Composite bridge project

Composite materials (Fiber reinforced plastics)

- Combination of two materials for higher performance
  - » Fibers
    - Glass fiber
    - Carbon
    - Graphite
    - Polymers (Kevlar, spectra)
    - Etc.
  - » Resins
    - Thermoset polymers (epoxy)
    - Thermoplastic polymers (PEEK)

SHOW SAMPLE

Composite bridge project

Status of bridges

- Many bridges are damaged
- One of the primary sources of deterioration is steel corrosion and fracture in concrete
- The total estimated cost of bringing deficient bridge superstructures to an acceptable level is $ 110 billion (FHWA, 1995)

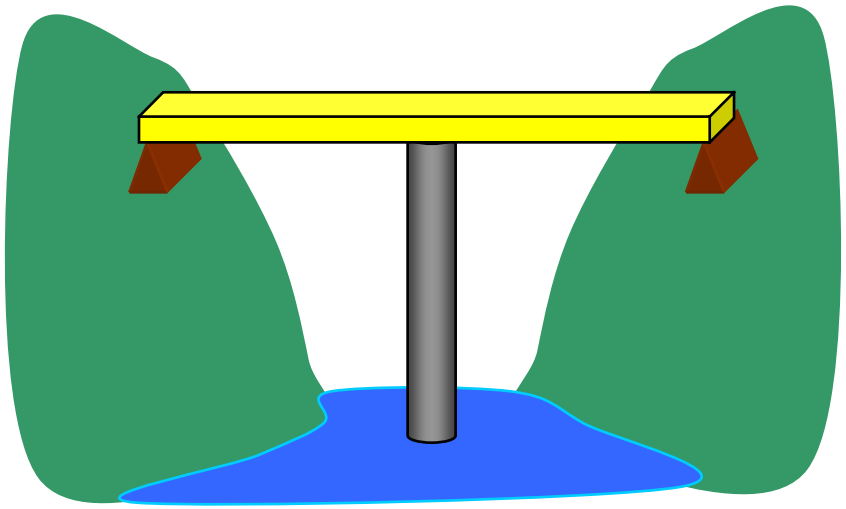
Fracture of concrete

Seismic Damage

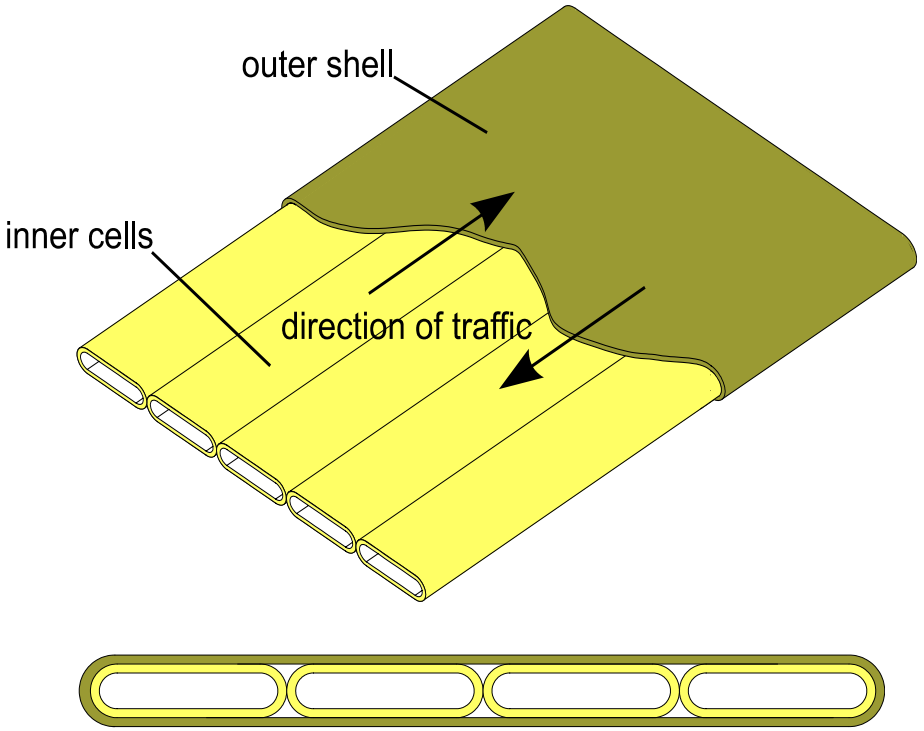
Failure of column

Composite bridge project

Design of a highway bridge superstructure

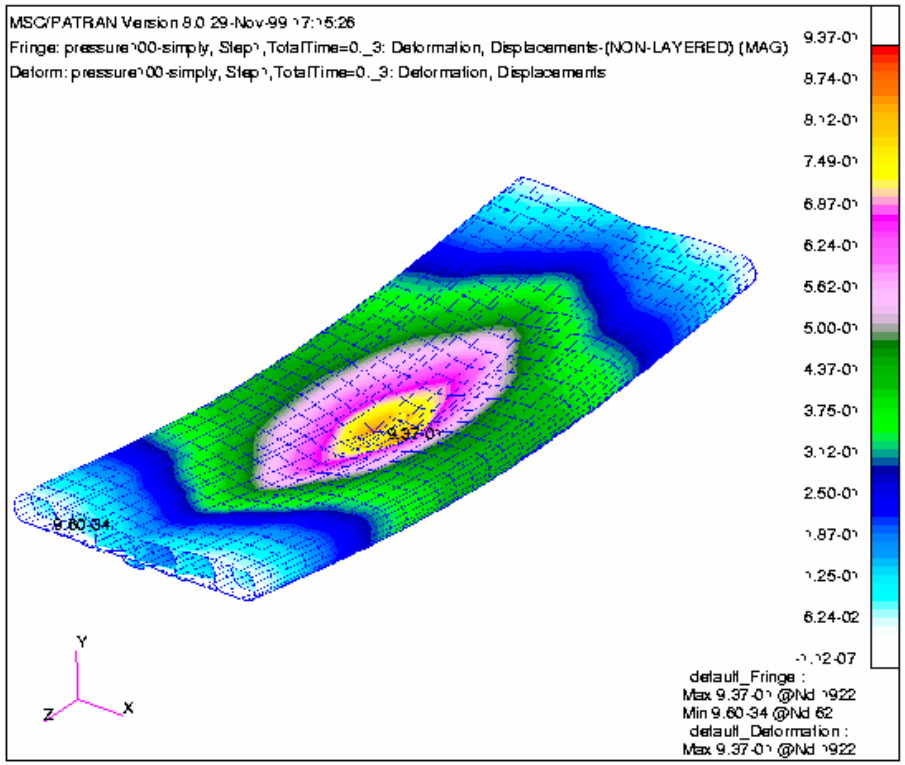


Cell-Shell design



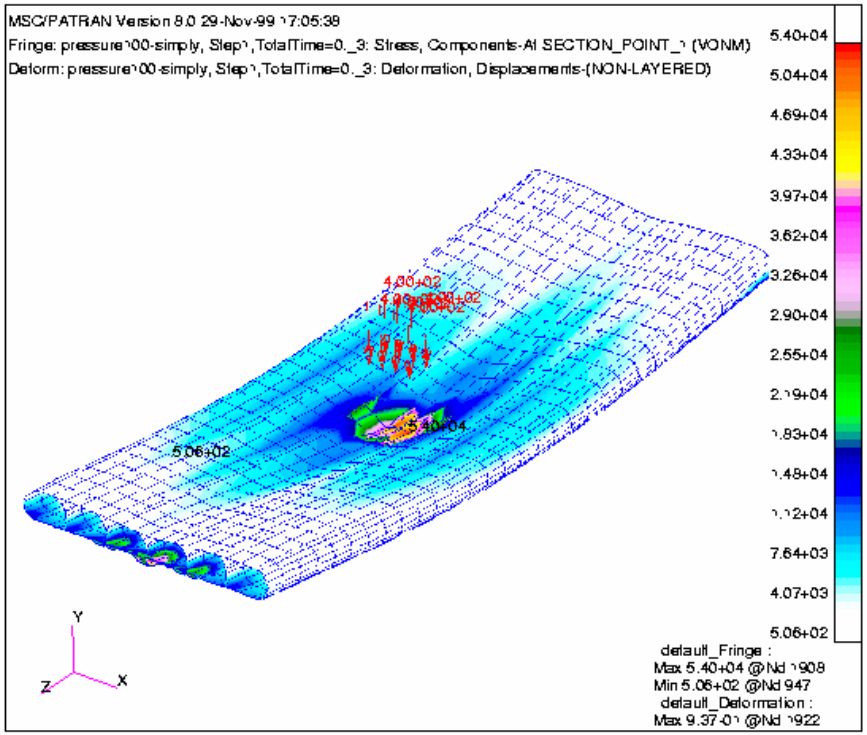
Composite bridge project

Preliminary design of prototypes



Deflection of Bridge

Stresses in Structure & Failure Criterion

