An Intelligent System for Real-Time Stress Alleviation

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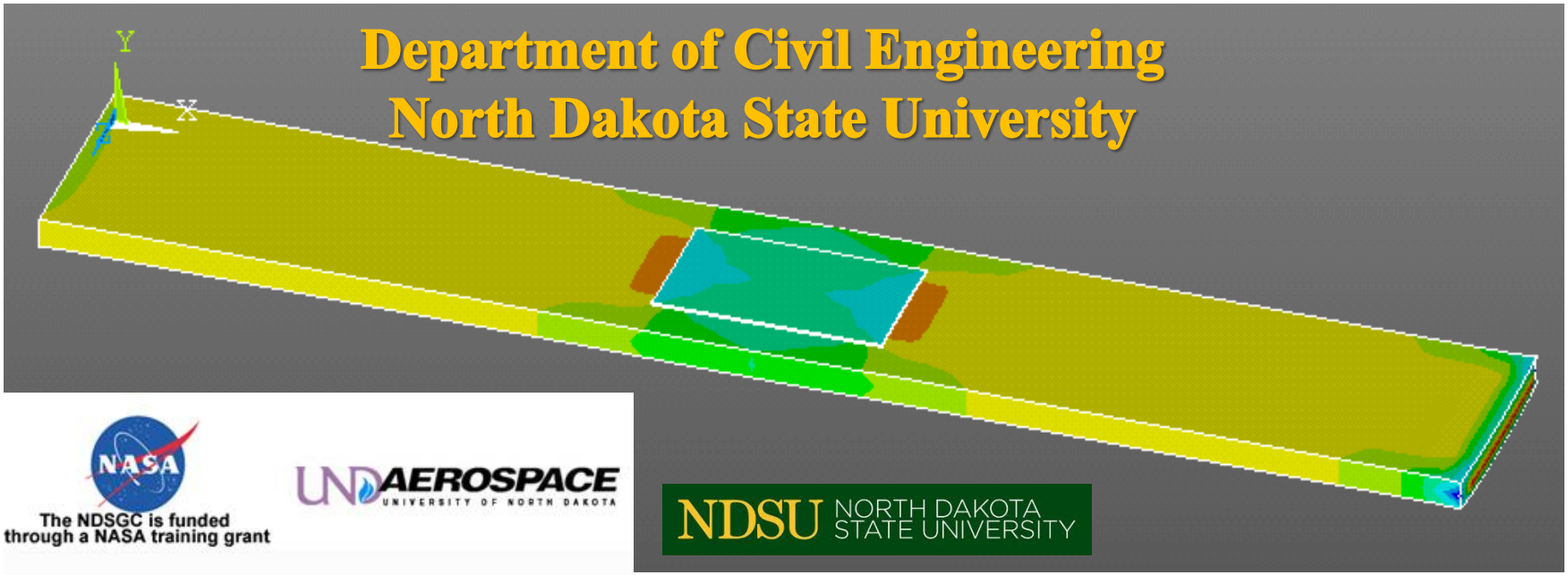

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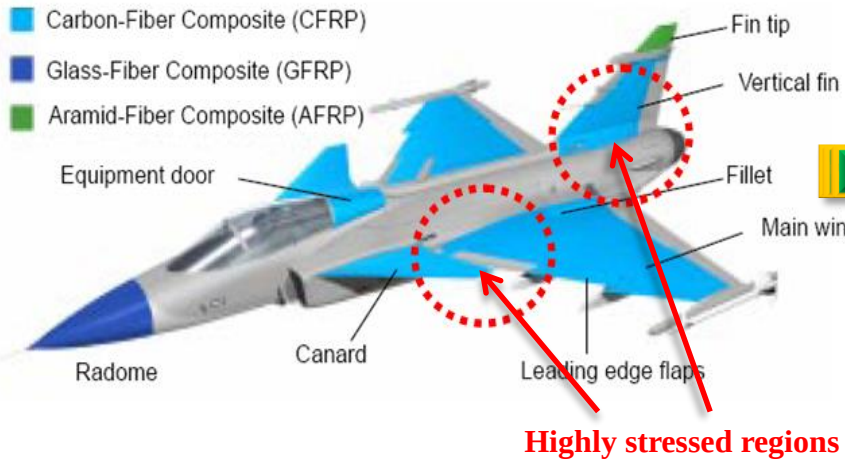
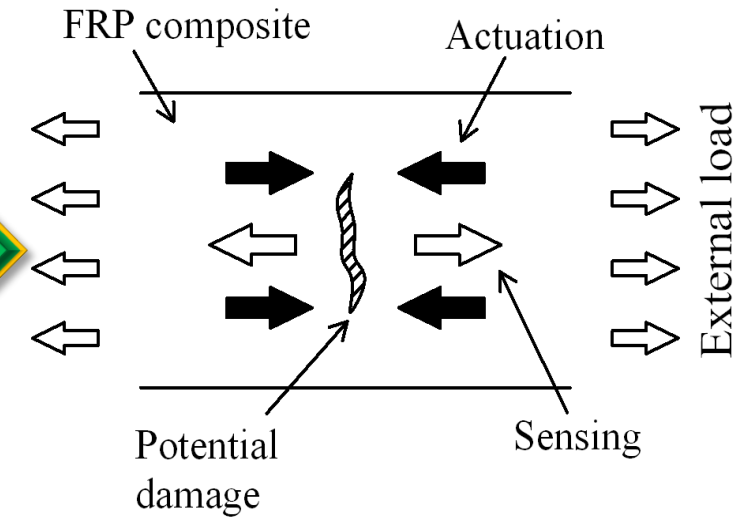
Contents

