Deflection Prediction Of Tensile Strength Within A Beam

Deflection prediction of tensile strength within a beam helps determine if the structural beam is airworthy. An experiment was conducted to show the process of a piece of wood, weighed down by a bucket of water to measure deflection, using the Euler Beam Deflection Formula and Young’s Modulus, to find the maximum deflection after applied loads. The wood is supported by barstools that are the cantilevers for the beam. The experiment called for a string attached to a bucket in the center of the beam. Considering that a string was not available, a bungee cord was used instead to hold the bucket. A liter of water was added, one at a time, then reflection of the wood beam was recorded. The results are compared to the loads on an aircraft that experience deflection by the weight of fuel, engine nacelle and external pylons attached to a wing of an aircraft. Final analysis will estimate material properties by using Beam Theory for commercial and military aircraft. Everything that has a load will have some type of deflection. By determining the deflection, will give us an idea of how deflection on aircraft is calculated.

What is deflection and why does it matter? Just like how we were measuring elasticity, deflection is the measurement of bending force of aircraft material when it is displaced under a load. Deflection can be calculated as a rectangular or cylindrical design and is used to calculate the load on springs, spars and stringers. Deflection is the bending of the material, while elasticity is the material experiencing spring back to its original form with no evidence of strain. When the material is bending the material is experiencing tensile and compressive forces and often will relax without suffering permanent material deformation. When a material is not reaching its elastic limit right away the material undergoes plastic deformation. Over time, the material will then meet its fracture critical point. An aircraft structural spar will bend while it experiences the ultimate tensile stress load; the material reacts under tension or compression by taking a new permanent shape through plasticity, and ultimately will reach its limit at fracture point.

Young’s modulus (Elasticity) is the measurement of materials resistant to its tensile strength. The force behind the tensile strength is measured in Pascals (Pa) or Newton Meters Squared (N/m2). The higher the refraction also means that there is a higher elastic point and it requires more force to get there. As the material is going through tensile and torsional stress, when you load each liter of water, it is also experiencing compressional stress. We will see tensile force and tension force work together and fracture before compression force fails. When compressional forces are more visible than the tensional forces material failure is apparent when cracks appear on the aircraft structure. While the material is under compressional conditions, deformation happens and causes material buckling. The maximum linear deflection formula calculates how much a structure can move under a given load before failure. With that being said, we will next discuss the deflection experiment where we used a piece of wood, rope, a bucket and some water.

As the aircraft bends the loads are shifted to area of deflection and are isolated between the cantilevers or structural beams of the aircraft. According to Russ Elliot, who wrote an article about deflection of beams, “When a self-piercing riveted joint experiences a load, part of the load will be transferred by friction between the contacting surfaces. The presence of such a frictional force is essential for the proper function of the joint; without this frictional force the joint will be weaker.” Buckling of the external skin is caused by a static overload when there is a compressive load on the structure then transfers its load to its weakest point. Almost like the spaghetti noodle experiment, when too much load is applied the material snaps. Some structures are designed to fracture and give while others are supported to never fail. So designing an aircraft that has very little elasticity will only cause damage in other locations of the aircraft.