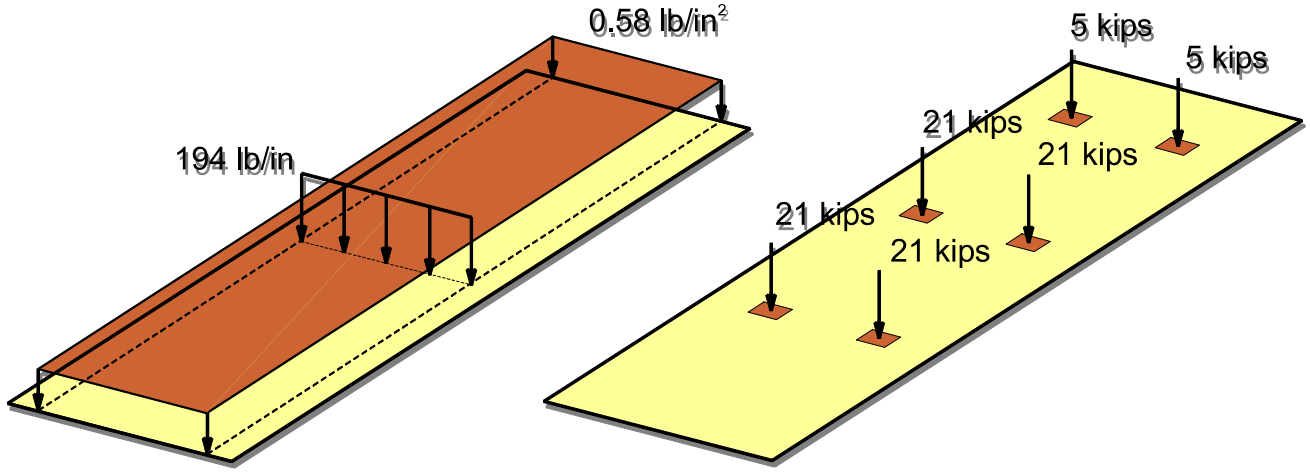


Preliminary Bridge Design

- **Length / 800 deflection criterion controls design (AASHTO)**
- **Two lane highway bridge**
- **60 ft. Span, 30 ft. Wide, 36 in deep**

Comparison of weight

- **Composite: 25,500 kg**
- **Steel-Concrete: 64,200 kg**



AASHTO Lane Load AASHTO HS 20-44 Load

A.J. Aref and I.D. Parsons, "Design Optimization Procedures for a Fiber Reinforced Plastic Bridge," ASCE Journal of Engineering Mechanics, 1999, pp. 1040-1047

Composite bridge project

En-Tec 4 axis (CML Lab of UIUC)

