described by the Institute for Sustainable Infrastructure.

See attached.

Please describe how the project approach and/or methods can be applied to support future developments in sustainability.

See attached.

Please attach additional project references, drawings, photographs, etc. as supplemental information if desired.

The ENV sustainability professional (ENV SP) listed in the project information form above shall complete a sustainability scoring of the project using the ISI Envision Rating tool available through the ISI website. An official independent review or verification by ISI is not required; however, a completed tabular summary of all the Envision credits is to be submitted as part of this application.

Project Merits (attachment)

Please provide a brief description of the project:

Boston Landing Station is a new MBTA Commuter Rail station along the Framingham/Worcester line as it runs along The Massachusetts Turnpike. The station includes an 800-foot long center island platform with canopies, stairs, elevators, a pedestrian overpass, and a bike storage area. There are two entrances to the new station, one from Arthur Street at the west end of the platform and one from Everett Street Bridge at the east end of the platform. Alterations have been to the existing tracks and communication system to accommodate the new station. These improvements have been made while maintaining nearly uninterrupted mainline service.

Please describe the extent to which the project's innovative design exemplifies the economic, social and environmental principles of sustainability as described by the Institute for Sustainable Infrastructure:

The station itself represents a return of rail service to the Lower Allston-Brighton neighborhood that, until the 1960s, was well served by rail. After the closures of several stations including the Green 'A' Line in 1969, the neighborhood was left with only a network of bus routes and at least a 1-mile walk to any mass transit options. NB Development Group, recognizing a public need in the neighborhood of its new development, worked in partnership with MassDOT and the MBTA to fund the design, permitting, and construction of a new station in Brighton. Using an integrated CM-at risk delivery, uncommon for infrastructure projects, the owner, engineer, contractor, and major stakeholders worked together to refine the design in terms of cost, functionality, and constructability a year before construction began. The preconstruction process resulted in a number of sustainable strategies including screening and reuse of existing track ballast, recycling of timber rail crossties, and construction re-phasing to maintain a safer work zone and streamlined schedule. Having recognized early on the many sustainable aspects of development, design, and construction, the team made the decision to pursue Envision verification. Boston Landing Station, as of April 2017, has been submitted with the goal of receiving at least Envision Gold verification.

Please describe how the project approach and/or methods can be applied to support future developments in sustainability:

As Charlie Baker has stated, "The commitment of New Balance and the City of Boston to expand…transportation opportunities is vital to bringing new economic activity and jobs to Greater Boston. These projects…will expand economic growth, accessibility and mobility for others as we work toward critical reforms for our Commonwealth's public transit system." The partnership between NB Development Group and the many stakeholders involved can serve as a model for future public infrastructure projects. Massachusetts Secretary of Transportation has said, "Partnership…is a really important thing for the MBTA now and in the future. There is far more to do than the T could ever do alone." Should private developers recognize the shared benefits of infrastructure investment as the owner has, and should state agencies embrace these partnerships, the construction and maintenance of public infrastructure assets will become much more sustainable.

Boston Landing Station

38-40 Guest Street, Brighton, MA

Action

51

Platinum

Project Stage

Assessment

Status: Awaiting verifier assignment...Submission to verifier.

Submit for Verification

QUALITY OF LIFE
13 credits

13 credits in progress, 0 credits completed

Project progress: 111 of 168 Possible points — 66%

				I	E	S	C	R
Purpose	QL1.1 Improve Community Quality of Life	N/A	0	2	5	10	**20**	25
	QL1.2 Stimulate Sustainable Growth and Development	N/A	0	1	2	5	**13**	16
	QL1.3 Develop Local Skills and Capabilities	N/A	0	1	2	**5**	12	15
Wellbeing	QL2.1 Enhance Public Health and Safety	N/A	0	2	–	–	**16**	–
	QL2.2 Minimize Noise and Vibration	N/A	0	1	–	–	**8**	11
	QL2.3 Minimize Light Pollution	N/A	0	1	2	**4**	8	11
	QL2.4 Improve Community Mobility and Access	N/A	0	1	4	7	**14**	–
	QL2.5 Encourage Alternative Modes of Transportation	N/A	0	1	3	6	12	**15**
	QL2.6 Improve Site Accessibility, Safety and Wayfinding	N/A	0	–	3	6	12	**15**
Community	QL3.1 Preserve Historic and Cultural Resources	N/A	0	**1**	–	7	13	16
	QL3.2 Preserve Views and Local Character	N/A	**0**	1	3	6	11	14
	QL3.3 Enhance Public Space	**N/A**	0	1	3	6	11	13
Innovate or Exceed	QL0.0 Innovate or Exceed Credit Requirements	**0**	Maximum Level of 8			◀	▶	8

