National Fire Research Laboratory (NFRL)

Joannie Chin, Director
Engineering Laboratory

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

NIST Laboratory Programs

Material Measurement Laboratory

Physical Measurement Laboratory

Engineering Laboratory

Information Technology Laboratory

Communication Technology Laboratory

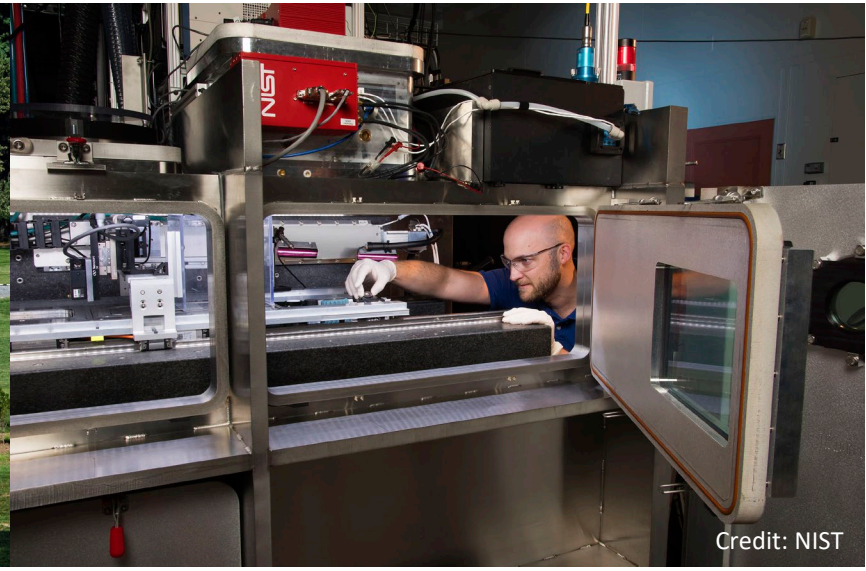
NIST Center for Neutron Research

Engineering Laboratory (EL) Mission

EL promotes U.S. innovation and industrial competitiveness by advancing **measurement science**, **standards**, and **technology for engineered systems** in ways that enhance economic security and improve the quality of life

Disaster Resilience

Building Energy and Environment



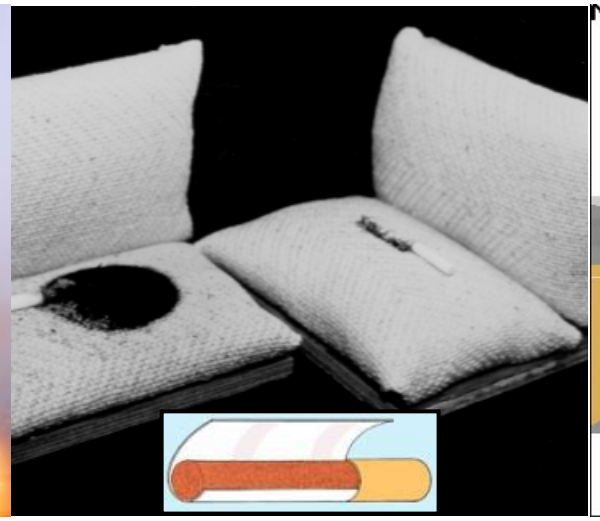
Advanced Manufacturing

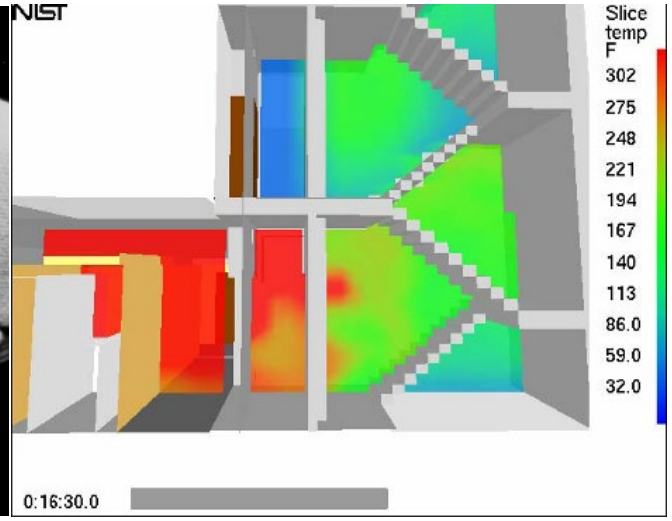
EL Organizational Structure

Fire Research Programs at NIST

Fire Risk Reduction in Communities: To improve the resilience of communities and structures through innovative fire protection and response technologies and tactics

Fire Risk Reduction in Buildings: To increase the safety of building occupants and the performance of structures and their contents by enabling innovative, cost-effective fire protection technologies

