NEHRP / Goal. Objective	*NEHRP / Priority Focus Area*	Directorate	Award Number	Title	Principal Investigator	Co-PIName(s)	Organization	Abstract
Infrastructure		BIO	**2215705**	Research Infrastructure: MRI: Acquisition of a Big Data HPC Cluster for Interdisciplinary Research and Training	Thomas Girke	Mark Alber, Adam Godzik, Jason Stajich, Wenxiu Ma	University of California-Riverside	An award is made to the University of California, Riverside (UCR) to acquire a Big Data High-Performance Computing (BD-HPC) cluster designed to enable novel and transformative research, outreach and training activities that are highly relevant to the environment and society. The system will be managed by UCR's HPC Center (HPCC) that serves a broad and diverse user population distributed across colleges and departments. As a highly shared resource, the instrument will enable a large number of NSF-funded programs, including those aiming to improve practices in agriculture, environmental protection, technology development and industry. Extensive educational and training activities are integrated to disseminate multidisciplinary concepts of Big Data Science. These outreach components will educate the public about the impact of Big Data Science on the environment, economy and society. The HPCC supports many undergraduate and graduate classes in a wide range of disciplines. Its resources are also instrumental for the development of new courses and programs in various data science areas. A high percentage of students in these classes and programs are from populations that are traditionally underrepresented in STEM disciplines. The availability of adequate computing and its beneficial impact on educational programs will attract outstanding students to computational and quantitative undergraduate and graduate programs. Combined with UCR's diverse ethnicity and research mission, this investment will benefit a wide array of translational research directions and technology-based economic development initiatives. The new BD-HPC cluster will enable novel research that cannot be performed on UCR's current research computing infrastructure or community cyberinfrastructure (CI), while also offering sufficient capacity to ensure support of ongoing research with greatly improved performance. Both current and new research addresses fundamental problems in a highly interdisciplinary environment bridging a broad array of science and engineering disciplines in basic and translational research. Grand challenge questions asked include: How do genetic and population dynamics determine phenotypic and evolutionary diversity? How can large-scale precision data be translated into improved stress and pathogen tolerance to feed a growing world population, and to develop interventions for reducing the rate and impact of environmental changes, ***natural disasters*** and climate change? How can quantitative modeling lead to high-performance molecules, materials, and help ***prevent wildfires and predict earthquakes***? UCR researchers working on these problems are from a wide range of research specializations, including environmental science, agriculture, biology, chemistry, physics, engineering, computer science, statistics and applied mathematics. Since their research relies heavily on high-throughput and computational modeling approaches, the BD-HPC cluster will permit new computational approaches for solving these research problems. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
2.8	**6**	CSE	**2228679**	CIVIC-PG Track B Digital Twin-based Framework for Development of Schools as Smart & Connected Community Resilience Hubs	John Taylor	Neda Mohammadi, Douglas Toomey	Georgia Tech Research Corporation	As the most recent United Nations Intergovernmental Panel on Climate Change (IPCC) report describes, climate change and the growing frequency and severity of disasters could soon outpace humanity's capacity to adapt. The severity of a disaster can be amplified by inadequate infrastructure investment, social marginalization, and a reduced capacity to adapt when a vulnerable community is impacted. Strengthening vulnerable communities' resilience and capacity to adapt is, therefore, a key challenge for emergency managers and community leaders. In this NSF CIVIC-PG project, we develop a community-led framework for adapting a public school to become a pilot Community Resilience Hub (CRH) for a community in the city of Portland, OR. CRHs are trusted, community-led facilities to support citizens before, during, or after a disaster event. This research and demonstration project will improve community self-sufficiency reaching more community members in need before, during and after a disaster event (e.g., wildfire, earthquake, flood) while also establishing the value of developing a network of CRHs in conjunction with community and city leaders and first responders. The research will elucidate strategies and logic for development of a network of CRHs that can be replicated in other communities across the United States. The findings of this project will be disseminated through collaboration with a NIST-sponsored Global City Teams Challenge SuperCluster and will be instrumental to the future development of CRHs. This NSF CIVIC-PG project will take critical steps toward developing a transformative vision of how local CRHs can connect to form a Community Resilience Network (CRN) leveraging the CRH sociotechnical infrastructure framework and serving communities across a larger geographic area during a disaster event. We lack an in-depth understanding of the dynamic characteristics of disruptions and the emergency response needs that evolve during a multi-hazard disaster event. The project's primary goal is to investigate how "digital twin" technology can facilitate establishment of community-led CRH sociotechnical infrastructure that integrates evolving community needs, resources, and conditions to facilitate emergency response, timely information-sharing, resilient connectivity, and resource distribution across a network of CRHs in response to disaster events. This will lay the foundation for establishment of a CRN that leverages updated city management and community-led strategies to expand CRH resource resilience capacity, distributed disaster response (across vulnerable communities and CRHs), and data-driven decision-making on disaster response. This project is part of the CIVIC Innovation Challenge which is a collaboration of NSF, the Department of Energy's Vehicle Technology Office, and the Department of Homeland Security's Science and Technology Directorate and Federal Emergency Management Agency. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
Infrastructure	**3**	ENG	**2227014**	Natural Hazards Engineering Research Infrastructure (NHERI) Decadal Visioning for FY 2026-FY 2035	Jared Kosters		Nexight Group LLC	The NSF-supported Natural Hazards Engineering Research Infrastructure (NHERI) awards, originally funded under the NSF 14-605 and NSF 15-598 program solicitations, will end on September 30, 2025. These awards, forming the NSF-supported NHERI mid-scale facility, have provided the natural hazards engineering (NHE) community with experimental, field, cyberinfrastructure, high performance computing, and computational modeling and simulation resources to conduct NHE research. This award, to Nexight Group LLC, will examine the influence of evolving natural hazards engineering (NHE) research, the national research infrastructure landscape, emerging technologies for resilient and sustainable civil infrastructure, state of climate change, and other driving forces on future NHE research directions, and will identify the research infrastructure (i.e., experimental and field equipment, instrumentation, and new experimental techniques and capabilities), cyberinfrastructure, and computational modeling and simulation tools needed to conduct future NHE research over the next decade, i.e., from fiscal year (FY) 2026-FY 2035. This study will review the state of natural hazards knowledge in the current and emerging areas of NHE research and research infrastructure and will generate recommendations for a comprehensive vision and strategy for the next decade of transformative science and engineering research and supporting research infrastructure at the frontiers of civil engineering, computational and data sciences, infrastructure materials, extreme natural hazard events, and other emerging fields. The study will also examine new modes of access to physical- and cyber-facilities by the NHE research community, and how these facilities can support education, outreach, and pathways for diversity, equity, and inclusion (DEI). The study can serve as input to NSF for designing research and research infrastructure program support during FY 2026-FY 2035 and will define and align NHE research to advance fundamental scientific knowledge in providing the nation with resilient and sustainable civil infrastructure under extreme event conditions. This award will contribute to NSF's roles in the National Earthquake Hazards Reduction Program (NEHRP) and the National Windstorm Impact Reduction Program (NWIRP). This award will gather input from the broad NHE and other related research communities to develop a Decadal Visioning (DV) Framework (FY 2026-FY 2035) for Grand Challenges research, research infrastructure, education, and outreach needs to advance the sustainability and resilience of the nation's civil infrastructure to natural hazard events. The key elements of this project comprise four main tasks: (i) conduct a preliminary assessment of the science drivers and current state of NHE research and research infrastructure by establishing a Task Group from the relevant NHE communities; define the vision, scope, and goals of the DV; and gather preliminary findings for the research agenda and research infrastructure needs; (ii) engage stakeholders to gather expert insights for organizing community-focused virtual workshops and coordinate review teams for developing the DV Framework; (iii) plan and facilitate collaborative community workshops to identify and prioritize the Framework's key science drivers (i.e., Grand Challenges), research infrastructure, education, and outreach needs; and (iv) develop the DV Framework, including key graphical concepts and final briefing materials to communicate the findings of the final DV report. The DV Framework report will be archived and made publicly available in the NHERI Data Depot (https://www.DesignSafe-ci.org). This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