Introduction

Purpose of Research

- **Fundamentally reframe our knowledge of composite materials and structures**
- **Diagnose potential damage and actively alleviate the damage in real-time**
- **Save significant maintanace, repair and replacement cost of composite structures**

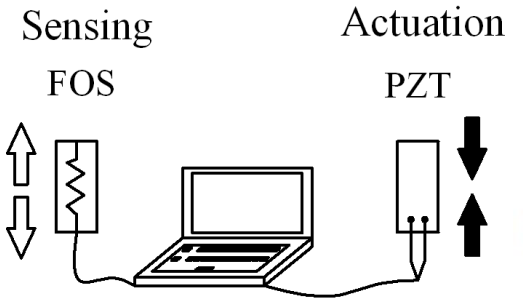




Introduction

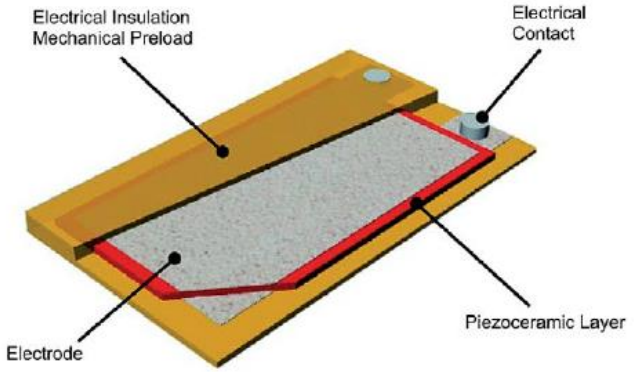
Purpose of Research

- **Develop a detection and trigger system for active stress alleviation**
- **Provide an advanced data processing method and determine a manufacturing approach**
- **Determine the best material to use for actuation**



Data processing

- LabView
- Proportional-integral-derivative
- MatLab



Piezoelectric Actuators

Introduction

Scope of Research

Phase 1:

Determine an experiment procedure and material selection through theoretical modeling

Phase 2:

Improve experiment and create active detection and triggering system

Phase 3:

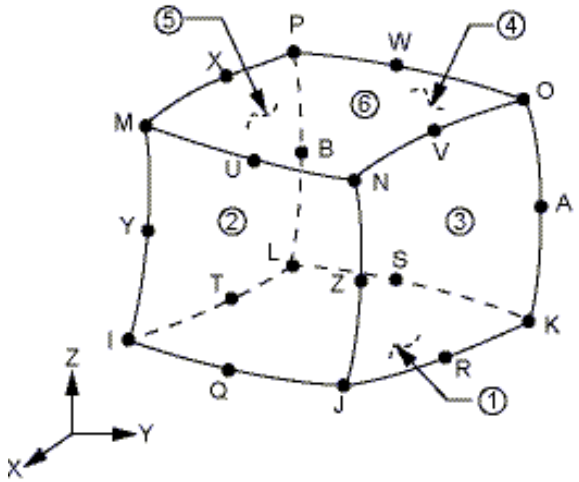
Design recommendations for applications involving composite structure stress alleviation

