NIST Special Publication 1111

Summary of Workshop on Research Needs for Full Scale Testing to Determine Vulnerabilities of Siding Treatments and Glazing Assemblies to Ignition by Firebrand Showers

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National Institute of Standards and Technology • U.S. Department of Commerce

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Summary of Workshop on Research Needs for Full Scale Testing to Determine Vulnerabilities of Siding Treatments and Glazing Assemblies to Ignition by Firebrand Showers

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Fire Research Division
Building and Fire Research Laboratory

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U.S. Department of Commerce
Gary Locke, Secretary

National Institute of Standards and Technology
Patrick D. Gallagher, Director

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1. Introduction

1.1 Objective for this workshop

Anecdotal evidence as well as post-fire damage assessment studies suggests that wind driven firebrand attack is responsible for the majority of structure ignitions in Wildland-Urban Interface (WUI) fires. A unique experimental apparatus, known as the NIST Firebrand Generator (NIST Dragon), has been constructed to produce a controlled and repeatable firebrand attack [1]. The experimental results generated from the marriage of the NIST Dragon to the Building Research Institute's (BRI) Fire Research Wind Tunnel Facility (FRWTF) in Japan are being used by standards organizations to guide/develop new standards and provide the scientific basis for new requirements with the intent to make structures more resistant to firebrand attack. An experimental database is also being created to support NIST's Wildland Fire Dynamics Simulator (WFDS) [2].

NIST planning is underway for a new experimental campaign scheduled for the fall of 2010 to determine vulnerabilities of siding treatments and glazing assemblies to firebrand bombardment using the NIST Dragon installed in the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute (BRI) in Japan. Input is desired for this testing series from interested parties in California (*e.g.* building officials, OSFM, code consultants, industry) since large WUI fires have occurred in this state recently. Specifically, guidance is desired in order to conduct experiments that will have the potential to provide the scientific basis for code change that can significantly reduce WUI fire losses.

1.2 Session Agenda

- Overview of the NIST Firebrand Generator (NIST Dragon) and prior application to determine vulnerabilities of roofing assemblies and building vents to firebrand showers (Presentation is provided in Appendix 2).

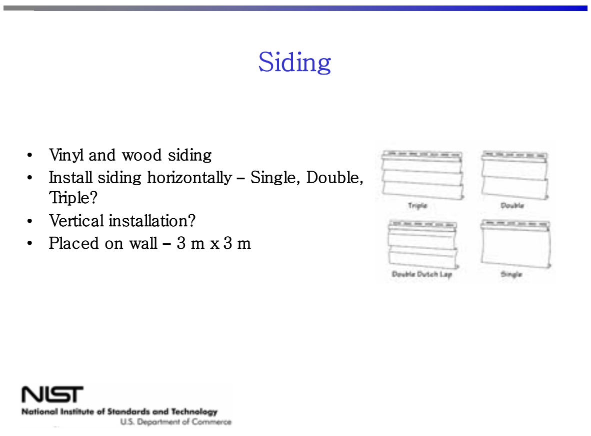
- NIST summary of planned experiments to determine vulnerabilities to siding treatments and glazing assemblies to firebrand bombardment using the NIST Dragon installed in the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute (BRI) in Japan. (Presentation is provided in Appendix 2).

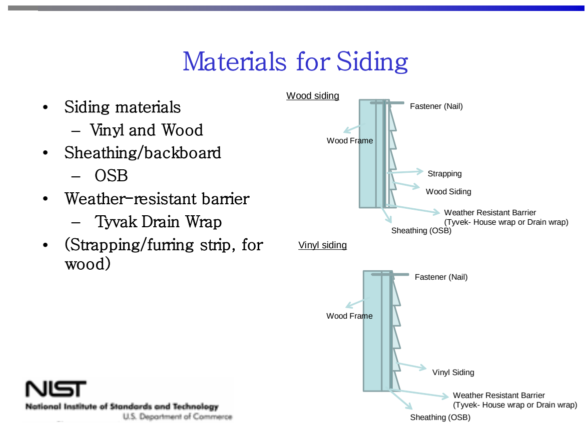
- Group input, discussions, and exchange of information.

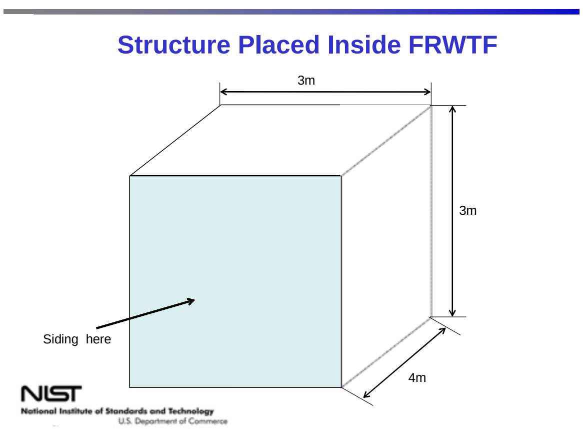
2. Results of Discussion

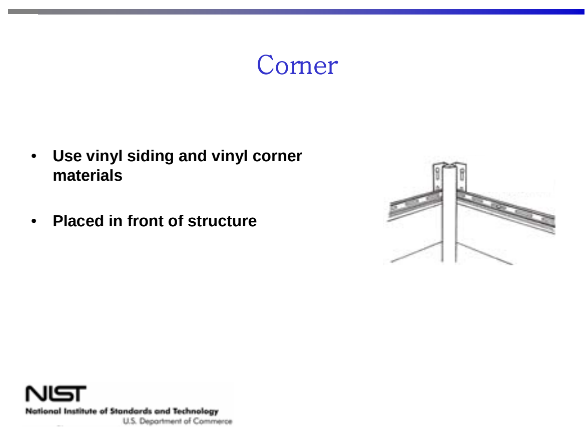
2.1 Input related to importance of exposing siding treatments to firebrand showers.

The NIST presentation about siding treatments is summarized in the following four slides:









Input from attendees:

- Siding treatments applied in corners are very important and should be considered for testing (See Fig. 1).
- In addition to corners, siding treatments installed on the face of a vertical wall should also be used for testing.

- Polypropylene should be included as a material to be used for experimentation, in addition to wood and vinyl siding since it is widely used as a siding material.

- Many siding treatments have some possibility to be ignited because the assembly has many gaps where firebrands may become lodged within these gaps and cause ignition. It was felt that wood siding has big gaps.

- Experiments of walls fitted with eaves should be included as part of the experimental planning. <u>A very important long standing question is whether firebrands may become lodged within joints between walls and eave overhang</u> (See Fig. 2).

- A detailed discussion was held in regard to the type of eaves that should be used for the tests. Namely, a gable end eave or standard eaves (run along the base of the roof - See Fig. 3).