Infrastructure	**3**	ENG	**2227407**	Natural Hazards Engineering Research Infrastructure: Large, High-Performance Outdoor Shake Table 2022-2025	Joel Conte	Jose Restrepo, John McCartney, Lelli VanDenEinde, Machel Morrison	University of California-San Diego	The Natural Hazards Engineering Research Infrastructure (NHERI) is supported by the National Science Foundation (NSF) as a distributed, multi-user national facility to provide the natural hazards engineering research community with access to research infrastructure that includes earthquake and wind engineering experimental facilities, cyberinfrastructure (CI), computational modeling and simulation tools, high performance computing resources, and research data, as well as education and community outreach activities. Originally funded under program solicitations NSF 14-605 and NSF 15-598, NHERI has operated since 2015 through separate, but coordinated, five-year research infrastructure awards for a Network Coordination Office, CI, Computational Modeling and Simulation Center, and Experimental Facilities, including a post-disaster, rapid response research facility. Information about NHERI resources is available at the NHERI web portal (https://www.DesignSafe-ci.org). Awards made for NHERI contribute to NSF's role in the National Earthquake Hazards Reduction Program (NEHRP) and the National Windstorm Impact Reduction Program (NWIRP). NHERI Experimental Facilities will provide access to their experimental resources, user services, and data management infrastructure for NSF-supported research and education awards. This award will renew the operations of the large high-performance outdoor shake table (LHPOST) Experimental Facility located at the University of California, San Diego, to support research in structural and geotechnical earthquake engineering. The LHPOST was recently upgraded through NSF award 1840870 to six degrees-of-freedom (6-DOF) capabilities (LHPOST6) and can reproduce the surface ground motions resulting from major earthquakes, including the three translations and three rotations of the ground surface. The shake table can support test structures with no height limitations and weighing up to 4.4 million pounds (20 meganewton). Building seismic-resilient and sustainable communities requires understanding and reliably predicting the seismic system-level response of buildings, critical facilities, utilities, lifelines, and other civil infrastructure systems. The experimental research conducted on the LHPOST6, together with computational models making use of the datasets collected from shake table tests, will advance the science, technology, and practice in earthquake engineering, leading to next-generation design codes and decision-making tools that will increase the seismic resilience and sustainability of the built environment. Experiments performed at this facility will have a significant educational impact by providing life-size demonstrations of the seismic performance of structural, geotechnical, and soil-foundation-structural systems to graduate, undergraduate, and K-12 students from diverse backgrounds, and will also educate the public about the urgency of the nation's efforts to develop effective technologies and policies to prevent natural hazards from becoming societal disasters. The research activities will train next-generation researchers, educators, and practitioners, who will be future leaders in natural hazard mitigation. An active outreach program will include annual user training and industry-academia workshops, Research Experiences for Undergraduates, traditional and social media campaigns, webinars from users of the facility, and computational challenges competitions. The LHPOST6 facility will transform natural hazard mitigation research by enabling large/full-scale system tests that will: (a) provide fundamental knowledge for understanding complete system behavior during earthquakes, from initiation of damage to the onset of collapse, including the effects of soil-foundation-structure interaction, the contributions of lateral and gravity load-resisting systems, and non-structural systems; (b) provide data for the development, calibration, and validation of high-fidelity physics-based computational models, therefore reducing future reliance on physical testing; (c) provide data and fragility information, which with validated simulation tools, will enable the full realization of performance-based design, the most rational/scientific way to evaluate and reduce the risks of natural hazards on the community; (d) provide validation tests for innovative structural systems and retrofit methods, as well as new materials, components, and manufacturing/construction methods for seismic protection; and (e) permit full-scale modeling of near-surface geotechnical systems and exploration of geotechnical phenomena and soil improvement techniques that cannot be explored at laboratory scale. The LHPOST6 will enable researchers to investigate the combined effect of realistic near-field translational and rotational earthquake ground motions on densely instrumented large/full-scale structural, geotechnical, or soil-foundation-structural systems, including the effects of kinematic and inertial soil-foundation-structural interaction, nonlinear soil and structural response, liquefaction, and seismic compression. Experimental data produced by the testing at this facility will be archived and made publicly available in the NHERI Data Depot (https://www.DesignSafe-ci.org). This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
Infrastructure	**5**	ENG	**2216294**	MRI: Acquisition of a Large-Scale Real-Time Digital Simulator for Cyber-Physical Energy Systems	Mohammed Ben-Idris	Poria Fajri, Hanif Livani, Hao Xu, Shamik Sengupta	Board of Regents, NSHE, obo University of Nevada, Reno	This NSF MRI project aims to make the U.S. power grid resilient and cyber-secure by acquiring a simulator that will allow researchers to realistically model how power grids work in practice, incorporating events like natural disasters, communication failures, and cyber-attacks. This equipment, called a real-time digital simulator, will bring a transformative change to the field of power and energy engineering through co-simulating different power system responses (transient, dynamic, and steady-state) at large scale and simulating cascading failures with actual devices via hardware-in-the-loop (HiL) capability. This will be achieved by building a large-scale cyber-physical energy systems testbed that will enable multi-disciplinary research, education, and training. The intellectual merits of the project include developing 1) user-friendly algorithms for multi-timeframe simulation of power system responses; 2) solutions that detect and mitigate potential cyber-attacks on power grids; and 3) resilient communication systems for power grids during extreme events. The broader impacts of the project include improving the resilience and stability of the power supply against extreme events, strengthening the cybersecurity of power grids, and providing training opportunities for graduate and undergraduate students and engineers. The testbed will lead to transformative research through testing, validating, and demonstrating the developed solutions on large-scale simulators with cybersecurity, communication, and HiL capabilities. Research activities to be enabled by this testbed include 1) developing solutions for proactive resource scheduling and hardening prior to natural disasters to protect power grids from wildfires, storms, and earthquakes; 2) developing components (technical controls and configuration options) needed for secure exchange of information with blind processing and privacy preservation, thereby hardening power grid cybersecurity; 3) researching solutions for the integration of renewable energy sources, mainly by using energy storage systems to provide grid services and synthetic inertia; 4) developing methods to detect and isolate high-impedance faults, which are known to cause wildfires and power system malfunctions; 5) using unmanned aerial vehicles to assess post-disaster damages to power grids and implement the restoration of the grid; 6) developing tools for power system operators that raise situational awareness; and 7) raising understanding of microgrid islanding and autonomous operation capabilities in cases of severe power outages. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