Submitted 111 Verified

LEADERSHIP
10 credits

10 credits in progress, 0 credits completed

Project progress: 48 of 121 Possible points — 40%

				I	E	S	C	R
Collaboration	LD1.1 Provide Effective Leadership and Commitment	N/A	0	2	4	9	**17**	–
	LD1.2 Establish a Sustainability Management System	N/A	**0**	1	4	7	14	–
	LD1.3 Foster Collaboration and Teamwork	N/A	0	1	**4**	8	15	–
	LD1.4 Provide for Stakeholder Involvement	N/A	0	**1**	5	9	14	–
Managment	LD2.1 Pursue Byproduct Synergy Opportunities	N/A	0	**1**	3	6	12	15
	LD2.2 Improve Infrastructure Integration	N/A	0	1	3	7	13	**16**
Planning	LD3.1 Plan for Long-term Monitoring and Maintenance	N/A	0	1	**3**	–	10	–
	LD3.2 Address Conflicting Regulations and Policies	N/A	0	1	2	**4**	8	–
	LD3.3 Extend Useful Life	N/A	**0**	1	3	6	12	–
Innovate or Exceed	LD0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 6			◀	▶	**2**

Submitted 48 Verified

RESOURCE ALLOCATION
14 credits

14 credits in progress, 0 credits completed

Project progress

72 of 140 Possible points — 51%

Category	Credit			I	E	S	C	R
Materials	RA1.1 Reduce Net Embodied Energy	N/A	**0**	2	6	12	18	–
	RA1.2 Support Sustainable Procurement Practices	N/A	0	2	**3**	6	9	–
	RA1.3 Use Recycled Materials	N/A	0	2	5	11	**14**	–
	RA1.4 Use Regional Materials	N/A	0	3	6	9	**10**	–
	RA1.5 Divert Waste From Landfills	N/A	0	3	6	**8**	11	–
	RA1.6 Reduce Excavated Materials Taken Off Site	N/A	0	2	**4**	5	6	–
	RA1.7 Provide for Deconstruction and Recycling	N/A	0	1	4	8	**12**	–
Energy	RA2.1 Reduce Energy Consumption	N/A	0	3	**7**	12	18	–
	RA2.2 Use Renewable Energy	N/A	**0**	4	6	13	16	20
	RA2.3 Commission and Monitor Energy Systems	N/A	0	–	**3**	–	11	–
Water	RA3.1 Protect Fresh Water Availability	**N/A**	0	2	4	9	17	21
	RA3.2 Reduce Potable Water Consumption	**N/A**	0	4	9	13	17	21
	RA3.3 Monitor Water Systems	N/A	0	1	3	6	**11**	–
Innovate or Exceed	RA0.0 Innovate or exceed credit requirements	0	Maximum Level of 8			◀	▶	8

Submitted 72 Verified

NATURAL WORLD
15 credits

15 credits in progress, 0 credits completed

Project progress

53 of 112 Possible points — 47%

Category	Credit			I	E	S	C	R
Siting	NW1.1 Preserve Prime Habitat	N/A	0	–	–	**9**	14	18
	NW1.2 Protect Wetlands and Surface Water	**N/A**	0	1	4	9	14	18
	NW1.3 Preserve Prime Farmland	**N/A**	0	–	–	6	12	15
	NW1.4 Avoid Adverse Geology	N/A	0	1	2	3	**5**	–
	NW1.5 Preserve Floodplain Functions	**N/A**	0	2	5	8	14	–
	NW1.6 Avoid Unsuitable Development on Steep Slopes	N/A	0	1	–	4	**6**	–
	NW1.7 Preserve Greenfields	N/A	0	3	6	10	**15**	23
Land & Water	NW2.1 Manage Stormwater	N/A	0	–	**4**	9	17	21
	NW2.2 Reduce Pesticide and Fertilizer Impacts	**N/A**	0	1	2	5	9	–
	NW2.3 Prevent Surface and Groundwater Contamination	N/A	0	**1**	4	9	14	18
Biodiversity	NW3.1 Preserve Species Biodiversity	**N/A**	0	2	–	–	13	16
	NW3.2 Control Invasive Species	N/A	0	–	–	**5**	9	11
	NW3.3 Restore Disturbed Soils	N/A	0	–	–	–	**8**	10
	NW3.4 Maintain Wetland and Surface Water Functions	**N/A**	0	3	6	9	15	19
Innovate or Exceed	NW0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 9			◀	▶	9

Submitted 53 Verified

CLIMATE AND RISK
8 credits

8 credits in progress, 0 credits completed

Project progress

51 of 122 Possible points — 42%

	Credit			I	E	S	C	R
Emissions	CR1.1 Reduce Greenhouse Gas Emissions	N/A	0	4	7	13	18	25
	CR1.2 Reduce Air Pollutant Emissions	N/A	0	2	6	–	12	15
Resilience	CR2.1 Assess Climate Threat	N/A	0	–	–	–	15	–
	CR2.2 Avoid Traps and Vulnerabilities	N/A	0	2	6	12	16	20
	CR2.3 Prepare for Long-Term Adaptability	N/A	0	–	–	–	16	20
	CR2.4 Prepare for Short-Term Hazards	N/A	0	3	–	10	17	21
	CR2.5 Manage Heat Island Effects	N/A	0	1	2	4	6	–
Innovate or Exceed	CR0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 5			◀	▶	5

