Introduce New Structural Material to Reduce the Environmental Impacts of Buildings：Composites Derived from Fossil Fuels

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https://youtu.be/lfmQ01pALCk

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Clean Energy Education & Empowerment (C3E)

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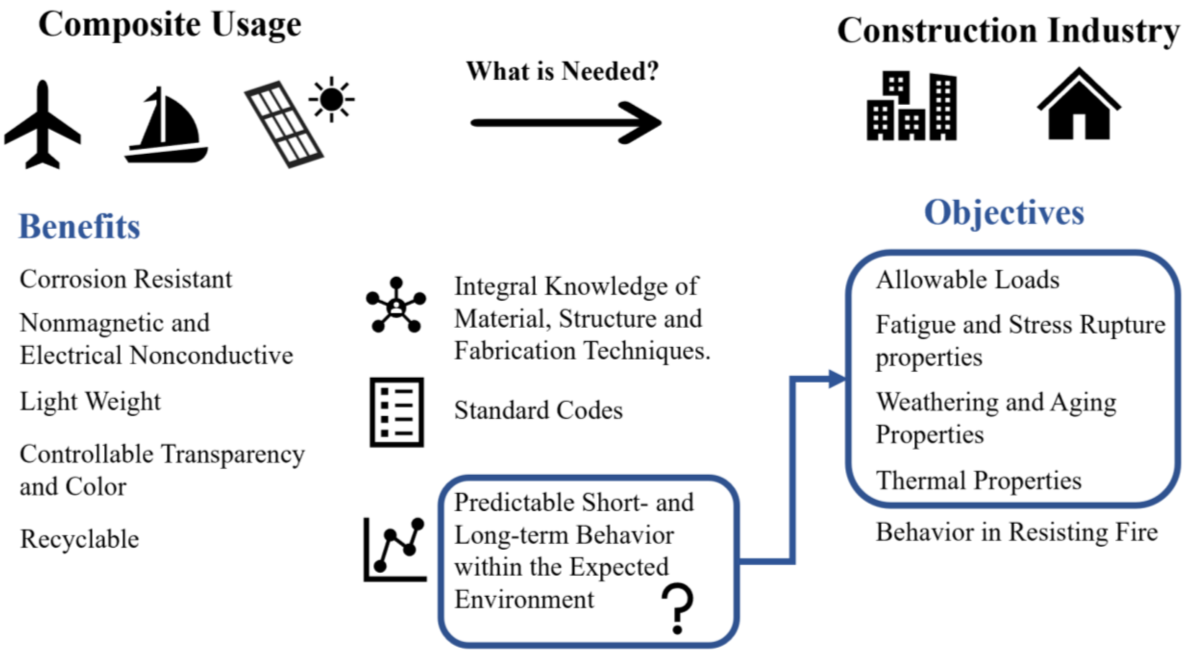
Introduction： Composite Usage in Buildings

SFMOMA façade



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Objective:

- This study presents a new multi-physics model that captures synergistic Degradation-Damage mechanisms of fossil fuels based composite materials subjected to long-term environmental exposures.

- The immediate goal is to bridge the gap between industrial applications and the new scientific challenges.

- The long-term goal is to reduce the environmental impacts of buildings throughout their life cycle by considering physical performance indicators at the design phase.

