Fire Response of Loaded Composite Structures - Experiments and Modeling

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In this work, the thermo-mechanical response and failure of loaded, fire-exposed composite structures were studied. Unique experimental equipment and procedures were developed and experiments were performed to assess the effects of mechanical loading and fire exposure on the service life of composite beams. A series of analytical models was assembled to describe the fire growth and structural response processes for the system used in the experiments. This series of models consists of a fire model (to predict the heat flux to the fire-exposed beam), a thermal response model (to calculate the temperature distribution within the beam due to this heat flux), a stiffness-temperature model (to calculate the loss in stiffness at elevated temperatures), a mechanical response model (to compute the strain distribution within the loaded beam), and a material failure model (to calculate the strain at which the beam is expected to fail). Each model was independently validated by comparisons of theoretical predictions with experimental results. The models were then used to predict the times-to-failure for beams over a range of fire and loading conditions. The predicted failure times agreed fairly well with experimental results, but it is expected that the agreement could be improved with enhancements to the first model in the series - the fire model.