- It was decided by the group that for the purposes of these experiments, a gable end eave is less important and testing should be done for standard eaves (See Fig. 2)

- A simple vertical wall should be constructed with an eave attached the top

- Architectural drawings were requested from the group of typical eave construction. An example of these are shown in Fig.3

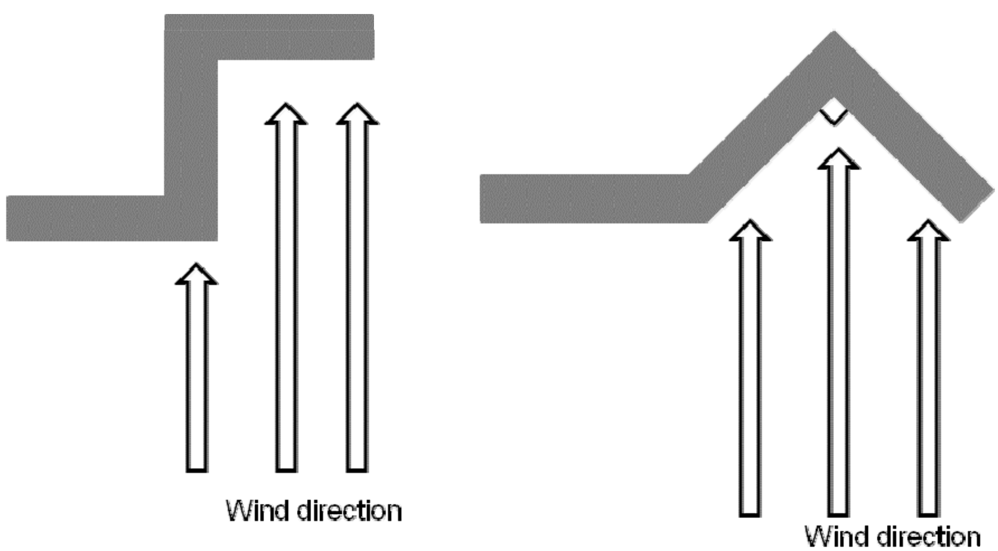


Fig.1 Schematic of Example of Corner

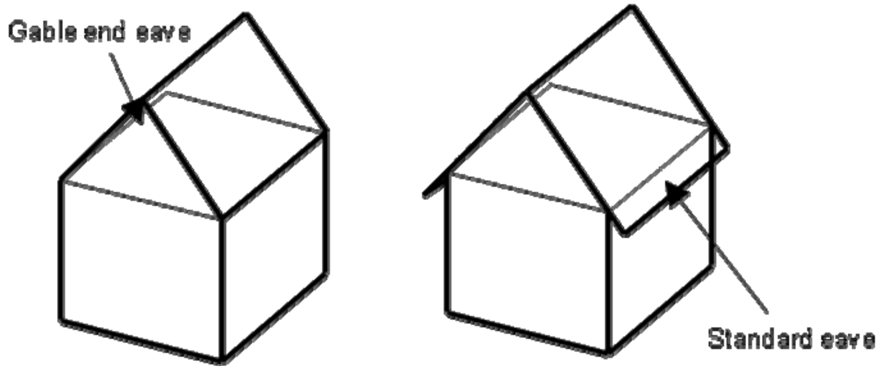


Figure 2 Schematic of eave configurations.

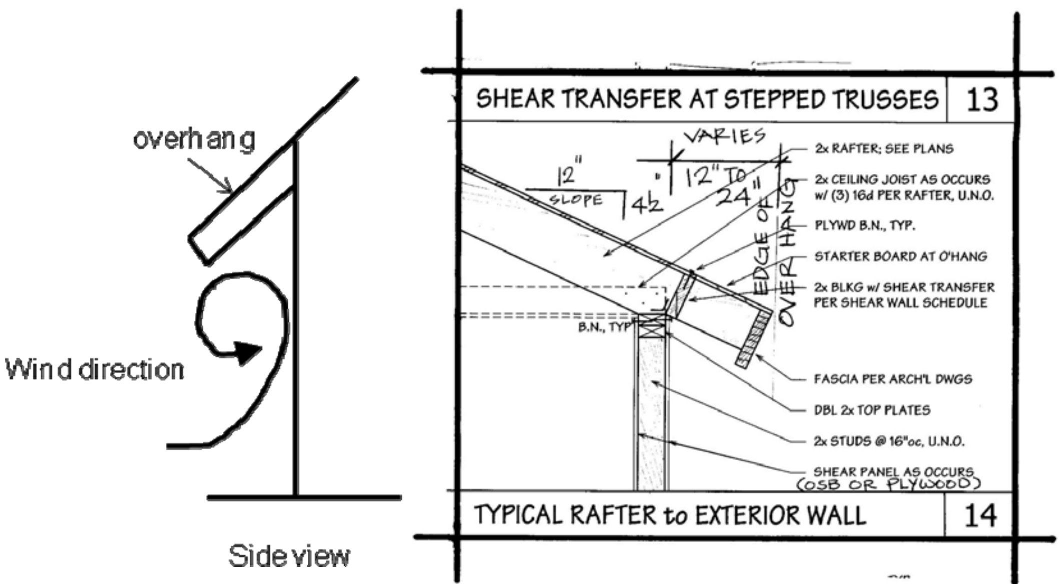
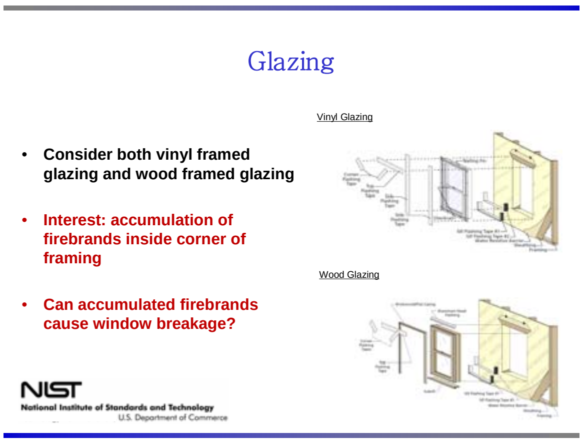


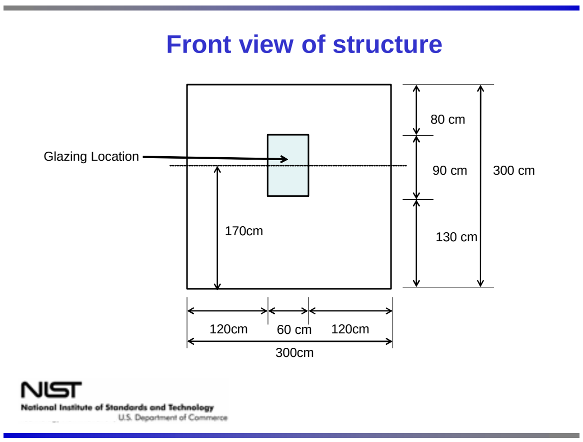
Fig. 3 Side view of standard eave assemblies.

2.2 Input related to importance of exposing window assemblies to firebrand showers.

The NIST presentation about window assemblies is summarized below:

Note that the dimensions of the window assembly (right slide) are for illustration purposes only.





Input from attendees:

- The group felt that double hung window assemblies would be more susceptible to firebrand showers since there is more space for firebrands to become lodged within the framing.
- Many types of materials are used for window frames: vinyl, wood, aluminum clad wood, and vinyl clad wood.
- It is important to know how to properly install window assemblies. The joint requires some sealing (flashing material) and firebrands may become lodged within the seal. The group felt that the flashing used should be paper not metal. Paper is a common flashing material and would be more dangerous to firebrand penetration.
- Window assemblies that are double hung with single pane glass may be more vulnerable than other type of window assemblies.

2.3 Summary

Anecdotal evidence exists related to vulnerabilities of siding treatments and glazing to firebrand attack yet standard test methods are not available to evaluate the ability of siding treatments and glazing assemblies to resist firebrand showers. Before the development of the NIST Firebrand Generator and the subsequent coupling of this device to the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute (BRI) in Japan, there was no method to actually generate firebrand showers in a controlled, laboratory setting to quantify these vulnerabilities. Therefore, full scale tests are planned to quantify the vulnerabilities of siding treatments as well as glazing assemblies to firebrand showers using the coupling of the NIST Dragon to BRI facilities. The results of the full scale tests will be reported to CALFIRE and ASTM and will serve as the basis for guiding reduced scale test methods for siding treatments and glazing assemblies as well as providing code change. A workshop was held in June, 2010 by NIST to provide input on the type of siding treatments and glazing assemblies most common and important to test. The focus has been placed on the state of California since many large WUI fires have occurred there over the past 10 years [3]. This document provides a succinct summary of the workshop results. The input from this workshop will be considered as NIST/BRI finalize their experimental plans.