Theoretical Modeling

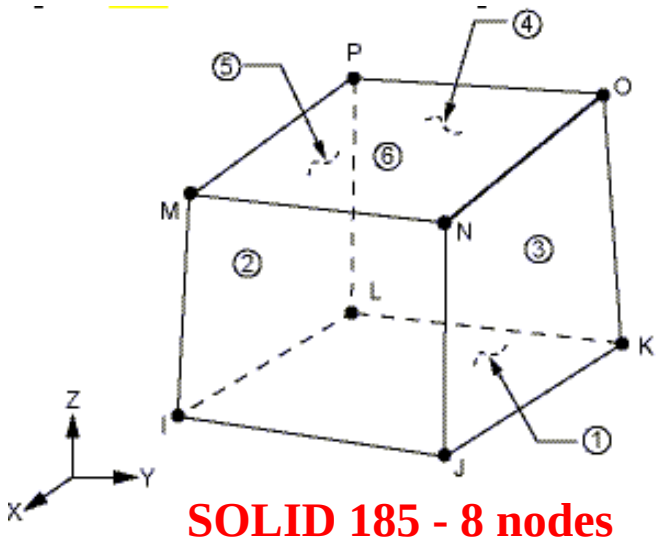
ANSYS (Finite Element Background)

- **The finite element method is the process of discitizing a structure or system into smaller parts call elements**