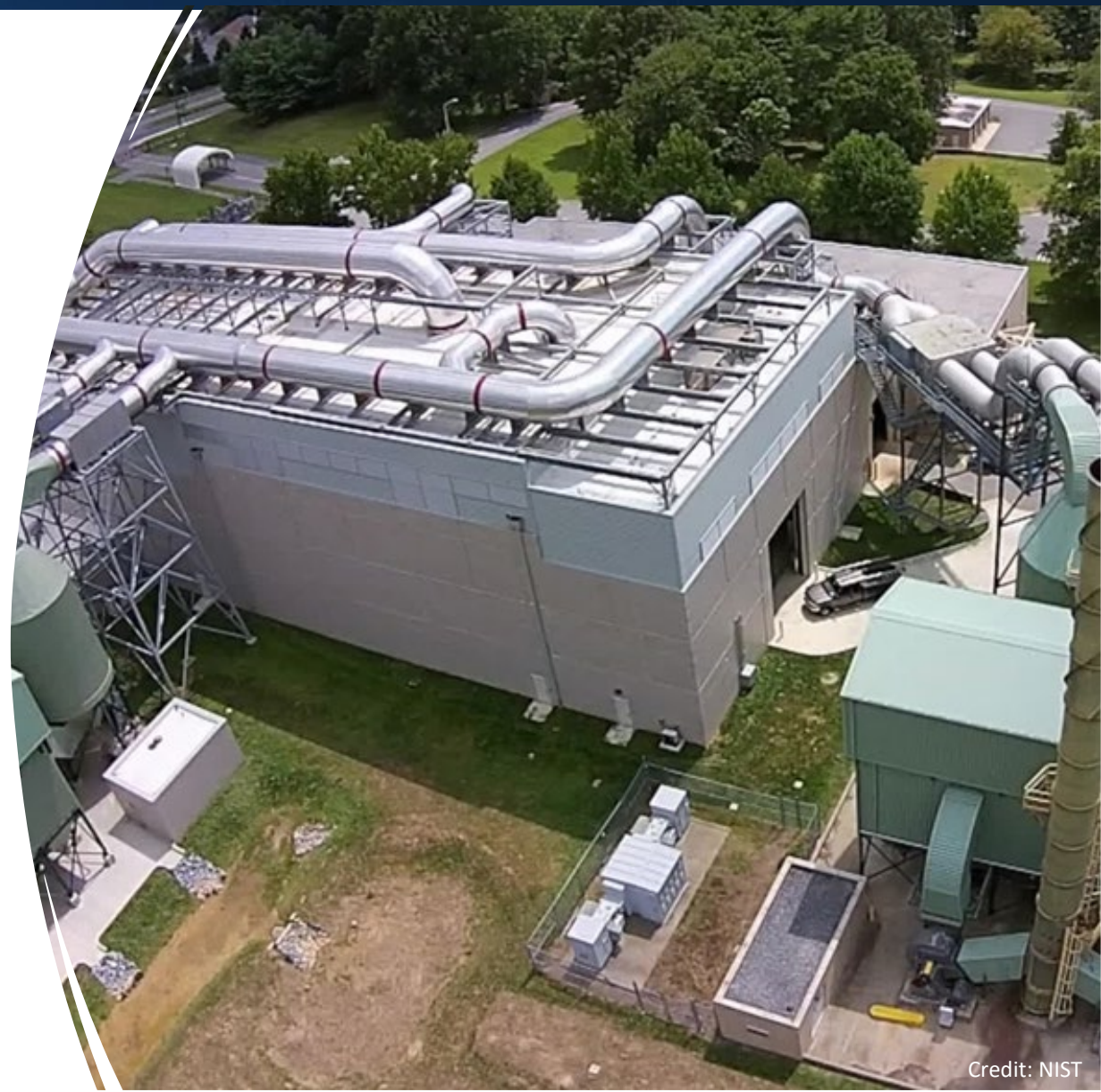




National Fire Research Laboratory (NFRL)

A unique national resource dedicated to understanding fire behavior and structural response to fire

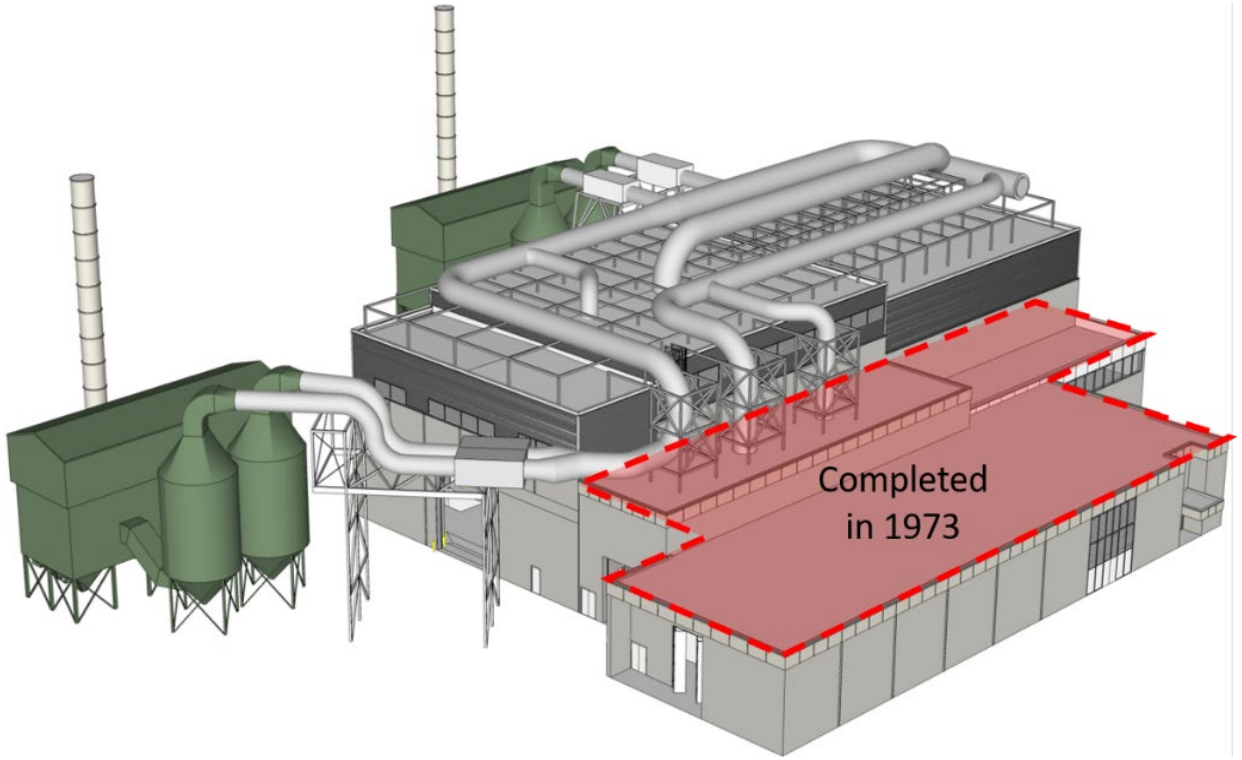
- Capability of conducting full-scale fire and structural fire measurements under controlled conditions
- Enables generation of science-based data to validate fire models and improve fire and building codes
- Contains one of the most accurate instruments in the world for measuring the heat release rate of large fires



Credit: NIST

NFRL History

Original lab ("legacy") built in 1973
(red highlighted section)