2.8	**2**	ENG	**2207294**	Collaborative Research: Regulatory Pragmatism and Building Codes for Hazard-Resilient Housing	Susan Ostermann		University of Notre Dame	Few aspects of life are more important to people than their homes. Building codes are a major form of regulation and one of the primary mechanisms by which states and societies try to make their homes safe in the face of hazards like hurricanes and earthquakes. This project advances the science needed to understand and improve compliance with key hazard-resistant practices in the design and construction of housing. It approaches this challenge using the concept of regulatory pragmatism, which argues that improving housing stock resilience and reducing disaster impacts for housing may necessitate prioritizing those aspects of the building code that allow builders to most cheaply and effectively reach these goals. Through engineering assessment, combined with interviews and surveys of builders and residents, this project is collecting the data necessary to design useful interventions to increase code compliance with key hazard-resistant building practices and, in so doing, protect human life and the built environment from the effects of a disaster. Despite the fact that building codes touch the lives of many, there is little research studying how regulatory strategies and sound engineering can together reduce disaster risk. Project work aims to examine compliance with key hazard-resistant building practices among builders and households, and explore the factors that influence compliance, including household and builder attitudes and experiences, local regulations, perceived and real costs, and local building practices. Crucially, in parallel, the project will use performance-based engineering methods to quantify the benefits and risks associated with complying with hazard-resistant building practices in terms of housing safety and post-event housing occupancy. These findings will be used to identify and prioritize key building practices based on their effectiveness in reducing disaster risk and their achievability (e.g., in terms of cost and compatibility with local building practices). Building on initial findings, the project will then consider the design and assessment of a pragmatic, compliance-fostering intervention. The project is conducted in two multi-hazard U.S. contexts, Alaska and Puerto Rico, providing a most-different comparison to explore how building practices, compliance, and intervention outcomes differ based on community characteristics. It will also involve interdisciplinary training of students supporting the development of a workforce trained to address regulatory and engineering challenges associated with disaster resilient housing. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

2.8		ENG	**2212116**	Assembly Mechanism Investigation and Theoretical Framework Development of Magnetorheological Emulsions for Low Power Energy Dampers	Amanda Koh	Shibin Dai	University of Alabama Tuscaloosa	To protect buildings from earthquake vibrations and residual limbs from the impact of movement, it is critical to develop materials that can dissipate the energy of these forces safely and effectively. Magnetorheological fluids (MRFs) are mixtures of magnetic particles in oil that form chains under a magnetic field. MRF chains resist being broken up due to vibration or impact, instead releasing that energy as heat, reducing the mechanical damage to surrounding structural or biological material. Typical MRFs, however, require large amounts of power to maintain a high magnetic field. This is a challenge due to inaccessible power during an earthquake or poor safety of wearable high-power batteries for prosthetics. This award seeks to develop a new type of MRF based on oil-in-water emulsions that can achieve better energy dissipation at lower magnetic fields, using significantly less power. The critical factors in MRF formulation will be explored as well as the relationship between MRF chain structure and overall performance both experimentally and theoretically. The results of this award will not only improve infrastructure resiliency to natural disasters as well as improve the quality of life of amputees but will also support the mentorship of graduate students along their path towards STEM careers. Materials which dissipate energy are necessary for a wide variety of engineering problems, such as to withstand seismic vibrations or the impact of human motion. New materials are needed to improve earthquake resiliency and prosthetic limb comfort. To address this need, magnetorheological fluids (MRFs) can be used as part of viscous dampers to dissipate large amounts of energy safely and effectively. MRFs are magnetic particle dispersions that, when subjected to a magnetic field, form chains and resist flow. The adoption of MRFs has been limited in large part due to unacceptable power requirements for large-scale or on-body applications. This award investigates a new emulsion-based formulation for MRFs to reduce the MRF power requirement. A combined experimental and theoretical approach will be used with the objectives of (1) determining the key parameters that govern the performance of MRF-emulsions, (2) visualizing the magnetized state MRF-emulsion morphology, and (3) developing a fundamental framework to generalize the phenomena. This award enables the improvement of infrastructure as well as prosthetic devices while also providing STEM mentorship and experience for graduate students. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
2.8	**2**	ENG	**2206018**	CPS Medium: Autonomous Control of Self-Powered Critical Infrastructures	Jeffrey Scruggs	Branko Kerkez, Heath Hofmann, James Van de Ven	Regents of the University of Michigan - Ann Arbor	This Cyber Physical Systems (CPS) project will develop novel sensing, actuation, and embedded computing technologies that allow civil infrastructures to be responsive, resilient and adaptive in the face of dynamic loads. Such technologies require delivery of electrical power, typically either via an external power grid, or through the use of battery storage. However, grid power may be unreliable during extreme loading events, and batteries must be periodically recharged or replaced. The novelty of the technologies developed in this project is that they power themselves, by storing and reusing energy injected into the infrastructure by external loads. The project focuses on three applications: (1) urban stormwater networks that actively control water levels to prevent flooding, using power generated from the hydrologic flows, (2) buildings that actively control their deformations during earthquakes and high winds, using power generated from vibrations, and (3) ocean desalination systems that actively control pumping rates, using power generated from waves. The project contains an experimental campaign for each application. It also contains an analytical component, focused on the development of control algorithms to maximize the performance of the technologies. Educational outreach activities include class modules and research experiences for undergraduate and graduate students, as well as a workshop for high school students. Control algorithms for self-powered infrastructures must explicitly optimize the balance between power generation and performance objectives. This project will innovate new Model Predictive Control algorithms for self-powered infrastructure technologies, such that they achieve the best performance possible while not running out of energy. These algorithms will be validated experimentally, for all three applications. There is presently no existing theory for optimal control of self-powered systems that is scalable to large and complex systems such as the ones under consideration. The research to be conducted here will augment recent advances in Model Predictive Control theory, to result in a new body of knowledge in this area. Challenges include: (1) innovation of optimization algorithms that can contend with the inherent nonconvexity of optimal self-powered control problems; (2) development of effective techniques for handling the stochastic nature of the dynamics for the target applications; (3) synthesis of controllers that are computationally tractable, but which also optimally compensate for the complex transmission losses and constraints in the power trains; (4) the derivation of systematic techniques for ensuring the robustness of the controllers, to uncertainties in the system model and disturbances. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.4	**2**	ENG	**2226154**	BRITE Synergy: Seismic Cracking of Embankments and Earth Dams	Antonio Bobet		Purdue University	The safety of embankments and earth dams relies on an adequate assessment of seismically-induced deformations. When subjected to earthquake loading, embankments and earth dams may settle, deform laterally and longitudinally, and may exhibit cracking in the longitudinal and/or transverse directions. Cracks are considered one of the most hazardous consequences of strong earthquake shaking on earthen dams, as they can lead to piping failure due to increased seepage and internal erosion through the cracks. Observed cracks in earth dams after an earthquake are most often associated with tensile stresses and strains resulting from earthquake-induced permanent deformations. Current methods to estimate earthquake-induced cracking seem inadequate, given the widespread damage observed in thousands of dams after the 2008 Wenchuan earthquake. The research is geared at advancing our understanding of the cracking processes in embankments and earth dams during an earthquake and at providing improved tools for practitioners. This Boosting Research Ideas for Transformative and Equitable Advances in Engineering (BRITE) Synergy project aims at proving the hypothesis that static analyses may provide information on the location and size of cracking caused by earthquakes but challenges the current standard of practice of performing two-dimensional plane strain analyses to estimate transverse cracking on earth embankments and dams. The work will not only benefit geotechnical and dam engineering, but society at large. An important outcome of the work is an updated database of case studies, as well as guidelines and protocols for collection of future information. The research will also benefit other fields such as mining engineering, e.g., tailing dams in seismic areas and will contribute to increasing infrastructure resilience. The objectives of the research will be accomplished through a number of synergistic activities that aggregate disconnected work, verify or validate unproven assumptions and perceptions and new work to reach generalizations such that the overall outcome is more than the sum of its parts. The work will combine existing information in the form of case studies and empirical recommendations, and outcomes from numerical simulations. It will expand and modernize databases, update and improve empirical methods, and perform detailed dynamic three-dimensional numerical analyses of actual dams, namely Lenihan Dam in California and Gatun Dam in the Panama Canal. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.4	**2**	ENG	**2211002**	Unified Multi-phase Numerical Framework for Understanding Co-Seismic Slope Failures in Complex Sites	Alba Yerro Colom		Virginia Polytechnic Institute and State University	This research project will focus on advancing the fundamental understanding of the mechanics of slope failures triggered by earthquakes and will help to predict, reduce, and mitigate their destructive consequences. Earthquake-triggered slope failures cause significant economic and life losses in seismically active regions. However, state-of-the-art procedures that address triggering and runout of co-seismic slope failures are highly idealized and do not incorporate the complexities of soil behavior subjected to cyclic loading. This research will develop a validated numerical framework to analyze the overall failure process, from the ground shaking and failure initiation to the post-failure processes. The numerical tool will accommodate large deformations and hydro-mechanical coupling and will be compatible with existing continuum-based constitutive models for the simulation of liquefaction triggering and cyclic mobility. The developed numerical tool and a tutorial manual will be shared through an open-source platform. The research will also be complemented by outreach activities, including lectures for graduate students and training sessions for practitioners. The outcomes of this research can be provide a more comprehensive understanding of the risk associated with earthquake hazards. The goal of this research is to better capture and understand the connection between ground motion characteristics, pore pressure evolution and final mobility of slope failures. Thus, the research objectives of this project include: (i) to establish and validate a generalized numerical framework capable of simulating earthquake loading, site response, and large deformations of complex sites, all within a unified computational framework; (ii) to quantify pore water pressure evolution during the entire instability process; and (iii) to correlate the intensity of the ground motions with the failure initiation, post-failure behavior, and hydro-mechanical response. To accomplish these objectives, the existing Material Point Method framework will be further developed to accurately simulate ground shaking, site response, and large deformations. State-of-practice constitutive models accounting for material damping and cyclic mobility will be considered in the same framework, and their performance will be evaluated. The developments will be validated using existing data from centrifuge testing and field case studies. This project will allow the PI to inform, advance, and transform the way co-seismic slope stability analyses are approached, especially for complex geometries and when critical infrastructure is at risk. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
2.8	**3**	ENG	**2211343**	Frequency-Domain Model Updating through Branch and Bound with Convex Relaxation	Yang Wang	Santanu Dey	Georgia Tech Research Corporation	A variety of engineering disciplines use computer models to describe the mechanical and dynamical behavior of structures. Examples include buildings, bridges, airframes, and ship structures, spanning various disciplines including civil, mechanical, and aerospace engineering. Despite decades of progress in computer simulation of structural behaviors, simulation by a computer model usually differs from the response measured in-situ at the as-built structure. Particularly when dynamic structural performance is of interest, the difference between simulation and measurement can be significant. The process of improving model accuracy by identifying structural parameter values is termed structural model updating. This project will study numerical algorithms that can improve model accuracy by effectively finding more optimized parameter values for the structural model. These model updating algorithms can be useful in a variety of real applications. This project has the potential to greatly improve the accuracy of simulation response of structures subject to dynamic loading conditions such as earthquake, blast, and impacts. Although many research efforts have been dedicated to model updating, the underlying optimization problems are known to be non-convex. In general, off-the-shelf optimization algorithms cannot guarantee global optimality of a non-convex problem that has unknown number of local optima. This project investigates convex relaxation and branch-and-bound algorithms that can guarantee global optimality toward solving non-convex model updating problems. Providing an optimality certificate, the approach offers transformative solutions for the model updating of various engineering structures. In particular, to find a high-quality underestimating bound, multiple convex relaxations will be comparatively studied, including the convex quadratic, the semi-definite programing, and the second-order cone programing relaxations. The branch-and-bound solution is applicable to both deterministic and probabilistic versions of the modal property difference formulation in model updating. In addition to numerical examples, densely instrumented sensor data from a number of as-built structures will be used to validate the model updating algorithms. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.4	**2**	ENG	**2230187**	Analysis, Design and System-Level Performance of Repairable Precast Concrete Buckling-Restrained Braced Frames under Seismic Loads	Yahya Kurama	Jose Restrepo, Laura Redmond	University of Notre Dame	The scale of losses from previous earthquakes has demonstrated the need for buildings that can rapidly restore their essential functions after a natural disaster. This concept is called functional recovery. This project will contribute to the nation's functional recovery objectives by creating and examining a repairable precast concrete buckling-restrained braced (BRB) frame structure with a new type of non-proprietary diagonal brace. The new brace will have low-cost features that permit practical replacement after an earthquake. This project will generate fundamental knowledge on the seismic design and performance of this building system. Data will be generated from numerical analyses, testing of isolated braces and their connections, and culminating tests on the seismic performance and repair of a three-story building utilizing the six-degree-of-freedom Large High-Performance Outdoor Shake Table operated by the University of California, San Diego, as part of the NSF-funded Natural Hazards Engineering Research Infrastructure (NHERI). The project will emphasize diversity and inclusion, will engage undergraduates from underrepresented groups in education and mentoring programs, and will create engineering learning modules for pre-college students. Precast industry partners will provide specimens and technical guidance emphasizing the project's focus on industry-preferred structural details for practical acceptance. Engagement with the broader engineering community will be achieved through a competition to predict the building response on the shake table. Data generated from this project will be archived and made publicly available in the NHERI Data Depot (https://www.DesignSafe-CI.org). This award will contribute to NSF's role in the National Earthquake Hazards Reduction Program (NEHRP). There is currently no comprehensive U.S.-based research on the seismic performance of precast BRB frame structures. This project will fill this research gap by 1) designing and characterizing the behavior of a novel, replaceable concrete brace, 2) evaluating the design and modeling of multi-story braced frames, and 3) evaluating the seismic behavior of these frames within a building. The new brace will achieve ductile and stable behavior by structurally efficient details incorporating energy-dissipating reinforcing bars crossing gap-joints at the brace ends and spliced with threaded couplers and upsized bars to minimize damage in the beam and column members. This threaded gap-joint connection will permit damaged precast braces to be replaced with cast-in-place concrete braces after an earthquake. Detailed numerical models will be developed and experimentally validated to predict three-dimensional stress gradients and damage conditions that could lead to premature failure of the brace, and to evaluate efficient design-basis models for multi-story braced frames. The modeling and design methods will be validated with the first system-level testing of a precast braced frame building on the six-degree-of-freedom shake table. These culminating tests will demonstrate the performance of the braced frames, their connections, and brace replacement under multi-directional demands. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.2		GEO	**2228180**	Implementation Grant: Community-driven Inclusive Excellence and Leadership Opportunities in the Geosciences (CIELO-G)	Aaron Velasco	Lin Ma, Marianne Karplus, Benjamin Brunner, Hugo Gutierrez	University of Texas at El Paso	The Community-driven Inclusive Excellence and Leadership Opportunities in the Geosciences (CIELO-G) project will form cohorts of graduate students, postdoctoral scholars, and educators at all levels to transform the culture of the geoscience community by: 1) Supporting a diverse and multi-disciplinary team to address fundamental climate change and Earth system science problems, 2) Training and synergistic learning with local educators to create a modern geoscience learning ecosystem in a bi-national community, 3) Increasing both the number and success rate of students from diverse socio-economic backgrounds that become geoscience professionals, 4) Increasing awareness of the importance of geosciences and inspiring underserved communities and students, and 5) Improving graduate students' and postdoctoral scholars' training through evidence-based professional development covering both technical and soft skills. To achieve these goals, the project leaders adopt a collective impact approach that provides a foundation for innovative, robust research that incorporates community engagement. The collective impact (CI) model develops a network of community members, organizations, and institutions by advancing a common agenda, providing centralized support, promoting continuous communication, creating