- **ANSYS elements used:**

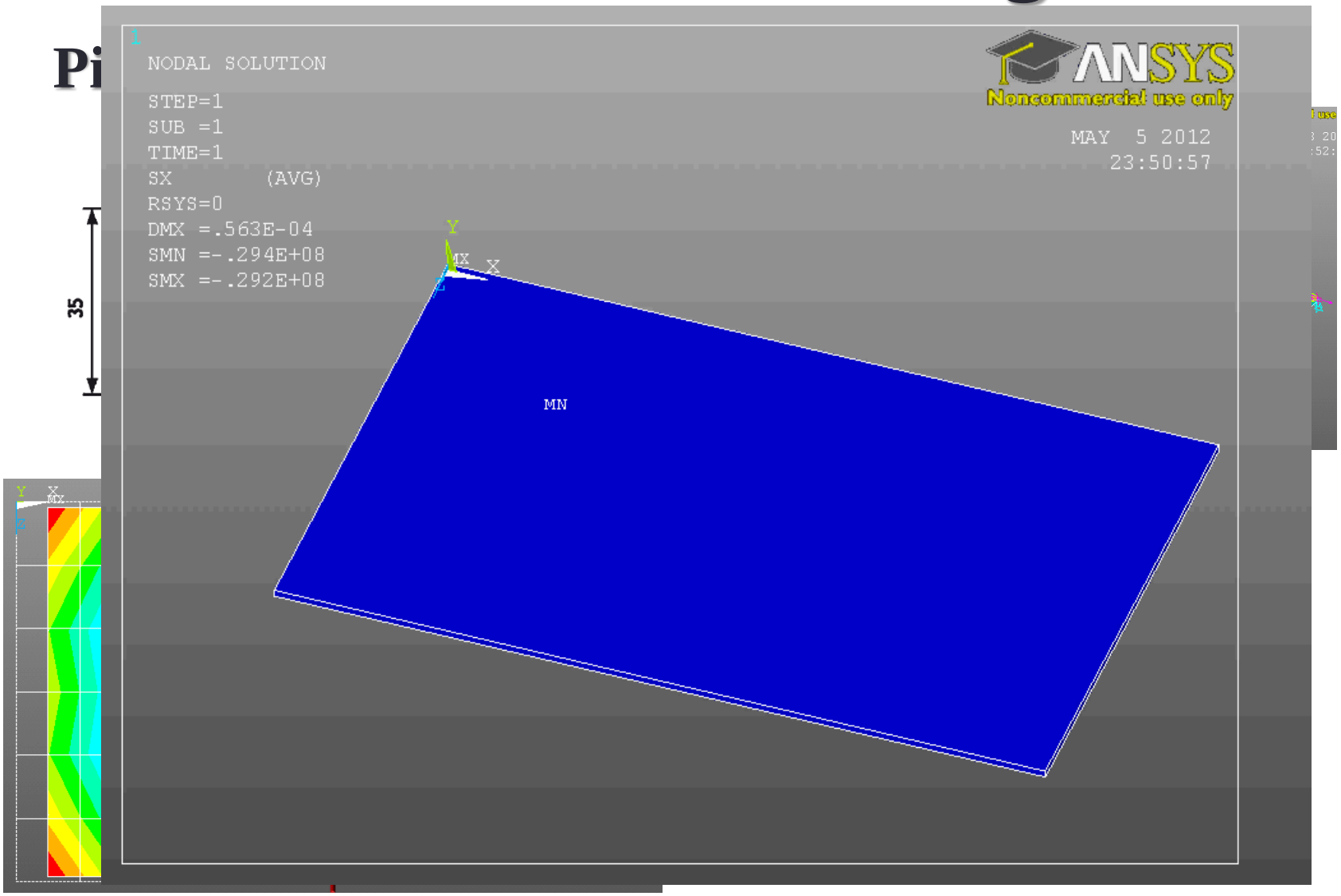


SOLID 226 - 20 nodes
Piezoelectric Element

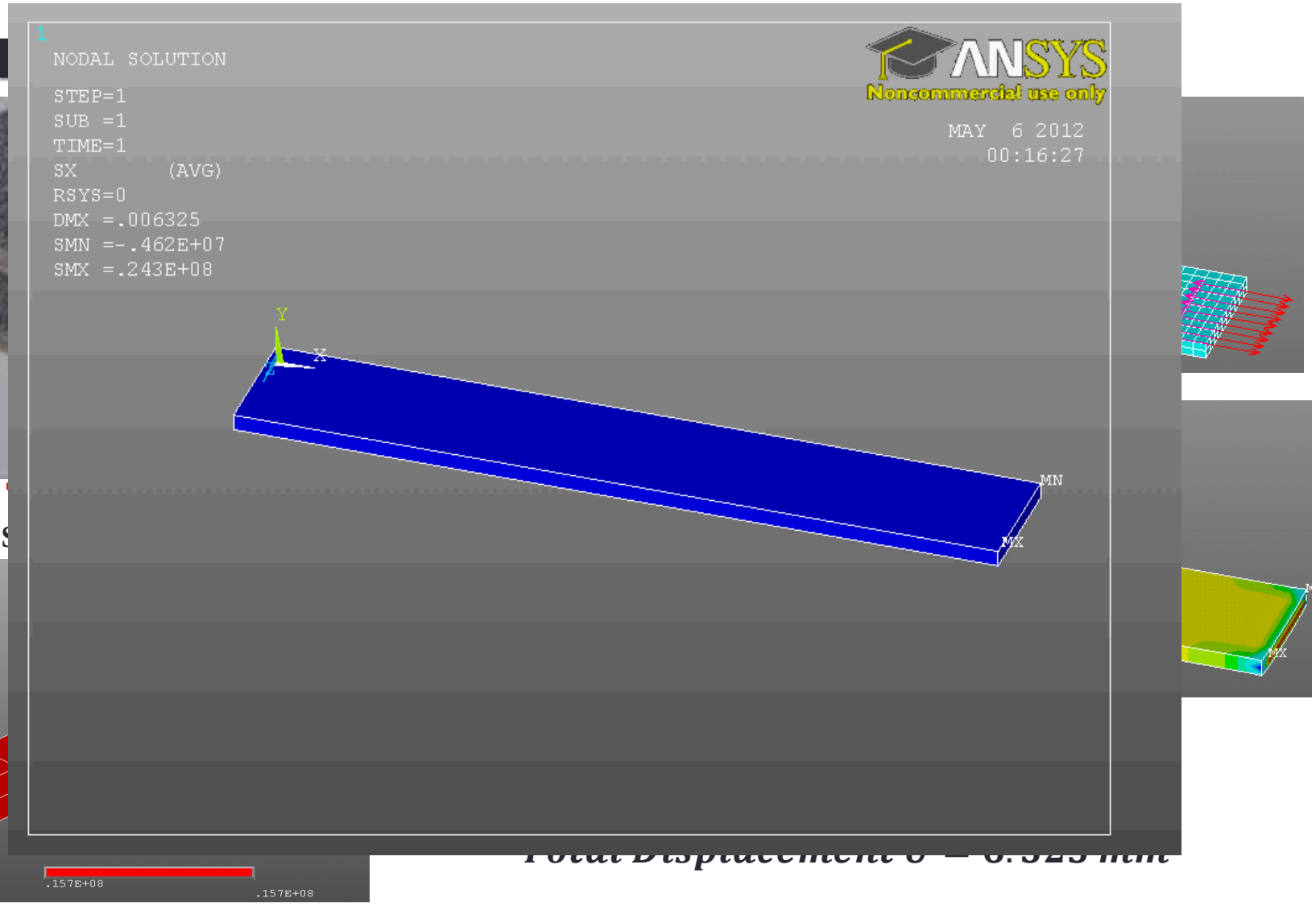


SOLID 185 - 8 nodes
Structural Element

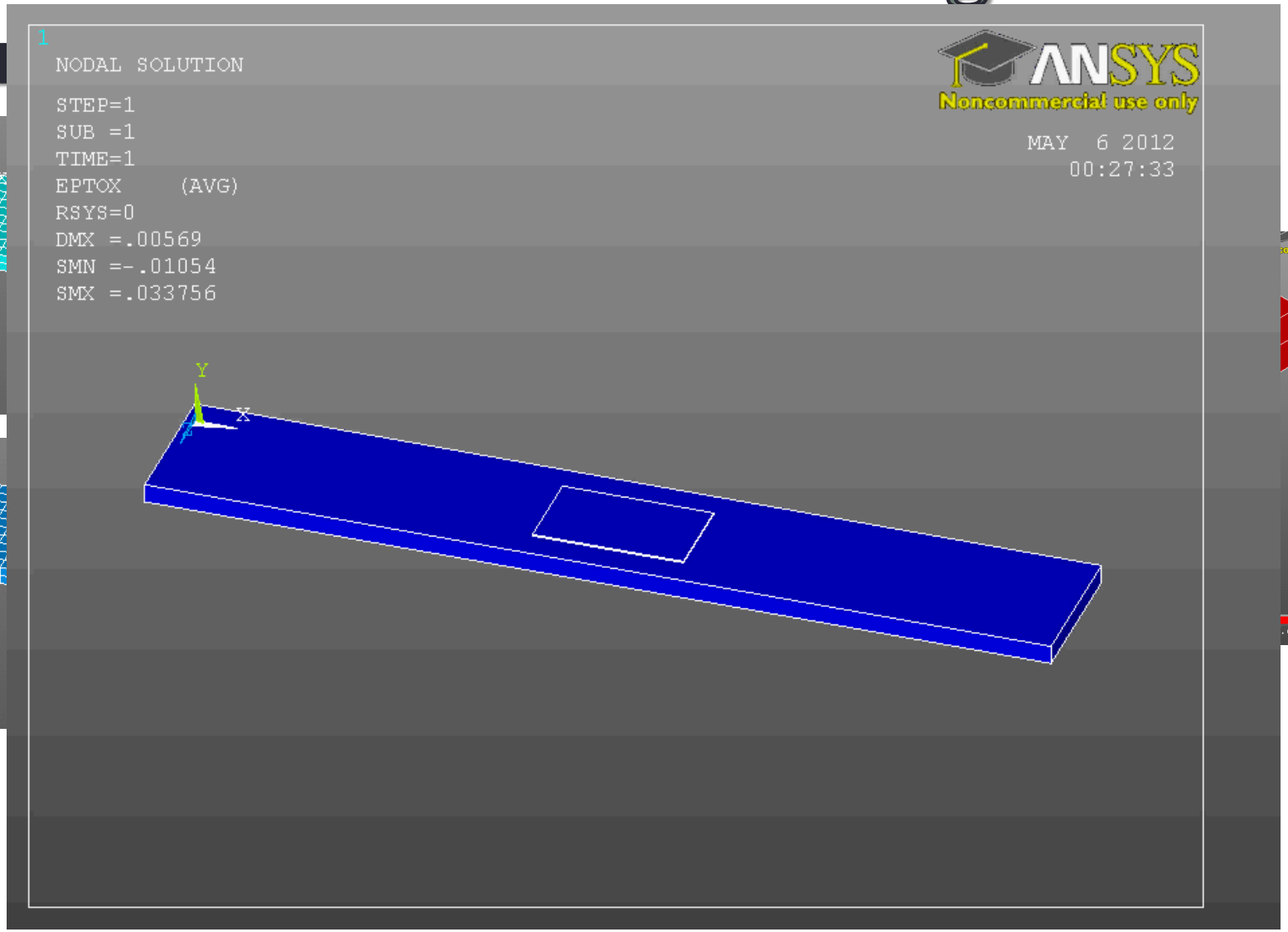
Theoretical Modeling



Theoretical Modeling

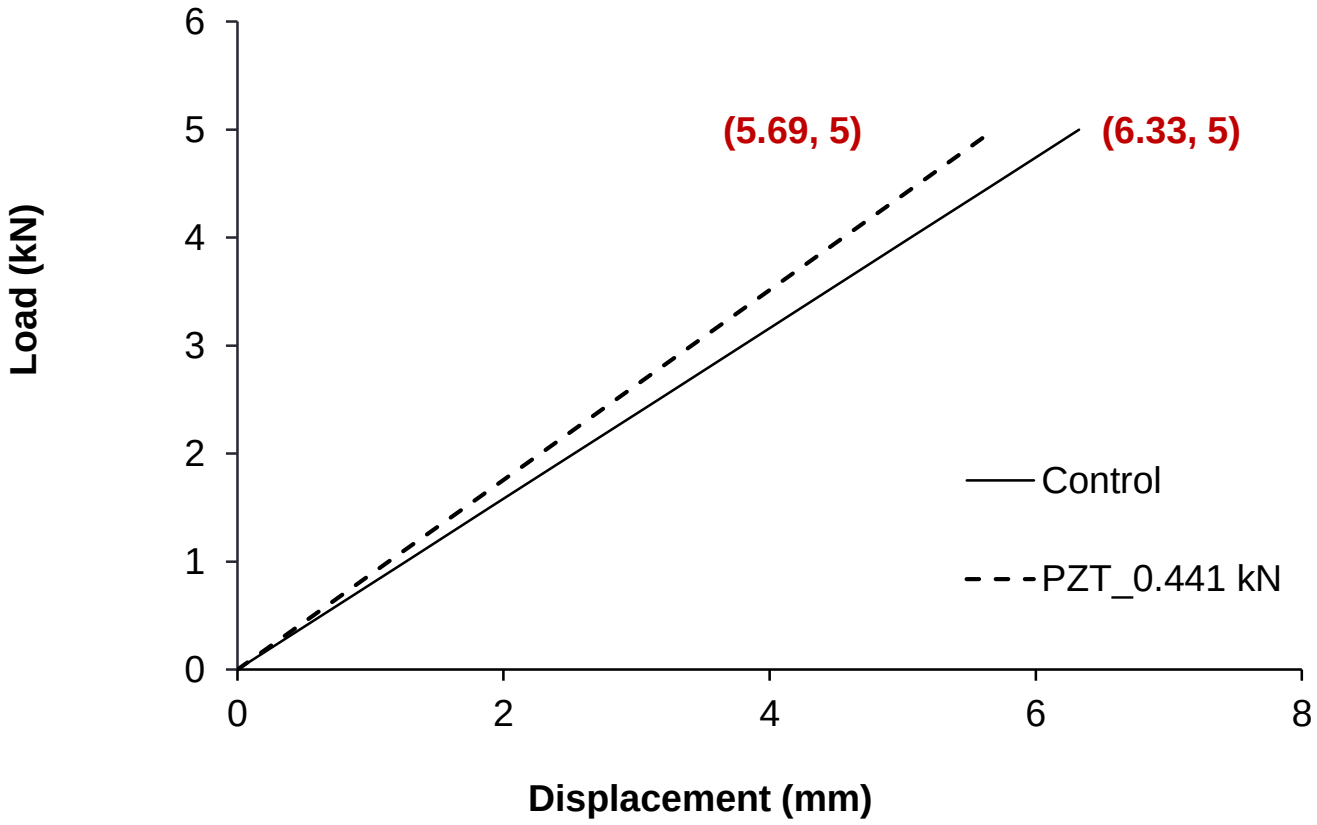


Theoretical Modeling



