National Construction Safety Team Advisory Committee

National Institute of Standards and Technology

NIST NCST Report to Congress 2022

December 12, 2022

The Honorable Eddie Bernice Johnson, Chairwoman
House Committee on Science, Space & Technology
Washington, D.C. 20515

Dear Madam Chairwoman,

I am pleased to submit the 2022 Annual Report of the National Construction Safety Team (NCST) Advisory Committee (the Committee) of the National Institute of Standards and Technology (NIST). The Committee serves as NIST's advisor on implementation of the NCST Act (P.L. 107-231; the 'Act'), and the opinions and recommendations expressed in this letter reflect our views as an independent, private sector body. This year the committee met via internet connection on June 8-9, and in person on Oct. 19. The meetings were used by NIST staff to brief the Committee on activities performed under the Act and closely related activities performed by NIST under other authorities.

The Act directs that the Committee annually report our findings and recommendations to Congress in two areas:

1. Evaluation of NCST activities, and
2. Assessment of the implementation of recommendations of NCST and the Committee

The Act was stimulated by the World Trade Center attack in 2001. NIST distinguished itself with its thorough study of the performance of the affected structures and the thoughtful recommendations for improvements in building standards and codes that came as a result. NIST has a long history of investigating disasters of various types, going back at least as far as the 1971 earthquake in the San Fernando Valley. The Act facilitates NIST's ability to conduct such investigations and enhances cooperation with other federal agencies.

On August 9, 2022, a change in the Act was approved. The change requires NCST's cooperation with civil litigants provided such cooperation does not compromise NCST's investigation or preservation of evidence. This change is an important step forward toward timely and just resolution of civil suits arising from events that NCST chooses to investigate.

Finally, we applaud that NIST agrees with the recommended revisions to the NCST Act that the Committee has addressed to Congress: broadening the Act to include structures other than just buildings in those cases those structures affect the safety and resilience of the services provided to communities from the built environment (buildings, infrastructure and other structures). See the Appendix.

Throughout this report, we have used indented paragraphs to highlight our recommendations as well as those NCST activities planned over the coming year for which we expect to see significant progress and results.

NIST has recently signed an Inter-Agency Agreement with the National Science Foundation to support their Natural Hazards Engineering Research Infrastructure (NHERI) awards. Considering natural hazards, the aims of the NIST National Construction Safety Team and the NSF NHERI program are similar, minimizing the negative consequences of natural hazard events, although the focus of the two programs is different. The committee thinks this is a significant first step to leverage the studies and capabilities of each agency to further this goal.

> We recommend that NIST takes advantage of the agreement with NHERI by exploring more specifically how these programs can cooperate.

NIST's Response to the 2021 Committee's Report to Congress

NIST is to be complimented on their thorough and thoughtful responses to our recommendations. We applaud their continued refinement of the automated scoring of events, especially the broadening of the damage prediction algorithm to incorporate a broad list of categories for measuring impact on the population, including health issues in addition to mortality rates.

We also are pleased that they are continuing to develop recommendations for construction guidelines for tornado effects on buildings and other structures, based on their NCST study of the Joplin tornadoes.

> We encourage additional efforts to broaden recommendations for design guidelines for tornado effects to include classes of buildings and other structures in addition to high-impact buildings, to include the building code Risk Category II, which includes most common buildings.

Their development of detailed timelines for all the projects for the Champlain Towers collapse study is especially welcome. This timeline is very important due to the sensitivity and public interest in determination of the likely sources of the collapse, and the committee believes that NIST has now created a realistic and thorough description of all aspects of the investigation.

Updates to the Disaster and Failure Studies Program, including Automated Scoring of Events

Events Scoring, to measure the significance of failures or natural disasters to help determine the focus of investigations, is an important function. In FY2022 NIST scored 19 domestic and international events, comprising two tornados, eight earthquakes, two structural failures, four building fires, two hurricanes and one wildland-urban interface fire. A few of these scored high but were in other countries where the lessons to be learned for the United States were judged minimal. One domestic event, Hurricane Ian, scored high, and a reconnaissance team has been deployed. Based on initial findings, a determination will be made as to whether to request a full NCST investigation. The decision must consider the potential impact on resources, since NIST

currently has two NCST investigations ongoing. Hurricane Fiona in Puerto Rico did not score high, but due to the current investigation into Hurricane Maria, NIST will consider if aspects of the ongoing studies can be significantly improved with data from Fiona.