Spools with extentioner

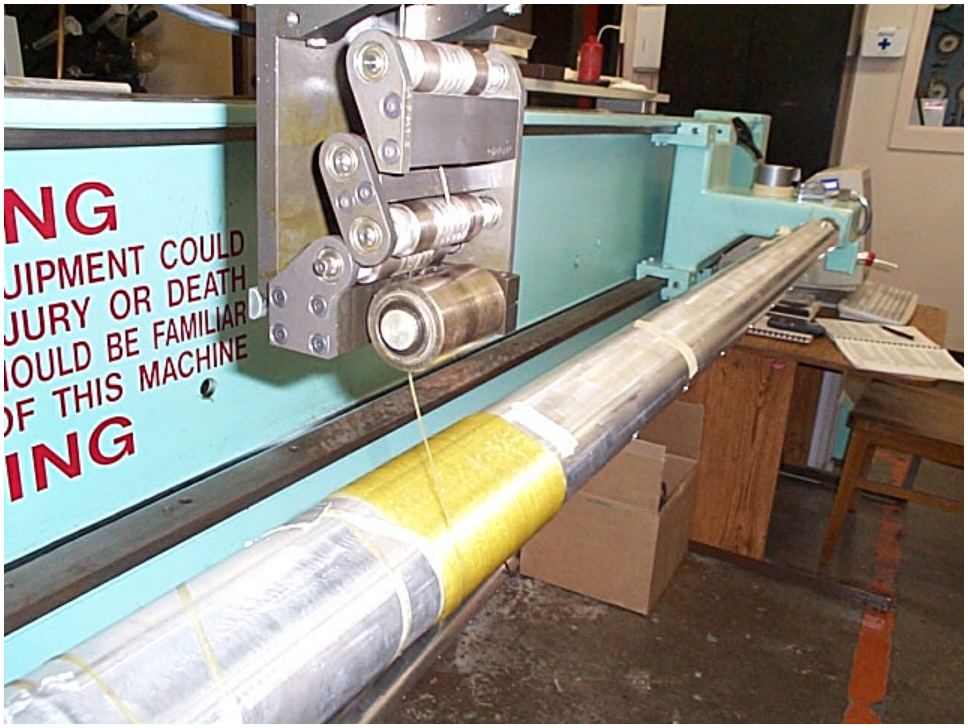
Composite bridge project

Large industrial filament winder

Composite bridge project

Manufacturing

- Inner cell (repeat six times)



Winding on mandrel

2 cells in the autoclave

Composite bridge project

Manufacturing

Winding of outer shell

Composite bridge project

Manufacturing

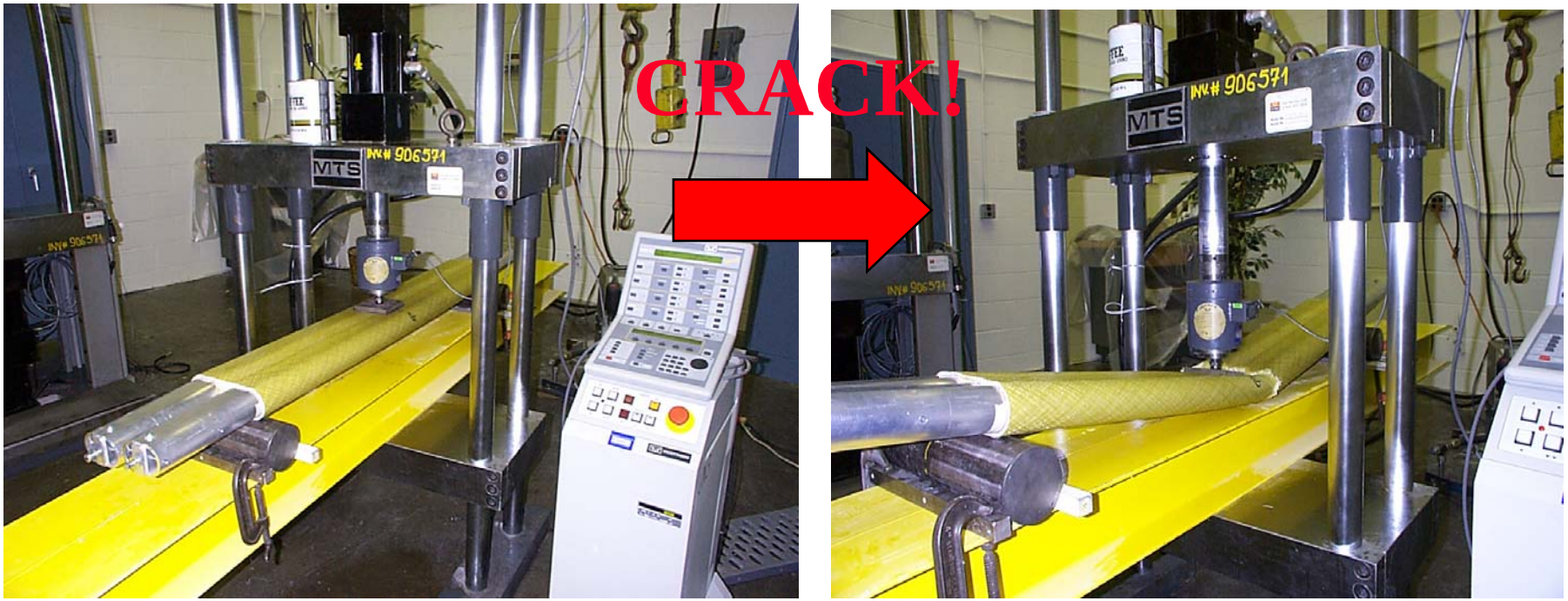
6-cell bridge wrapped in vacuum bag ready for curing in autoclave