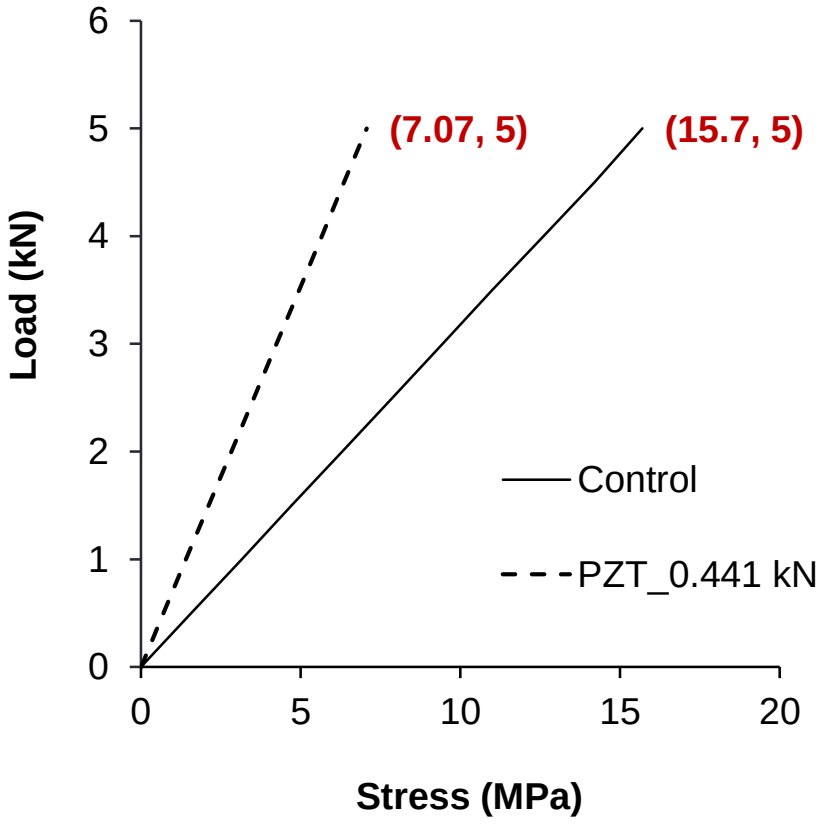
Results and Discussion

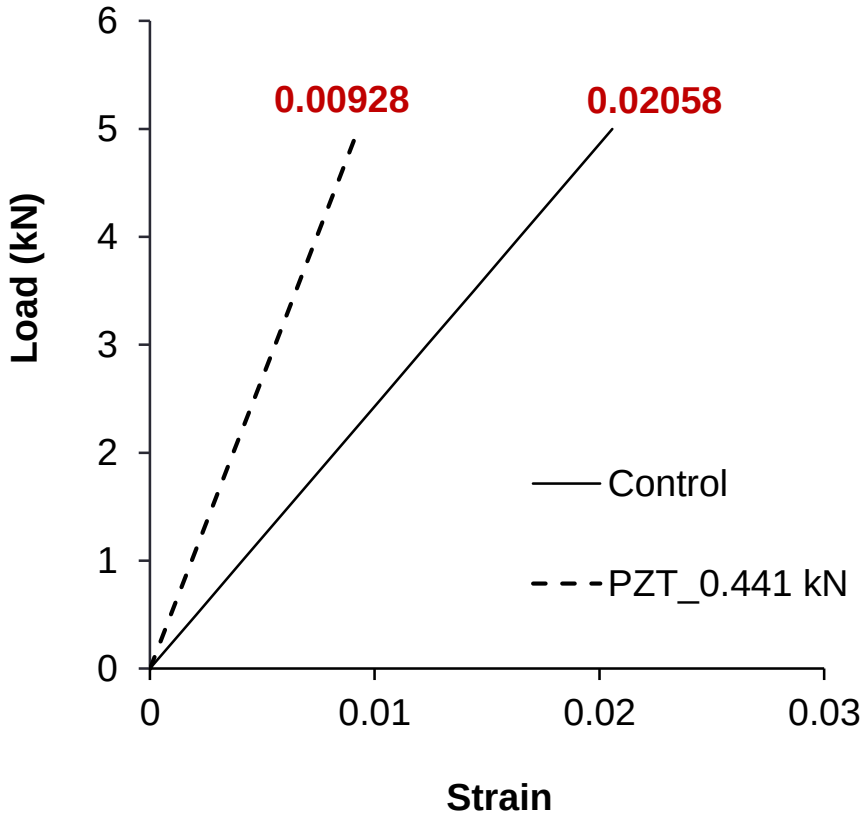
Actuation Reduces Displacement



Results and Discussion

Actuation Reduces Local Stress and Strain





Preliminary Conclusions and On-Going Work

- **Theoretical modeling was successful in reducing localized stress in the composite strip**
- **These results show that localized stress alleviation of composite materials is a promising concept**
- **Select best material for physical experiment**
  - **Possible canidates are piezoelectric actuators (PZT) or shape memory alloy (SMA)**
- **Begin phase 2 and 3 of research plan**
  - **Create detection and triggering system**
  - **Design recommendations for practical applications**

SHAPE MEMORY ALLOY ALTERNATIVE

Material Properties of SMA

- Made of nickel-titanium
- Contract to typically 2% to 5% of their length
- Density = 0.235 lb/in3 (6.45 g/cm3)
- Melting Point = 2370 °F (1300 °C)
- Thermal Conductivity = 10.4 BTU/hr * ft * °F (0.18 W/cm * °C)
- Anti-Corrosive
- Young's Modulus
  - Low Temp Phase = 28-40 GPa
  - High Temp Phase = 86 GPa