NIST will be further developing the automated scoring method, beginning with hurricanes this year. They continue to explore additional means of looking at human impacts in addition to mortality. The initial trials should help to clarify if the current methodology is adequate for their purposes. As previously mentioned, work on the damage prediction model should help to inform the human impact. The addition of a damage prediction model and the automated scoring algorithm, combined with input from subject matter experts, has demonstrated the ability to score events in anticipation of the occurrence as well as at different points of time as the event unfolds. NIST has used a past hurricane (Michael) in order to test the procedure, which has shown results that are reasonably consistent with those from human judgement. NIST is working on adding forecasting and wind field modeling to better assess physical damage and mortality predictions. Perhaps results from the Hurricane Maria Morbidity and Mortality study can be useful in revising this piece. Eventually, it is hoped the model can be expanded to additional hazards.

> The mortality and a Social Vulnerability Index (SVI) piece are still in process, and we look forward to seeing how the automated scoring initiative continues to improve with the incorporation of those pieces.

The Committee notes the excellent advancements in terms of enhanced procedures for team readiness, including the implementation of the Hot Team, which has pre-approval for travel and the necessary gear set aside.

> Planned additional development of processes for assessment team readiness related to equipment and procedures are welcome and will be followed by the Committee.

The OMB Generic Clearance for Community Resilience Data Collections was renewed on July 27, 2022, and will expire on July 31, 2025. This renewal makes reviews of interview requests timelier for data collection purposes, a welcome change for those processes that have been moving slowly in the past in several investigations.

Hurricane Maria NCST Investigation

The NIST team should be commended on the thorough job they have done in the area of hazard characterization for Hurricane Maria. In particular, the work on quantifying the topographic effect on wind speed is critical in accurately characterizing the wind profile on the island, and the subsequent loading induced on the buildings and other infrastructure systems. It documents an understanding of the wind environment and other hazards, including storm surge, rainfall, flooding and landslide. The approach being taken, which includes wind tunnel testing, field observations and measurements, and computational fluid dynamics modeling is thorough and

provides the theoretical understanding of the hurricane forces. It is also good to see that uncertainty analysis is being considered in the hazard characterization.

We appreciate the methodological rigor that is being applied in the Hurricane Maria studies, including the selection of survey participants and the Mortality Study including the use of verbal autopsies.

> NCST investigations and mortality studies in general will greatly benefit if a standard protocol for conducting verbal autopsies is developed.

For studies of the physical conditions of buildings and infrastructure, as well as the hazard characterization, they have been able to proceed without significant disruption due to the pandemic, relying on physical observations and interviews.

Initial observations by NCST indicated that, despite good structural performance, critical buildings suffered damage to the building envelope, often allowing rainwater penetration, and extensive nonstructural damage resulting in loss of function. Loss of function was also often caused by loss of power and failure of backup generators.

NCST has selected five hospitals and five schools for detailed study, including document review, interviews and field investigation. These studies are ongoing. Two of the selected hospitals are also undergoing wind-tunnel studies, with particular emphasis on gaining a better understanding of topographic effects.

> Conclusions of the Hurricane Maria study should emphasize that loss of function, a key measure of resilience, is not only dependent on structural damage, but also depends on other building systems and surrounding infrastructure.

NIST has done an excellent job of reformatting its data processes due to the pandemic. They have made considerable progress in their data collection efforts especially for the morbidity and mortality study. The usefulness of this study is heavily dependent on the completeness of data collection. This will be particularly important as the differences between those interviewed and those not interviewed skews towards those with lower education not being interviewed. It is understandable that it has been more difficult to interview a next of kin of people who were never married. They have employed a specialized people finder service to find next of kin in the verbal autopsy process.

> The NCSTAC is closely following the verbal autopsy effort and the use of the people finder service in improving these interview completion rates for the Hurricane Maria study.

Considerable effort has been made toward the research on public response to emergency communications, with much of the data collection completed and now being analyzed by the research team. While most of the face-to-face interviews and surveys have been conducted in

Spanish, translation services have been necessary for facilitating coding and analysis of some data sources; there may be nuances that are lost through coding in English.

> It may be useful to consult Spanish language speakers who can comment about these potential nuances for the Hurricane Maria study.

We are also aware of the exceptional challenges that the population of Puerto Rico experienced due to failures of communication and power infrastructure. The important exception was radio broadcast, whose transcripts could provide valuable insights into what was communicated over the airwaves in the days leading up to the hurricane making landfall.