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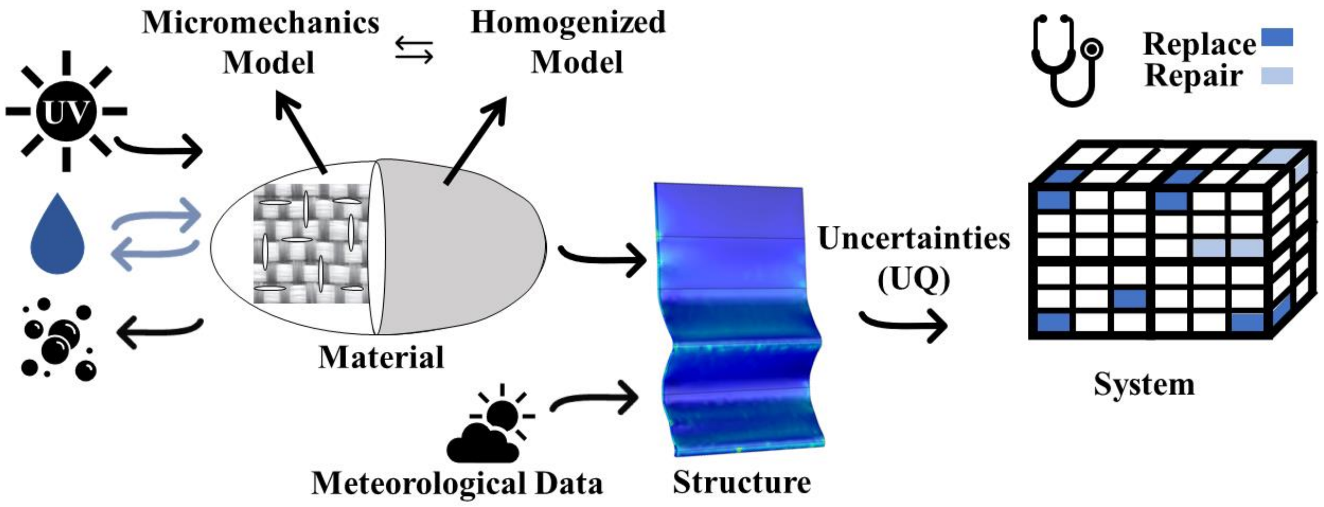
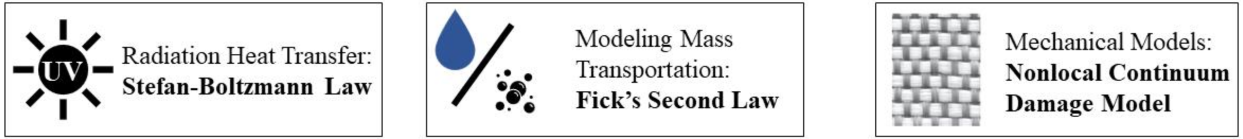
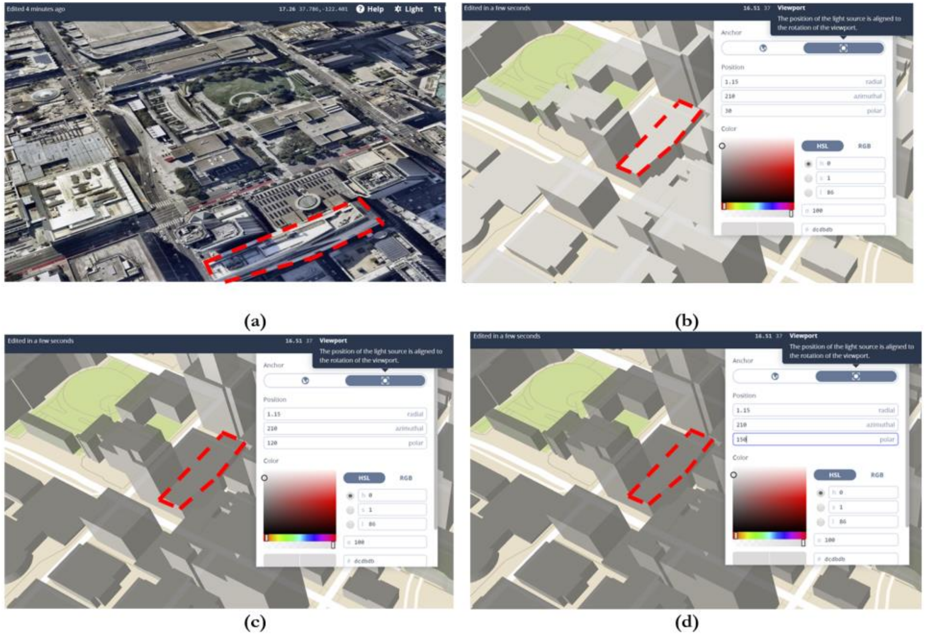
Methods: Sustainable Integrated Materials, Structures and Systems (SIMSS) Research Paradigm





Methods: Using 3D Building Model and Meteorological Data to Calculate the Environmental Exposure



