MECHANISMS FOR IMPLEMENTATION OF NHERI RESEARCH RESULTS

NHERI Technology Transfer Committee
April 2020

The NHERI TTC is a volunteer group of about 20 individuals, mostly engineers, experienced in design and the various aspects of technology transfer. The TTC reviews research funded by NSF in the NHERI program to encourage and facilitate results that are implementable. In addition, the committee is a resource for researchers interested in implementation, either in preparation of proposals, during the research, or after the research is complete. The TTC can be contacted through the NHERI website.

INTRODUCTION

The Network Coordination Office (NCO) of the Natural Hazards Engineering Research Infrastructure (NHERI) program created the Technology Transfer Committee (TTC) to encourage and facilitate implementation of NHERI research results. Funded by the National Science Foundation (NSF), NHERI enables researchers to explore and test ground-breaking concepts to protect homes, businesses and infrastructure lifelines from the impacts of earthquakes, windstorms, and water hazards such as tsunami and storm surge. Although investigators include education and outreach in their research plans, implementation of improved mitigation measures is often slow. This paper summarizes the most common processes for implementation of research results and should be useful to researchers interested in implementation, particularly young researchers.

For the purpose of this paper, “NHERI research” is defined as research funded by NSF under the Engineering for Civil Infrastructure (ECI) program and carried out at one of the NHERI Experimental Facilities (EFs). The ECI program focuses on the physical infrastructure, such as the soil-foundation-structure-envelope-nonstructural building system; geostructures; and underground facilities. It seeks proposals that advance knowledge and methodologies within geotechnical, structural, architectural, materials, coastal and construction engineering, especially those that include collaboration with researchers from other fields, such as biomimetics, bioinspired design, advanced computation, data science, materials, additive manufacturing, robotics and control theory. Further descriptions and limitations of the program can be found on the ECI program page. These NSF awards will be the focus of the TTC.

Nevertheless, the TTC will also consider research at a NHERI experimental facility that is funded by others and appears implementable.

There are many factors that contribute to the pace of implementation. To start, the goals of NSF include a "strategy to advance the frontiers of knowledge," which often requires intermediate steps of further research and/or translation of results to implementable practices. The transfer of knowledge from researchers to policymakers and engineers who can implement mitigation measures is not systematic, nor has it been a primary goal of NSF. At the federal agency level, technology transfer per se has been assigned to other agencies, such as the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), and agencies responsible for the oversight and control of federally funded housing and lifeline infrastructure (e.g., the nation's federally funded highway system). Often, these agencies are assisted in their implementation efforts by private sector or non-profit organizations, such as the American Association of State Highway and Transportation Officials (AASHTO), the American Society of Civil Engineers (ASCE), and the Applied Technology Council (ATC). Implementation activities carried out by federal agencies, and the organizations that assist them, are often adopted or adapted by enforcement agencies at the state or local level.

This white paper focuses primarily on technology transfer mechanisms to improve the performance of civil infrastructure within the scope of NSF's ECI program during and after natural hazard events. While these mechanisms include the development and promulgation of (a) new methods of analysis, (b) guidelines for the design and retrofit of buildings, and (c) building performance policy at the community level, the focus in this paper is primarily on the updating of building codes and associated standards. The reason for this is that such updates carry the force of law, thereby enforcing the widespread use of the latest information and technology. Many of the ideas cited below, however, work equally well for other forms of technology transfer, which are also described.

The updating of building codes and standards takes place in cycles of 3-5 years, although the research basis for the updates may have been under consideration for a longer period (in some cases, as long as one or two decades). The timing of adequate development of new input is critical in order to fit within a normal cycle. The other methods of implementation discussed here require extensive education and developmental efforts, early adopters, and considerable time to change the standards of practice or become law.

The technology transfer mechanisms involving codes and standards are primarily applicable to improvements for which materials, design methods and construction methods can be fully described within a published code or standard document, without proprietary aspects that are copyright protected. Once proprietary materials, design methods or construction methods are introduced, the improvements are typically identified as being beyond the purview of the codes and standards, and fall to different implementation mechanisms, often relying on private funding for development. Further discussion is provided towards the end of this paper.