mutually reinforcing activities, and executing a shared measurement. Programmatically, the project leaders will create cohorts of six graduate students, six high school and community college educators, two postdoctoral fellows along with junior faculty, and six faculty research mentors, with integrated efforts for community research and engagement with five local non-government organizations. Together with the local community, the project leaders will design and execute geoscience research projects that combine four essential elements: 1) a basic science question addressing fundamental climate change and Earth system science issues impacting the Paso del Norte Region (west Texas, southern New Mexico, and northern Mexico), 2) use-inspired research which results may lead to implementation of practical solutions for the community, 3) socially relevant outcomes driving substantial changes of awareness towards the importance of geosciences in the community, and 4) strong community engagement leading to a long-lasting and sustainable geoscience learning ecosystem in the region. The project leaders identify four initial research projects, recognizing that new projects may develop as CI is implemented: 1) Urgent challenges around water and agriculture sustainability in arid lands, 2) Exploring interactions between geologic structure and water pathways, including impacts on erosion, floods, landslides, and aquifer recharge, 3) Investigating intraplate earthquake hazards in West Texas and southern New Mexico, and 4) Understanding and mitigating increasing urban heat and dust. The projects will be designed to address key science challenges while reaching deep into the communities that they will impact in an organic way, allowing them to evolve in response to continuous community input. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

1.2	**7**	GEO	**2225395**	Track 1: Center for Collective Impact in Earthquake Science (C-CIES): Building Inclusive Excellence, Diversity, Equity, and Community into Earthquake Science	Aaron Velasco	Jeffrey Weidner, Marianne Karplus	University of Texas at El Paso	This project will develop the Center for Collective Impact in Earthquake Science, which has the vision to become a leading-edge earthquake research center dedicated to improving resiliency from seismic hazards in an equitable, accessible, and sustainable manner. The mission will be to advance earthquake science with the aim of meeting the natural hazard mitigation needs of all communities in regions of low probability, high impact earthquake risk. Low probability disasters tend to have an oversized impact on local communities. Additionally, even small- to moderate-magnitude human-made (induced) earthquakes induced by anthropogenetic activities have resulted in heightened public awareness, damages to the built environment, and the shutting-down of economic and energy infrastructure. Low probability, high impact earthquakes sometimes occur in places not easily identified by the theory of plate tectonics and typically present unique challenges to understanding how communities respond to risks from these earthquakes. By studying low probability, high impact earthquakes, including induced events, the project will develop strategies for better identifying and potentially quantifying seismic hazards, plus inform many aspects of fundamental earthquake science of broad importance. The goals of the center will be to: 1) Advance basic earthquake science and engineering; 2) Establish a foundation for sharing, value-driven understanding of science; 3) Be responsive to the needs of all kinds of communities through use-inspired research; 4) Recruit, retain, and train the next generation of diverse earth scientists; and 5) Develop a framework for impactful geoscience that translates results of scientific discovery into actions that can improve resilience and reduce risk from seismic hazards. To achieve these goals requires an innovative and robust research plan that incorporates community engagement. The project will adopt the collective impact model for establishing this center, which develops a network of community members, organizations, and institutions through the development of a common agenda, centralized support, continuous communication, mutually reinforcing activities, and shared measurement. The center will emphasize research with potential to respond to the needs of vulnerable populations that have been historically underserved by current earthquake science, engineering, and public policy. The investigators will solicit pilot projects and use them these pilot projects to establish mechanisms for increasing partnership and for evaluation of the proposals. Using these pilot projects as case studies, a strategic plan we will be developed on how to structure the center. All projects will begin as pilot projects, be evaluated and given feedback, and then transition to a full project when the center is fully funded. In this fashion, the project can guarantee that the full-scale projects meet the goals of the center prior to implementation. Each project must include four elements: 1) the basic science question that must align with the research themes discussed above, 2) the use-inspired research where results may lead to implementation of practical solutions for the community, 3) the social impact of the project, and 4) the community engagement. The pilot projects will be designed to address key science challenges and reach deep into the communities that they will impact. Our initial projects may include projects on 1) investigating earthquake risk in under-resourced communities, 2) using citizen science to understand the earthquake hazard in New England, 3) developing new techniques to get more information out of seismic data, 4) refining the earthquake hazard in a vulnerable, bi-national, multi-lingual community (El Paso, TX), and 5) using crowdsourcing to help with cataloging vulnerable buildings. Priority will be given to projects that engage low-resourced communities (such as small rural towns) or historically marginalized populations (such as low-income or immigrant populations). Second, pilot projects will be asked to include an element of workforce development, particularly of those who are historically under-represented in geosciences. Third, pilot projects will be asked to articulate their contributions towards promoting interdisciplinary research or practice. Fourth, full center projects will be asked to fund graduate and/or undergraduate students and provide opportunities for students to be cross trained between projects. By adopting collective impact as a guiding principle for the center along with funding pilot projects, the center will, by necessity, make Inclusive Excellence, Diversity, Equity, and Community a fundamental principle of the center. This award is supported by the Division of Earth Sciences and the Geoscience Opportunities for Leadership in Diversity (GOLD-EN) in the Directorate for Geosciences. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.1	**1**	GEO	**2245540**	The Influence of Fault Geometry on Shallow Frictional Sliding in Subduction Zones	Rob Skarbek		Planetary Science Institute, Columbia University	Recent observations of faults in the shallow regions of subduction zones - where one tectonic plate dives under another - have revealed a variety of behaviors. These include tsunami earthquakes, shallow slow slip events, and the extension of fast coseismic slip to the seafloor. How subduction zones produce this range of fault behaviors is still poorly understood. Here, the researchers investigate the effects of fault network geometry and frictional properties on their potential ruptures. They explore whether interactions between faults and with the seafloor can generate the observed range of behaviors. They use a combination of innovative theoretical analysis and numerical simulations. The goal is to constrain the relationships between shallow fault behavior and large megathrust earthquakes. The simulation outcomes unveil gradually the mechanics of earthquakes and tsunamis. They help assessing the associated risks. The codes developed by the team are shared with the community as open source. The project also provides support for an early career scientist and training for an undergraduate student at Columbia University. This project is focused on understanding the spatial and temporal relationships between different types of slip behavior in the shallow region of subduction zones. The researchers conduct complimentary theoretical and numerical analyses of slip on a dipping thrust fault that obeys rate and state friction. They use a new technique to include the effects of the wedge-shaped geometry that is typical of shallow subduction zones. The goal is to determine how sliding stability of the fault is controlled by interactions between frictional and elastic properties and effective stress with the wedge taper angle and distance on the fault from the trench. The team also develops and implements a numerical model for slip on a fault network in a shallow subduction zone geometry. The network consists of a main plate-interface fault with a single splay thrust fault that branches off and intersects the seafloor. The model is used to simulate sequences of slip on the fault network. A special focus is to understand how shallow fault patches can alternate between producing events with different stability characteristics, and how this behavior influences megathrust events that nucleate in the locked zone. These analyses will allow answering important questions about the slip behavior of subduction zones, including: How does fault zone geometry control the sliding stability of thrust faults? How do shallow slip events nucleate and propagate within a subduction zone fault network over multiple seismic cycles? This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.2	**7**	GEO	**2303139**	Collaborative Research: RAPID: Capturing the Elgin-Lugoff earthquake swarm with a dense nodal array	Zhigang Peng		Georgia Tech Research Corporation	This RAPID project involves a seismic deployment of 86 Smartsolo 5Hz nodes