Final 6-cell bridge structure

Composite bridge project

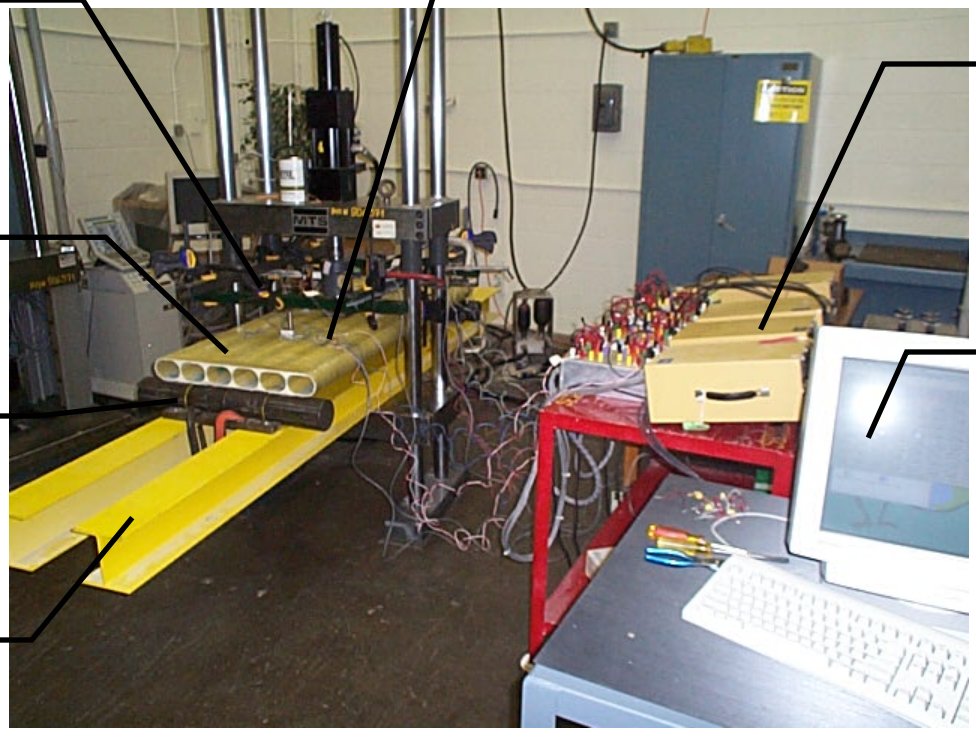
2-cell bridge tests

- Measurement of the Load vs. Deflection of the actuator
- Load applied until failure