COMMON METHODS OF IMPLEMENTATION OF RESEARCH FINDINGS

POST-RESEARCH STUDIES AND REPORTS AND THE DEVELOPMENT OF DESIGN PRE-STANDARDS

Especially when promising new technology or design methodologies are suggested by an accumulation of collaborative research, a transitional study may be prepared by any number of entities, such as the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the Applied Technology Council (ATC), or code-development committees of the American Society of Civil Engineers (ASCE), the Building Seismic Safety Council (BSSC), industry and building material associations or professional organizations. See further descriptions of the activities of these organizations below.

A particular format for some such reports is the "pre-standard." In general, these pre-standards constitute nonmandatory guidelines that attempt to provide a recommended procedure, in which some of the provisions may not be fully vetted, although they are often in standards format. They do not constitute consensus-based provisions since they are often compiled by a smaller interest group or a team of hired technical consultants. A pre-standard may be considered a "test-bed" of provisions for engineers to consider, subject to each professional's judgement, that may undergo later substantial technical revisions based on feedback and experience.

BUILDING CODES AND STANDARDS

The following issues are usually addressed before research results are implemented into codes or standards. To maximize the efficiency of implementation, it is recommended that the following goals be considered in research planning.

STEPS TO MAKE RESEARCH READILY IMPLEMENTABLE INTO CODES AND STANDARDS

- The research addresses established problems and offers one or more clear solutions.
- The limitations on the conditions for application of the research should be clearly defined.

- Case examples should be developed to help preclude misinterpretation and to determine whether a practical application has actually been developed. Numerical comparisons with existing requirements are also helpful.
- There should be an explanation of the relationship of the proposed measure to existing codes and standards and what related provisions might be impacted.

Without these characteristics, other champions must emerge to conduct further studies, perhaps study economic impacts, and achieve adoption of results into law, policies or practice. Other nonprofit and industry groups with an interest in further developing and utilizing research in engineering practice may then take further efforts to formulate the means of its application.

Many organizations in the U.S. participate in the development of building codes and related standards. These organizations do not operate under the jurisdiction of the federal government, but rather involve public and private sector stakeholders in a formalized code development process. Those organizations most relevant to NHERI research results are discussed below.

I-CODES AND SIMILAR BUILDING CODES

The predominant code for buildings in the U.S. consists of the I-Code family developed by the International Code Council (ICC). These model codes are not law, but they are commonly amended for local conditions and adopted by states and local jurisdictions as binding regulations. The primary model codes of interest are the International Building Code, which controls most new buildings, the International Residential Code, which controls most single and two-family dwellings, and the International Existing Building Code, which controls remodels, renovation, and additions to existing buildings. The ICC also develops many other published specialty codes that may be promoted for adoption, such as the following:

- International Energy Conservation Code
- International Fire Code
- International Fuel Gas Code
- International Green Construction Code
- International Mechanical Code
- ICC Performance Code
- International Plumbing Code

- International Private Sewage Disposal Code
- International Property Maintenance Code
- International Swimming Pool and Spa Code
- International Wildland Urban Interface Code
- International Zoning Code

The code development process affecting implementation of research findings has several steps. For I-Codes, the steps are clearly described on the ICC website. Voting memberships are retained by building officials and fire officials. The I-Codes adopt many standards developed by others, most notably for buildings, including the American Society of Civil Engineers' "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (ASCE/SEI 7) and "Seismic Evaluation and Retrofit of Existing Buildings" (ASCE/ SEI 41).

INTERNATIONAL BUILDING CODE (IBC)

The provisions of the IBC apply to the "construction, alteration, relocation, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures."

Detached one- and two-family dwellings and townhouses not more than three stories above grade plane in height with a separate means of egress can be designed using the International Residential Code in lieu of the IBC.

The purpose of the IBC is to establish the minimum requirements to provide a reasonable level of safety, public health and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire, explosion and other hazards, and to provide a reasonable level of safety to fire fighters and emergency responders during emergency operations.

INTERNATIONAL RESIDENTIAL CODE (IRC)

The IRC is applicable to one- and two-family dwellings and townhouses and is unique in that it provides a complete set of requirements from structural to energy applicable to such structures within a single code volume. The requirements are focused on prescriptive solutions that typically require little or no additional technical input intended to streamline approval and construction. Qualifying buildings constructed in accordance the provisions of the IRC are expected to provide the same performance as the full IBC. Certain highly complex buildings or those on sites with exceptionally high natural hazards are excluded by the IRC and must be designed using the IBC.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA's code and standards development process is described on its website. NFPA lists over 700 Codes and Standards on their website mostly concerning fire protection and associated hazards. Examples include NFPA 70, the "National Electrical Code," NFPA 1, the "Fire Code," and NFPA 101, the "Life Safety Code." Similar to the I-Codes, NFPA codes adopt many standards developed by others.