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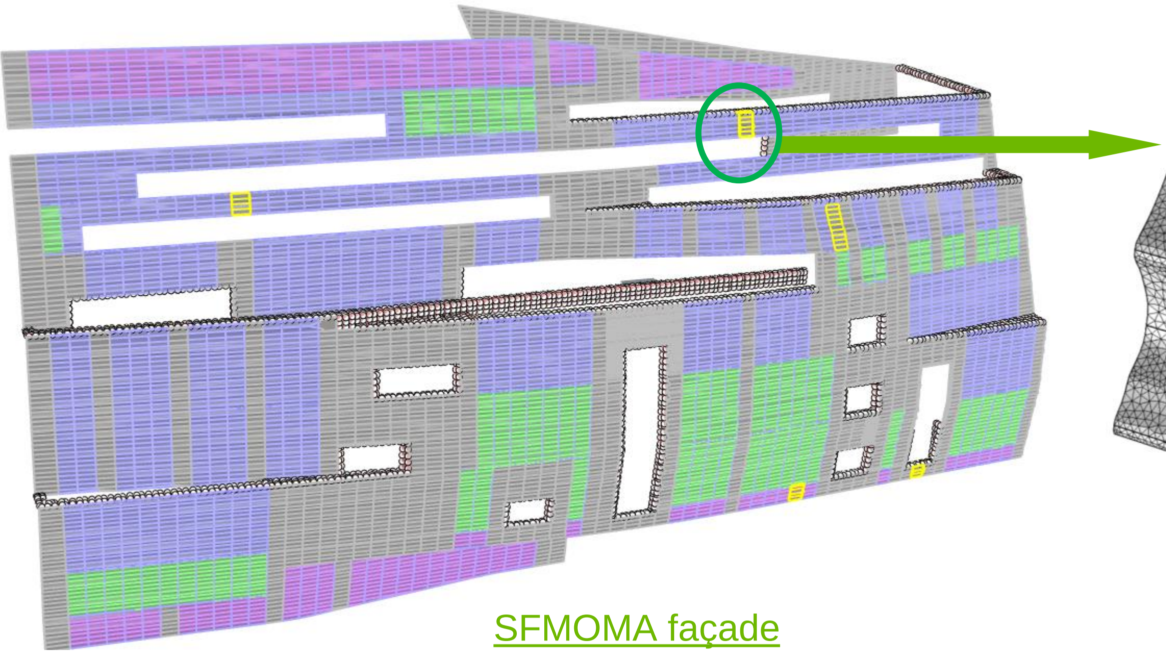
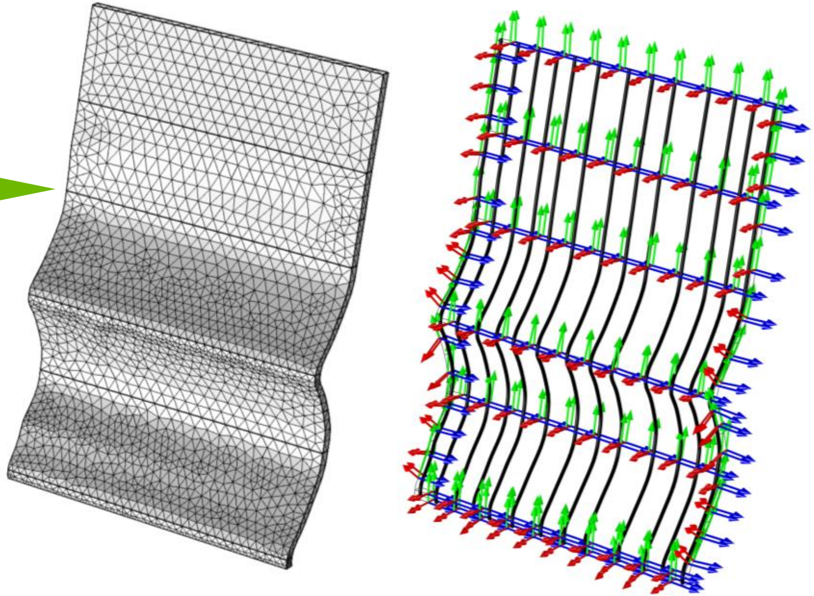
Methods: Create a FEM model from Digital Architecture Design



