MAE 459/559 Characterization of "STARS" (Strategically Tuned Absolutely Resilient Structures) - 3 hrs.

Fall 2004

Time/Place	Friday 11:30 a.m - 2:10 p.m. TH S104
Instructor:	John A. Gilbert, Ph.D.
Office:	OB 301E (office)
Telephone:	(256) 824-6029 (direct); (256) 824-5117 (Beth)
Fax/E-Mail:	(256) 824-6758; jag@eng.uah.edu
Grading:	See below.
Text:	Reference material will be distributed in class.

Course Description:

MAE 459/559 Characterization of "STARS" (Strategically Tuned Absolutely Resilient Structures) - 3 hrs.

Prerequisite: permission of instructor.

The STARS concept makes it possible to build a structure capable of storing potential energy in the form of elastic deformation that can be released in a controlled fashion in the form of work or kinetic energy. The composite section must be designed based on the strength, stiffness, and the position of the component materials. The ability to store and release energy depends upon a complex interaction between the shape, modal response, and the forcing function initiated to the structure. Since the method relies on energy recovery through elastic deformation, steps must be taken to prevent damage so that the structure is absolutely resilient.

The course will include lectures and independent study in this exciting new area. Topics will range from proof of principle to practical application. Specific areas to be addressed include composite section design, structural analysis, stress analysis, integrated sensing, non-destructive evaluation, finite element modeling, and modal analysis.

Grading and Attendance Policies:

Sixty-five percent of the grade will be based on attendance and homework assignments. Grades received for attending class periods and those received for homework assignments will be averaged; students will earn 100 points for being in class and zero points for not being there; homework assignments will be scored on the basis of 100 points each. The remaining thirty five percent of the grade will be based on a final oral presentation scored collectively by the instructor and fellow class members. Students are also encouraged to keep a class log and must show satisfactory progress in guided readings and laboratory work.

For the purpose of lecture and coordination of field activities, the class will meet on Friday from 11:30 a.m. to 2:10 p.m. in Tech Hall Room S104.

Course Outline:

1. **Introduction to STARS**; Review of Statics and Mechanics of Materials - Forces, Moments, Stress, Strain, and Displacement. Homework assignment includes formulating shear and moment diagrams and calculation of maximum bending and shear stresses in prismatic beams subjected to transverse loading.
2. **Overview of Solid Mechanics** - Equilibrium, Compatibility, Strain-Displacement, Transformation, and Constitutive Equations. Homework assignment concentrates on deflection criteria and derivation of the elastic curve for prismatic beams subjected to transverse loading.
3. **Design Strategy for Producing STARS** - Stiffness, Strength, Geometry, Forcing Functions, Adaptive Reinforcement, Embedded Sensors, Control Elements, and Moire Measurement Techniques. Discussion focuses on highly compliant structures with an example given (collapse of World Trade Center) to illustrate how such structural behavior can be measured by using relatively crude sensing techniques.
4. **Visualizing Stress Transfer in STARS via Photoelasticity** - Design of STAR Structures, Transform Section Theory, Plane and Circular Polariscopes, Isoclinic and Isochromatic Fringe Patterns, Calibration and Compensation Techniques; and Stress Concentration Factors. Homework assignment involves comparing experimentally determined stresses in composite photoelastic models with results obtained from the transform section theory and showing how stress transfer can be accomplished by adjusting the compliance of the materials in a composite section.
5. **Concrete Mixture Design** - Binders, Aggregates, Additives, Mix Proportioning, and ASCE Concrete Canoe Competition. Homework geared toward improving UAH design report.
6. **Design of Composite Structures** - Design Considerations, Composite Laminates, Inter-Laminar Stresses, Woven Composite Structures, and Structural Failure.
7. **Numerical and Experimental Characterization of STARS** - Modified Transform Section Theory, Equivalent Composite Properties, Parametric Study of Electrical Resistance Strain Gages, Rosettes, Circuitry, and Application to STARS. Homework involves appreciating how the constitutive equations are affected by material properties such as the elastic modulus, Poisson's ratio, and the shear modulus.
8. **Vibration Analysis** - Discrete Systems, Continuous Systems, Modal Analysis, Resonance, Eigenvalues, and Mode Shapes.
9. **RRAPDS** - Remote Readiness Asset Prognostics/Diagnostics System, Strategic Defense Applications, Remote Sensing, MEMS, Accelerometer Measurements, and Application to STARS.
10. **Dynamic Characterization of STARS** - Modal Analysis of Graphite Reinforced Cementitious Composite Plates, Dynamic STAR Structures, Experimental Testing, and Finite Element Analysis.
11. **Stress Analysis** - Method of Attack, Conventional Measurement Techniques, Advanced Optical Methods, Sensors, and Transducers.
12. **Advanced STARS Concepts** - Embedded Sensors, Control Elements, Morphing, Self Healing, etc.