to the epicenter region of the ongoing Elgin-Lugoff earthquake swarm sequence in South Carolina. This sequence started with a magnitude (M) 3.3 on December 27, 2021, in a region with relatively low background seismicity. This sequence appears to occur in several episodes, sometimes initiated by M 3+ events, and has up to months of gaps in between. While they occurred along the ancient Eastern Piedmont Fault System, a close examination of the earthquakes reveals that most of the events occurred in between the fault system. At this point, it is still not clear what is the driving force for this earthquake swarm and how long it will last. This deployment is timely, because this sequence is still ongoing, with no signs of ending soon. In addition, only one station was deployed within a few kilometers of the swarm. Such station distribution is not sufficient enough to provide a detailed high-resolution detection/relocation of microseismicity during an earthquake swarm, which are needed for better deciphering the spatio-temporal evolutions of the swarm sequence and their physical mechanisms. In addition, the seismic data collected in this deployment will be used to construct a velocity model of the local subsurface structure. Accurate seismic models are crucial particularly for developing ground motion models for seismic hazard assessment and delineating fault locations. Up to 15 undergraduate/graduate students from both Georgia Tech and University of South Carolina will be involved in the nodal deployment. Data will be made available through the IRIS Data Management Center. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
			2303140		Daniel Frost		University of South Carolina at Columbia	
1.1	**1**	GEO	**2232638**	Collaborative Research: Near-Trench Community Geodetic Experiment	Mark Zumberge		University of California-San Diego Scripps Inst of Oceanography	Collaborative Research: Near-Trench Community Geodetic Experiment The largest earthquakes (and the resulting tsunamis) occur offshore, but the instruments traditionally used to study the ground deformation associated with these events can only be used on land. Therefore, traditional surveying cannot quantify the offshore seismic hazards. Studying these hazards requires tools designed to collect data offshore. One such tool is the GNSS-Acoustic method, an offshore GPS (Global Positioning System) method with sets of instruments set up on the seafloor in circular groupings. These instruments are positioned relative to a remote-controlled sea surface robot using sound pulses. This 'Wave Glider' can use GPS to determine its position, allowing the seafloor instruments to be located with cm-level accuracy. Tracking these positions over time allows researchers to learn how the deforming seafloor builds up stress that ultimately results in earthquakes. This project follows recommendations by a large group of scientists who are interested in knowing how seafloor deforms in subduction zones as the seafloor crust gradually slides beneath the continental crust. The project aims to detect the motions of the seafloor at six stations in the offshore Cascadia region and six in the offshore Alaska region. This will aid the scientific community in assessing the seismic and tsunami hazards in these regions. The data will all be open access and the project will contribute to training the next generation of geodetic scientists. The 2011 Tohoku earthquake demonstrated that coseismic rupture can extend to shallow depths along a subduction megathrust, where large vertical displacements of the seafloor can generate damaging tsunamis. This project will clarify whether a similar event can happen in the offshore Cascadia and Alaska regions by using seafloor geodetic observations to infer the level of elastic strain stored in the accretionary prisms of Cascadia and Alaska subduction zones. The researchers will deploy GNSS-Acoustic instruments from the seafloor geodesy community pool, which consists of 51 GNSS-Acoustic transponders (enough for 17 new GNSS-Acoustic sites) and 3 Wave Gliders, following recommendations from 165 scientists and students who attended a seafloor geodesy community workshop on how best to make use of the instrument pool. Twelve new GNSS-Acoustic sites will be established during this experiment, with six along each of the Cascadia and Alaska subduction zone trenches, which were identified by workshop attendees as high-value science targets. The researchers will survey these new sites as well as the seven sites already established in these regions annually throughout the five years of the project. These positions will be used to infer interseismic velocities from which the rate of elastic strain buildup in the accretionary prisms can be determined, with implications for the earthquake and tsunami hazard in Alaska and the Pacific Northwest. The data will all be open access and the project will contribute to training the next generation of geodetic scientists. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
			2232639		Andrew Newman		Georgia Tech Research Corporation	
			2232640		David Schmidt		University of Washington	
			2232641		Donna Charlevoix	David Mencin	UNAVCO, Inc.	
			2232642		Noel Bartlow		University of Kansas Center for Research Inc	
			2232643		Surui Xie		University of Houston	
			2232644		Spahr Webb		Columbia University	
1.1	**1**	GEO	**2237773**	Structure and Hydration of the Explorer-Juan de Fuca-Gorda Plate System at the Onset of Subduction Beneath Cascadia	Juan Pablo Canales	Hanchao Jian, Nathaniel Miller	Woods Hole Oceanographic Institution	Earthquakes, tsunamis, and explosive volcanism are geohazards associated with subduction zones. Understanding the variability along the subduction zone is important for what controls geohazards in this populated region of North America. This project will analyze marine seismic profiles along the Cascadia margin from offshore Vancouver Island to southern Oregon. Measurements and analyses will constrain variability in subducting sediment thickness, amount of water in the downgoing plate, and topography of the sediment-basement interface. This project will contribute to the education of two graduate students by providing them support, data and training in geophysical imaging. In 2021, a suite of modern and extensive controlled-source seismic datasets was collected along profiles spanning most of the length of the Cascadia margin. The datasets along ten of the profiles consist of co-located ultralong-streamer multichannel seismic reflection and wide-angle seismic reflection/refraction data recorded in ocean bottom seismometers (OBSs). The project will use these datasets to model the seismic properties and structure of the sediments, crust and mantle of the incoming and down-going plates as well as those of the accretionary prism. Fracturing and alteration of crustal and mantle rocks give rise to detectable changes in seismic velocities, and seismic methods provide an important remote sensing tool for assessing plate hydration. The researchers will produce models of the P-wave and S-wave seismic velocity structure along each OBS transect using state-of-the-art wide-angle seismic data processing and imaging methods, including downward-continuation of ultra-long streamer data, super-virtual refraction interferometry, and joint travel-time refraction/reflection tomography of streamer and OBS data. The seismic velocity models will be used together with effective medium theory to constrain crust and mantle porosity, and the amount and distribution of fluid and chemically-bound water of the incoming and down-going plate. The findings from this project will be of great interest to researchers investigating Cascadia subduction zone processes, from the deformation front to sub-arc depths. The project results will also be a key component for updating and improving the U.S. Geological Survey's margin-scale 3-D seismic velocity model for Cascadia. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
1.4	**6**	GEO	**2220219**	NNA Research: Collaborative Research: Arctic, Climate, and Earthquakes (ACE): Seismic Resilience and Adaptation of Arctic Infrastructure and Social Systems amid Changing Climate	Majid Ghayoomi	Katharine Duderstadt	University of New Hampshire	Navigating the New Arctic (NNA) is one of NSF's 10 Big Ideas. NNA projects address convergence scientific challenges in the rapidly changing Arctic. This Arctic research is needed to inform the economy, security and resilience of the Nation, the larger region, and the globe. NNA empowers new research partnerships from local to international scales, diversifies the next generation of Arctic researchers, enhances efforts in formal and informal education, and integrates the co-production of knowledge where appropriate. This award fulfills part of that aim by addressing interactions among social systems, natural environment, and built environment in the following NNA focus areas: Arctic Residents, Education, and Resilient Infrastructure. The state of Alaska and many other areas of the Arctic are seismically active, experiencing thousands of earthquakes with different magnitudes every year. Given the vulnerability of the Artic to earthquakes and the accelerating environmental and social changes, it is critical to evaluate the resiliency of the region's infrastructure to seismic events in the context of the natural environment, built environment, and social systems and understand how these changes interact and impact the region's preparedness and response to earthquakes. The overarching goals of this NNA Collaborative Research project are to: 1) Improve the fundamental understanding of the impact of Arctic changes on the region's preparedness and response to future earthquakes through seismic monitoring/modeling, community engagement, and targeted investigations of the interactions between the relevant components of the natural environment, built environment, and social systems; and 2) Enhance the seismic resilience of Arctic communities by providing them with the necessary training and tools to manage future earthquake-related disasters including planning, preparedness, mitigation, and recovery. The project research and education activities will include targeted research studies, workshops, and workforce development including the training and mentoring of three graduate students at the University of New Hampshire, one graduate student and an undergraduate student at the University of Georgia, one graduate student at Pennsylvania State University, one graduate student at the University of Alaska Fairbanks, and one graduate student at the University of Virginia. This NNA Collaborative Research project builds upon the results of a planning grant and a workshop with significant community input that identified six major community concerns and high priority research topics regarding the seismic challenges facing the new Arctic and the region's preparedness and resilience to manage future earthquake-related disasters. To address these challenges, the Principal Investigators (PIs) of this NNA Collaborative Research project propose to carry out a convergent research and education program structured around four strategic pillars and objectives. The specific objectives of the research include 1) Infrastructure seismic response assessment under climate-driven changes of the Arctic ground through the monitoring of key infrastructure systems in Alaska in combination with centrifuge physical modeling to simulate and evaluate the impact of permafrost thawing on soils and building/infrastructure foundations, 2) Co-development of equitable seismic resilience capacities for local communities through surveys, interviews, and participatory mapping workshops, 3) Seismic resilience modeling and assessment through systems dynamics modeling, review of seismic design/planning strategies, and climate adaptation planning at community and state levels, and 4) Outreach and education through ACE youth training camps, STEM research experience for Indigenous youth, and an international workshop on Arctic seismic resilience and adaptation. The successful completion of this project has the potential for transformative impact by seeding and catalyzing research that could lead to breakthroughs in fundamental science and engineering, informed by community participation and Indigenous knowledge, to address seismic challenges facing the new Arctic and improve the region's preparedness and response to future earthquake-related disasters. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

			2220220		Michelle Ritchie		University of Georgia Research Foundation Inc	
			2220221		Guangqing Chi		Pennsylvania State Univ University Park	
			2220222		Alexander Kholodov		University of Alaska Fairbanks Campus	
			2220223		Matthew Jull		University of Virginia Main Campus	
1.1	**1**	GEO	**2228413**	Collaborative Research: Geophysical Study of Ongoing Subduction Initiation Along the Matthew-Hunter Trench	Douglas Wiens		Washington University	Subduction, where one plate plunges downward beneath another plate and produces a volcanic arc on the overriding plate, is a fundamental component of plate tectonics. However, there is little understanding of how subduction begins, largely because there have been no observations of this process happening at the present time. Recent studies show that subduction is just beginning along the Matthew and Hunter Trench, between Vanuatu, New Caledonia, and Fiji in the South Pacific. This project will conduct a pair of scientific cruises to the Matthew-Hunter Subduction Zone to deploy and recover ocean bottom seismographs, as well as gather marine geophysical datasets. The seismic data will be used to image the downgoing plate and magma source regions beneath volcanoes. The cruises will also map the seafloor and make gravity and magnetic measurements that will provide evidence concerning tectonic structures, volcanism, crustal deformation, and ages of subduction initiation processes. This project will be carried out in collaboration with scientists from France and New Caledonia. Subduction initiation may be the most enduring question in terrestrial geodynamics. Most knowledge of subduction initiation comes from the study of past initiation events where some of the volcanic products have been preserved. The lack of present-day examples of subduction initiation that include the classic sequence of forearc magmatism limits the understanding of how these processes occur. However, recent studies show that subduction initiation with accompanying magmatic activity is occurring along the Matthew and Hunter Trench between the New Hebrides Trench and the Fiji Platform. The Matthew-Hunter Subduction Zone thus offers a unique opportunity to study a young subduction zone in the process of formation but sufficiently advanced to create magmatic products. This project will deploy an array of 25 passive ocean bottom seismographs (20 US and 5 French) and carry out a marine geophysical survey to define the slab geometry, seismicity, structure, and mantle flow patterns associated with this developing subduction zone. The seismographs will be deployed along lines to be shot by a collaborative French cruise to take advantage of shallow structure constraints, and the array is designed to image the structure of the forearc, the volcanic Hunter Ridge, and the extensional Monzier Rift. Seismic data will be analyzed using Rayleigh wave tomography from ambient noise and earthquakes, body wave tomography, and shear wave splitting. In addition, an extensive multibeam bathymetric, acoustic backscatter imagery, gravity and magnetic survey will be carried out to identify tectonic structures, regions of recent seafloor volcanism, and magnetic isochrons. Geophysical track spacing will be sufficiently dense to fully map the forearc area and carry out three-dimensional geophysical inversions over the same regions as the main seismograph deployment. This combination of near surface and coincident deeper crustal and mantle imaging will provide powerful constraints for understanding subduction initiation. This project will be carried out in collaboration with investigators from IFREMER and New Caledonia, who have proposed a French cruise currently awaiting scheduling to collect active source seismic data as well as heat flow and fluid samples. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
			2228414		Fernando Martinez		University of Hawaii	
1.2	**7**	O/D	**2229770**	RII Track-4: NSF: Gouge Mineral Strain Mapping under Shearing and Implications for EGS-Induced Seismicity	Long Fan		University of Alaska Fairbanks Campus	The frequency of induced earthquakes has increased dramatically over the past few years globally due to massive fluid injection in enhanced geothermal systems (EGS), where small perturbations may prematurely trigger earthquakes. Recent observations associated with EGS and a purposely reactivated fault in a field pilot experiment exhibit significantly larger magnitudes than predicted. The increased likelihood of inducing large seismic events has jeopardized several geothermal projects. However, there is not a clear understanding of these events and the prevention and mitigation of EGS-induced seismic events are still a concern. With the transmission of Alaska EGS from shallow hot springs to deep borehole drilling, there is a pressing need to develop a better understanding of the mechanism of triggering the seismicity with the influence of heat exchange and fluids intrusion. This fellowship project will experimentally investigate the property evolution of the fault gouge with thermal treatment to reveal the triggering mechanism of ESG-related seismicity from a microscale perspective. The project will build on the capacity of geohazards evaluation and EGS-related geo-risk evaluation in Alaska through extended collaborations with institutions in the lower forty-eight (48) states. These research resources acquired through the fellowship project will be leveraged to develop new course and workshop materials to provide women, minorities, and Alaska remote community students with research experience and training. This Research Infrastructure Improvement Track-4 EPSCoR Research Fellows (RII Track-4:NSF) project would provide a fellowship to an Assistant Professor and training for a graduate student at the University of Alaska Fairbanks (UAF). The PI proposes to develop a novel fault sliding test system in collaboration with experts from the Center for Geomechanics, Geofluids, and Geohazards at the Pennsylvania State University. It has been proved that the mineral lattice strain in the gouge layer is critical for predicting the residual stress on the surface and its failure status. Mineral strain variation with thermal treatment and fluid intrusion within the fault gouge layer is critical for predicting localized stability that initializes seismic events. However, direct evidence has not been reported in the lab to identify and quantify the mineral strains due to the hurdle and difficulties of direct measurement of mineral strains under in situ conditions with a dynamic sliding process. The proposed test system enables the unique capacity of using neutron diffraction to conduct mineral strain mapping of the gouge layer with shear sliding. The stick-slip faulting test will be conducted using the proposed test system with thermal treatment and fluid intrusion. Combining neutron diffraction and nanoindentation techniques, the properties of minerals in the gouge layer will be investigated from a microscale perspective to reveal the triggering mechanism of ESG-related seismicity. The proposed test system enables the investigation of the evolution of mineral properties under shearing and its implications on seismic events with thermal treatment and fluids intrusion. The outcome will provide a unique perspective for evaluating the EGS-related geohazards and their prediction and prevention. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