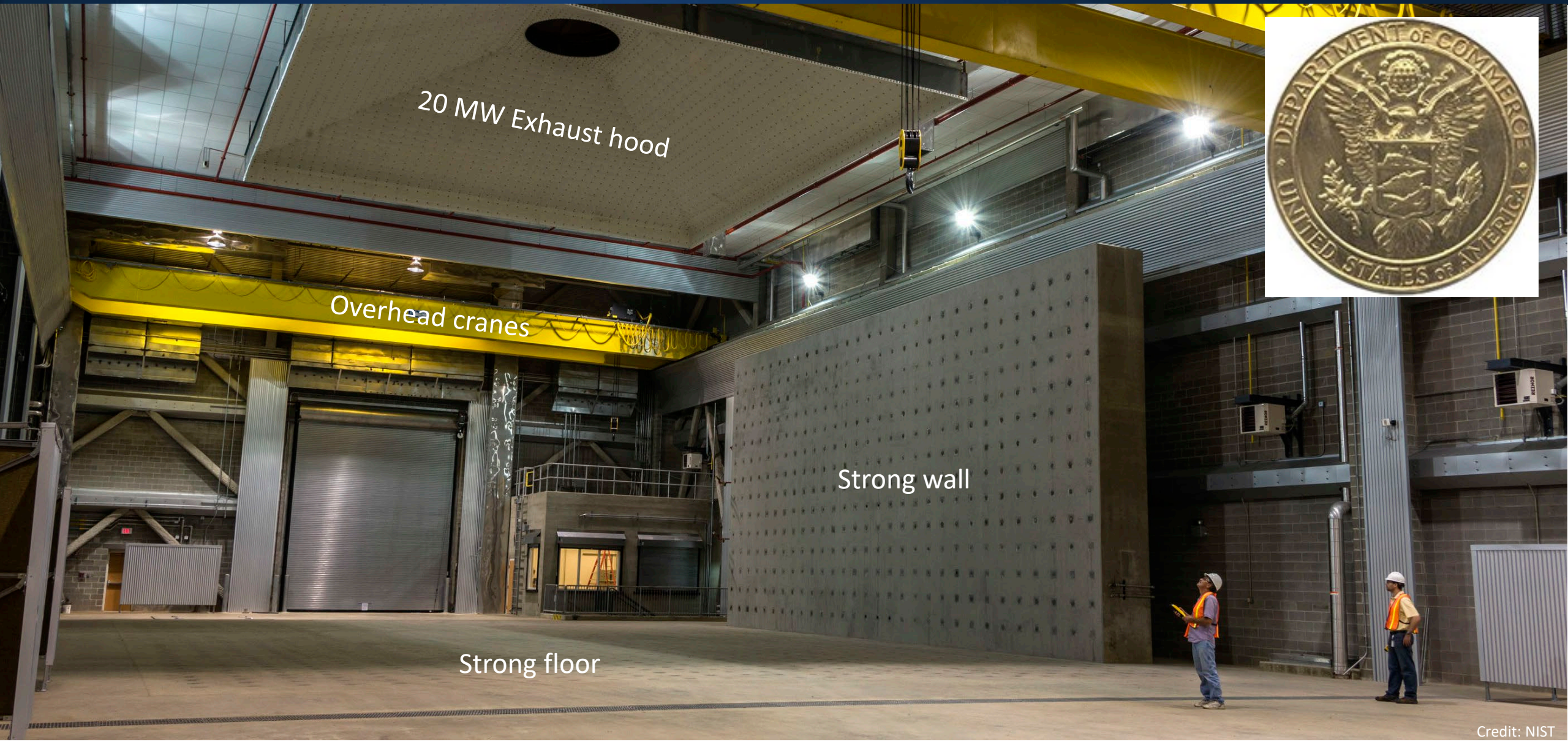


After the WTC 7 collapse, it was recognized that no facilities existed to evaluate the performance of full scale structure under realistic fire loads

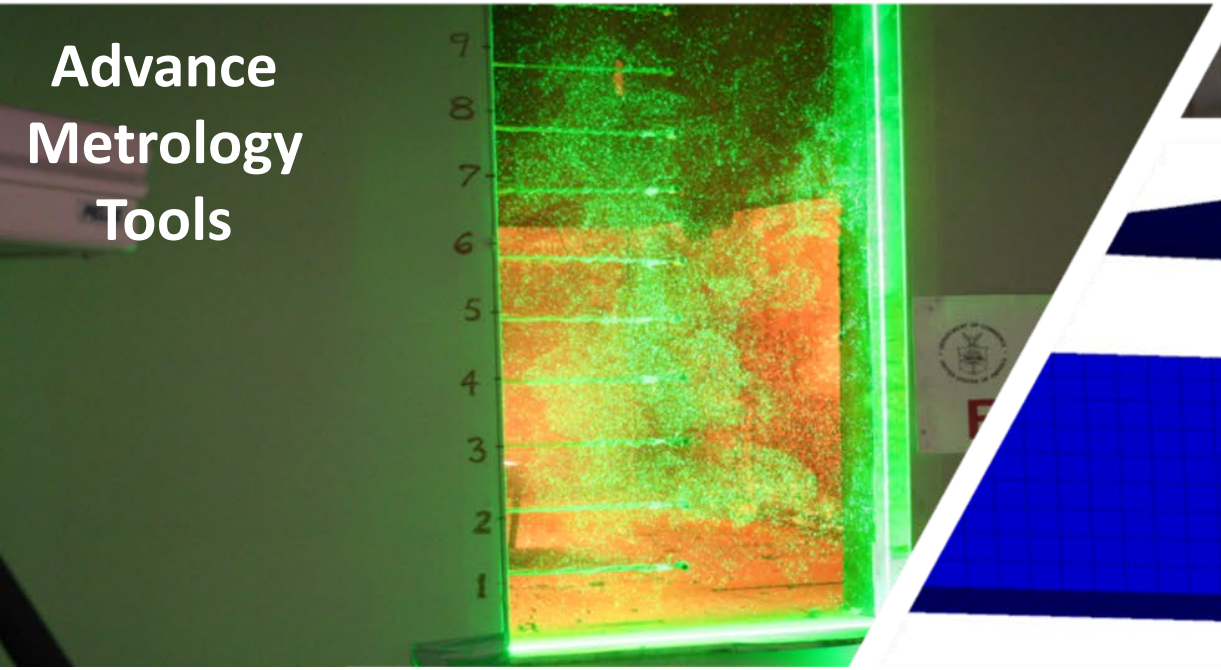
A 2012 study conducted by the Fire Protection Research Foundation stated:

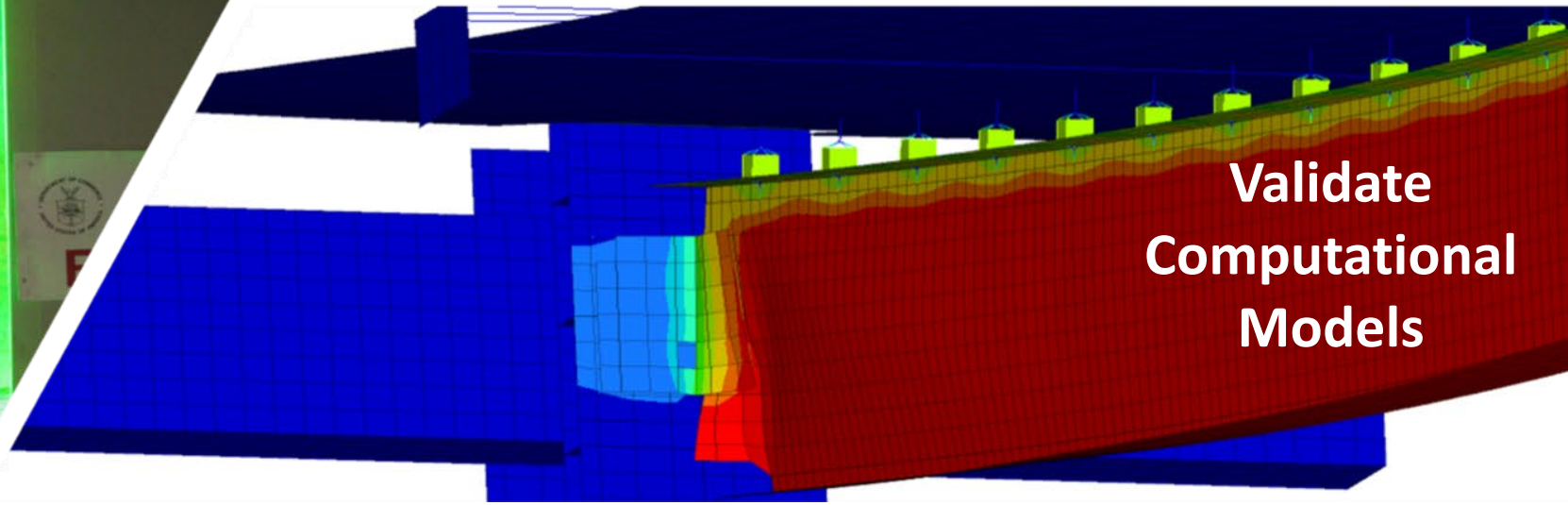
> *"The NFRL presents a unique opportunity to explore a broad range of unanswered questions regarding the performance of real structures in the fire condition, and to inform performance-based design methods and standards…"*

Expansion of the NFRL in 2015



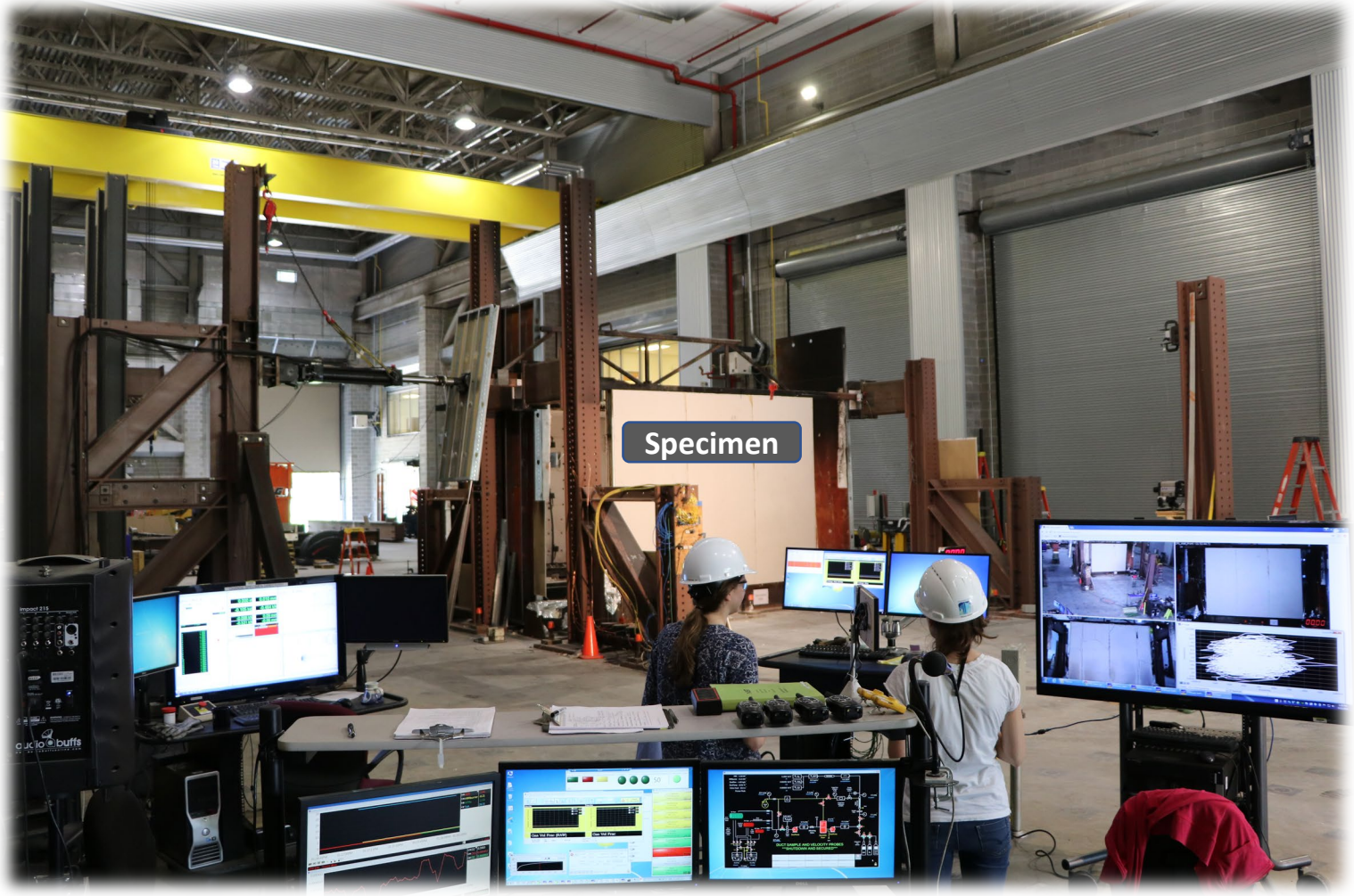
NFRL Research Thrust Areas





Fire Following Earthquake Impact on Cold-Formed Steel Construction

To study **the influence of fire on the lateral load resistance** of cold-formed steel shear walls



