Fundamentals of Structural Bolted Joint Design and Installation Training Topics

Fundamentals of Structural Bolted Joint Design and Installation

Training Topics

Following is a summary of potential training topics that can be delivered to suit a company's or organization's specific requirements. Customization may include unique materials or conditions, particular problems, or other topics the client provides.

Course Introduction

- *Introductions.*
- *Primary Bolted Joint Application Types.*
- *References Standards.*

Structural Bolted Parts

- *Bolted parts.*
- *Holes.*

Threaded Fasteners[1]

- *Common thread and fastener terminology.*
- *Common head styles, thread points, and nut styles.*
- *Background to modern threads - the roles of Whitworth and Sellers and the development of the modern thread form.*
- *The basic profile of unified thread forms.*
- *Thread tolerance classes.*
- *Structural bolting components and assemblies.*

Strength of Threaded Fasteners[1]

- *The principles of bolt elongation, bolt stress, load.*
- *Yield, tensile strength, and proof load properties.*
- *Details of the common bolt and nut specifications and markings.*
- *Nut/bolt combinations, nut strength versus bolt strength.*
- *Relationships between bolt size, area, stress, bolt elongation, and load.*

Washers[1]

- *Washer purposes and requirements.*
- *Compressive Stress under Bolt Head & Nut Face.*
- *Explanation of compressive stress.*
- *The bolted joint 'stress cone'.*
- *Simplified equation to calculate compressive stress.*
- *The effect of the washer.*
- *Slotted joint plates.*
- *Demonstration of compressive yield failure and the effect of the washer.*

Fastener Finishes and Corrosion[1]

- *Background and corrosion mechanisms.*
- *Common corrosion protection methods.*
- *The galvanic series, barrier, and sacrificial protection.*
- *Common fastener coatings.*
- *Effect of the coating thickness on thread dimensions.*
- *Limits of coating thickness on the threads.*

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Training Topics

Structural Bolted Joint Types

- *Structural bolted joint types.*
- *Load types.*

Pretensioned Fasteners

- *Minimum Pretension.*
- *Methods of Pretension.*
  - *Turn-of-Nut.*
  - *Calibrated Wrench.*
  - *Tension-Control Bolt.*
  - *Direct-Tension-Indicator.*
  - *Pros and Cons of each Method.*
- *Pre-installation Verification.*
- *Inspection.*
- *Marking of Bolts.*

Pretensioning Demonstrations

- *Demonstration of Turn-of-Nut Pretensioning.*
- *Demonstration of Calibrated Wrench Pretensioning.*
- *Demonstration of Direct-Tension-Indicator Pretensioning.*
  Note: Tension-Control Bolt Pretensioning will not be demonstrated. An example bolt will be passed around to the class.

Tightening Procedures[1]

- *Problems associated with the tightening of the multi-bolt joint.*
- *Elastic interaction.*
- *Single pass tightening sequence.*
- *Two-pass and multi-pass tightening sequences.*
- *Tightening sequences for non-circular bolted joints.*
- *Tests investigating the effects of elastic interaction.*
- *Use of multiple tightening tools.*

Loads and Limit States

- *Load cases.*
- *Limit States in bolted joints.*

Work Problem

- *Bolted joint in shear and tension.*
- *Determine joint type.*
- *Determine applicable load case.*
- *Calculate limit states.*

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Optional:

Overview of Fastener Failure Mechanisms and Causes[1]

- *Overview of the ways threaded fasteners can fail.*
- *Introduction to the common fastener failure mechanisms.*
    - *Combined stress fracture*
    - *Torsional shear fracture*
    - *Transverse shear fracture*
    - *Galling*
    - *Stripping*
    - *Compressive yield of joint*
    - *Fatigue fracture*
    - *Tensile fracture*
    - *Wear failures*
    - *Hydrogen embrittlement*

Thread Stripping[1]

- *Identify the cause of thread stripping.*
- *Shear cylinder concepts.*
- *Estimating the shear area of an internal or external thread.*
- *How the tapping drill size affects the strength of the bolt thread.*
- *Long thread engagements.*
- *Thread inserts.*
- *Weld nuts.*

Relaxation Loosening[1]

- *Explanation of relaxation*
- *Explanation of embedment*
- *Current understanding of embedment and parameters that affect it.*
- *Embedment and the Joint Diagram*
- *Loss of preload due to embedment – springs in series.*
- *Reference values from VDI 2230.*
- *Effect of joint thickness on embedment and other forms of relaxation.*
- *Effects of paint in bolted joints.*
- *Methods of reducing relaxation.*

Self-Loosening of Threaded Fasteners[1]

- *Appreciate the forces acting on the threads that tend to self-loosen a fastener.*
- *The inclined plane analogy.*
- *Junker's theory on self-loosening of fasteners and why fasteners self-loosen.*
- *The Junkers transverse vibration test.*
- *The phases of self-loosening.*
- *Preload decay curves of various locking devices resisting vibrational loosening.*
- *Micro slip in joints resulting in self-loosening.*
- *Conclusions from the research and methods of reducing the likelihood of loosening.*

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Typical Questions Addressed in the Training

- *What bolt specifications should I use?*
- *What are the differences between the allowed bolt specifications?*
- *When do I need to specify galvanized hardware?*
- *When do I need to specify a washer?*
- *When can I use oversize or slotted holes?*
- *When do I need a pretensioned joint over a snug tight joint?*
- *When do I need to specify a slip-critical joint?*
- *How are bolts installed?*
- *What area should I use in bolt strength calculations?*
- *How do I figure out why my fastener failed?*
- *Why are my joints loosening when they were installed tight?*

Training Course Instructors

Breanna Veltkamp is an Instructor and Consulting Engineer specializing in bolted joints at Matrix Engineering with over 8 years of engineering and design experience. Her experience includes designing buildings and shipboard structures, including bolted and welded steel connections and aluminum balcony connections. She also has experience in investigating bolted joint failures. She received a Bachelor of Science in engineering from Dordt University.

Jon Ness, PE, is a Managing Governor and Principal Engineer at Matrix Engineering. Jon has over 36 years of engineering and design experience in developing mobile equipment components and sub-systems, including dynamically loaded bolted joints. His work has included the design of multiple gearboxes, powertrain systems, engine installations, and developing test and validation plan strategies. He has taught numerous classes related to Failure Modes and Effects Analysis and Bolted Joint Design for design engineers.