# New Project Proposal: Understanding Elevated Temperature Response of Wood and Wood Composites (RFP-24)

Arijit Sinha, Islam Hafez, and Wenjia Wang, Oregon State University

**Anticipated Start Date and Duration**: October 1, 2024 for three years

## Need and Industrial Relevance, Related WBC Research Theme(s):

Considering the escalating global prevalence of wildfires, comprehending the fire performance of building materials used in residential structures has gained paramount significance. Wood composites are widely used in various applications, ranging from construction to furniture manufacturing. Wood composites comprise of 90% of the materials within a single-family residence. However, their performance under elevated temperatures is not well-documented. This research aims to address this gap by comprehensively understanding how wood composites behave under increased temperatures. During fire scenarios, most of the structural wood composites are conventionally shielded by fire-resistant materials to mitigate direct flame exposure. However, the intense temperatures associated with house fires, reaching up to 600°C, can significantly alter the properties of wood composites. This study aims to explore the influence of elevated temperatures, preceding the composites' flash point (212°C), on its mechanical properties. This study extend previous studies by the PI on elevated temperature properties, which resulted in three WBC student theses and papers – Sinha (2010); Mirazei (2016); Miyamoto (2022).

- Current structural models to predict fire performance of wood structures are not robust
  - lack of data on wood composites
- This research attempts to fill the fundamental gap and understand the elevated temperature performance of four different wood composites
- Elevated temperature performance is dependent microstructural changes in wood. This work will also try to discern the influence of such an interaction.

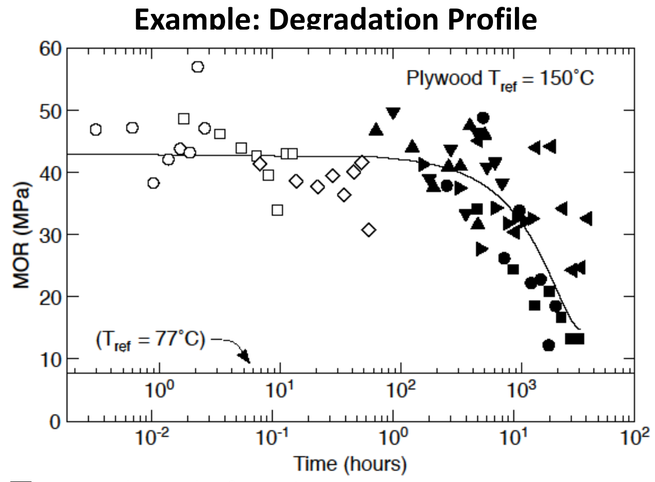
***Members will benefit from increased understanding of functionality (A2) and performance (A3) of wood-based composites eventually leading to improved product (A1).***

## Goals and 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.

**Example: Degradation Profile**




- Developed after time-temperature superposition using short-term exposure data
- Tests were not conducted at elevated temperature

**Testing to be conducted at FPL using a custom designed chamber**

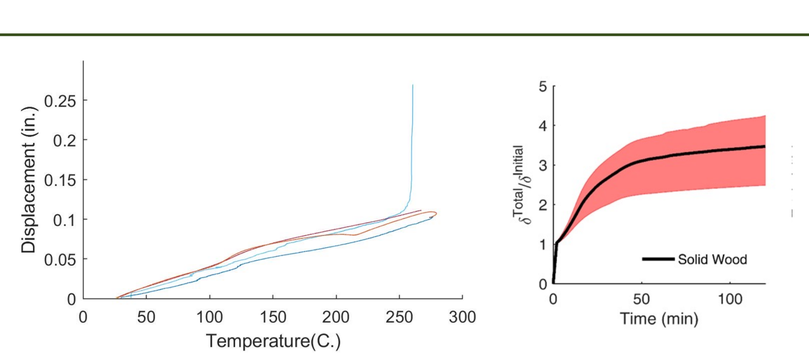
## Methods:

1. 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.
2. Material Selection: The full range of material and products will be selected after discussions with Roseburg Forest Products (RFP) and other technical advisors for the project. Material of interests are **Solid lumber, Laminated Veneer Lumber, Plywood, MDF, and I Joists**. As materials are added on the project scope and timeline can change exponentially.
3. Experimental Design: Based on discussions with RFP and other technical advisors, and experimental design will be developed and testing will be conducted at OSU and at FPL.
   1. Bending/compression tests under elevated temperatures will be conducted in a special chamber
   2. Another set of tests will monitor deflections at a constant load in two different scenarios:
      - Constant elevated temperature
      - Changing temperature at a constant rate
4. Data Analysis will be followed by statistical and ANN modeling
5. Microstructure evaluation: Conduct microscopic examinations, such as scanning electron microscopy (SEM), to observe microstructural alterations.
6. 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.

## 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




**Examples of Data and Profiles**

## Budget & Request for Funding:

**BUDGET (including expected duration):**

**Year 1 Budget Estimate:**

Student GRA and benefits: $38,880

Tuition and Fees: $16,270

**Total Yr. 1: $55,150**

**Expected Duration: 3 years**

## Project 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 |