Load cycling without fire

Load cycling following fire

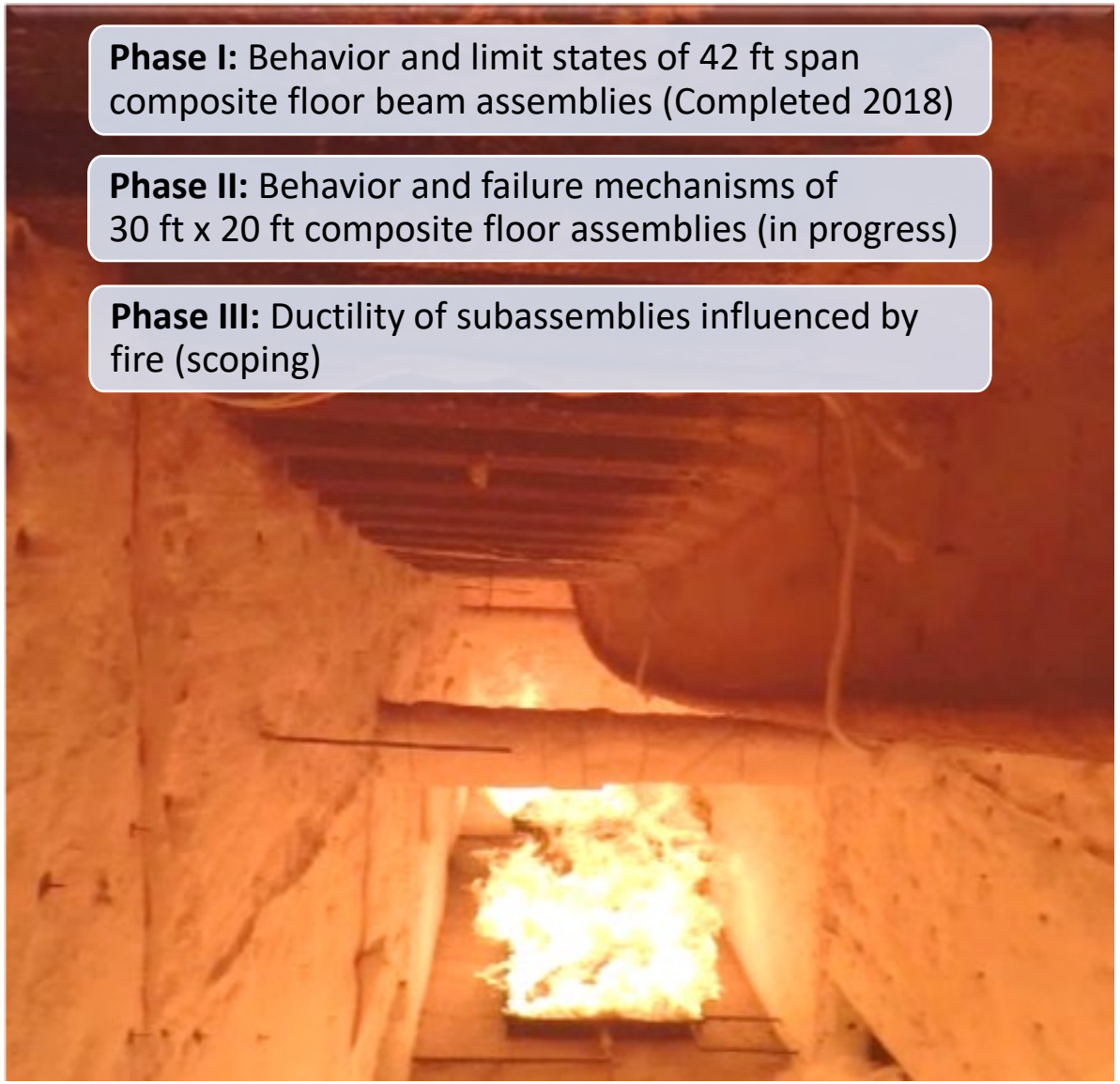
Large Scale Experiments of Cross-Laminated Timber Compartments

To quantify the **contribution of Cross-Laminated Timber elements** to compartment fires with varied ventilation, encapsulation and exposure

- 9.1 m x 4.6 m x 2.7 m studio apartment
- 175-mm thick 5-ply CLT structural panels

Provided the technical basis to transform the International Building Code to allow the expanded use of cross-laminated timber structures in North America while ensuring occupant safety

Steel-Framed Structures with Composite Floor Systems



Phase I: Behavior and limit states of 42 ft span composite floor beam assemblies (Completed 2018)

Phase II: Behavior and failure mechanisms of 30 ft x 20 ft composite floor assemblies (in progress)

Phase III: Ductility of subassemblies influenced by fire (scoping)

Largest composite floor test constructed with full compliance with U.S. practice

First-of-kind structural-fire experiments in the U.S. with **real boundary conditions** in **a two story, multi-bay steel frame**

Unique Safety Challenges

Large forces imposed by high-capacity hydraulic loading systems

Large fires (long durations, high thermal radiation)

Large forces and large fires applied simultaneously

Use of scissor lifts, forklifts, and skid loaders

Use of high-capacity overhead cranes

Multi-level test structures

General NFRL Safety Policies

NFRL Lab spaces are restricted to **authorized personnel** through use of badge card reader

At least two authorized workers are required to be present for all lab activities

Each experimental test series must have an approved Hazard Review, including approved standard operating procedures and required PPE

A safety briefing is conducted by the Activity Leader prior to each experiment involving fire or large-scale structure

Automatic Fire Suppression Deluge System

The NFRL High Bay Labs (113 and 125) are equipped with a total of 8 IR fire detectors aimed beneath the hoods and 3 linear beam smoke detectors located below the ceiling.

A fire suppression system (deluge sprinklers and fire monitor nozzles) is activated by the fire detection system or manual pull stations.

The water deluge system will deliver up to 3000 GPM of water and must be bypassed during a fire experiment.