Submitted 51 Verified

Project Summary

Refresh Summary

	Submitted Score Information			Verified Score Information		
Credit Category	Applicable	Submitted	Percentage	Applicable	Verified	Percentage
QUALITY OF LIFE	168	111	66%	181	0	0%
LEADERSHIP	121	48	40%	121	0	0%
RESOURCE ALLOCATION	140	72	51%	182	0	0%
NATURAL WORLD	112	53	47%	203	0	0%
CLIMATE AND RISK	122	51	42%	122	0	0%
Total Points / %	663	335	51%	809	0	0%

Boston Landing Station

Project Location: Guest Street, Boston, MA 02135, USA

Project Score: 51%

51

Platinum

Project ID: 1225
Project Stage: Assessment
Registration Invoice ID: 1923
Verification Invoice ID: 1924
Project Team: Christopher Frano
Ryan Prime

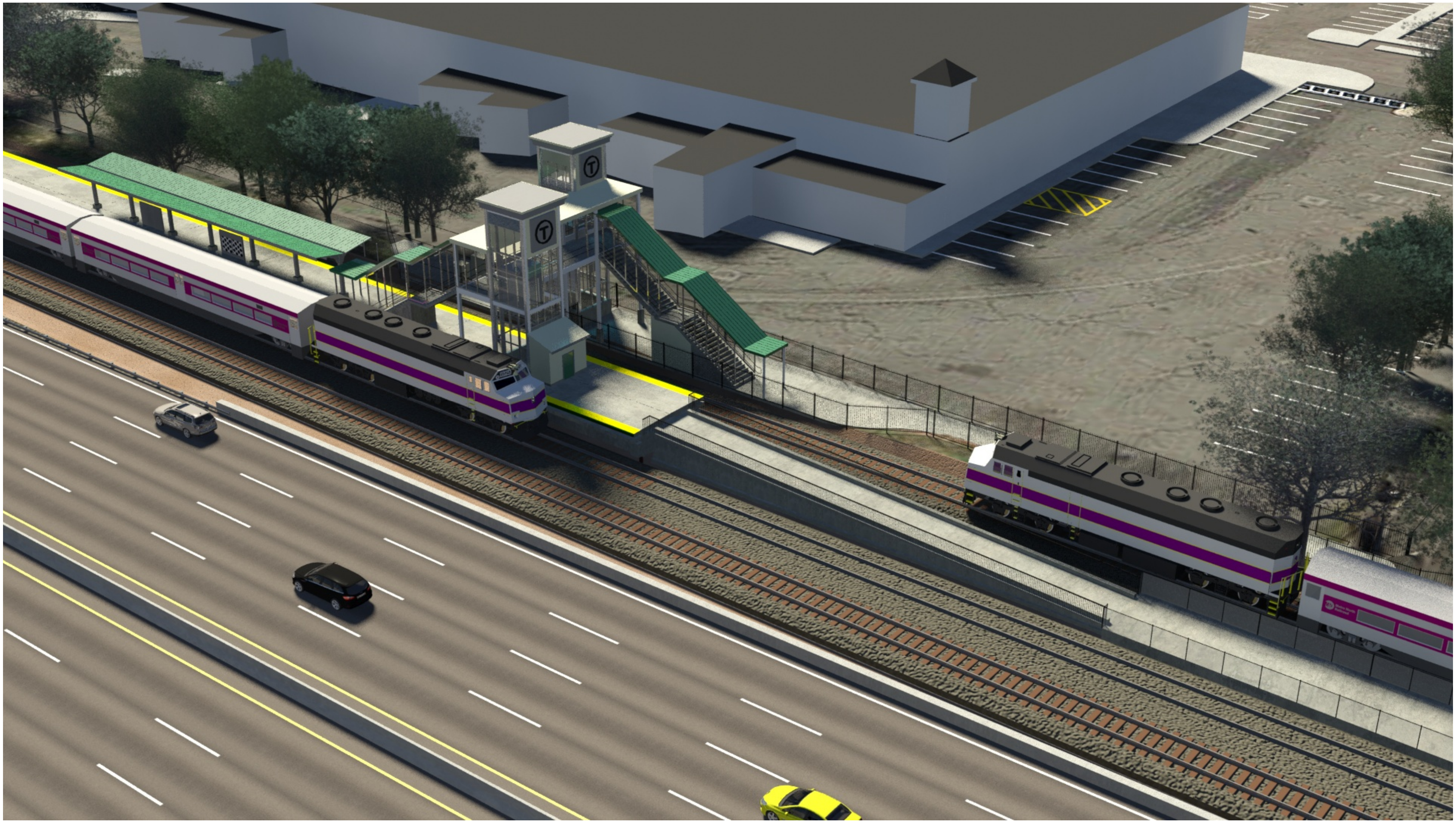
Created: 11/24/2015
Registered: 04/24/2017

Project Contact: Chris Hersey
christopher.hersey@skanska.com
(617)590-5546

ENV SP: Chris Frano
chris.frano@skanska.com
(347)946-4365

Project Description:

Work at the New Boston Landing Station at Allston/Brighton (BLS) will consist of the construction of a new 785 foot long, high level center island platform along the Worcester Commuter Rail. It includes two platform canopies, a pedestrian overpass, platform access stairs and elevators, lighting and security system, a variable message sign system, signage, sidewalks, and other site improvements. Alterations will be made to the existing track and communications system to accommodate the new center island platform including the reconstruction/relocation of the mainline tracks #1 and #2, as well freight line track #4. The existing interlocking CP-4 near the project site will be reduced from a universal interlocking to a single hand operated switch with electric lock on track #1. These improvements will be made while maintaining mainline service on the Worcester/Framingham Commuter Rail Line. The proposed site exists at a location along the Worcester/Framingham line as it runs adjacent to the Massachusetts Turnpike, west of the Everett Street overpass and just north of the existing Stop & Shop facility at 60 Everett Street in Allston, MA. Two (2) mainline tracks approach the project site from the west before splitting into four (4) sets of tracks at the existing CP-4, east of the Everett Street Bridge, and eventually further splitting into the several track sets of Beacon Park Yard.There are five major elements to this project: 1 – Passenger platform system, 2 – Pedestrian overpass and stair/elevator system to the west end of the platform, 3 – stair/elevator system from Everett Street to the east end of the platform, 4 – Track and systems reconfiguration, and 5 – site and drainage features.



Boston Landing Station at Allston Brighton,
MBTA Framingham / Worcester Commuter Rail

Boston Society of Civil Engineers Section

SUSTAINABILITY IN CIVIL ENGINEERING AWARD
SUBMISSION INFORMATION

PROJECT INFORMATION

Project name	Greenough Boulevard Greenway Expansion
Project location	Cambridge and Watertown, MA
Date of completion	Fall 2016

Project owner

Agency/Corporation	Department of Conservation and Recreation (DCR)
Contact name	Rick Corsi
Contact phone number	617.626.1431
Contact email	mass.parks@state.ma.us
Agency/Corporation	The Lawrence and Lillian Solomon Foundation
Contact name	Herbert Nolan
Contact phone number	781.431.1440
Contact email	herbnolan@solomonfoundation.org

Project engineer/designer (list design team members if multiple companies involved)

Company name	VHB
Contact name	Peter Sorensen, PE, ENV SP
Contact phone number	617.607.2161
Contact email	psorensen@VHB.com

BSCES nominating member (if applicable, not required)

Company name	
Contact name	
Contact phone number	
Contact email	

Envision™ Project Rating | Envision Sustainable Professional (ENV SP)

Company name	VHB
Contact name	Kari Hewitt, LEED AP, CEM, ENV SP
Contact phone number	617.607.0971
Contact email	khewitt@VHB.com

Project Merits

Please provide a brief description of the project.

After years in the making, the expansion and development of the Greenough Boulevard Greenway creates an inviting shared-use path and places for people to simply rest and relax, while enjoying the view of the Charles River. With four wide travel lanes, rusting twisted guardrails, and a crumbling, overgrown multi-use path on the river side of the road, Greenough Boulevard was far less picturesque and inviting than the other roadways abutting the Charles, such as Storrow and Memorial Drives. However, the fortunes of Greenough Boulevard and the people who use the neglected pathway have changed. In a $1.8 million public/private partnership, the Department of Conservation and Recreation (DCR) and the Lawrence and Lillian Solomon Foundation worked together to reconfigure and right-size Greenough Boulevard to create a more balanced and appealing greenway along the corridor. The overall project also included development of the 8-foot Marsh Path, which provides connectivity along the boulevard, and an ADA compliant pedestrian ramp connecting the DCR parking lot on Greenough Boulevard to the existing path in the Cambridge Cemetery.

The Greenough Greenway project's objectives included enhancing public safety along the river, providing a fully accessible multi-use path next to the river, reclaiming parkland and enhancing the scenic value of the Charles River Reservation, improving the environmental quality of the Charles River, and maintaining Greenough Boulevard as a fully functional parkway, as well as demonstrating an efficient and cost-effective public/private partnership.

VHB completed the design, reducing the pavement from four lanes (two lanes in each direction) to two lanes (one lane with five-foot shoulders in each direction), while maintaining the existing lane configuration at intersections. Pavement was sawcut and removed and the 10-foot shared-use path was constructed within the new limits of the Greenway. To maintain acceptable stormwater drainage for the roadway and the new path, VHB collaborated with the City of Cambridge and the Watertown Conservation Commissions to identify an appropriate open mitigation system. Additionally, VHB designed modifications to the Grove Street pedestrian crossing along with designing a restriping plan for the boulevard. Included with recommendations for locating street trees and park benches, VHB provided advice regarding the landscape elements, such as vegetation removal and new areas of lawn and meadow. Construction began in the Spring 2015 and was completed in Fall 2016. The Greenough Boulevard Greenway Expansion is the recent recipient of the 2017 Institute for Sustainable Infrastructure (ISI) Envision Bronze award.

Please describe the extent to which the project's innovative design exemplifies the economic, social and environmental principles of sustainability as described by the Institute for Sustainable Infrastructure.

Throughout the process, VHB focused on how to implement sustainability features into this transformative project. When planning for the Marsh Path, VHB and our clients made the decision to use a stabilized aggregate path—a pervious surface to aid in increased water quality to the Charles River and appropriate, resilient material for the tough terrain surrounding the new path.

The backbone of this project was creating an environment that was welcoming to all forms of travel—pedestrians, bicyclists, and vehicles. This shared-use space promotes green commuting and safe vehicular traffic, improving the well-being of community residents and encouraging a green environment for the future.

A highly used bike/ped route, this project also required careful attention to re-routing runners and bikers throughout construction. VHB successfully proposed and implemented a plan that allowed for all modes of travel to remain open to users during each phase of the renovation.

Quality of life—The Lawrence and Lillian Solomon Foundation put up seed money and engaged VHB to prepare a proposal for a riverfront park restoration along Greenough Boulevard. DCR engaged in this effort, forming a public/private partnership and expanding funding to improve the quality and extent of renovations. The project had been on DCR's *Master Plan for the Charles River Basin* (2002); following the Solomon Foundation's efforts, DCR recognized it as a viable project and offered to pay for construction.

The project transforms a degraded, mile-long section of the Charles River by reducing pavement and restoring natural landscaping, increasing safety for cyclists and pedestrians, and providing improved access to the Charles River and nearby recreational facilities. The project has broad community support through the public/private partnership as well as endorsements by community boards in both Cambridge and Watertown, MA.

Leadership—From concept, design, and completion, the Greenough Boulevard Greenway was led by the public/private partnership of DCR and the Lawrence and Lillian Solomon Foundation, with VHB providing integrated services. The team hosted several community meetings to seek ways to improve connections to other major roadways, amenities, and residential areas. The resulting project restores a previously sub-par pedestrian and cycling path along Greenough Boulevard and strengthens the final link in the recreational loop of trails connecting to Herter Park.

Natural world—VHB proposed a plan that was sustainable and environmentally friendly, managing invasive plants and adding plants and wildflower meadows. The team removed mass brush that had grown throughout the years and replaced distressed highway scenery with an open view of the Charles River—welcoming back the riverfront to Greenough Boulevard.

A major challenge was finding a solution to the passive drainage system that directly discharged into the Charles River and during storm events caused flooding and puddling along the road—leading to safety concerns for roadway users. Collaborating with the City of Cambridge and the Watertown Conservation Commissions, VHB identified an appropriate open mitigation system, reducing puddling in the road and improving safety.

Please describe how the project approach and/or methods can be applied to support future developments in sustainability.

A key piece of this project was the public/private partnership that was developed to improve this roadway. What started as a pro-bono proposal between VHB and The Lawrence and Lillian Solomon Foundation, transformed into a $1.8M project when DCR came on board. Collaboration and leadership between the private and public sectors provided an opportunity that would not have otherwise been possible. With the driving force of our private partner and economic support from our public partner, VHB delivered a project that improved mobility and safety and exceeded the community's expectations.

Another of the strong aspect of this project was the implementation of the road diet along Greenough Boulevard. VHB was able to reduce land overtaken by pavement and create larger green space for users. VHB's design reduced the pavement from four lanes (two lanes in each direction) to two lanes (one lane with a five-foot shoulder in each direction), while maintaining the existing lane configuration at intersections. The addition of the road diet resulted in improved safety for drivers and more room to welcome multimodal travel. Throughout the process, careful consideration was given to making sure that the design properly celebrated the Charles River—a prominent feature of Cambridge, Watertown, and Boston.