CODE REFERENCE STANDARDS

Both the I-Codes and the NFPA codes adopt many standards developed by others. These referenced standards become part of the building code to the extent specifically cited in sections of the code. Some of these are developed by industry and trade groups such as the American Concrete Institute (ACI), the American Institute for Steel Construction (AISC), the American Iron and Steel Institute (AISI), the American Wood Council (AWC), APA – Engineered Wood Association, and The Masonry Society (TMS).

Research on the performance of various structural components and systems are often implemented in these material industry standards, rather than the building code itself. ASTM International, formerly known as the American Society for Testing and Materials (ASTM), promulgates standards for materials, products, specialized components and testing methods used for determining their acceptability. The International Code Council itself has developed some of the reference standards, such as those for storm shelters and residential construction in high-wind regions. When these standards are adopted by reference in the building code, they govern certain detailed aspects of design and construction of specific structural components and systems.

AASHTO STANDARDS AND SPECIFICATIONS

"Building Codes" discussed above are just that, covering buildings and building-like structures. Many other structures are designed using similar standards developed by others. For example, the American Association of State Highway and Transportation Officials (AASHTO) develops many standards covering design of transportation systems, such as highways and rail. Much-used examples are the AASHTO LRFD Bridge Design Specifications and the Bridge Construction Specifications. Many states also have developed their own design and construction criteria for bridges. AASHTO has hundreds of other publications dealing with transportation systems. In general, research regarding transportation systems and components such as bridges and tunnels is done under the auspices of the United States Department of Transportation rather than under the National Earthquake Hazards Reduction Program (NHERP), although NHERP experimental facilities can be used for research funded by others.

OTHER STANDARDS

Similarly, several groups have developed design standards for dams, levees, and canals. The Bureau of Reclamation, the Army, and many states have their own design and construction criteria for these structures. Other specialty structures such as power plants, petroleum storage and manufacturing facilities, and pipelines and transmission lines also are covered by various codes and standards developed by interested parties.

CONSENSUS STANDARDS

Most codes and design standards qualify as "consensus standards." Consensus standards are standards developed through a process involving a representative balance of stakeholders who have an interest in participating in the development and use of the standards. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution through a formalized procedure. This involves conformance to rules for notice of changes to standards and a method for resolving comments such as through public hearings, committee meetings or ballot, and voting. There are consensus standards in many fields including medicine, manufacturing, engineering, and construction. Many of the consensus standards used in the design and construction industry are developed by organizations whose procedures have been accredited by the American National Standards Institute (ANSI). In addition to functioning as an accreditation body, ANSI is one of several standards development organizations in the U.S. and is a member of the International Organization for Standardization (ISO).

THE AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

One of the most important standards adopted by building codes in the U.S. is ASCE/SEI 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, by the American Society of Civil Engineers/Structural Engineering Institute. ASCE/SEI 7 is a loading and basis of design standard and specifies minimum loads of all kinds that structures must be designed for. Loads range from occupant loads (e.g. office, warehouse, etc.) to loads from natural hazards (wind, earthquake, snow, etc.). The document also contains structural design requirements and analysis methodologies associated with those loads. Criteria for design loading of most buildings are obtained by design engineers from ASCE/SEI 7; resistance to that loading from systems and components of various materials from materials standards are mentioned above.

The scope of ASCE/SEI 7 can be gleaned from its Table of Contents:

1. General
2. Combinations of Loads
3. Dead Loads, Soil Loads, and Hydrostatic Pressure
4. Live Loads
5. Flood Loads
6. Tsunami Loads and Effects
7. Snow Loads
8. Rain Loads
9. Reserved for Future Provisions
10. Ice Loads—Atmospheric Icing
11. Seismic Design Criteria
12. Seismic Design Requirements for Building Structures
13. Seismic Design Requirements for Nonstructural Components
14. Material-Specific Seismic Design and Detailing Requirements
15. Seismic Design Requirements for Nonbuilding Structures
16. Nonlinear Response History Analysis
17. Seismic Design Requirements for Seismically Isolated Structures
18. Seismic Design Requirements for Structures with Damping Systems
19. Soil-Structure Interaction for Seismic Design
20. Site Classification Procedures for Seismic Design
21. Site-Specific Ground Motion Procedures for Seismic Design
22. Seismic Ground Motion, Long-Period Transition, and Risk Coefficient Maps
23. Seismic Design Reference Documents
24. Reserved for Future Provisions
25. Reserved for Future Provisions
26. Wind Loads: General Requirements
27. Wind Loads on Buildings: Main Wind Force Resisting System (Directional Procedure)
28. Wind Loads on Buildings: Main Wind Force Resisting System (Envelope Procedure)
29. Wind Loads on Building Appurtenances and other Structures: Main Wind Force Resisting System (Directional Procedure)
30. Wind Loads: Components and Cladding
31. Wind Tunnel Procedure

ASCE/SEI 7 and its referenced material standards are a major vehicle for implementation of NHERI research related to buildings and similar structures. More information about ASCE/SEI 7 can be found on the ASCE website.

Most significant updates to ASCE/SEI 7 related to seismic provisions originate in the NEHRP Provisions Update Committee (PUC) of the Building Seismic Safety Council (BSSC). The PUC is the primary implementer of seismic research results related to building design. More information on the PUC can be found on the BSSC website. The recommendations of the PUC are taken up by the ASCE/SEI 7 Seismic Subcommittee.

Updates to ASCE/SEI 7 related to other hazards are developed directly by subcommittees related to the various chapters on other natural hazards such a flood, wind, and tsunami. These subcommittees are open to researchers and such participation can accelerate implementation of research results.

ASCE/SEI 41, Seismic Evaluation and Retrofit of Existing Buildings is another important ASCE standard adopted by building codes. ASCE/SEI 41 provides multiple seismic hazard levels, which determine the demand on the existing buildings. It also provides multiple levels of performance objectives and corresponding strength and deformation capacities of different structural component types, including steel, concrete, wood or masonry members, and nonstructural components. The multiple hazard and performance objective levels are the basis of the performance-based seismic evaluation and design procedures in ASCE/SEI 41. ASCE/SEI 41 also includes a simple evaluation methodology using a set of checklists up to an advanced evaluation methodology using the nonlinear dynamic analysis of 3D computational models.

Provisions of ASCE/SEI 41 have been updated based on the experimental and analytical studies of structural and nonstructural components detailed with outdated practices and codes, and the components compliant with the current building codes since a retrofitted structure includes both existing and new structural components. The information on the current code-compliant structural components and analysis procedures in ASCE/SEI 41 is often adopted for the performance-based seismic design of new buildings as well. ASCE /SEI 41 also includes properties of the materials that are no longer used in the current practice and procedures for field test and condition assessment to obtain the properties of the existing components.

The new technical information for updating the ASCE /SEI 41 standard is conveyed to the ASCE /SEI 41 committee by various task groups in the committee or other liaison technical organizations with ASCE/SEI 41. ACI Committee 369, Seismic Repair and Rehabilitation and AISC Committee 342, Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings are the liaison committees and provide a basis of technical updates for concrete and steel buildings, respectively. The task groups and committees actively collect and review the new technical information from recent research and industry practice.

ASCE covers the entire spectrum of civil engineering through its various institutes and technical groups. The results of research can be introduced, discussed, and prepared for implementation in any of them:

Institutes	Technical Groups
Architectural Engineering	Aerospace
Coasts, Oceans, Ports, and Rivers	Changing Climate
Construction	Codes & Standards
Engineering Mechanics	Cold Regions Engineering
Environmental & Water Resources	Computing
Geotechnical Engineering	Energy
Structural Engineering	Forensic Engineering
Transportation & Development	Infrastructure Resilience
Utility Engineering and Surveying	Wind Engineering

ASCE also has local chapters in many cities through which research results can be disseminated in meetings, seminars, and newsletters.

More information about ASCE can be found on its website.

OTHER ORGANIZATIONS INVOLVED IN IMPLEMENTATION

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

FEMA is one of the four federal agencies that make up the National Earthquake Hazards Reduction Program (NEHRP). The other agencies are the National Science Foundation (NSF), the National Institutute of Standards and Technology (NIST), and the United States Geological Survey (USGS). NEHRP was first established by the U.S. Congress under Public Law (PL) 95-124 in 1977 and most recently reauthorized in December 2018 under Public Law 115-307.

Under NEHRP, one of FEMA’s responsibilities continues to be the implementation of the Program, including the translation of new knowledge and research results into design guidance for use by the nation’s building codes and consensus standards. FEMA accomplishes this by creating technical design and construction guidelines and pre-standards, by supporting the adoption and enforcement of building codes, and by developing and disseminating post-earthquake building performance assessment studies and associated Recovery Advisories.

FEMA also undertakes special projects to improve the field of earthquake engineering. One of these was the 15-year, $10 million effort to develop performance-based seismic design and assessment guidelines, recently published as the seven volume FEMA P-58. Another example of a special project is the recently completed Seismic Evaluation of Older Concrete Buildings for Collapse Potential (FEMA P-2018), which could be used in local mitigation ordinances similar to that in place in Los Angeles. FEMA also coordinates with USGS to publish national seismic design ground-motion maps and IRC Seismic Design Category (SDC) maps in each new edition of the NEHRP Provisions for adoption by ASCE/SEI 7, IBC and IRC.

FEMA provides over 100 earthquake-related publications covering a broad range of topics on mitigation of seismic risk for new and existing buildings, education and outreach on building codes and standards, methodology and tools for seismic hazard assessment, practical guidance to reduce damage to nonstructural components, and design examples for new changes in ASCE/SEI 7 and ASCE/SEI 41. More information on the FEMA earthquake program and its publications can be found on the FEMA website.

FEMA also provides guidelines, technical bulletins, fact sheets, and code resources for mitigation of wind, flood, tsunami, wildfire and multi-hazard risks. The FEMA Building Science Branch deploys post-disaster Mitigation Assessment Teams (MATs) to conduct investigation of disaster induced damages. Each MAT deployment is organized based on severity of incurred damage and funding received from the disaster response operation. The MAT reports provide building performance observations, recommendations and technical guidance for recovery from the disasters, and improvement to relevant codes. FEMA Building Science publications and related trainings can be found on the FEMA website.

NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

NIST supports the development and advancement of model building codes and nationally applicable design and construction standards. To support this mission, NIST researchers work to implement applied research results into practice. Broad dissemination by NIST is accomplished through technical publications and presentations and working directly with code committees and standard development organizations. A fundamental aspect of NIST research projects is planning knowledge transfer mechanisms during the project development stage. NIST research projects are developed either as 1) an internal research activity conducted by NIST or 2) an external NIST-funded research activity that supports a NIST-identified goal based on national need. Research results are presented in journals, project reports, conferences and with active participation in the code provision proposal process (e.g., ASCE 7, ASCE 41, AISC, ACI, etc.).

Somewhat parallel to NEHRP, NIST is the lead agency for The National Windstorm Impact Reduction Program (NWIRP). This Program consists of three components:

- Understanding of Windstorms
- Assessing Windstorm Impact
- Reducing Windstorm Impact

The Program agencies are the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Institute of Standards and Technology (NIST), and the Federal Emergency Management Agency (FEMA), each having defined responsibilities in research, development and implementation.

The National Windstorm Impact Reduction Act Reauthorization of 2015 (Public Law 114-52) calls for the creation of a National Advisory Committee on Windstorm Impact Reduction (NACWIR or Committee). NACWIR is charged with offering assessments and recommendations on:

• trends and developments in the natural, engineering, and social sciences and practices of windstorm impact mitigation;

• the priorities of the National Windstorm Impact Reduction Program's Strategic Plan;

• the coordination of the program;

• the effectiveness of the program in meeting its purposes; and

• any revisions to the program which may be necessary.

Additional information about the Committee is available on the NACWIR website.

BUILDING SEISMIC SAFETY COUNCIL

Established as a Council of the National Institute of Building Sciences in 1979, the Building Seismic Safety Council (BSSC) deals with the complex technical, regulatory, social and economic issues involved in developing and promulgating building earthquake risk mitigation provisions that are national in scope. The BSSC is a voluntary organizational membership body representing a wide variety of building community interests. It serves as a neutral platform and brings together the needed expertise and relevant public and private interests to resolve issues related to the seismic safety of the built environment through authoritative guidance and assistance backed by a broad consensus. BSSC's fundamental purpose is to enhance public safety by providing a national forum that fosters improved seismic planning, design, construction and regulation in the building community.