Activity Hazard Reviews

Primary Hazards

- Large fires (heat, toxic gases)
- Large forces and heavy material handling (cranes, forklifts)
- Flammable liquids, chemicals, compressed gases
- Fabrication equipment (band saws, mills, lathes, drill presses)
- Working at high elevations (ladders, manlifts, platforms, scaffolding)
- Confined Spaces
- Electrical Hazards

Engineering and Administrative Controls, PPE and Training

Described in Activity Hazard Reviews and Standard Operating Procedures

- NFRL general use Activities for crosscutting hazards
- Project Hazard Reviews for specific experiments conducted in NFRL

Activity ID	Version	Name	RHI	Status	Expiration Date	Created by
733.06.0047	010920	NFRL Industrial Powered Trucks (Forklifts and Skidloader)	2 - Medium	Approved/Update Pending	2023-01-09 in 28 days	Marco G. Fernandez
733.06.0051	082421	NFRL Scissor and Boom Lifts	2 - Medium	Approved	2024-08-26	Anthony R. Chakalis
733.06.0052	052322	NFRL Overhead Cranes	2 - Medium	Approved	2025-05-23	Anthony R. Chakalis
733.06.0054	070120	NFRL Roof Work	2 - Medium	Approved	2023-07-23	Rodney Bryant
733.06.0062	041822	Operation of Mill, Lathe and Drill Press at NFRL	2 - Medium	Approved	2025-05-04	Laurean DeLauter
733.06.0069	081020	Assembly and Installation of Reaction Yoke	3 - Serious	Approved	2023-08-11	Anthony R. Chakalis
733.06.0071	083120	Post-Tensioning of High Strength Threaded Bars	2 - Medium	Approved	2023-09-04	Anthony R. Chakalis
733.06.0072	080520	Surface Preparation and Bonding of Strain Gauges	1 - Low	Approved	2023-08-05	Selvarajah Ramesh
733.06.0073	101520	Operation of NFRL Structural Loading Systems	2 - Medium	Approved	2023-11-19	Anthony R. Chakalis
733.06.0125	011122	NFRL General Scaffolding Use	2 - Medium	Approved	2025-01-11	Anthony R. Chakalis
733.06.0126	090220	Removal and Installation of Concrete Pit Covers	2 - Medium	Approved	2023-09-04	Anthony R. Chakalis
733.06.0132	062121	NFRL Large Fire Experiments	2 - Medium	Approved/Update Pending	2024-06-21	Matthew Bundy
733.06.0148	050522	Composite Floor System Stabilization and Demolition	2 - Medium	Approved	2023-05-16 in ~5 months	Anthony R. Chakalis
733.06.0163	062420i	NFRL Welding and Torch Cutting	2 - Medium	Approved	2023-08-21	Anthony R. Chakalis
733.06.0168	092820i	Structural fire test of steel connections	2 - Medium	Approved	2023-10-16	Selvarajah Ramesh
733.06.0194	060622i	Fog visualization of buoyancy induced vortices	1 - Low	Approved	2024-11-23	Giovanni Di Cristina Torres
733.06.0195	120622	FireLiDAR Operation	2 - Medium	Approved	2023-12-06	Matthew Hoehler
733.06.0197	103122	Structural Metrology Fire Experiments with Natural Gas Burners	2 - Medium	Approved	2024-12-07	Matthew Hoehler
733.06.0203	112322i	Handheld XRF Spectrometer (clone of 731.07.0304.061422i)	2 - Medium	Approved	2024-12-06	Matthew Bundy
733.06.0204	121222	NFRL Category 2 Specialty Tools	2 - Medium	Approved	2024-12-12	Anthony R. Chakalis

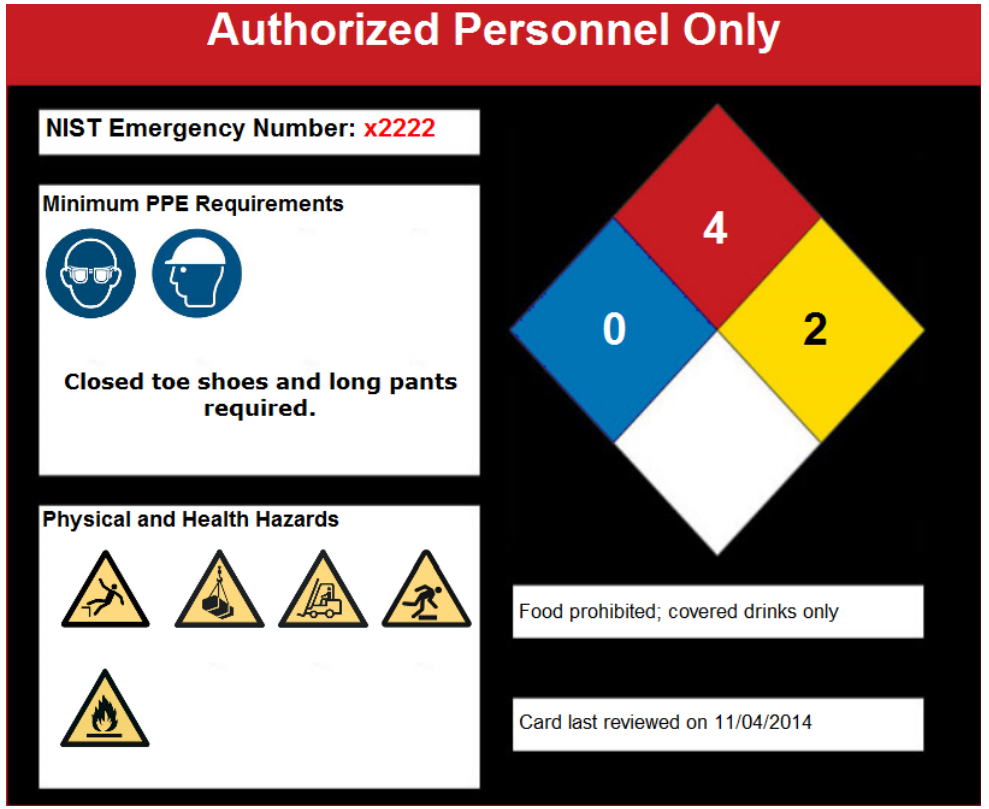
Required Personal Protective Equipment

Minimum Required Personal Protective Equipment

- Safety glasses
- Hard hats
- Closed toe shoes
- Long pants

Activity-Specific PPE examples (prescribed in hazard review)