The key toward successful recovery of infrastructure is resilience. The key toward resilience is to understand the inter dependencies of the infrastructure systems. In order to improve power, water, transportation and communications, a five-project component plan is underway. They are hazard characterization, evaluation of critical buildings, assessment of emergency communications, study of morbidity and mortality, and an integrative study to develop a model for resilience decision making. Progress has been made in reference to communication towers performance as a function of hazard level and code requirements. In the area of integrative study schools and businesses are being incorporated.

The original four representative areas in Puerto Rico have two additions, the municipalities of Ponce and Mayagüez for their concentration of manufacturers. Through contractor supported efforts the three objectives of the business and supply chain plan are advancing. Over 400 have been completed, both in retail & services (373) and manufacturing (43); the rest will be completed in the summer of 2023. In addition, a shipping and transportation Interview guide has been developed in order to complete the analysis.

> After the Hurricane Maria data analysis is completed in the following months, NIST plans to develop a draft guideline that will incorporate analyses based in econometric modeling of recovery trajectories and SEM modeling of intended mitigation and adaptation behavior. The committee looks forward to learning how this development progresses.

Their study on the recovery of social functions will be used to advance an empirical understanding of long-term recovery, including measurement, identification of predictors (e.g., resources, characteristics associated with resilience), and exploration of interdependencies across the community.

> The pilot test program of methodologies to assess recovery of social functions has been completed (it was affected by COVID-19 limitations) and data collection has started this past summer. The committee looks forward to an update on this endeavor.

When looking at organizational types together, the slowest progress in restored services occurred with transportation (strongly affected by COVID-19 restrictions). When looking at schools and

hospitals together, only slightly more than half had some form of backup for power and water and only a quarter had a form of backup for landline telephone.

Champlain Towers South Partial Collapse NCST Investigation

Led by Dr. Judith Mitrani-Reiser and Mr. Glenn Bell, NIST has assembled a world-class team of experts from NIST and elsewhere. In addition to structural, geotechnical, and materials science experts, the team includes experts in building codes, evidence collection, remote sensing, and social science. The team is committed to reliably identifying the cause of the collapse and recommending steps to avoid similar events.

We commend NIST for acknowledging the value of adding social scientists to the Champlain Towers South investigation.

> We look forward to hearing how the addition of social scientists to the Champlain Towers South investigation adds to the knowledge gained from studying this tragedy.

The team has developed and is following a comprehensive investigation plan. Key features of the plan include the following:

- Collection and analysis of evidence from building records, public and surveillance video, social media, and eyewitness interviews;
- Site investigation including geometric surveys, subsurface testing, and structural testing of removed samples;
- Strategies for identifying and storing collapse remnants from the site for further study;
- Nondestructive and invasive testing of collapse remnants;
- Review of the design based on codes and methodologies in place at that time;
- Computer models capable of simulating the cause and progression of the collapse; and
- Structural testing of replicas of building elements involved in the collapse, which will allow for parametric study of potential contributing causes.

In addition, the social science team maintains ongoing communication to family members and other concerned persons who were affected by the collapse.

Testing and documentation of the collapse site are essentially complete and other aspects of the investigation are well underway. However, the original schedule slipped considerably due to difficulties in procuring warehouse facilities for storing and testing collapse remnants, but a new comprehensive timeline has been developed for the entire investigation and report production.

> The advisory committee recommends careful attention to the following highly challenging elements of the investigation:

- NCST is advised to not miss out on potentially valuable information that can only be gained through interviews that may not be tied to physical evidence. It is also important to keep in mind the fact that some memories may be quite perishable over time.
- Regarding the design review, it would be very useful to find a set of calculations for a similar building in in South Florida designed in the late 1970s or early 1980s; such a set would be helpful in establishing probable design practices and the standard of care.
- With respect to the structural testing of replicas, we recommend that NCST recognize the uncertainty of pre-collapse conditions and conduct tests on specimens that represent a reasonable range of probable conditions.
- The computational models and laboratory test results should be adjusted to reflect the effects of long-term sustained load, which cannot be fully simulated in the laboratory tests.

Although the final report is not scheduled until mid-2025, overall, the advisory committee is highly impressed with the progress and plans to understand and learn from this tragic event.

> In light of the significance of the collapse and its potential impact on the US construction industry, we urge NCST to expedite their investigation and issue interim summaries of critical lessons learned as the investigation progresses.

