Resilient Infrastructure for Sustainability and Equity (RISE)

Recurring hazards over the past decade have severely challenged current capacity to manage risk in communities across the nation. In California alone, increasingly severe wildfires impose major risks for property and human life, and have grown into a key source of poor air quality. As wildfires were burning in California, hurricanes were striking the Gulf Coast states of Texas, Louisiana, and Florida, and floods were inundating the states of Iowa, Nebraska, and Illinois. In 2020 in Puerto Rico, a major earthquake further damaged infrastructure unrepaired from Hurrican Maria two years prior, leaving thousands without permanent shelter. In 2021, a massive winter storm disabled the electrical grid in Texas, shutting down power and leaving millions of people without heat, water, and fuel in sub-zero temperatures.

These events illustrate the increasing severity and frequency of hazards that threatens our communities. They damage community infrastructure and erode the foundations of our prosperity. Cascading hazard events call for quick recovery and the inter-dependence of infrastructure failures for an integrated one. The result is this new initative for a trans-disciplimary infrastructure engineering with the sustainabily, resilience, and equity of our communities at its center. At the same time, much of our critical infrastructure is aging and has not been adequately maintained. How do we rehabilitate or create our infrastructure in a sustainable and resilient manner so that future generations do not suffer the infrastructure challenges we are currently facing?

These complex problems cannot be solved without deep consideration of the complex socio-economic and political considerations that impact different communities at different scales. Inequities exist in transportation, housing, urban heat island effects, flooding, energy and water supply. In underserved communities in the U.S. and around the globe, including rapidly growing urban areas, much formal infrastructure has not yet been built, and there is an opportunity to transformative innovation. Rather than imposing solutions, engineers should take into consideration local context including needs, resources, climate, and social factors. Infrastructure systems must create equitable communities in the face of growing environmental challenges. We need future leaders in developing equitable, inclusive, interdisciplinary solutions and evaluating their integration with complex civil infrastructure, as well as the societal, institutional, and natural systems in which they are embedded.

Resilient Infrastructure for Sustainability and Equity (RISE) has been identified as a strategic multidisciplinary research theme for Berkeley Engineering. We aim to create a new generation of engineers that is both socially sensitive and technologically equipped.

This initiative will bring resources (faculty hires, research funding, *etc*.) in the following areas:

Zero or negative carbon systems: Our buildings, transportation, water, and energy systems must be designed to be efficient, generate their energy or rely exclusively on renewable energy, and eliminate or capture direct emissions of greenhouse gases while withstanding the aforementioned hazards. Radically new ways of thinking are needed that incorporate systems integration, holistic analysis, technology innovation, working with policy drivers, and understanding behavior changes. The upgrading of our ageing building and infrastructure inside the campus offers an opportunity to incorporate and study our innovative designs in situ and to be used as a living laboratory.

Autonomous infrastructure and construction: Autonomy in construction and infrastructure can revolutionize the way we design, construct, maintain and operate infrastructure. Autonomous infrastructure is not static, but senses and responds to changing conditions. Robotics, sensing and data analytics are being incorporated in resource optimization and in the construction and operation of infrastructure. At the same time, the boundary between design, construction, and operation is blurring, necessitating new approaches and synergies to management, materials innovation, and engineering. Structural and non-structural elements are going 'smart', imposing novel requires for the structures themselves. Autonomy enables insights into how the built environment is functioning that were

previously unattainable and empowers new business models that leverage data to achieve unprecedented efficiencies.

Smart and equitable infrastructure: The transition from our existing aging infrastructure to zero-carbon infrastructure must be equitable. Infrastructure that is equitable by design must involve communities as partners in understanding current disparities and developing long-term solutions. The definition of infrastructure is expanding, and we need to integrate organizational infrastructure (human interactions) and informal infrastructure (unplanned) to the existing physical and digital infrastructure framework. Scientific and technological advances allow us to generate and analyze data about how our infrastructure and the environment are used by communities and pave new ways that are more inclusive, fair, and sustainable, and resilient.

Adaptive and resilient communities: Adaptation is no longer a choice, but a requirement for sustainable living. Our communities and our infrastructure must adapt to major environmental shocks that are here now and are expected to become worse. New materials, new structural systems, and rapid construction techniques are necessary to meet the fast evolving needs for prosperity in our communities. Interdependencies between resources and the built environment, including energy, water, housing stock, emergency service centers, transportation, etc. lead to multifaceted resiliency challenges in the face of exacerbated natural disasters. Complex multiscale, multidisciplinary modeling is essential to design for true resilient communities.

Sustainable living requires multi-scale approaches that start at the neighborhood and become intercontinental. Our world is becoming more resource-poor, more connected, and more interdependent. The parameters that affect prosperity are also constantly evolving, spatially varying and have a greater uncertainty about the future. Berkeley's scientific and engineering contributions have had global impact, but never before has the need for international leadership been greater than now. Solutions and collaboration will not just come from the western world but with action-based global partnerships.

To realize our vision, we can leverage unique resources and build upon our strengths at Berkeley:

- The College already has a strong track record in infrastructure engineering with multiple centers such as Pacific Earthquake Engineering Research Center (PEER), Berkeley Water Center, Institute of Transportation Studies (ITS), SimCenter, SwamLab, Center for Smart Infrastructure (CSI), and the Blum Center for Developing Economies, along with other university-level initiatives, including the Global Metropolitan Studies, the Center for Information Technology Research in the Interest of Society, Tsinghua-Berkeley-Shenzhen Institute, and SinBerBEST.
- The faculty members are influential to the infrastructure industry, governments (local, state, and international) and have strong ties to the Silicon Valley entrepreneurship ecosystem. We also have existing relationships with the Lawrence Berkeley National Laboratory on their 'critical infrastructure' initiative.
- Many existing infrastructure-related centers (PEER, ITS, and CSI) are currently housed at the Richmond Field Station (RFS). These centers have large-scale testing facilities by utilizing the large space available at RFS. However, the space is still under-utilized and there is an excellent potential for the site to become a collaborative working laboratory space to tackle the infrastructure-related problems.

We also propose to create an innovation hub for smart infrastructure and transportation systems, broadly defined to integrate shipping, aviation, and the surface, at RFS. The hub will involve an interdisciplinary industrial consortium comprising infrastructure owners, the construction sector and technology providers and will leverage and link to current Centers and activities. It can become an innovation park, hosting startups that will utilize the testing facilities. It also will have hoteling and permanent space for faculty, staff, students that allows them to conduct joint research with industry consortium and to launch startups.

Berkeley engineers are known for their leadership in society. We have a long history of service to industry, to the state of California, to government, to communities, and to society in general. Being of service involves having a vision, seeing what is needed now and will be needed in the future. It involves having the ability and know-how to address what is needed. But essential to service is the ability to listen and respond to the people we serve. And we will continue to strive to make real changes in the lives of real people.