- Steel toe shoes
- Respirator or Self-Contained Breathing Apparatus
- Face shield
- Fall protection harness
- Hearing protection
- Gloves
- Fire fighting turnout gear
- Amber tinted safety glasses



Pre-test Safety Briefings and Checklists

NFRL Pre-Test Inspection Checklist

Performed by Test Safety Officer prior to Safety Briefing

Safety Officer_____

Date_____

Project_____

1) Verify Following Safety Conditions:
   a. ☐ - NIST FD notified and water deluge system in bypass
   b. ☐ - Restricted access signs placed at lab entrance doors
   c. ☐ - Carbon monoxide monitors in place
   d. ☐ - Tripping hazards identified and mitigated
   e. ☐ - Exclusion zones clearly identified
   f. ☐ - Flammable items have been identified and removed or controlled
   g. ☐ - Pressurized fluids have been identified and removed or controlled
   h. ☐ - Fire hoses, handheld extinguishers and sprinklers are in place

NFRL Safety Briefing Checklist / Test Parameters

Date (MM/DD/YYYY): ___ /___ /_____ Select Exhaust Hood (3m 6m 9m 15m)

Project Name / Folder ID: _____/_____

Test Name(s):_____

Specimen:_____ Ignition:_____

Test Description:_____

_____

Fuel Type:_____ FuelHOC:_____(kJ/g) Ef:_____ (kJ/gO_2)

Initial Specimen Weight: _____ (kg) Final Specimen Weight_____ (kg)

1) Roles and Responsibilities
   a. Test Director/ Safety Officer: _____/_____
   b. DAQ Operator HRR/Project: _____/_____
   c. Video Operator / Photos: _____/_____
   d. ECS / NG Operator: _____/_____
   e. Ignition/Suppression Operator: _____/_____
2) Hazard Mitigation
   a. Activity Hazard Review - briefly review **safety controls** and **PPE**
   b. Emergency procedures and evacuation and Incident reporting
   c. Review Rules for Guests and Visitors - exclusion zones and exits
3) Review Experimental Sequence and Verify Tasks
   a. ☐ - Hood Air Mass Flow Rate _____ kg/s
   b. ☐ - Smokemeter Laser on?
   c. ☐ - Visible Emission Required? (yes/no). Observer _____
4) Verify Safety Tasks:
   a. ☐ - NIST FD Notified and Water Deluge System in Bypass
   b. ☐ - Restricted Access Signs and Barriers at Doors
   c. ☐ - Carbon Monoxide Monitors in Place
   d. ☐ - Safety Briefing and Pre-Test Inspection Completed

Fatal Accident on September 26, 2022

- On September 26, 2022, an engineering technician in the NFRL was involved in a tragic accident involving a fall from elevation.
- He arrived at NIST 10 years ago and brought more than two decades of experience in executing large-scale experiments and critically needed knowledge of the hydraulic systems used for large-scale structural testing.
- There are currently two on-going investigations: Occupational Safety and Health Administration (OSHA) and the NIST Office of Safety, Health, and Environment (OSHE).
- The structural high bay has been in a stand-down mode and structural experiments are on hold indefinitely.
- Low-hazard experiments in the legacy NFRL are in the process of being re-reviewed for re-start.

Questions

Additional Slides

Core Areas of Expertise in EL

Sustainability, and service life prediction of engineered materials

Fire protection, fire physics, materials flammability

Intelligent sensing, control, robotics and automation

Economic impact analysis and modeling

Structural analysis, disaster and failure studies

Building and renewable energy, indoor environment, and building systems performance measurement

Systems integration, information modeling, model-based engineering

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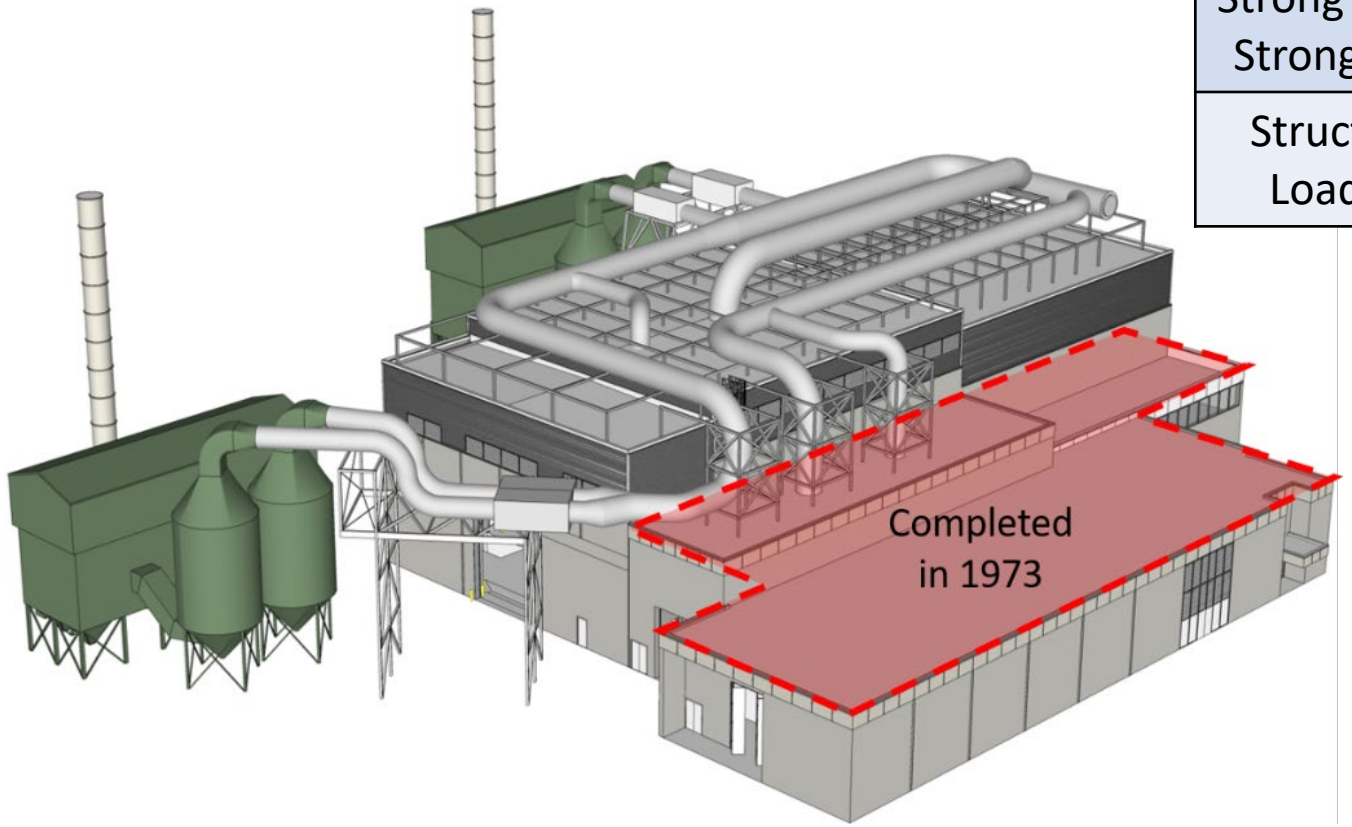


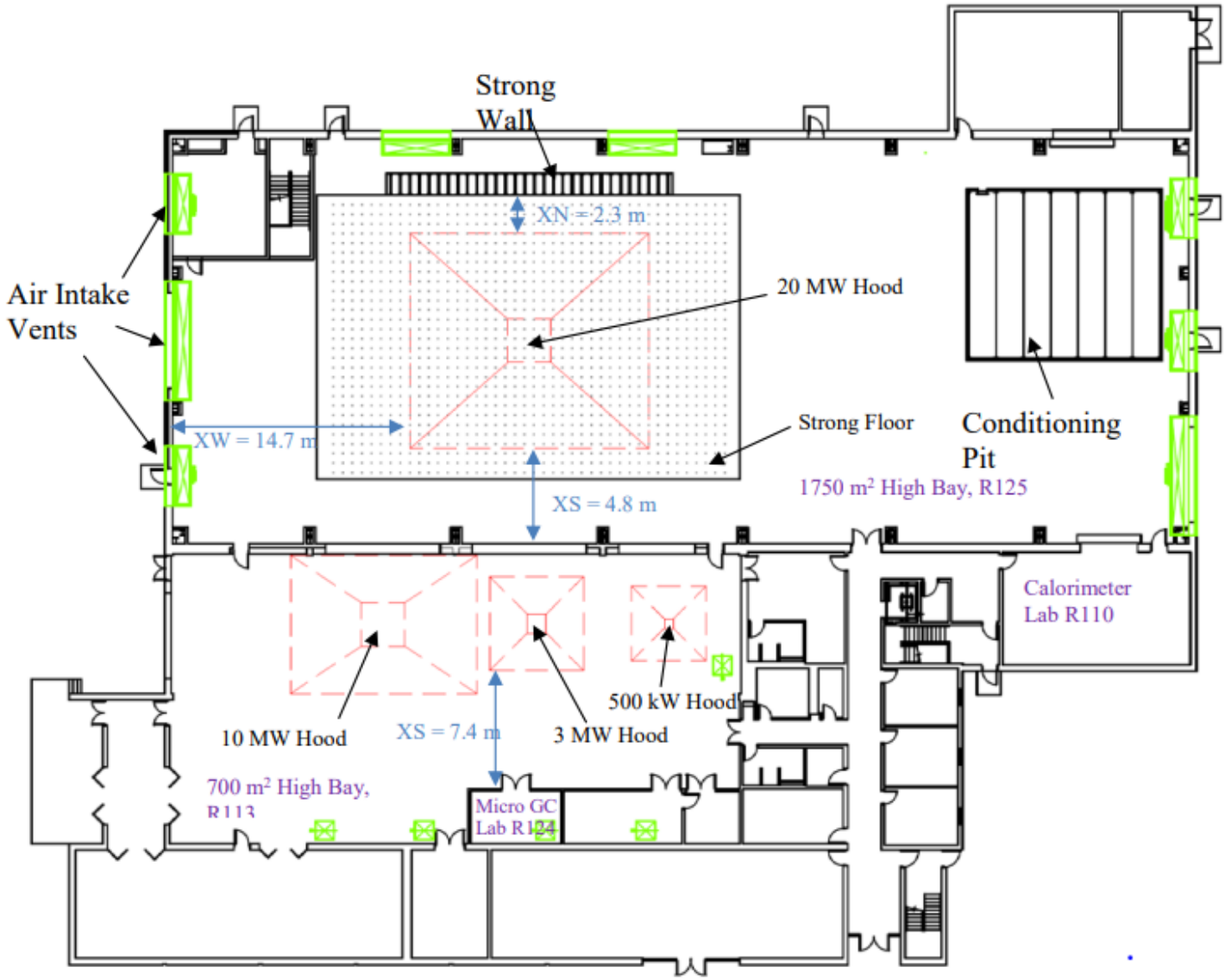
Specification	Original	New Expansion
Floor Area	1000 m^2	2000 m^2
Fire Capacity	1 MW | 3 MW | 10 MW	20 MW
Strong Floor/ Strong Wall	None	Strong floor: 18 m x 27 m Strong Wall: 18 m x 9 m
Structural Loading	None	up to 960 kN actuators

The 2015 expansion allowed for the combined study of fire and structural response

NFRL Operating Model

- NFRL operates as a collaborative facility through partnerships among NIST, the private sector, and other government agencies
- Scientists and engineers from industry, non-profits, academia, and government agencies work side-by-side with NIST researchers to address significant problems and fill critical knowledge gaps
- International scientists and engineers can also partner with NIST in areas aligned with EL priorities of mutual interest.
- Project funding is shared among collaborators, with NIST covering basic facility costs and support of NFRL crew.

NFRL Floor Plan



Safety in the NFRL

Hazard Identification

- Large forces, working at elevation, high-capacity overhead cranes
- Large fires (long durations, high thermal radiation)
- Failure or collapse of test structures

Engineering Controls

- Access control system
- Control room and Observation room
- Fire detection and suppression systems
- Controlled hydraulic loading
- Strong wall and reaction frames for stabilizing test structures
- Building monitoring system (video, air quality, temperatures, strains)
- Cranes and hydraulic system with state-of-the-art safety features

Administrative Controls

- Hazard reviews and SOPs, Staff training/certification, maintenance and inspection
- Pre-test Safety Briefings

Personal Protective Equipment

Near-Miss and Incident Reporting