Implementation of Recommendations from Previous NCST Investigations

NCST reported significant progress on implementation of recommendations arising from previous investigations. Based on NIST proposals arising from the World Trade Center investigation, a draft ASCE/SEI standard on mitigation of disproportionate collapse recently completed balloting. Also, in response to NIST recommendations, ASCE has revised wind tunnel testing standards and wind velocity pressure profiles.

The most significant advances in implementation, however, arise from the Joplin tornado investigation. Most importantly, the ASCE tornado hazard maps and load methodology were unanimously approved for adoption into the 2024 International Building Code. The tornado load requirements are supplemented by improvements in the EF Scale, enhanced tornado field data collection methods, and analyses of estimated cost increases for consideration of tornado loads. The codification of tornado loading requirements is a significant advancement in the resistance of ASCE 7 Category III and IV buildings (such as hospitals and elementary schools) to EF1 and EF2 tornadoes, which are by far the most common. Most buildings, including the housing stock, are classified in Risk Category II.

> To enhance life safety for occupants of houses and ordinary buildings, and to protect occupants of all buildings in the event of severe tornadoes, NIST is working on development and implementation of sheltering strategies, shelter design and emergency communications. The Committee is interested in and will follow these developments.

National Construction Safety Team Advisory Committee

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Summary

NCSTAC met with NIST to review progress on initiatives over the past year and to provide feedback to NIST. On the basis of our discussions with NIST, we make the following observations:

The NCST program is highly valuable to the safety and resilience of the built environment in the United States.

We commend NIST for diligently administering the NCST program.

The NCST teams investigating Hurricane Maria and the Champlain Towers South collapse are making appropriate progress toward completion of their assignments, using comprehensive state-of-the-art investigative tools and techniques.

NIST and the NCST teams have been responsive to feedback from NCSTAC.

The Act that authorizes NIST to conduct investigations presently limits those studies to buildings. NCSTAC advocates for the Act be broadened to include infrastructure and structures other than buildings when performance of those constructions significantly impacts safety and resilience of services provided to communities in the United States. The specific changes that we recommend are contained in the appendix to this letter.

Sincerely yours,

Ross B. Corotis

Ross B. Corotis
Chair, National Construction Safety Advisory Committee

Attachment

National Construction Safety Team Advisory Committee

National Institute of Standards and Technology

Appendix

Proposed amendments to the NCST Act:

Sec. 2, paragraph (a):
"…after events causing the failure of a building or ~~buildings~~ structure that has resulted in substantial loss of life or that posed significant potential for substantial loss of life. Where the failure of the structure is the proper subject for investigation by another Federal agency, the Director shall defer to the authority of that agency. To the maximum extent practicable…"

And Sec. 2, paragraph (b)
"(1) PURPOSE.—The purpose of investigation by Teams is to improve the safety and structural integrity of ~~buildings~~ the built environment in the United States.

And replace the term "buildings" with "the built environment" in Sec. 2 paragraph (b)(2)(D)

And replace the term "building standards, codes, and practices" with "engineering standards, practices, and building codes" at the following locations:
Sec. 8 paragraph (3)
Sec. 9, paragraph (2)
Sec. 14

And replace the term "building failure" with "failure" at the following locations:
Sec. 2, paragraph (b)(2)(a)
Sec. 2, paragraph (c)(1)(G)
Sec. 2, paragraph (c)(1)(J)
Sec. 4, paragraph (a)
Sec. 4, paragraph (a)(1) *[2 locations]*
Sec. 4, paragraph (a)(3)
Sec. 4, paragraph (b)(a)
Sec. 4, paragraph (b)(2)
Sec. 4, paragraph (c)(1)
Sec. 4, paragraph (c)(2)
Sec. 4, paragraph (d)(3)
Sec. 4, paragraph (d)(4)
Sec. 7, paragraph (c)
Sec. 8, paragraph (1)
Sec. 8, paragraph (4)

And replace the term "building components" with "components" at the following locations:
Sec. 4, paragraph (a)(1)
Sec. 4, paragraph (a)(3)
Sec. 4, paragraph (b)(1)

And broaden Sec. 4, paragraph (d) on Interagency Priorities to include other agencies that have legislative mandates for the investigation of the failure of selected types of failures, such as the Army COE for dams and levees, the NRC nuclear power generation, the DOE for nuclear weapons facilities, and the DOT for vehicular bridges. *[Such mandates are assumed, not verified, by this advisory committee]*

Lastly, unrelated to the preceding, consider updating Sec. 2 paragraph (c)(1)(J) by adding a reference to the National Windstorm Impact Reduction Program.