

NA 514 (MFG 515): Fatigue of Structures (3 credits)

Instructor: Dr. Pingsha Dong
Office: 216 NAME Building
Email: dongp@umich.edu
Phone: 734 615 7484

Prerequisites:

Graduate standing. Prior exposures in finite element methods would be highly desirable.

Course Description:

This course intends to prepare students with fundamental concepts of fatigue damage and failure in engineering structures and contemporary design and analysis procedures. Major limitations in existing design and analysis procedures practiced by industry and research community will be discussed. A particular emphasis will be placed upon fatigue behavior of as-manufactured components (e.g., welded structures) and recent developments in finite element based fatigue design and evaluation procedures. Recommended fatigue testing procedure and data interpretation method will be illustrated. Fatigue-resistant joint design principles will be discussed along with real-world examples. On-going research in addressing some of the limitations will also be highlighted.

Class Schedule: Lecture Hours: Tuesday and Thursday 5PM-6:30PM

References:

- 1) Lecture notes (to be distributed prior to each lecture)
- 2) Supplemental reading materials (to be distributed prior to some lectures):
 - Selected chapters in WRC Bulletin No. 523: "The Master S-N Curve Method: An Implementation for Fatigue Evaluation of Welded Components in the ASME B&PV Code, Sec. VIII Div 2 and API 579-1/ASME FFS-1"
 - Selected chapters in Bureau Veritas NT 3199: "Guide for Application of the Mesh-Insensitive Methodology"

Student Learning Objectives:

- 1) Understand the basic concepts of fatigue damage in engineering structures
- 2) Understand the uniqueness of fatigue behavior in welded structures and effective analysis and design methods
- 3) Learn basic fatigue design and analysis procedures stipulated in relevant national and international Codes and Standards and underlying assumptions
- 4) Learn finite element implementation of modern fatigue assessment procedures for solving practical fatigue problems in engineering structures.

Course Topics:

1. Introduction: importance of fatigue considerations in engineering design
2. Fatigue damage definitions: perspectives from material science and structural mechanics
3. Laboratory fatigue testing and data interpretation
 - Smooth bar versus structural specimens
 - Crack initiation versus crack propagation
4. Stress concentration definitions and difficulties for applications in as-manufactured components
5. Fatigue behaviors of welded joints
 - Observations from test data
 - Classical nominal stress based characterization method
6. Finite element based fatigue evaluation methods and limitations
 - Hot spot stress method

- Local approach – notch stress method
- 7. Mesh-insensitive method
 - Traction stress definition and mechanics basis
 - Simple calculation examples
 - Generalized solution procedure
- 8. Master S-N curve method
 - Fracture mechanics considerations
 - Formulation
 - Validations
 - Applications in structures
 - Implications on fatigue testing procedures
- 9. Fatigue-resistant joint design principles and examples
- 10. Structural strain method
 - Low cycle fatigue considerations
 - A unified treatment of both low cycle and high cycle fatigue regimes
- 11. Variable amplitude loading
- 12. Multi-axial fatigue
 - Effective damage parameter
 - Path-length dependent cycle counting method
 - Cycle counting law
- 13. Implementation in Codes and Standards
- 14. Applications for defect assessment or fitness-for-Service (FFS)

Grading:

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| 1) Homework assignments (7~8): | 20% |
| 2) Term project and final presentation: | 20% |
| 3) One mid-term: | 25% |
| 4) Final exam: | 35% |

Class attendance: Mandatory

Honor Policy:

The CoE Honor Policy applies. Collaborations on homework problems are encouraged, as long as final solutions are developed independently.