3. NIST Research Plan

A detailed list experiments that are being considered is provided below:

1. Siding Treatment Experiments (Vertical Wall and Corner)

Three kinds of siding materials:

- Wood siding
  - Cedar shake shingle (both untreated and fire treated)
- Vinyl siding
  - Polyvinyl chloride
  - Polypropylene

2. Window Assembly Experiments

Two kinds of window frames:

- Wood frame
- Vinyl frame

Window assemblies used will be double hung, either single or double pane with flashing paper.

3. Vertical Wall Experiments Fitted With Eaves

- Eave overhang: 24 inches
- Eave slope: 12 inches by 4.5 inches
- Vertical wall fitted with wood and vinyl siding

4. References

1. S.L. Manzello, Y. Hayashi, T. Yoneki, and Y. Yamamoto, Quantifying the Vulnerabilities of Ceramic Tile Roofing Assemblies to Ignition during a Firebrand Attack, *Fire Safety Journal*, 45:35-43, 2010.

2. W.E. Mell, A. Maranghides, R. McDermott, and S.L. Manzello, Numerical Simulation and Experiments of Burning Low-Moisture Douglas-Fir Trees, *Combustion and Flame*, 156:2023-2041, 2009.

3. W.E. Mell, S.L. Manzello, A. Maranghides, B. Butry, and R. Rehm, Wildland-Urban Interface Fires: Overview and Research Needs, *Int'l J. Wildland Fire*, 19: 238-251, 2010.

5. Acknowledgements

Mr. Ethan Foote, Assistant Chief, Wildland Protection Building Construction – CALFIRE OSFM, organized this workshop and his assistance in greatly appreciated. The valuable input of all participants is warmly appreciated.

Appendix 1

Workshop Attendee List

	Name	Affiliation
1	Ali Fattah (via conference call)	PE Senior Research Engineer –Division of Building and Safety
2	Bill Hendricks	(representing) Cedar Shake & Shingle Bureau
3	Cal Lewis	Building & Fire Code Consultant –C. A. Lewis and Associates
4	Darren Drake	Fire Marshal, Napa City Fire Department
5	Dave Sapsis	Wildland Fire Scientist – CALFIRE OSFM
6	Donn Harter	President & Director of Technical Service, Americas Glass Association
7	Ethan Foote	Assistant Chief, Wildland Protection Building Construction – CALFIRE OSFM
8	Howard Stacy	Vice President- Western Fire Center, Inc.
9	Jeff White	Building Official, Calaveras County Building Department
10	Jon S Traw	PE, Traw Associates Consulting
11	Joseph B Zicherman	PhD, SFPE, Fire Cause Analysis
12	Kuma Sumathipala	Senior Manager, Fire Research, American Wood Council, AF&PA
13	Mike Dobson	(representing) Hoover Treated Wood Products
14	Mike Mentink	Fire Marshal, Moraga-Orinda Fire District
15	Ray Zachau	Fire Marshal, South Lake Tahoe Fire Department
16	Rick Thornberry	PE Building & Fire Code Consultant – The Code

		Consortium, Inc.
17	Samuel L. Manzello	NIST
18	Sayaka Suzuki	NIST
19	Scott Alber	PE, Fire Marshal, Marin County Fire Department
20	Steve From	Western Red Cedar Lumber Association(WRCLA)
21	Steve Quarles (via conference call)	UC Corporative Extension Advisor
22	Steven R. Winkel	FAIA, PE, The PREVIEW Group, Inc. (Architect Member Calif Bldg. Stads. Commission)
23	Vahid Toosi	Fire Protection Engineer-Orange County Fire Authority

Appendix 2

Presentation Delivered at Workshop.

Input for Future Full Scale Testing: Siding Treatments and Glazing Assemblies

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Experiments Conducted Yesterday

- Determine firebrand production from burning structures
  - Proof-of-concept testing
  - Heat flux; firebrand size/mass
  - Temperature/humidity
  - IR; visual imagery
  - Experiment in Dixon, California
  - Collaboration with Northern California Fire Prevention Officers:
    - Vacaville Fire Department
    - Dixon Fire Department

Mr. Matt Lage and Mr. George Laing – Thanks!!

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NIST At A Glance

Gaithersburg, MD

Boulder, CO

- 2,800 employees
- ~2,500 associates and facility users
- 3 Nobel laureates

The NIST Laboratories

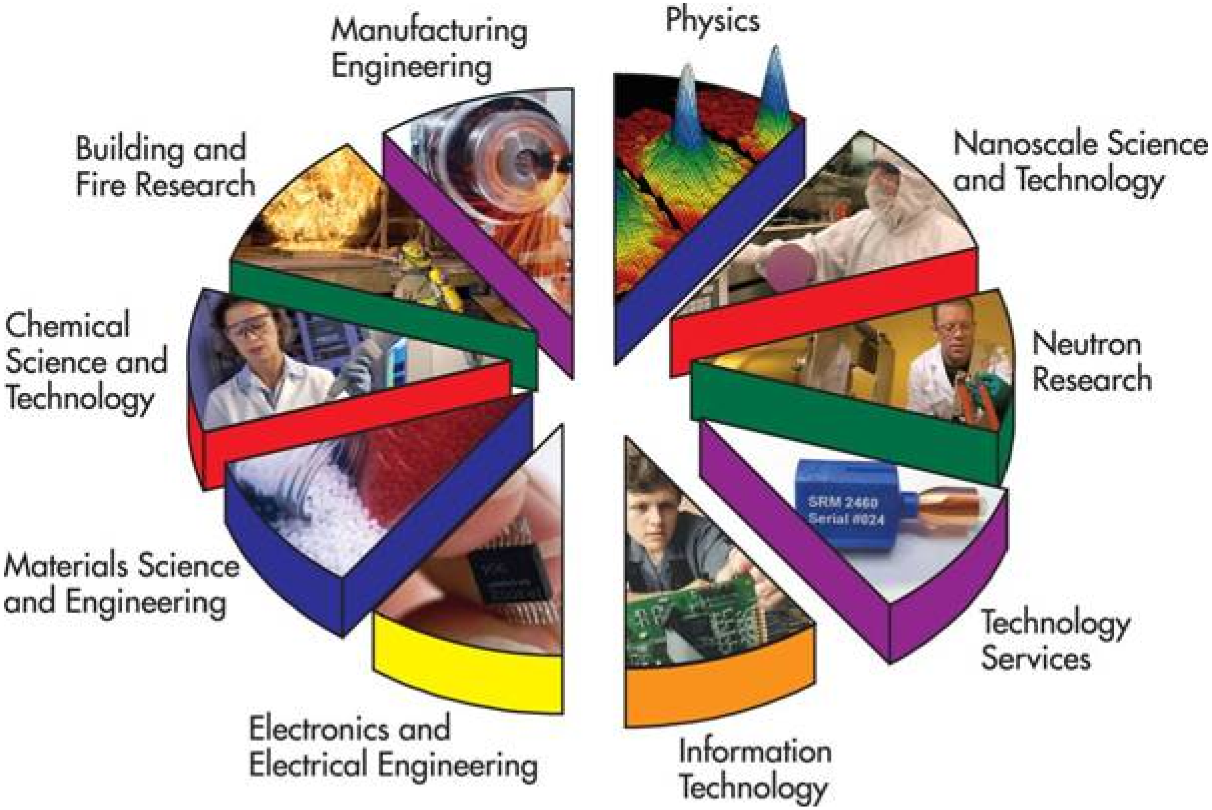
Mission: Promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

NIST's work enables

- Science
- Technology innovation
- Trade
- Public benefit

NIST works with

- Industry
- Academia
- Other agencies
- Government agencies
- Measurement laboratories
- Standards organizations



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Wildland-urban Interface (WUI) Fires

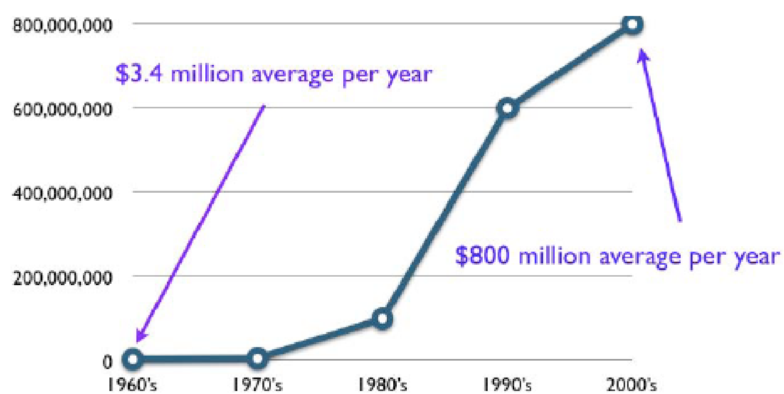
Wildland fires spread into WUI communities

Of the 10 largest fire loss incidents (> $1B) in U.S. history, 5 were WUI fires - all within the last 17 years

- **Current approach:**
  - Wildland-fuel and residential-fuel treatments
  - Not the outcome of a well coordinated scientific effort

Photo by JOHN GIBBINS / Union-Tribune
Cedar Fire about to engulf the Scripps Ranch residential community

Annual Insurance Claims for Structure Lost in WUI fires



Proven risk assessment and mitigation tools are needed

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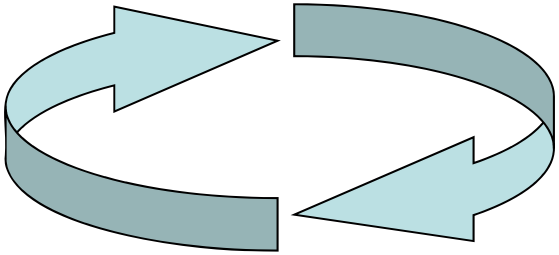
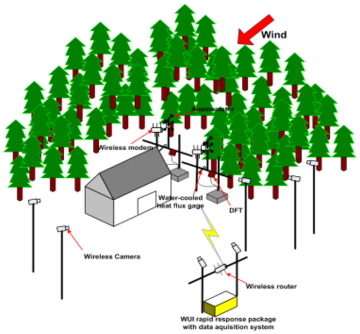
Integrated Approach to Reducing Losses in the WUI

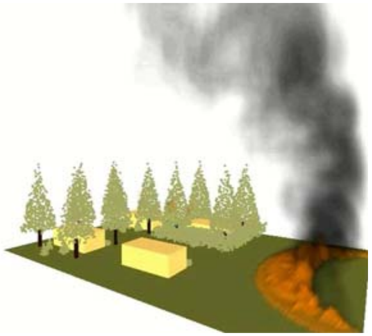
Pre- and Post-Fire Data Collection & Analysis



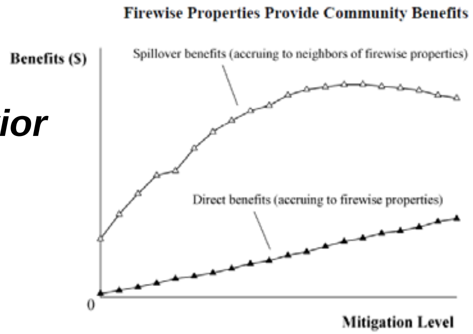
Structure Ignition



Physical Modeling



Economic Modeling



Large Scale Fire Behavior and Wind Measurements

Lab Scale Fire Behavior Measurements

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Collaborators

- Building Research Institute (BRI)
- Dr. Yoshihiko Hayashi

BFRL-NIST

Structure Ignition

- Dr. Sayaka Suzuki (Japan)
- Dr. Seul-Hyun Park (Korea)
- Mr. John R. Shields

WUI Program

- Dr. William 'Ruddy' Mell
- Mr. Alexander Maranghides
- Dr. David Butry

Structure Ignition in Urban and WUI Fires

- **Firebrands major cause of ignition**
- **Understanding firebrand ignition of structures – important to mitigate fire spread Japan/USA**

Objective: Investigate ignition of structures to firebrand showers

2007 Southern California Fire

Wakkanai Fire

Partnerships

- BRI - Japan
- US Department of Homeland Security

Customers

- CALIRE
- ASTM (Manzello voting member)
  - Subcommittee E14.06 Vents
  - Subcommittee E14.08 WUI Exposures
- Results useful for:
  - ASTM, CALFIRE, ICC, NFPA, ISO, Insurance Industry

International Collaboration
BRI (Japan) and BFRL-NIST (USA)

- Firebrands: generation, transport, ignition
- Research focused on how far firebrands travel for 40 yrs!!
- Nice Academic Problem – Not helpful to design structures

- Vulnerable points where firebrands may enter structure
  - Unknown/guessed!
- Difficult to replicate firebrand attack!
- Entirely new experimental methods needed!

Goals

Science - Building Codes/Standards; Retrofit construction

Design structures to be more resistant to firebrand ignition

Douglas-Fir Tree Burns at NIST

– **Firebrand Collection using water pan array**
  - **Range of crown heights: 2.4 m – 4.5 m**
  - **Different moisture regimes**

– **Mass loss using load cells**

4.5 m Douglas Fir, MC = 25%

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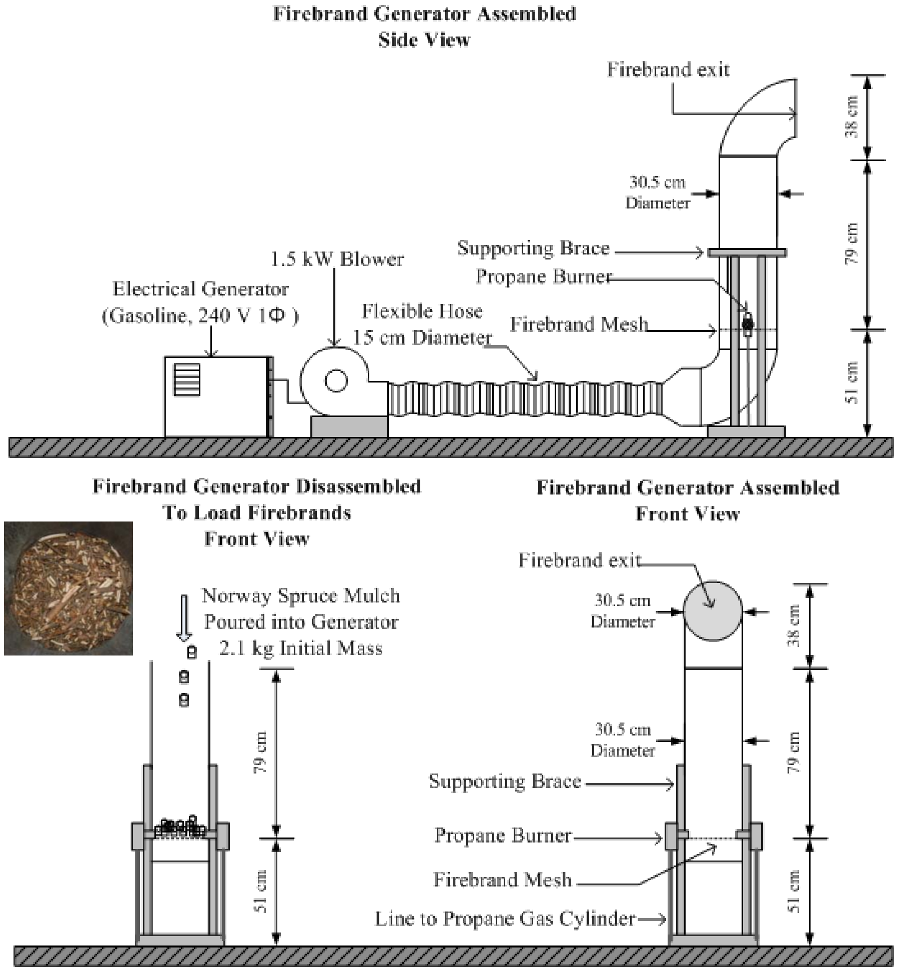
Firebrand Generator (NIST Dragon) 龍