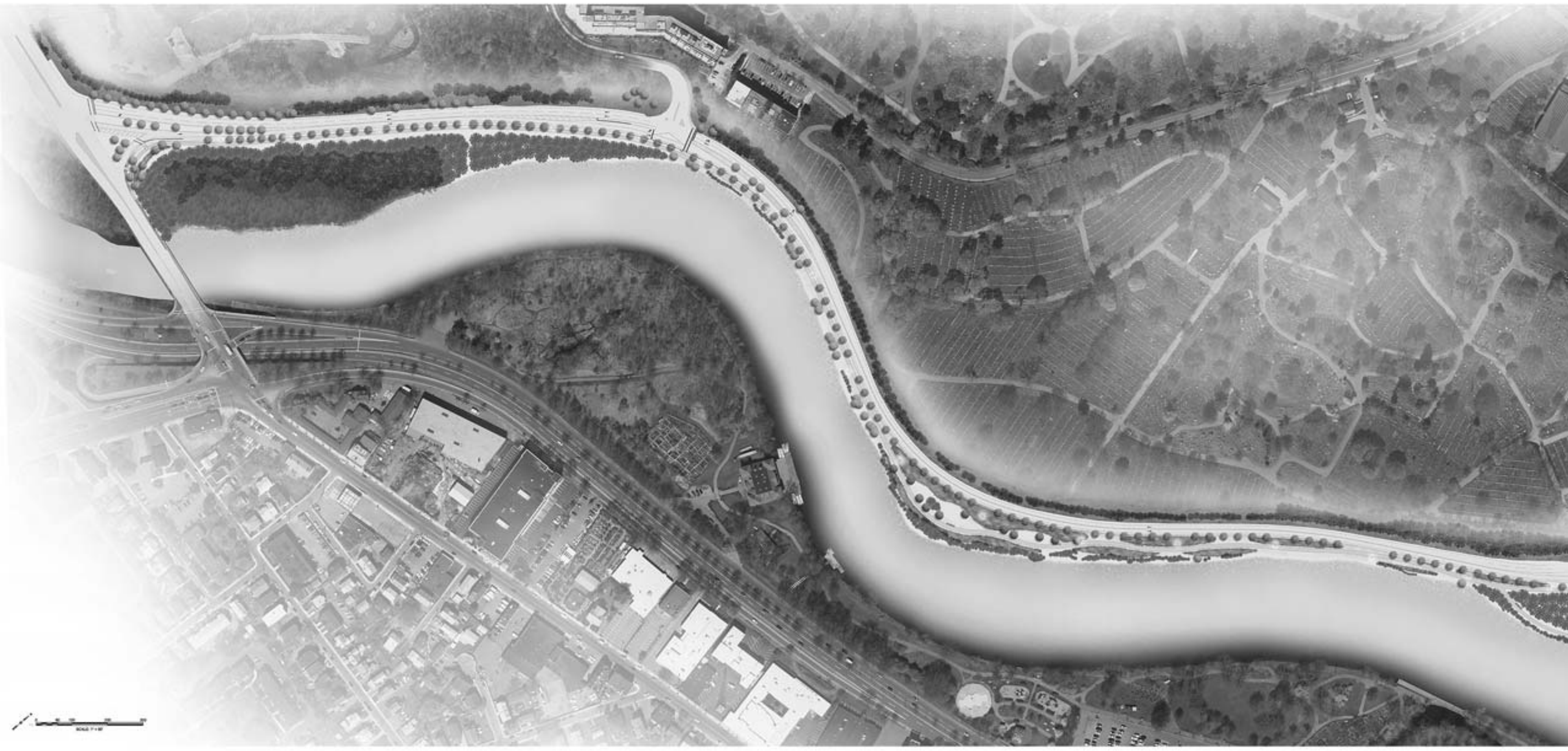
Please attach additional project references, drawings, photographs, etc. as supplemental information, if desired.

Please see project photos and graphics on the following pages.

Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 1: Photo simulation of proposed conditions showing the road diet and the addition of shared use path to accommodate future park improvements such as scenic overlooks, trees and plantings, and benches.



Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 2: Proposed roadway concept

Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 3: Greenough Boulevard shared use path construction

Greenough Bou
Watertown and

VHB

Image 4: Complete
pavement markings

Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 5: Greenough Boulevard access open for multimodal and recreational use

Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 6: Greenough Boulevard access open for multimodal and recreational use