BSSC, under contract with FEMA, develops and maintains a key resource — the NEHRP Recommended Seismic Provisions for New Buildings and Other Structures. These provisions are used as the primary resource for the professional design standard ASCE/SEI 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures and model building codes. BSSC also develops educational training materials and explanatory information to support the structural engineering community. Webinars, workshops, and colloquia are held to explain the principles behind the provisions. Periodically, the BSSC advises government bodies on their programs of seismic research, development, and implementation. For example, in 2012-2013, the BSSC prepared for NIST the Development of NIST Measurement Science R&D Roadmap: Earthquake Risk Reduction in Buildings, NIST GCR 13-917-23 to assist NIST in planning future research efforts related to seismic safety for new and existing buildings. The BSSC also supported NIST on behalf of the Interagency Committee on Seismic Safety in Construction (ICSSC) in development of the Standards of Seismic Safety for Existing Federally Owned and Leased Buildings, ICSSC Recommended Practice 8 (RP 8), NIST GCR 11-917-12.

APPLIED TECHNOLOGY COUNCIL

The Applied Technology Council (ATC) is a nonprofit, tax-exempt corporation established in 1973 through the efforts of the Structural Engineers Association of California (SEAOC). ATC's mission is to develop and promote state-of-the-art, user-friendly engineering resources and applications for use in mitigating the effects of natural and other hazards on the built environment throughout the U.S. Extreme loads addressed by ATC include those caused by earthquakes, windstorms, floods (including tsunami), fire, and explosion. ATC also identifies and encourages needed research and develops consensus opinions on structural engineering issues in a nonproprietary format.

ATC products and outcomes include guidelines and technical reports, workshop and conference proceedings, seminars, webinars, and most recently, an interactive website to determine wind, tornado, snow load, and seismic design loads by location. Landmark documents developed by ATC to date include nationally applicable guidelines for the seismic design of new buildings, the seismic retrofit of existing buildings, the safety evaluation and repair of earthquake damaged buildings, the safety evaluation of buildings damaged by wind storms and floods, guidelines for the design of structures for vertical evacuation from tsunamis, and most recently, guidance for increasing community disaster resilience through improved lifeline infrastructure performance.

While ATC is not a code-development body, many of the documents developed by ATC serve as the basis (and were the starting point), as described above, for ASCE standards and for model codes. Involvement in ATC projects by leading university research faculty enable implementation of their research findings, although perhaps not as rapidly as through immediate adoption of research findings in the code updating process.

More information about ATC can be found on its website.

NATIONAL COUNCIL OF STRUCTURAL ENGINEERING ASSOCIATIONS (NCSEA)

NCSEA is made up of 44-member structural engineering associations, each representing a state. Most state organizations have active committees that focus on structural engineering issues in that state. However, the National Council also has active committees including a Code Advisory Committee, which includes a Seismic Provision subcommittee, a Wind Engineering subcommittee, and an Existing Building subcommittee.

Many state associations include membership categories for geotechnical engineers, which create unique opportunities to achieve changes in practice not directly related to building code provisions.

Structural Engineering Associations can be an excellent means of dissemination of research results through their local meetings, seminars, and newsletters. They may also develop recommended design practice guidelines for their region.

NATIONAL ASSOCIATION OF HOME BUILDERS (NAHB)

A federation of more than 700 state and local associations, NAHB represents more than 140,000 members. About one-third are home builders and remodelers. The rest work in closely related specialties such as sales and marketing, housing finance, and manufacturing and supplying building materials.

NAHB’s affiliates include:

- Home Innovation Research Labs, which develops, tests and evaluates new materials, methods, standards and equipment to improve the technology and the affordability of America’s housing.
- The Home Builders Institute (HBI) is the workforce development arm, which develops and administers a wide range of educational and job training programs.
- The National Housing Endowment, the philanthropic arm, dedicated to helping the housing industry develop more effective approaches to home building, enhancing

education and training for future generations of leaders in residential construction and increasing the body of knowledge on housing issues.

INSURANCE INSTITUTE FOR BUSINESS AND HOME SAFETY (IBHS)

IBHS is an independent, nonprofit, scientific research and communications organization supported solely by property insurers and reinsurers. IBHS develops numerous guidance documents for resistance to natural hazards including wind, flood, and wildfire.

FEDERAL ALLIANCE FOR SAFE HOMES (FLASH)

FLASH® is a nonprofit organization that serves as a consumer advocate for strengthening homes and safeguarding families from natural and manmade disasters. It promotes life safety, property protection and resiliency, and designs and develops effective and easy-to-use tools and techniques to foster mitigation behavior change. A variety of informational resources for communities and homeowners can be found on the FLASH website.

