

FLEXURAL FIRST PLY FAILURE OF NOTCHED COMPOSITE LAMINATES

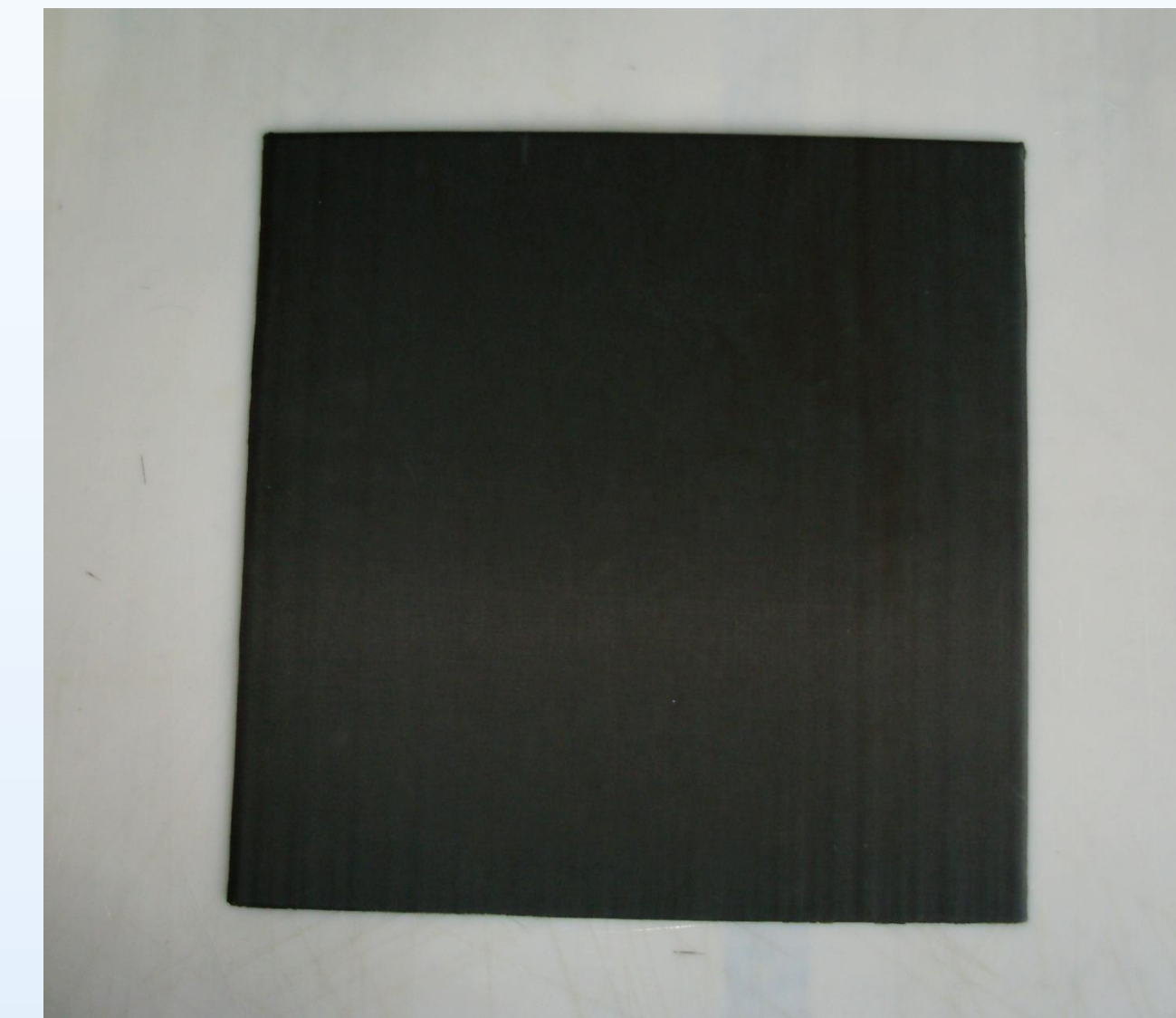
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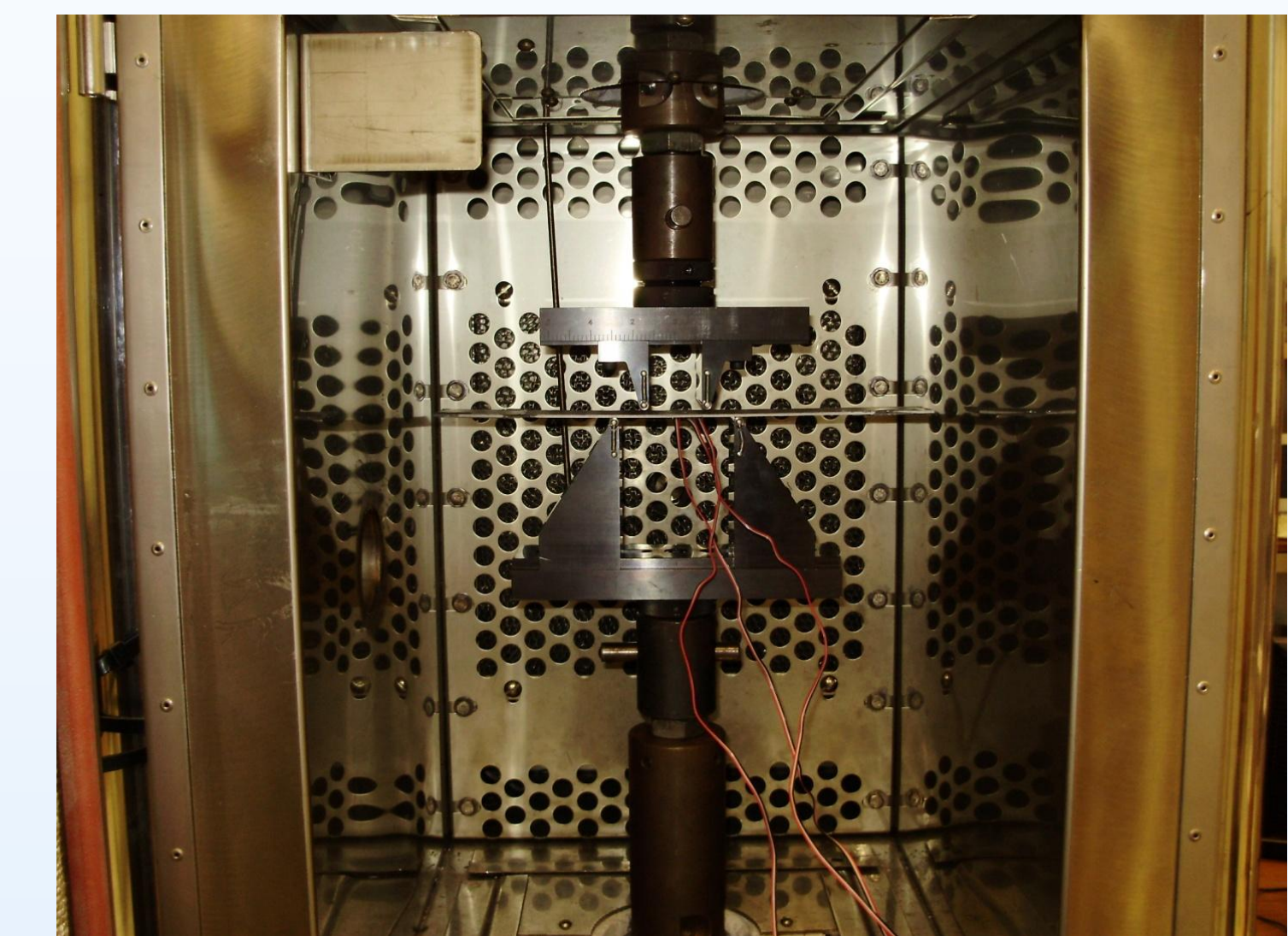
Introduction

Composite materials are being used more and more as a lightweight alternative to metals. Composites are materials made of two or more chemically different materials which are combined yet still retain their own physical and chemical identities. Boeing is currently constructing the new 787 Dreamliner jet using mostly composites. Strength characteristics of composites vary widely depending on a number of factors. One variable Boeing was especially concerned with was stress concentrations around holes (where rivets will be secured) in a composite plate.

My project dealt with measuring those stress concentrations (in flexure) around the notch to find the first ply breaking point, or the maximum load the coupon could withstand before its outer fibers broke. Unlike metals composites cannot be welded together, so in order to join pieces of composite materials they must be riveted making this test of great importance to Boeing.



A cured Carbon Epoxy composite plate



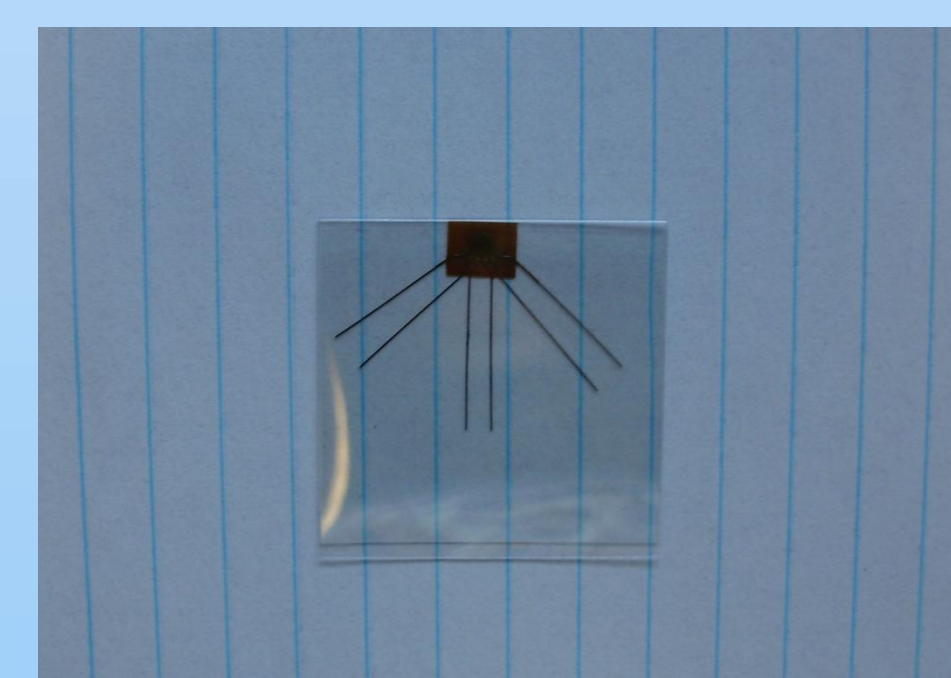
Coupon in the four point flexural setup

Strain Gages

After being cured in the autoclave the sheets are then cut into coupons about two inches wide. Rosette strain gages and terminal strips are then glued to the coupons next to the hole. Rosette strain gages are actually three gages stacked on top of each other able to measure strain in the X, Y, and Z planes. Three sets of wires are soldered to the terminals and the coupon is ready for testing.



The Autoclave used to cure the composite plates



The Rosette Strain Gage



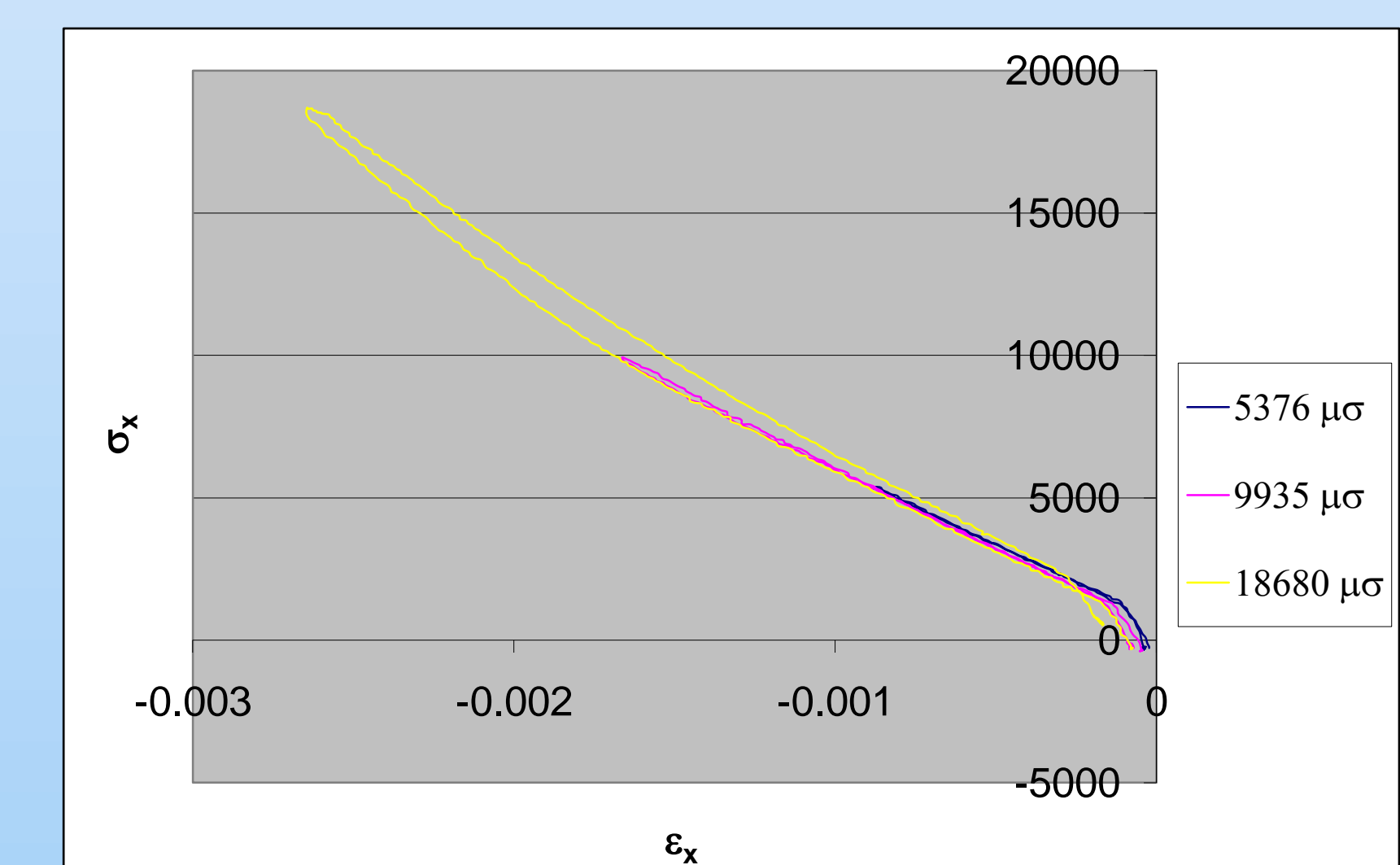
A coupon with strain gage attached

Four Point Flexural Test

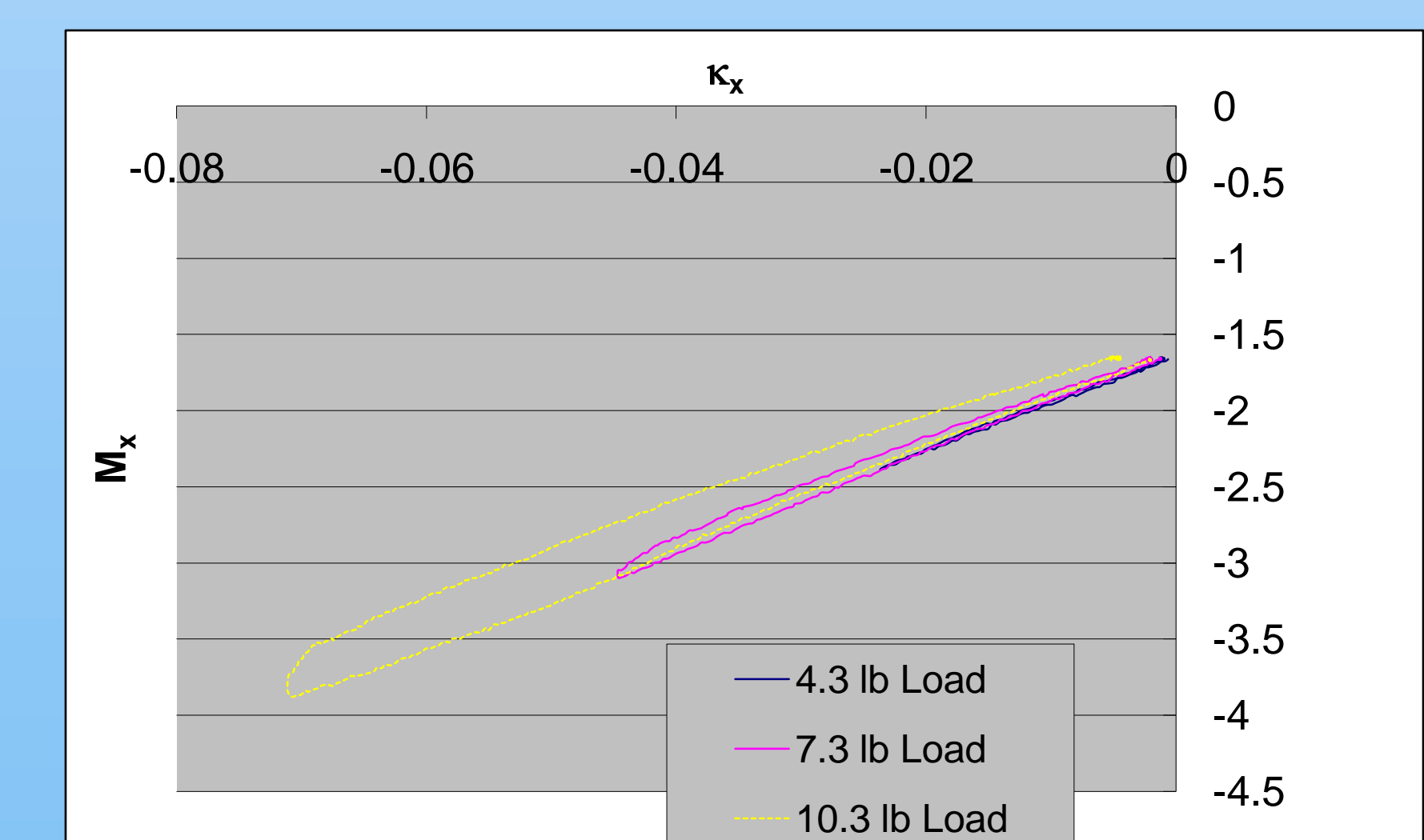
The coupons were tested using the four point flexural method. According to ASTM standards the support span is correlated to the depth of the coupons being tested and a certain ratio is then chosen. A span-to-depth ratio of 40 to 1 was chosen for my tests. Subsequently, the load span was one half the support span. The coupons were tested using a loading-unloading method. In this method the load is increased in steps while being unloaded between steps.

Results

Results were mixed between the five coupons tested. A couple of the coupons bent without breaking but had more than five percent strain. According to ASTM standards failure is defined as breaking of the outer fibers or more than five percent strain. Two more failed as expected having outer fiber failure. One coupon broke completely in half.



A pair of loading-unloading graphs from one of the coupons



Future Studies

Now that strain measurements have been taken using the strain gages it is time to proceed with the DICM and see if how the two sets of data compare before making any definite conclusions.

Fabrication

The first step in the process is making the coupons. All the coupons tested are sixteen ply, however their ply angles differ. Carbon epoxy sheets are layered onto an aluminum plate and then sealed air tight. The sheet is then cured in an autoclave for several hours.