**Notre Dame University**

**Faculty of engineering**

**Cen 204**

**Section "D"**

**Experiment #5**

**Beam deflection**

**Case1: determination of the elasticity modulus**

**Case2: superposition principle**

**Abstract**

The topic of this experiment is the deflection of a beam this topic will be divided into two cases first case is the determination of the actual modulus of elasticity of a simply supported beam where in the second case the superposition principle will be in question. Experimental values will be calculated and compared to the theoretical ones the percentage error will be calculated and discussed and all these will be accompanied with graphs and data sheets.

**Introduction**

The experiment will be divided into two cases:

The first case will enable to calculate the actual modulus of elasticity of three different materials which are steel, copper and aluminum and these values will be compare with the theoretical values as well as computing the percentage error. While in the second case the principle of superposition will be under testing where this test will be applied to the three materials steel, copper and aluminum. Values will be compared to the theoretical ones also percentage error will be calculated.

**List of equipments used:**

For the first case: 2 roller supports

A dial gage

Steel, aluminum and copper beams with a 20\*6mm cross section

A slider

Weight of 10, 20 and 25N respectively

For the second case: 2 roller supports

A dial gage

Steel, aluminum and copper beams with a 20\*6mm cross section

2 sliders

2 weights of 20N

**Theoretical analysis:**

The computation of the modulus of elasticity of the beams was through the equation of deflection at mid- span from the appendix "C" which is the following:

F=p\*l^3/48Ei → E=p\*l^3/48Fi

Where, F: is the deflection

P: is the force applied

L: is the length of the beam

I: is the moment of inertia

E: is the modulus of elasticity

Since the deflection of the beam is known applying this equation yield

For example taking the steel beam for testing the deflection of the beam is 1.62mm for a force of 10N hence the modulus of elasticity is: E= 10\*(800^3)/48\*360\*1.62 → E= 182,898.94 the same equation is applied for the different materials and the different weights

For the second case: the principle of superposition was brought to question this principle states that in linear systems the sum of the effects of different loads is equal to the effect of these loads applied together. The equation involved in the calculation is the following:

F=(P\*B\*A/6E\*I\*L)\*(L^2-B^2-A^2) where:

F: is the deflection

P: is the load

L: is the length of the bar

A: is the distance between the load and the furthest support

B: is the distance from the load and the nearest support

I: is the moment of inertia

E: is the modulus of elasticity

As an example of the calculation done the following

The load applied is 20N it is first applied at 200mm from the left support the deflection is F=1.987353207 mm

When the same load is applied but at distance of 500mm from the left support the deflection is F=2.642276423 mm

Hence the deflection due to the both loads together is F=4.62962963

**Discussion of the work done:**

From the obtained values in the data sheet for the first case:

For the steel beam the average error was about 11% for the three weights as for the copper beam the average error was about 38.5% and for the aluminum the average was 0.25% the value for the aluminum beam seems to be perfect for the steel it is acceptable and it is a high value for the copper. The modulus of elasticity will be calculated by the equation F=p\*l^3/48Ei → E=p\*l^3/48Fi as for the dependence of the modulus of elasticity on the moment of inertia these they are independent since each one is a property by its own so they can change without affecting each other and when it comes to describe the modulus of elasticity in terms of the deflection the moment of inertia is disproportional to the modulus of elasticity. The experimental modulus of elasticity is lower than the theoretical values.

For the second case:

The superposition principle states that the sum of effects of different loads is equal to the effect of the loads applied together. In this experiment since we are applying 2 loads at different places separately then we put the loads simultaneously so we need to apply the superposition principle to get the desired results. The % difference between the total deflection and the sum of deflections is acceptable for the copper and aluminum since the values is 0.6 for aluminum and 2.1 for the copper and 11 for the steel then it could be said that the superposition theorem is true and verified as for the values of the experimental sum they nearly the same as the theoretical ones.

**Procedures followed:**

For the first case:2 roller supports spanned by 800mm three different beams were under test steel, copper and brass a dial gage is placed at the middle span and a weight suspended the aim was to determine the modulus of elasticity of each beam using consequently 10, 20 and 25N

For the second case same apparatus was used but now the load is placed at 2 different places each time alone then they were placed together this time the aim was to test the superposition principle with a weight of 20N only.

**Conclusion**

For the first case:

The modulus of elasticity is the same for the same material with different cross section

For the second case:

The superposition principle can be a solution to avoid challenging mathematical equations to solve for simple supported beam under several loads at several locations.

**Data sheets and graphs**

For the first case:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  | F=10N | | | F=20N | | | F=25N | | |
| Beams 6x20mm2 | E.Theo (N/mm2) | f (mm) | E.Exp (N/mm2) | % error | f (mm) | E.Exp (N/mm2) | % error | f (mm) | E.Exp (N/mm2) | % error |
| ***Steel*** | 205,000 | 1.62 | 182898.95 | 10.781 | 3.27 | 181221 | 11.5995 | 4.09 | 181110.2 | 11.6536 |
| ***copper*** | 123,000 | 3.94 | 75202.106 | 38.8601 | 7.79 | 76070.94 | 38.1537 | 9.75 | 75973.41 | 38.233 |
| ***Aluminum*** | 69,000 | 4.31 | 68746.24 | 0.36777 | 8.61 | 68826.09 | 0.25205 | 10.75 | 68906.12 | 0.13606 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | *Steel* | *Brass* | *Aluminum* |
| **Average E.Exp (N/mm2):** | | 181,743.38 | 75,748.82 | 68,826.15 |
| **Average % error for E:** | | 11.34469427 | 38.4155959 | 0.251960897 |

The graph for this case is:

For the second case:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Beam 20\*6mm2 | Deflection (mm), F at 200mm | Theo Deflection | Deflection (mm), F at 500mm | Theo Deflection | Exp.Sum of deflection | Total deflection F at 500mm & 200mm | Theo.Sum of deflection |  |
| ***Steel*** | 2.2 | 1.9873532 | 2.95 | 2.6422764 | 5.15 | 4.67 | 4.6296296 |  |
| ***copper*** | 5.27 | 3.3122553 | 6.91 | 4.403794 | 12.18 | 12.44 | 7.7160494 |  |
| ***Aluminum*** | 5.905 | 5.9044552 | 7.83 | 7.8502415 | 13.735 | 13.82 | 13.754697 |  |
|  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *steel* | *copper* | *Aluminum* | ***average*** |  |
| **% difference** | 10.278373 | 2.0900322 | 0.6150507 | 4.3278185 |  |
| **% error** | 0.872 | 61.2224 | 0.4747707 | 20.85639 |  |
| **Difference** | -9.4063726 | 59.132368 | -0.1402799 |  |  |
|  |  |  |  |  |  |

The graph of this case is: