RFP-24-SIN

Understanding Elevated Temperature Response of Wood and Wood Composites

PI(s): Ari Sinha, Islam Hafez, Wenjia Wang | Site: OSU

Anticipated Start Date: October 2024 | Expected Duration: 36 *Months*

Need & Industrial Relevance | Goals & Objectives

Need & Industrial Relevance

- Understanding the fire performance of building materials used in residential structures is critical particularly in light of the escalating risk of wildfires.
- Wood composites comprise of 90% of the materials within a single-family residence, yet their performance under elevated temperatures is not well-understood.
- There is a need for robust models for the behavior of wood composites under elevated temperatures.

Long Term Goals

Develop a comprehensive understanding of the thermal degradation behavior of wood composites and leverage this knowledge to predict and enhance their performance under elevated temperatures.

Research Roadmap Topics

Members will benefit from increased understanding of functionality (A2) and performance (A3) of wood-based composites eventually leading to improved product (A1).

Objectives

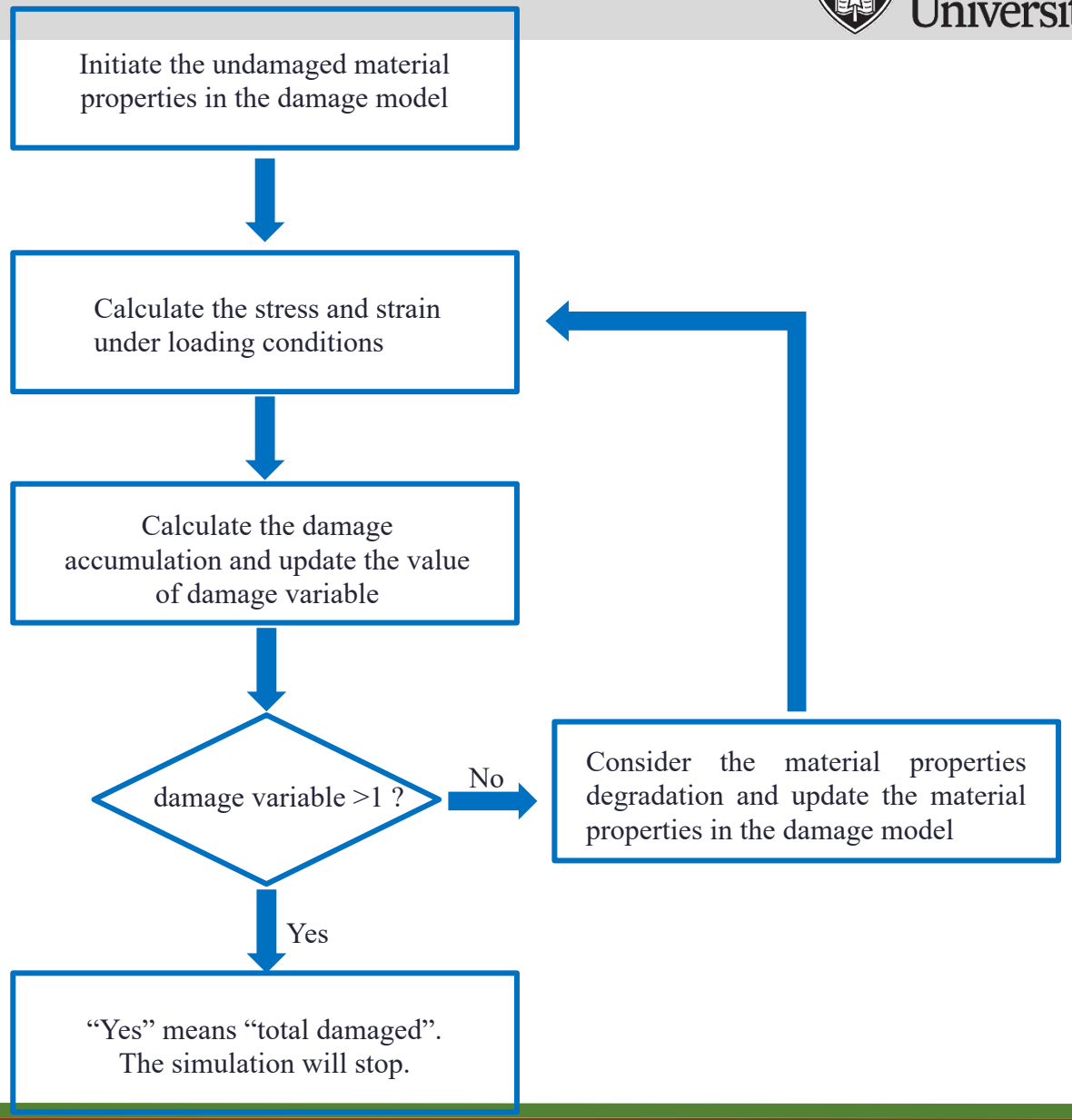
The specific objectives of this project are to:

- **Analyze** the wood composites' bending and compression properties after being exposed to elevated temperatures.
- **Determining the degradation curve of over time**, achieved through applying a constant load while exposing the material to a temperature gradient.
- **Identify Thermal Degradation Points**: Determine the temperature thresholds at which significant degradation occurs in various wood composites.
- **Discern analytical relationships between parameter and performance using statistical and machine learning based models**, more specifically – Artificial Neural Network Models.
- **Examine Microstructural Changes and build a preliminary damage mechanics based numerical Model**: Utilize microscopy to study the microstructural changes in wood composites subjected to elevated temperatures. Using the observations along with numerical automated solutions build preliminary numerical model to gain further insights into material performance.

Materials and Methods

- Systematic Literature Review (SLR): SLR uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review.
- Material Selection: After discussion with Technical Advisors. Potential candidates: **Solid lumber, Laminated Veneer Lumber, Plywood, MDF, and I Joists**.
- Experimental Design: Details to be developed based on discussions and testing will be conducted at OSU and at FPL.
    - Bending/compression tests under elevated temperatures will be conducted in a special chamber
    - Another set of tests will monitor deflections at a constant load in two different scenarios:
        - Constant elevated temperature
        - Changing temperature at a constant rate
- Data Analysis will be followed by statistical and Advanced Neural Network modeling
- Microstructure Evaluation: Conduct microscopic examinations, such as scanning electron microscopy (SEM), to observe microstructural alterations.
- Preliminary Numerical Model: Based on collected and in house data, a preliminary numerical model will be developed that help us gain insights into a variety of parameters for which experimental costs are prohibitive.

- Damage mechanics-based material model
- Material properties degradation will be considered
- Numerical modeling of mechanical behavior: thermo-mechanical coupled simulation
- Platform: ABAQUS (finite element simulation)



Outcomes and Deliverables

Tasks	Deliverables	Months	Responsibility
Systematic Literature Review	A paper summarizing the literature and lay of land	0-6	Sinha and Student
Material Selection, Procurement and Prep	Completed experimental design	2-3	Hafez and Student
Experimental Design		4-6	All
Testing at OSU	Baseline data on WBCs	6-9	Student, Hafez, Sinha
Testing at FPL	Temporal Degradation Curves; Exposure time and temperature interactions	9-18	Student at FPL; Hafez; Sinha
Data Analysis and Statistical Interpretation	Statistical model to understand the data and underlying phenomenon	9-18	Wang, Student and Sinha
ANN Modeling	Predictive models using machine learning methods	18-24	Student and Sinha
Microstructure Evaluation	Data on microstructural changes	20-26	Student and Hafez
Numerical Model	Predictive simulations that are user friendly	25-33	Wang and Student
Reporting and Dissemination	Dissertation; Papers; Reports	33-36	All

Expected Practical Implications/Impacts

Gaining insights into the elevated temperature performance of wood composites is essential for ensuring the safety, compliance, and efficiency of various applications across industries, while also contributing to sustainable and resilient design practices. More specifically:

1. Performance characterization at elevated temperatures for common wood composites.
2. Temporal data on elevated temperature performance of wood composites
3. Analytical and numerical models for prediction of performance of wood composites.
4. Integration of machine learning into model development.
5. Data sets that feeds into material models for any finite element or structural modeling package to build a fire endurance model.
6. WBC reports on elevated temperature performance and publications in peer-reviewed journals
7. A student dissertation.

Budget

- Graduate student support:
  - Stipends
  - Benefits
  - Tuition

- Not requested - travel and supplies
- Material donation will be asked from members
- Travel to FPL supported by the PIs

BUDGET	AMOUNT
First Year Expenses	
GRA & Benefits	$38,880
Tuition & Fees	$16,270
Materials/Supplies	
Travel	
Other (specify):	
YEAR 1 TOTAL:	$55,170
Expected future request amounts: $56,000 for the next two years.	

Thank You

Questions?