Greenough Bou
Watertown and

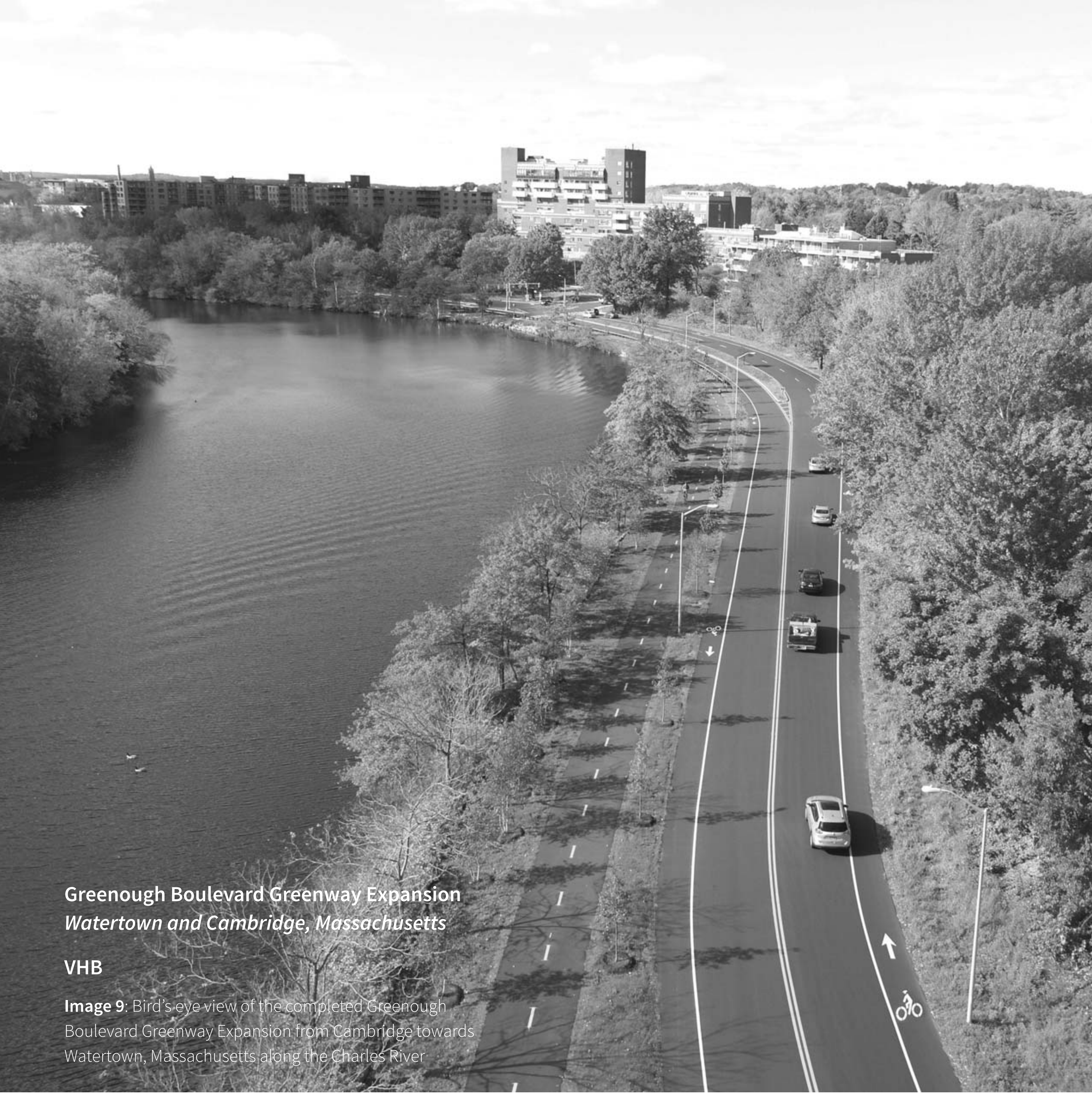
VHB

Image 7: Greenoug
multimodal and rec

Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 8: Park benches, trees, and plantings line the shared-use path and the Charles River



Greenough Boulevard Greenway Expansion
Watertown and Cambridge, Massachusetts

VHB

Image 9: Bird's eye view of the completed Greenough Boulevard Greenway Expansion from Cambridge towards Watertown, Massachusetts along the Charles River

Envision™ Project Assessment Scoring Table

The ENV sustainability professional (ENV SP) listed in the project information form shall complete a sustainability scoring of the project using the ISI Envision™ Rating tool available through the ISI website. An official independent review or verification by ISI is not required; however, a completed tabular summary of all the Envision credits is to be submitted as part of this application.

Please see the Envision™ Project Assessment Scoring Table and details on the following pages.

Project Summary

Refresh Summary

	Submitted Score Information			Verified Score Information		
Credit Category	Applicable	Submitted	Percentage	Applicable	Verified	Percentage
QUALITY OF LIFE	165	61	37%	165	56	34%
LEADERSHIP	121	68	56%	121	53	44%
RESOURCE ALLOCATION	129	17	13%	129	6	5%
NATURAL WORLD	149	50	34%	159	32	20%
CLIMATE AND RISK	122	25	20%	122	18	15%
Total Points / %	686	221	32%	696	165	24%

Greenough Greenway

Watertown, MA

24

Bronze

Project Stage

Complete

Print Award

QUALITY OF LIFE
13 credits

13 credits in progress, 13 credits completed

Project progress

61 of 165 Possible points — 37%

Purpose

QL1.1 Improve Community Quality of Life

QL1.2 Stimulate Sustainable Growth and Development

QL1.3 Develop Local Skills and Capabilities

		I	E	S	C	R
N/A	0	2	5	10	20	25
N/A	0	1	2	5	13	16
N/A	0	1	2	5	12	15

QUALITY OF LIFE
13 credits

13 credits in progress, 13 credits completed | **Project progress** | **61 of 165 Possible points — 37%**

Wellbeing	QL2.1 Enhance Public Health and Safety	N/A	0	2	—	—	16	—
	QL2.2 Minimize Noise and Vibration	N/A	0	1	—	—	8	11
	QL2.3 Minimize Light Pollution	N/A	0	1	2	4	8	11
	QL2.4 Improve Community Mobility and Access	N/A	0	1	4	7	14	—
	QL2.5 Encourage Alternative Modes of Transportation	N/A	0	1	3	6	12	15
	QL2.6 Improve Site Accessibility, Safety and Wayfinding	N/A	0	—	3	6	12	15
Community	QL3.1 Preserve Historic and Cultural Resources	N/A	0	1	—	7	13	16
	QL3.2 Preserve Views and Local Character	N/A	0	1	3	6	11	14
	QL3.3 Enhance Public Space	N/A	0	1	3	6	11	13
Innovate or Exceed	QL0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 8					8

Submitted 61 Verified 56

LEADERSHIP
10 credits

10 credits in progress, 10 credits completed

Project progress **68 of 121 Possible points — 56%**

				I	E	S	C	R
Collaboration	LD1.1 Provide Effective Leadership and Commitment	N/A	0	2	4	9	17	—
	LD1.2 Establish a Sustainability Management System	N/A	0	1	4	7	14	—
	LD1.3 Foster Collaboration and Teamwork	N/A	0	1	4	8	15	—
	LD1.4 Provide for Stakeholder Involvement	N/A	0	1	5	9	14	—
Managment	LD2.1 Pursue Byproduct Synergy Opportunities	N/A	0	1	3	6	12	15
	LD2.2 Improve Infrastructure Integration	N/A	0	1	3	7	13	16
Planning	LD3.1 Plan for Long-term Monitoring and Maintenance	N/A	0	1	3	—	10	—
	LD3.2 Address Conflicting Regulations and Policies	N/A	0	1	2	4	8	—
	LD3.3 Extend Useful Life	N/A	0	1	3	6	12	—
Innovate or Exceed	LD0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 6					6