Experimental Test: 6 cell bridge

Testing setup

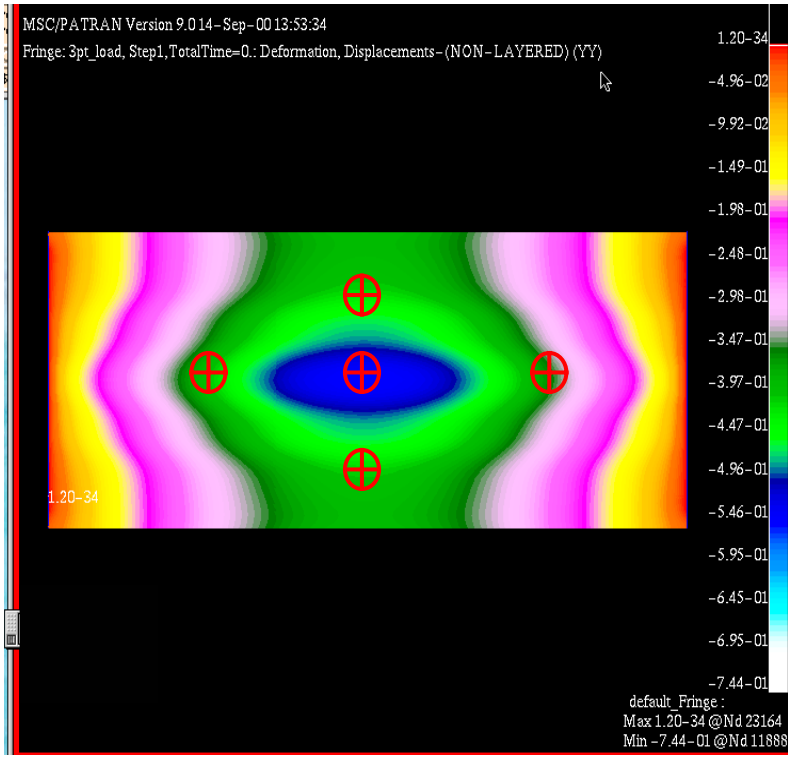


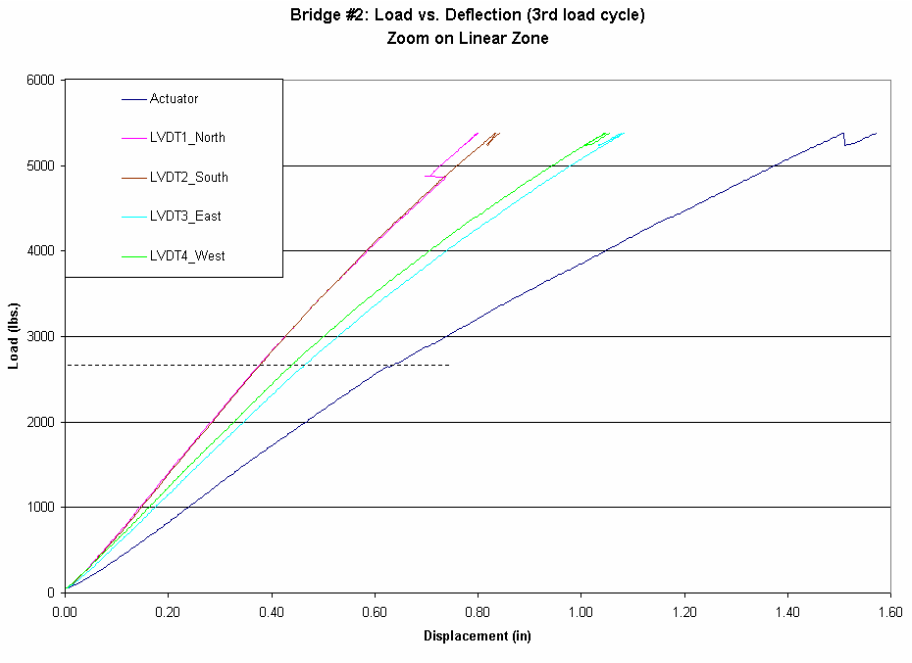
Composite bridge project

6-cell bridge tests

Structure deformation under load

Composite bridge project





Numerical predictions **vs.** **Experimental results**

Match structure stiffness and strength ➔ **IMPROVE DESIGN**

Bridge failure

Failure of outer shell at 7.7 kips
(max. load carried by structure)

Local buckling of fibers in compression
(top surface)

Experimental Test: 6 cell bridge

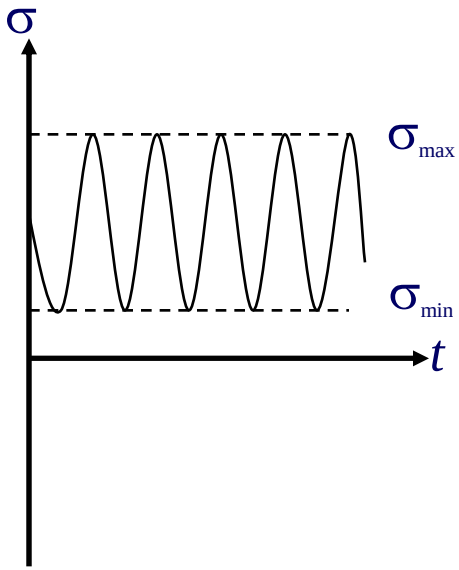
- **Bridge #1**
  - **Debonding of cell-shell in the center of the bridge**

- **Bridge #2**
  - **No observation of debonding**

Experimental Test: 6 cell bridge

Fatigue test performed on Bridge #3

- 3 million cycles (8 days of testing)
- Displacement controlled = Length / 800 + 20 %
- Sin function with frequency of 5 Hz
- *R* ratio around 0.1
- Stiffness test is performed after each million cycles (0, 1, 2 and 3 million cycles)



Experimental Test: 6 cell bridge