3.14	**6**	SBE	**2228559**	SAI-R: Reducing Natural Hazards Risks by Incorporating Community Impacts and Equity	David Johnson	Julio Ramirez, Shirley Dyke, Hong Wang	Purdue University	Strengthening American Infrastructure (SAI) is an NSF Program seeking to stimulate human-centered fundamental and potentially transformative research that strengthens America's infrastructure. Effective infrastructure provides a strong foundation for socioeconomic vitality and broad quality of life improvement. Strong, reliable, and effective infrastructure spurs private-sector innovation, grows the economy, creates jobs, makes public-sector service provision more efficient, strengthens communities, promotes equal opportunity, protects the natural environment, enhances national security, and fuels American leadership. To achieve these goals requires expertise from across the science and engineering disciplines. SAI focuses on how knowledge of human reasoning and decision-making, governance, and social and cultural processes enables the building and maintenance of effective infrastructure that improves lives and society and builds on advances in technology and engineering. Concrete buildings designed prior to the implementation of modern building codes in the mid-1970s may be highly vulnerable to collapse. Many thousands of these structures in seismically active areas like California are still in service. This includes residential buildings, schools, and critical facilities like hospitals. Although these vulnerabilities are known, local ordinances mandating retrofits have been largely unsuccessful in achieving risk reductions. Building codes governing seismic retrofits focus almost exclusively on structural vulnerability and preventing loss of life during an earthquake. They tend to ignore the value that people place on the functionality of buildings and the ability to reoccupy them as quickly as possible after an extreme event. This SAI research project identifies different stakeholders' willingness to pay for seismic retrofits on various types of buildings. It also investigates the priorities and incentives that are necessary to successfully motivate action. The long-term aim of this research is to identify effective policy-making strategies to motivate communities to mitigate seismic risks before a future earthquake disaster strikes. This project uses several approaches to better capture the feedback between human interaction with the built environment and infrastructure vulnerability. One approach uses a mix of qualitative and quantitative methods to elicit measures of building functionality and usage that can be used to predict how community members prioritize different retrofit options based on their cost, the buildings affected, and resulting performance in the event of a major earthquake. Another approach uses physical experiments and simulation of earthquakes on archetypal building features to better characterize the vulnerability of this type of concrete building and the effectiveness of different retrofit options. The data generated by these social and physical experiments are combined to produce a decision support system that policy makers can use to design retrofit and funding strategies that are closely aligned with the revealed preferences of the community. Incorporating stakeholder preferences into risk mitigation efforts will improve and strengthen resilience to future earthquake disasters. This award is supported by the Directorate for Social, Behavioral, and Economic (SBE) Sciences and the Directorate for Engineering. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
2.9	**6**	TIP	**2229702**	POSE: Phase I: Tuitus - A sustainable, inclusive, open ecosystem for Natural Hazards Engineering	Krishna Kumar	Ellen Rathje, Joseph Stubbs	University of Texas at Austin	This project is funded by Pathways to Enable Open-Source Ecosystems (POSE) which seeks to harness the power of open-source development for the creation of new technology solutions to problems of national and societal importance. Natural hazards, such as floods, landslides, earthquakes, tornadoes, and wildfires, threaten more than 57% of the US national infrastructure. Modeling these complex natural hazards pushes the frontiers of high-performance computing, multi-scale modeling, in-situ visualization, big-data analysis, and machine learning. Scientific software codes are often developed in an ad hoc manner by university researchers and graduate students with very little exposure to software development principles and practices. The robustness and open-source nature of these scientific codes are essential for the safety and security of the nation, its people, and the environment. The project establishes the Tuitus Foundation (Latin for "to protect or care for"), a sustainable, inclusive, open ecosystem of scientific codes for Natural Hazard Engineering (NHE). The project's novelties are creating a unified interface that supports integration testing, research reproducibility, and workflow provenance in distributed computing environments. The project supports building scalable, automated testing and workflow management for high-performance computing (HPC) environments. The project tackles the social issues around building and sustaining a community by establishing a Governing Board of Directors and supporting community-driven software development in NHE. The project creates an inclusive community by offering guidelines and training for onboarding and supporting new developers through hackathons and Google Summer of Code. By auto-deploying thoroughly tested HPC software to the NSF-funded DesignSafe Cyberinfrastructure, the project impacts the broader community of 6,000 NHE researchers by making robust NHE codes immediately accessible. Open-source codes in NHE will significantly impact the decision-making process and regional-scale risk assessment. The integration of Tuitus Foundation's HPC Continuous Integration/Continuous Delivery (CI/CD) service with DesignSafe creates a paradigm shift in open-source code delivery in NHE, improving real-world policy decisions during critical natural hazard events. The Tuitus Foundation adopts a holistic approach to address the critical technical challenges in the Open-Source Ecosystem (OSE) by offering a standard Application Programming Interface (API) for HPC and heterogenous hardware architectures and supporting a wide range of applications from HPC, machine learning, database schemas, Jupyter notebooks, and visualizations. This project is the first attempt to integrate HPC-scale CI testing with natural hazard engineering codes for multi-job pipelines. The Tapis framework provides programmable interfaces that enable developers to automate data management and job execution on HPC and cloud resources. Tapis OAuth2 provides a separate security layer for managing user credentials, allowing Tapis to access many different storage and computing resources on behalf of the user. HPC-scale CI/CD with theTapis API enables testing for extreme-scale problems on distributed computing environments and future exascale systems. The project offers workflow provenance in Jupyter notebooks by tracking workflows and packaging runtime environment, thus enhancing research reproducibility. The novel CI developments bring together literate programming and HPC testing to provide the much-needed robustness to improve trustworthiness in engineering decision-making. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.
2.8	**6**	TIP	**2306180**	I-Corps: Artificial intelligence-based software package for end-to-end structural health monitoring of infrastructure systems	Togay Ozbakkaloglu		Texas State University - San Marcos	The broader impact/commercial potential of this I-Corps project is the development of technology that uses the internet-of-things and/or fiber optic-based monitoring systems to solve problems faced by structural health monitoring companies related to data processing, interpretation, and storage. During its service life, civil infrastructure should satisfy the requirement of safety and sustainability for the designated operation. However, due to natural disasters and extreme events (such as strong winds and earthquakes), structures degrade in performance over time, or they get damaged severely and even collapse. For example, America's Infrastructure received an overall grade of C- according to the American Society of Civil Engineers Report Card 2021, indicating that the nation's infrastructure is in mediocre condition, has deficiencies, and needs attention. Structural health monitoring systems have gained rapid popularity in providing real-time information for the safety assessment of structures. However, structural health monitoring companies worldwide are facing challenges in data processing, interpretation, and storage, which limits their ability to obtain sufficiently comprehensive information about the health of infrastructure asset that is being monitored. This I-Corps project is based on the development of smart and effective data processing, interpretation, and storage in the structural health monitoring systems using conventional artificial intelligence and computational intelligence. Conventional artificial intelligence in this technology will describe the problem and build logical reasoning using explicit rules. Computational intelligence, which comprises an interconnected network of simple units, will be used to acquire information about the output from specific input data. The novelty of this innovation includes the development of a hybrid system by incorporating new techniques from both conventional artificial intelligence and computational intelligence to automatically accomplish the process of data acquisition and data analysis. A provision of cloud services in the core technology is used to store data before and after analysis and evaluation for further processing. Finally, this technology will interpret analyzed data to detect and locate damages and make decisions on the deterioration level of an infrastructure asset. This will allow the system to determine the required actions before danger occurs. This technology will provide an effective way for data processing, interpretation, and storage in monitoring systems in real-time by dividing the processes into three main components, namely checking for plausibility, short-term data analysis, and long-term data analysis. This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.