Testing Size and Electrical Guidlines

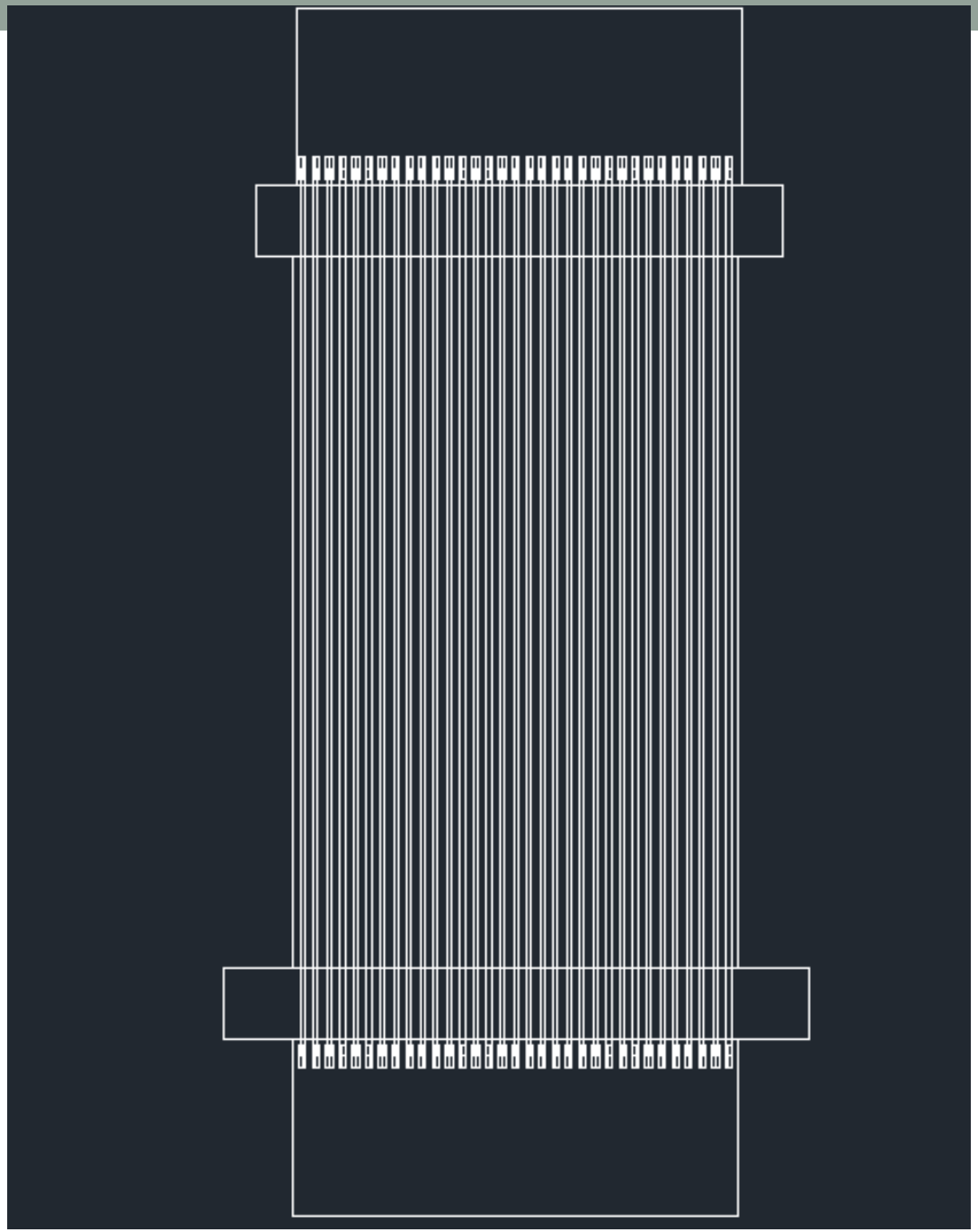
- Diamter size = 0.020in (0.51mm)
- Resistance ohms/inch (ohms/meter) = 0.11 (4.3)
- Pull Force - pounds (grams) = 7.85 (3560)
- Approximate Current for 1 Second Contraction = 4000mA

Cycle Time

- Contraction occurs from the current heating the wire
- Reaction occurs when there is a cooling effect or lack of current
- Current which will heat the wire from room temperature to over 212 °F (100°C) in 1 millisecond
- Any current application will need to be cycled
- Depending on our test results, a cooling method may need to be used

Options for attaching physically

- Screws
- Wedged into a PC board
- Glued into a channel with conductive epoxies
- Crimping –works the best because the wire expands inside the crimp under loading
- Soldering does not work due to high temps and expansion



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