Capable of producing controlled and repeatable size and mass distribution of firebrands

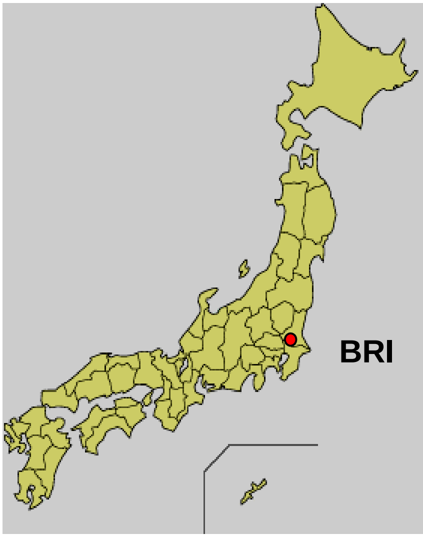
Firebrand Generator Side View



Firebrand Generator Front View

Building Research Institute (BRI)

- **Fire Research Wind Tunnel Facility (FRWTF)**
- **Unique facility – investigate influence of wind on fire**



Fire Research Wind Tunnel Facility (FRWTF)

NIST Dragon 龍

First Generation Device

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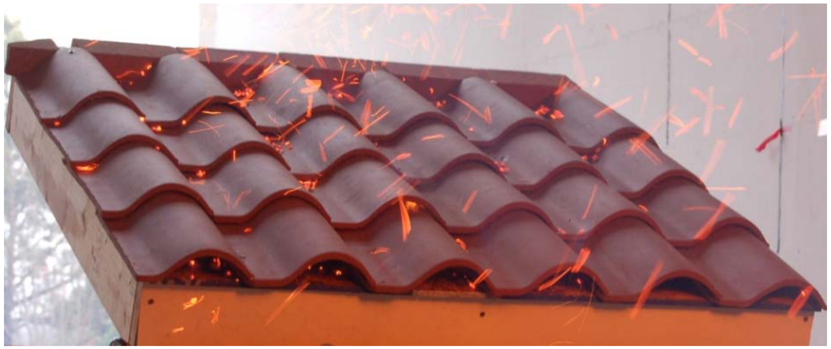
Ceramic Roofing

Aged Roofing Simulated: OSB, then tiles (no tar paper)



U_∞ (m/s)	OSB/TP/CT No Bird Stops	OSB/TP/CT With Bird Stops	OSB/CT No Bird Stops	OSB/CT With Bird Stops
7	SI	NI	SI to FI	SI
9	SI	NI	SI to FI	SI

New Roofing Construction: OSB, Tar Paper, then Ceramic Tiles

Ceramic Roofing

Aged Roofing Simulated: OSB, then tiles (no tar paper)

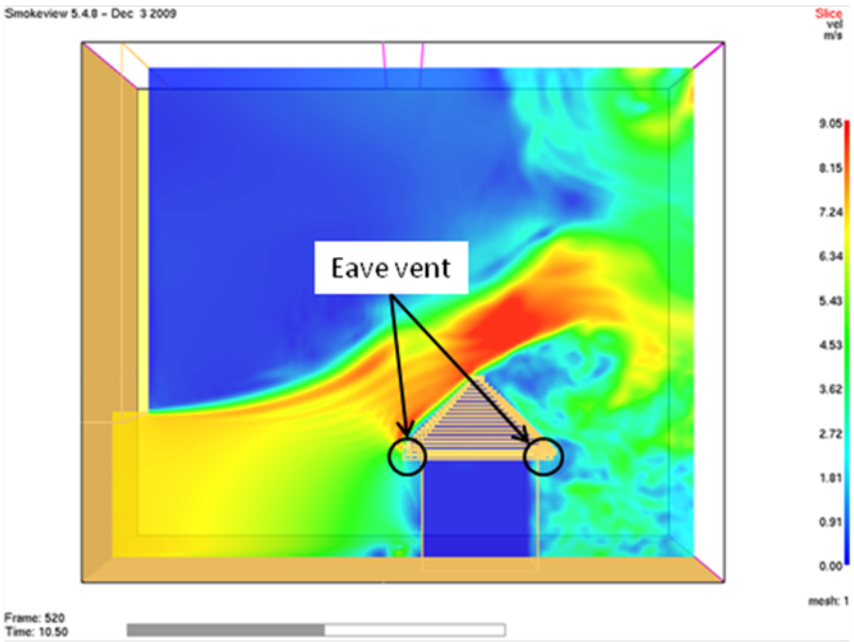
U_∞ (m/s)	OSB/TP/CT No Bird Stops	OSB/TP/CT With Bird Stops	OSB/CT No Bird Stops	OSB/CT With Bird Stops
7	SI	SI	SI to FI	SI
9	SI	SI	SI to FI	SI

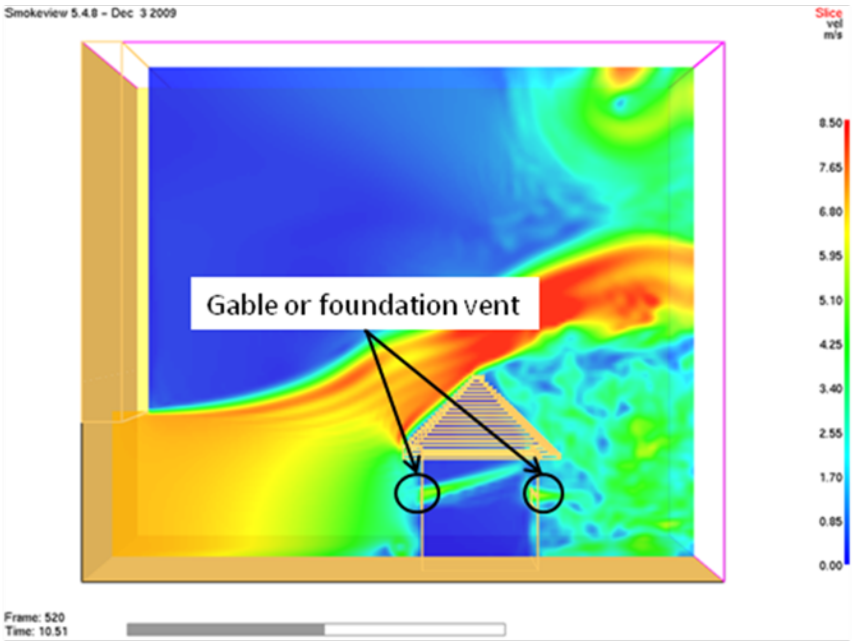
New Roofing Construction: OSB, Tar Paper, then Ceramic Tiles

