

3-Point Bending Test

1. Aim and Background

The goal of this experiment is to understand the bending stiffness, bending structural stiffness, and bending strength from a single cycle (static) bend test on metallic bone plates using cylindrical rod. Bending strength or flexural strength is defined as a material's ability to resist deformation under load. The bending strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress.

Bending rigidity of the plates is one of the biomechanical issues arise in the design of fracture fixation plates. This is important because load sharing between bone plate and bone, which is influenced by the bending rigidity of plate vs. For this reason metallic bone plates need to undergo several tests before gaining approval as internal fixation devices of the skeletal system. Four point bend tests are commonly used to determine the flexural strength of a specimen. One standard, ASTM F382-99, defines the test methods for single cycle bend (static) testing and for determining the bending fatigue properties of metallic bone plates.

When a specimen is bent, it experiences a range of stresses across its depth. At the edge of the concave face of the specimen, the stress will be at its maximum compressive value. At the convex face of the specimen, the stress will be at its maximum tensile value. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the specimen fails is its bending strength. The bending strength would be the same as the tensile strength if the material were homogeneous. In the case of bones, the complex structure and small defects within the specimen serve to concentrate stresses locally, effectively causing localized weaknesses and lower bending strength values.

2. Materials and Methods

The test sample is a cylindrical rod and test apparatus was illustrated schematically in Figure 1. Shimadzu universal testing system will be used to observe load-displacement graphs. The cylindrical rod made of Ti-6Al-4V (6 mm diameter and 150 mm length).

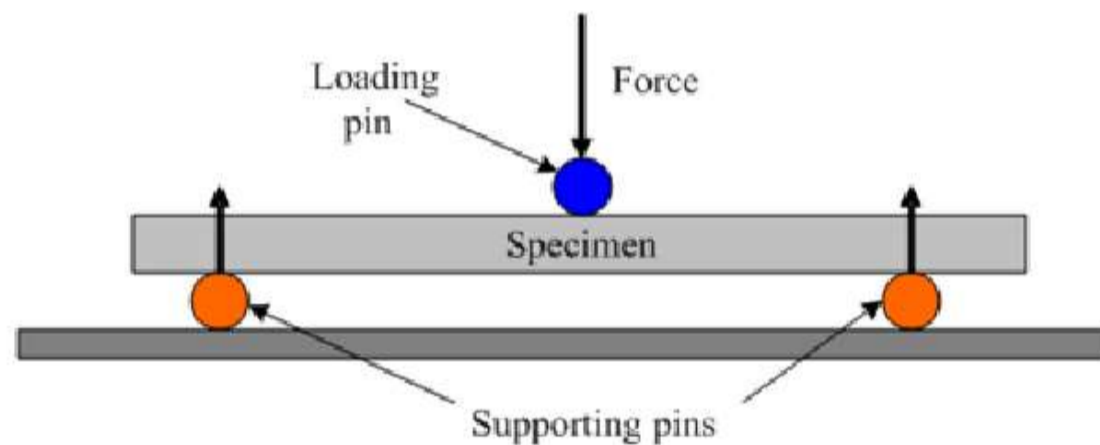


Figure 1. Schematic illustration of test specimen and 3-point bend fixture.

Determine the bending stiffness, bending structural stiffness, and bending strength for each tested bone plate according to the method that follows:

A load versus load-point displacement curve (see Fig.2) is produced either autographically or from numerical data acquired during the test.

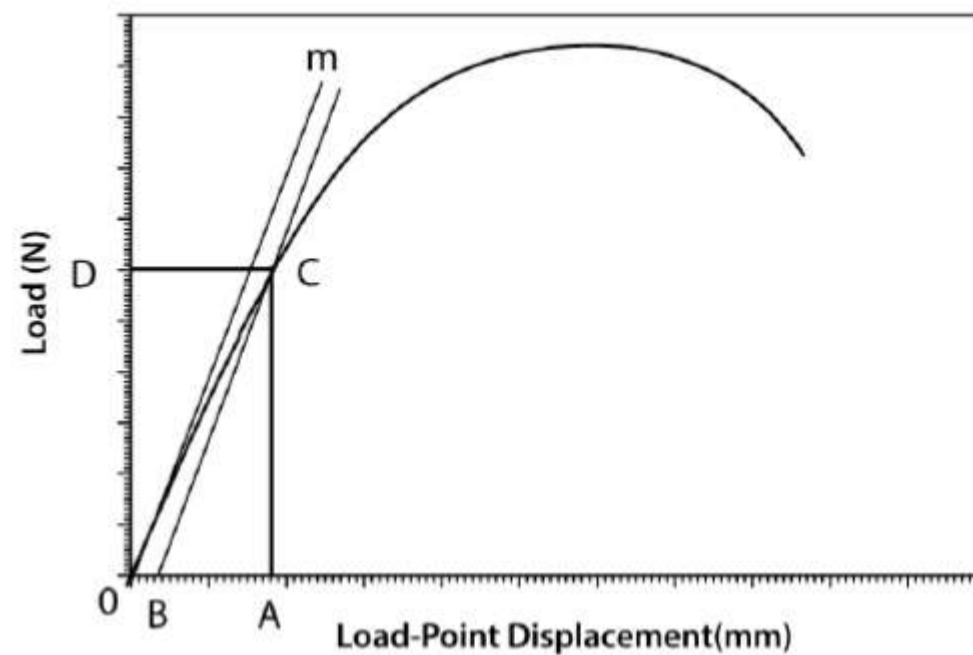


Figure 2. Diagram illustrating methods for determining bending properties of bone plates.

On the load versus load-point displacement diagram generated for the test, draw a best fit straight line (Om) through the initial (linear) portion of the load versus load-point displacement curve.

Determine the bone plate's bending stiffness (K) by calculating the slope of the line.

Figure 2. Diagram illustrating methods for determining bending properties of bone plates.

Determine the bone plate's bending structural stiffness with the following expression:

$$El_e = \frac{(2h + 3a)Kh^2}{12}$$

where:

K = the bending stiffness,

a = the center span distance, and

h = the loading span distance.

Calculate the 0.2 % offset displacement from the expression:

$$q = 0.0023 a$$

where:

a = the center span distance.

On the load versus load-point displacement diagram lay off OB equal to *q*. Then draw line BC parallel to Om.

Locate the proof load at the intersection point of line BC with the load versus load-point displacement curve.

4.References

- 1] ASTM - Standard Specification and Test Method for Metallic Bone Plates, Designation: F 382 - 99 (Reapproved 2003)