LOCAL LAWS AND POLICIES

Local zoning policies, development permitting processes, and disaster preparedness also can be influenced by NHERI research, particularly through zoning that considers the risk from natural hazards. These decisions may be informed by hazard and risk analyses. For example, regional loss studies help define vulnerable systems and facilities, and facilitate development of emergency response and recovery plans. Fragility functions used in such studies come directly from research or post event reconnaissance.

EARLY IMPLEMENTATION OF RESEARCH IN PRACTICE

Various national material or industry institutes will sponsor standing technical committees to develop specific guides and reports for practitioners. These are non-mandatory documents presenting a committee's recommendations for topics relating to types of analysis, detailed methods of design, specifying of material or products, testing and evaluation of materials or products, and construction methods and quality control. Research incorporated into these technical committee guides may gain higher recognition and earlier application without becoming formally adopted provisions in the code. However, the committees have a responsibility to avoid direct conflicts with the code or their institute's standards.

The planning and design of the built environment is not solely controlled by codes and standards. In cases not addressed by codes, planners and designers often apply applicable research and their own design experience and skill to the special or site-specific issues presented. Early adopters may use research results within the code's constraints to refine or improve both functional value and performance under loads from natural hazards. Geotechnical engineers, in particular, must generally operate under "best practice" rules because very little is contained in building codes controlling geotechnical issues.

The extent that research results are implemented directly into practice is totally dependent on knowledge of the applicable research. An early adopter practitioner (and sometimes reviewers and/or building departments) must decide on applicability, so education and outreach by researchers is always important. Education and outreach are discussed below.

METHODS OF IMPLEMENTATION WHEN PROPRIETARY MATERIALS, DESIGN METHODS, OR CONSTRUCTION METHODS ARE INVOLVED

The technology transfer methods discussed up to this point have focused on research results that can be incorporated into building codes and reference standards. As discussed in the introduction, if research incorporates proprietary materials, methods of design, or methods of construction, the resulting recommendations often fall outside the purview of the building code. In part, this is because complete descriptions in the building code transform the developer's proprietary knowledge into common knowledge.

Other avenues involve full development of the proprietary product by the manufacturer and often involve the manufacturer's use of product evaluation reports. The reports are developed through an accredited product certification body (such as the International Code Council Evaluation Service) to recognize product-use as meeting one or more requirements of the building code. Examples of product research developments that fall in this category include new uses of fiber-reinforced polymer (FRP) materials, innovative steel moment frame connections, and others. Those conducting research that involve development of new innovative products or use of existing proprietary products in new applications should consider partnering with a product manufacturer.

EDUCATION AND OUTREACH

As previously discussed, research results can be implemented by many avenues. Often, some uses of research results may be unknown to the researcher, so it is important for the results of research to be widely disseminated. Commonly researchers describe their work at technical conferences and in peer-reviewed technical journals. Although these venues are important to academic progress and disseminate information among peers, potential implementers such as engineers and policy makers may not be exposed to the results. Therefore, presentations at cross disciplinary meetings, webinars with a question-and-answer forum, and local technical groups (e.g. ASCE chapters, local structural engineering associations, and meetings such as the Natural Hazards Workshop in Colorado) are more likely to expose the data and the researcher's findings to potential implementers.

Another venue likely to reach a broad and varied audience are semi-technical informational magazines with an interest in highlighting new technology, such as Engineering News Record (ENR), Steel Construction (by AISC), Concrete International (by ACI), Civil Engineering (the magazine of ASCE), Structure (the magazine of the National Council of Structural Engineers Associations), and Earth (the magazine of the American Geosciences Institute).

One of the most effective methods of outreach is to have a practitioner or committee of practitioners review the research on an ongoing basis or better yet to include a knowledgable practitioner as member of the research project team. Not only does this association create some dissemination of results, but it can also result in important input to guide the research and make the results more implementable.

CONCLUSION

Potential implementers must be made aware of the research results that may be useful to apply. Increased and repeated dissemination of results will more likely result in the appropriate person or group becoming interested and pushing for implementation. This document describes some of the groups or individuals who may be able to implement results, but certainly not all. Local and state policy makers, in particular, are too numerous and varied to describe. Participation in any of these groups by researchers will enable dissemination of results and eventual implementation.

NCO NHERI

Network Coordination Office