Pine Needles/Leaves Under Tiles

Vent Placement

Experiments simulate severe exposure case
Conducted using FDS





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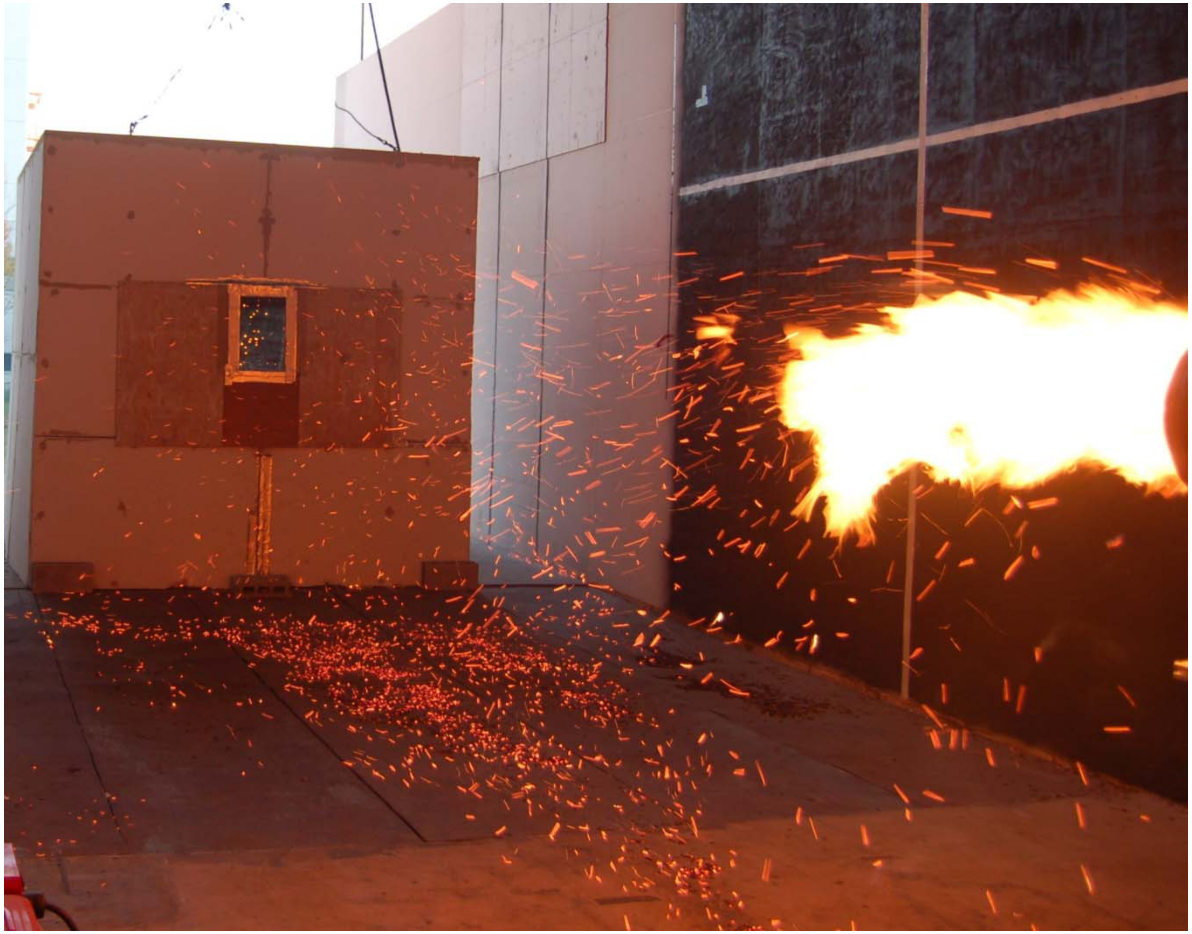
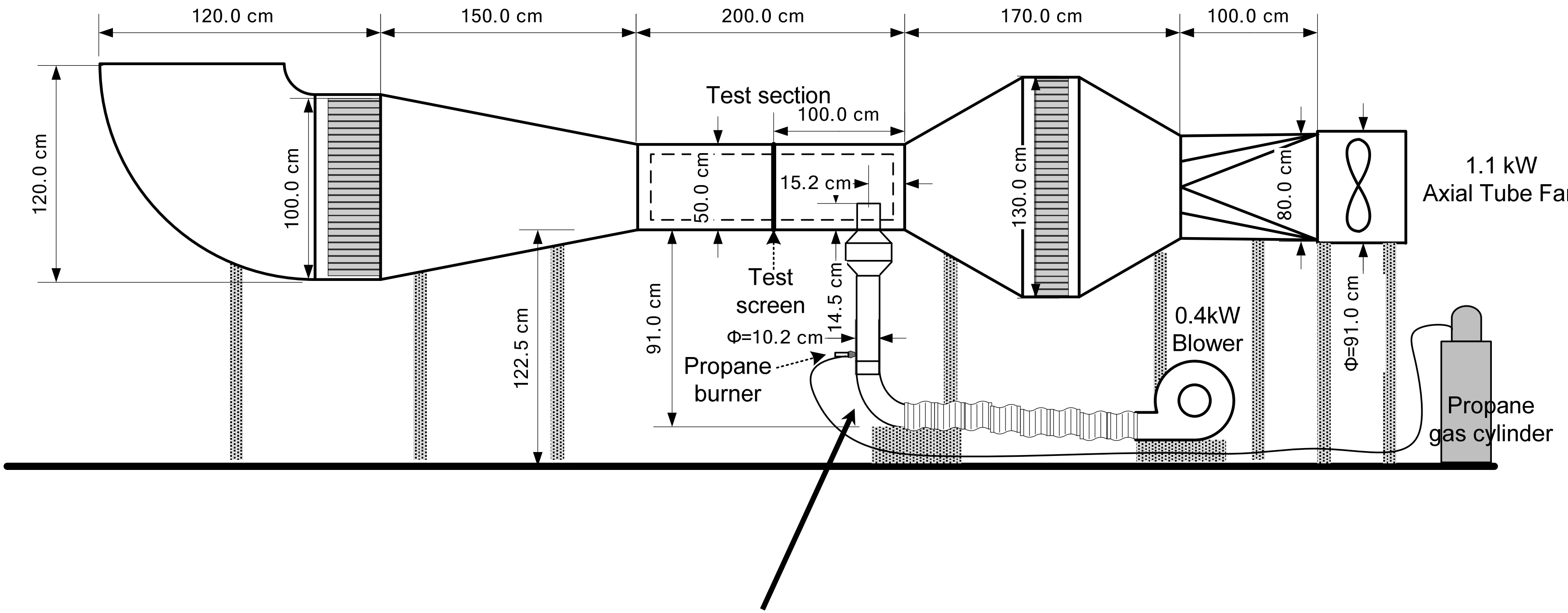
BRI/NIST Full Scale Experiments

20 x 20 mesh (1.04 mm) is shown



NIST Dragon's LAIR (Lofting and Ignition Research)

Couple 'Baby Dragon' with wind tunnel
Compare to BRI/NIST full scale results



NIST Baby Dragon

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Firebrand Accumulation in Front of Obstacles

Firebrand Accumulation

Firebrand Accumulation

Wood Boards Placed In Front

Easily Ignited!!!