Submitted 68 Verified 53

RESOURCE ALLOCATION
14 credits

14 credits in progress, 14 credits completed | **Project progress** | **17 of 129 Possible points — 13%**

Category	Credit			I	E	S	C	R
Materials	RA1.1 Reduce Net Embodied Energy	N/A	0	2	6	12	18	—
	RA1.2 Support Sustainable Procurement Practices	N/A	0	2	3	6	9	—
	RA1.3 Use Recycled Materials	N/A	0	2	5	11	14	—
	RA1.4 Use Regional Materials	N/A	0	3	6	9	10	—
	RA1.5 Divert Waste From Landfills	N/A	0	3	6	8	11	—
	RA1.6 Reduce Excavated Materials Taken Off Site	N/A	0	2	4	5	6	—
	RA1.7 Provide for Deconstruction and Recycling	N/A	0	1	4	8	12	—
Energy	RA2.1 Reduce Energy Consumption	N/A	0	3	7	12	18	—
	RA2.2 Use Renewable Energy	N/A	0	4	6	13	16	20
	RA2.3 Commission and Monitor Energy Systems	N/A	0	—	3	—	11	—
Water	RA3.1 Protect Fresh Water Availability	N/A	0	2	4	9	17	21
	RA3.2 Reduce Potable Water Consumption	N/A	0	4	9	13	17	21
	RA3.3 Monitor Water Systems	N/A	0	1	3	6	11	—

Category	Credit			
Innovate or Exceed	RA0.0 Innovate or exceed credit requirements	0	Maximum Level of 8	8

Submitted 17 Verified 6

NATURAL WORLD 15 credits	**15 credits in progress, 15 credits completed**	**Project progress**	**50 of 149 Possible points — 34%**

	Credit			I	E	S	C	R
Siting	NW1.1 Preserve Prime Habitat	N/A	0	—	—	9	14	18
	NW1.2 Protect Wetlands and Surface Water	N/A	0	1	4	9	14	18
	NW1.3 Preserve Prime Farmland	N/A	0	—	—	6	12	15
	NW1.4 Avoid Adverse Geology	N/A	0	1	2	3	5	—
	NW1.5 Preserve Floodplain Functions	N/A	0	2	5	8	14	—
	NW1.6 Avoid Unsuitable Development on Steep Slopes	N/A	0	1	—	4	6	—
	NW1.7 Preserve Greenfields	N/A	0	3	6	10	15	23
Land & Water	NW2.1 Manage Stormwater	N/A	0	—	4	9	17	21
	NW2.2 Reduce Pesticide and Fertilizer Impacts	N/A	0	1	2	5	9	—
	NW2.3 Prevent Surface and Groundwater Contamination	N/A	0	1	4	9	14	18
Biodiversity	NW3.1 Preserve Species Biodiversity	N/A	0	2	—	—	13	16
	NW3.2 Control Invasive Species	N/A	0	—	—	5	9	11
	NW3.3 Restore Disturbed Soils	N/A	0	—	—	—	8	10
	NW3.4 Maintain Wetland and Surface Water Functions	N/A	0	3	6	9	15	19
Innovate or Exceed	NW0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 9					9

Submitted 50 Verified 32

CLIMATE AND RISK
8 credits

8 credits in progress, 8 credits completed | **Project progress** | **25 of 122 Possible points — 20%**

Category	Credit			I	E	S	C	R
Emissions	CR1.1 Reduce Greenhouse Gas Emissions	N/A	0	4	7	13	18	25
	CR1.2 Reduce Air Pollutant Emissions	N/A	0	2	6	—	12	15
Resilience	CR2.1 Assess Climate Threat	N/A	0	—	—	—	15	—
	CR2.2 Avoid Traps and Vulnerabilities	N/A	0	2	6	12	16	20
	CR2.3 Prepare for Long-Term Adaptability	N/A	0	—	—	—	16	20
	CR2.4 Prepare for Short-Term Hazards	N/A	0	3	—	10	17	21
	CR2.5 Manage Heat Island Effects	N/A	0	1	2	4	6	—

Category	Credit			
Innovate or Exceed	CR0.0 Innovate or Exceed Credit Requirements	0	Maximum Level of 5	5

Submitted 25 Verified 18

Project Summary

	Submitted Score Information			Verified Score Information		
Credit Category	**Applicable**	**Submitted**	**Percentage**	**Applicable**	**Verified**	**Percentage**
QUALITY OF LIFE	165	61	37%	165	56	34%
LEADERSHIP	121	68	56%	121	53	44%
RESOURCE ALLOCATION	129	17	13%	129	6	5%
NATURAL WORLD	149	50	34%	159	32	20%
CLIMATE AND RISK	122	25	20%	122	18	15%
Total Points / %	686	221	32%	696	165	24%