SFMOMA façade



SFMOMA façade
Plate No. 9-44

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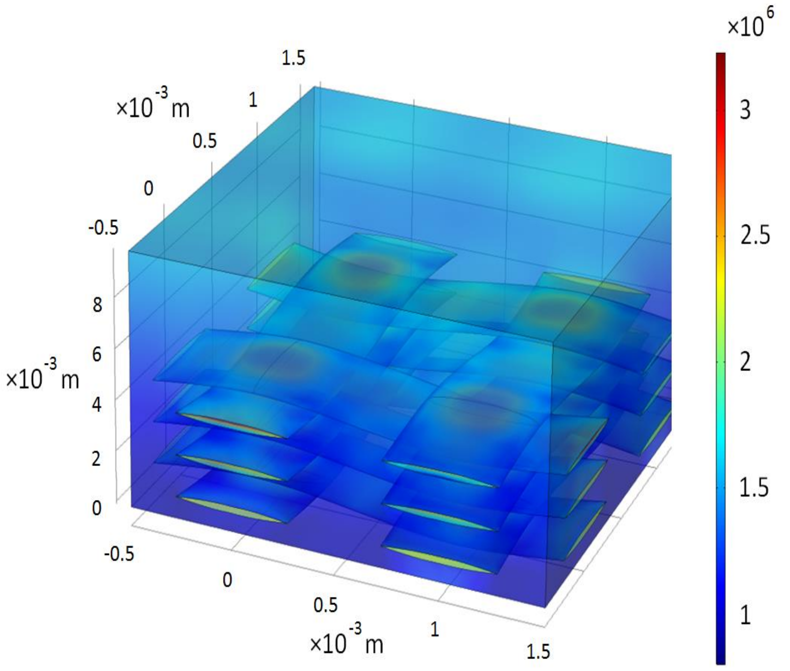
Results in Material Level

- The stress concentrations primarily result from thermal strains caused by three mechanisms:

(1) reversible thermal stresses specific to the material coefficient of thermal expansion,
(2) the temperature field generated by heat transfer,
(3)the irreversible volume change due to loss of polymer molecules.

- The resulting stress concentrations reduce the remaining deformation and/or load capacity of the composite member before any external loads are applied.



Von Mises stress contour for the SFMOMA RVE after 250 hours UV exposure simulation (Unit: Mpa)

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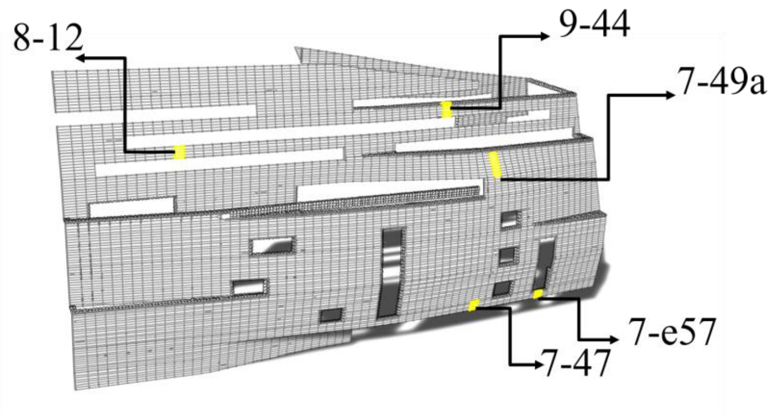
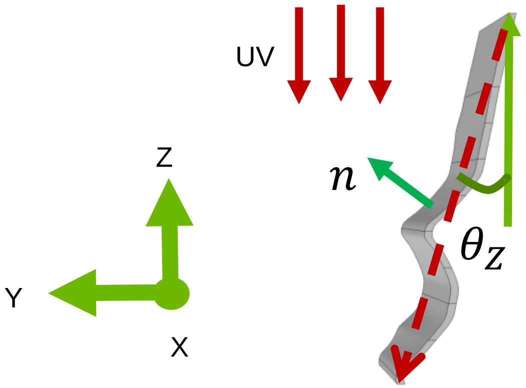
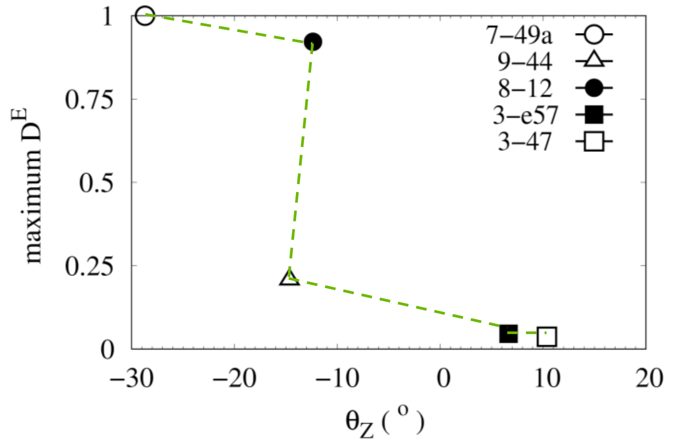
Results in Structrual Level

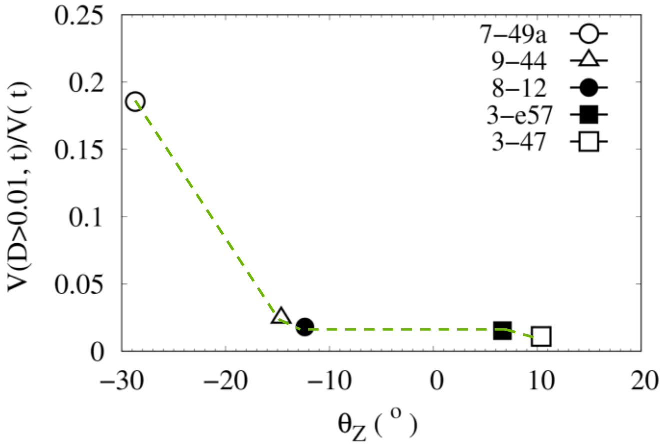




maximum damage variable of entire plate



ratio of damaged deformed volume over total volume



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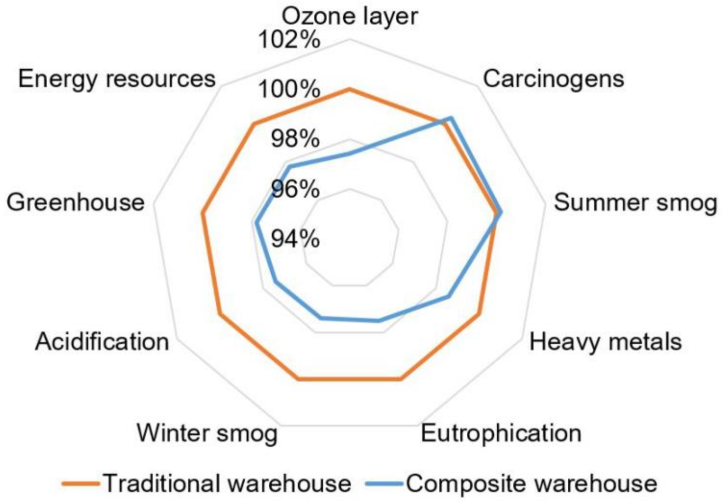
Conclusions

- This study presents a new multi-physics model that captures synergistic degradation mechanisms of fiber-reinforced polymer composite materials subjected to long-term environmental exposures.
- The model is validated against experimental studies.
- Results indicate that the synergistic effect of combined UV and moisture exposure on composite material degradation is more severe than simple linear superposition of each exposure's damage.
- This research fills the gap between experiments and modeling of structural components of real civil infrastructure. The structure models are defined and analyzed in its corresponding curvilinear coordinate at the macroscopic level.

Future work

In future work, the models developed in this study will be combined with life cycle assessment (LCA) tools to better support sustainability focused design of new material, thus reducing costs and environmental impacts of the built environment.



Life cycle impact of SFMOMA Facade comparison by indicator (Chow et al. CEE226 Project).

References

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- Li, Z., Lepech, M.D., 2020. Development of a Multiphysics Model of Synergistic Effects between Environmental Exposure and Damage in Woven Glass Fiber Reinforced Polymeric Composites

Acknowledgments

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