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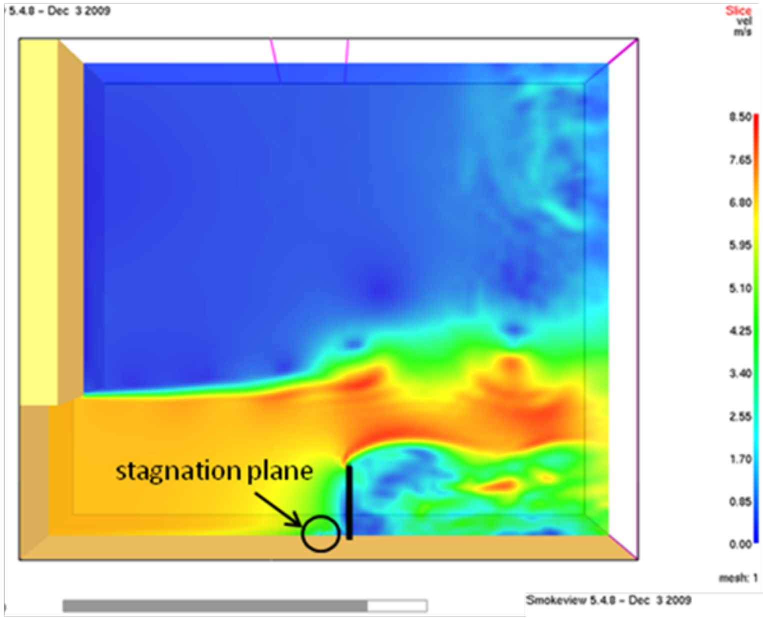
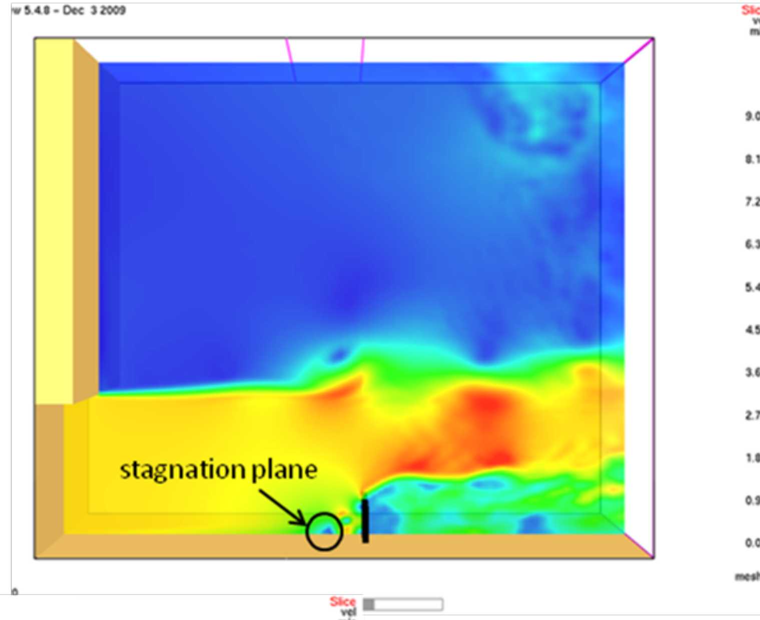
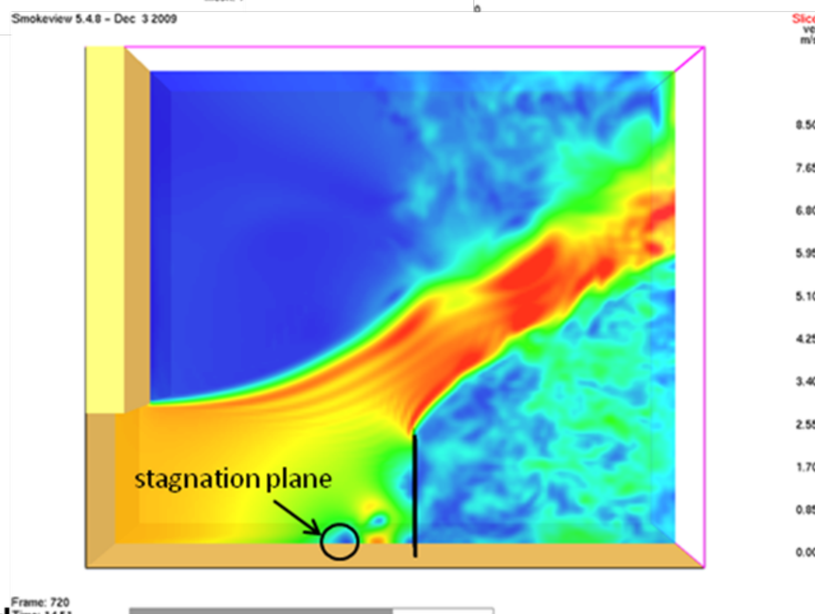
Obstacles in Flow



1 m by 2 m



2 m by 1 m



3 m by 3 m

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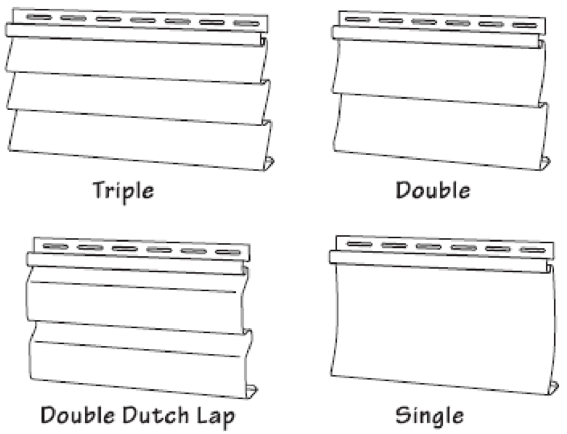
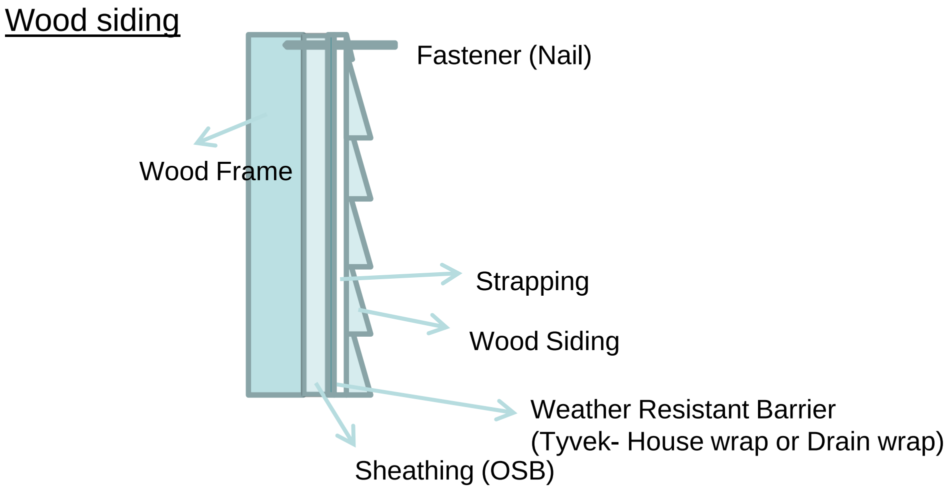
Siding

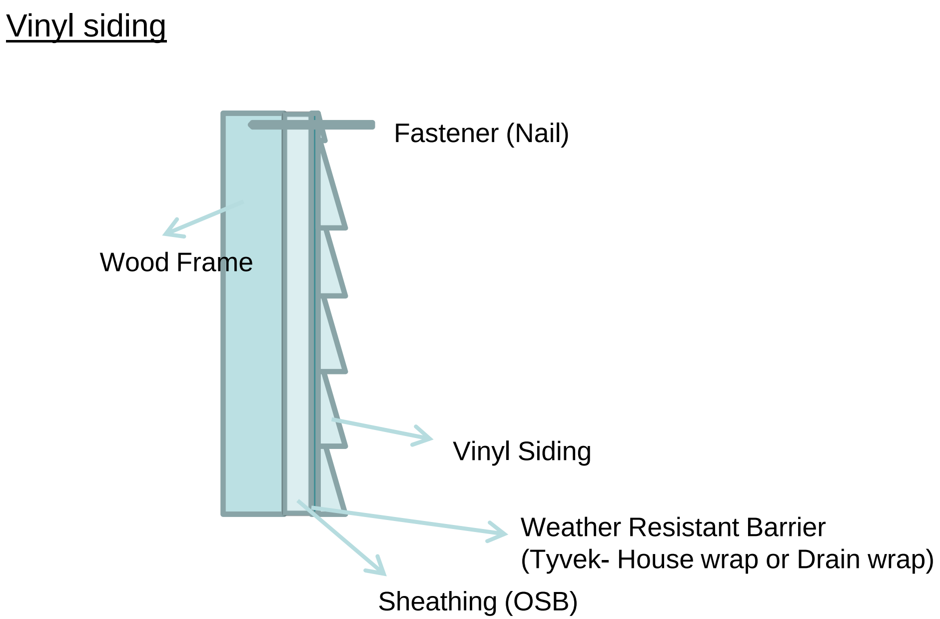
- **Vinyl and wood siding**
- **Install siding horizontally – Single, Double, Triple?**
- **Vertical installation?**
- **Placed on wall – 3 m x 3 m**



