University of Portland
ME 421 – Failure Analysis
Fall 2013

1. With your team, develop a test plan (which is part of Phase II) of your main failure analysis project. You will not be able to conduct much testing beyond visual; however, your plan should assume you can. Here are some things to keep in mind:
   a. Conducting tests is an essential task for failure analysis, but testing always costs money and time. You must use your engineering judgment to determine "appropriate" tests. For this project, while you won't be actually doing much testing, treat it as if you were.
   b. Do not identify a test "just because". Each test must have a definitive purpose and you need to explain that purpose. For example, if you want confirm heat treat condition, hardness testing would be appropriate.
   c. In actual practice, not all tests are appropriate. For example, if you want to confirm the yield strength of the material, you would need to create a tensile bar from the actual specimen. This is rarely justified. It is difficult (sometimes impossible) to create a valid tensile bar from the actual failed part. There are more viable ways to characterize the material than tensile testing. Select those.
2. Read the Mars Climate Orbiter article (link on course web page) to gain some background as to the root cause of this accident. In about one-half page, explain similarities between the accidents of Space Shuttles Challenger and Columbia and Mars Climate Orbiter. Discuss general lessons learned (decision "root cause" not technical details).
3. Based on the visual evidence provided, explain the technical cause(s) for the failure of the bolt shown here. Identify where the crack initiated at. Mark on this print showing/explaining features on which you base your conclusions.

4. Read the attached memo (dated October 23, 2013) and respond to the requests made.

TO: Students, ME 421
FROM: Dr. K. Lulay
DATE: October 23, 2013

The purpose of this memo is to inform you of your job reassignment. As you may know, our company is involved with designing a 3-lane bridge for Highway 99 in California. One of our designers (Mr. Smite) has taken a position at another company. You have been assigned to this project as his replacement. Mr. Smite was responsible for designing the hanger joints. He had completed the concept phase of the design, but had not completed any details. In this memo, I will describe the overall bridge design as well as Mr. Smites concepts. At the end of this memo, I am requesting specific work from you.

This bridge is supported from pillars beneath the decking. It consists of three sections: left, center and right (see Figure 1). The left and right sides are each supported by two sets of pillars. The left and right sides support the center section. The center section will be 88 feet long. The loads from the center section are transferred to the left and right sections through hanger joints. The joints consist of a hanger plate bolted to both the right side and center side (and left side and center side). There is one hanger joint per section, per side of the bridge (four total hanger joints – one on each corner of the center section). The center section is supported in this manner to allow for thermal contraction and expansion. Steel girders (I-Beams) support the bridge decking.

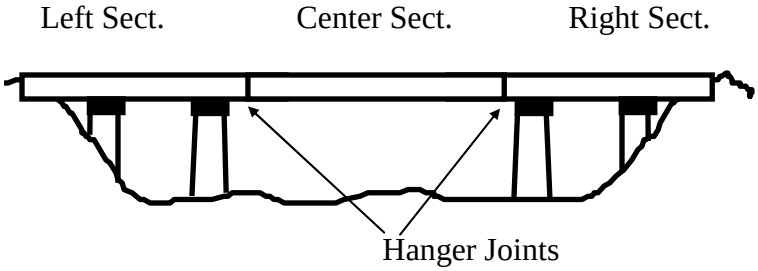

Figure 1 - Overall bridge design.

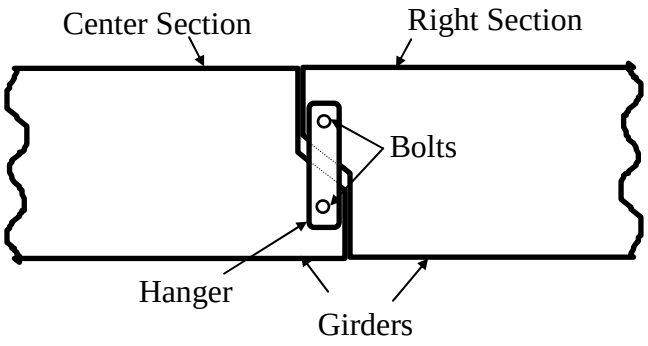

Figure 2 - Details of the hanger joint for the Center/Right Section joint (the Center/Left Section is similar)

The hanger joints that you will need to design consist of the hanger and the bolts (as shown in Figure 2). At a later date, I will provide you with loading information so that you may conduct detailed design.

Your job for now is to evaluate the design. Describe your top two concerns you may have with this design, and discuss what should be done to mitigate your concerns. i.e., "I am concerned about fatigue of the hangers at the bolt holes – a complete fracture mechanics and stress analysis should be conducted to determine the expected fatigue life of the hangers and bolts, as well as determine an appropriate inspection plan." Note, I am not asking you to conduct any analysis – other than qualitative evaluation of the design. Is the concept sound?