Materials for Siding

- **Siding materials**
  - **Vinyl and Wood**
- **Sheathing/backboard**
  - **OSB**
- **Weather-resistant barrier**
  - **Tyvak Drain Wrap**
- **(Strapping/furring strip, for wood)**





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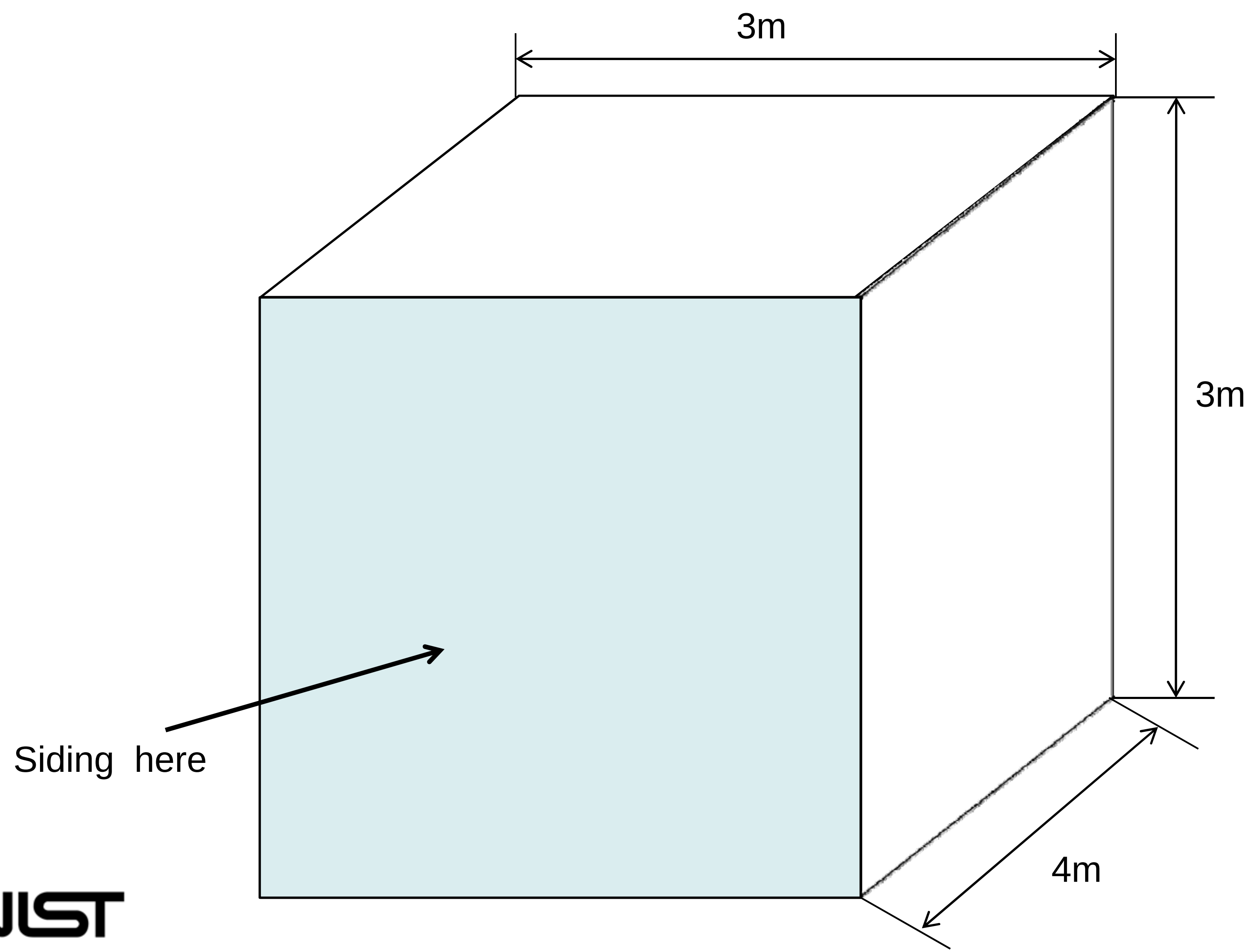
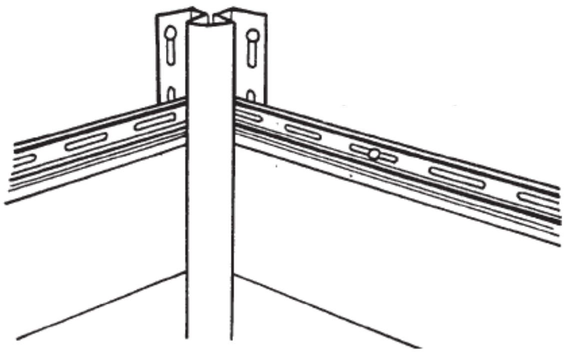
Structure Placed Inside FRWTF



Corner

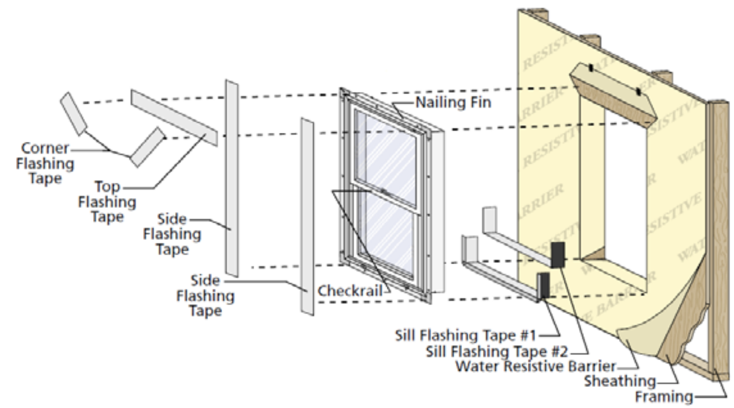
- **Use vinyl siding and vinyl corner materials**
- **Placed in front of structure**



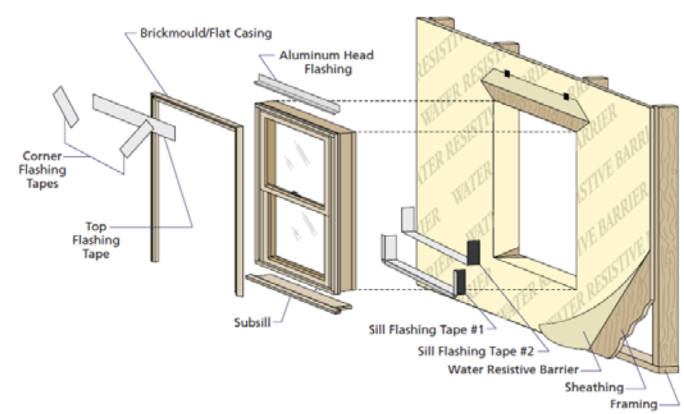
Glazing

- **Consider both vinyl framed glazing and wood framed glazing**
- **Interest: accumulation of firebrands inside corner of framing**
- **Can accumulated firebrands cause window breakage?**

<u>Vinyl Glazing</u>



<u>Wood Glazing</u>



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Front view of structure