Experiment AM1.3 – Shear force in simply supported beams

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Executive summary
This experiment shows the shear force in a beam. The experiment consists of a beam which is cut. To stop the beam collapsing a simple mechanism is place in the gap which only allows movement in the shear direction. This causes the shear stress to come down on a load cell which then measures the shear force. Two support beams are acting on the beam, one 0.3 metres to the left and one 0.14 metres to the right. Weights are then placed a distance away from each beam, then by equating the forces acting about each pivot we can calculate the shear stress force. We can then compare this value to the experimental value given by the mechanism.

Introduction and Background
This experiment looks at how shear force effects cuts on a beam where forces on either side of the cut are taking place. It helps to consolidate the understanding of shear forces acting on a system across varying conditions.

When a weight only acts around one pivot:

Shear force = (W.a)/L (equation 1)
Where W.a is the moment around the pivot and L is the total distance between both pivots.

Equation to calculate the force from the supporting beam on the right
R_b = moments around R_a/L (equation 2)

Equation to calculate the force from the supporting beam on the left
$R_a = \Sigma W - R_b$ (equation 3)

Equation to find shear force
Shear force = $R_b - W_b$ (equation 4)

Equation for moments
M = W x a (equation 5)

This experiment is useful in the real world as it can be used to calculate the shear forces acting on a bridge where a cut is present. This can be used to determine whether or not the bridge will collapse cause damage to those on or around the bridge.

Aims and Objectives
The aim of this experiment is to further understand how the shear force acting on a cut varies with differing load under set conditions such as the distance away from the support beams. The experiment also helps to consolidate the calculations of shear forces within a system. Using the statement "the shear force at the cut is equal to the algebraic sum of the forces acting to the left or right of the cut." (Birmingham, 2016)

Methods
For the first experiment I placed a differing load 0.16 metres away from the pivot in the direction of the cut. The range of loads was between 100grams and 500 grams increasing with 100 grams each time. I then measured the experimental shear force acting on the cut using the mechanism which reads the forces acting in the direction of shear force. I then calculated the theoretical shear force using equation 1 with the load (W) changing each time, a being 0.16 metres and L being 0.44 metres. From the two values of experimental and theoretical shear forces I calculated the percentage error that the experiment gave. Below is a force diagram of the first experiment.

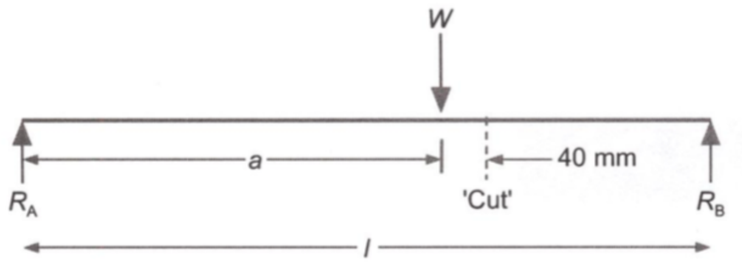


Figure 1 – force diagram of experiment 1 (birmingham, 2016)

In the second experiment I was given various load conditions. The first condition was a weight of 3.92 N 0.14m to the left hand side of R_a. This caused a negative shear force as the moment around the support beam R_a was acting in the opposite direction. Below is a force diagram for this particular condition.

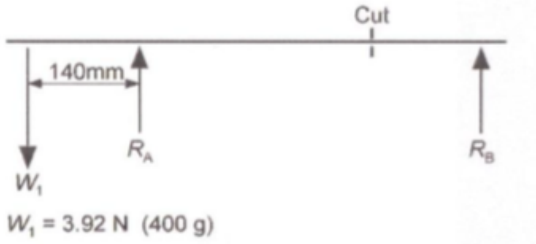


Figure 2 – force diagram of experiment 2, first condition.

The second condition was two weights on the right hand side of the cut, weight 1 was 1.96N and 0.22m away from the support beam R_a. Weight 2 was 3.92N and 0.26m away from R_a, I then calculated the moments around R_a using the equation 5, then using equations 2 and 3 we can calculate the theoretical shear force and compare it to that the mechanism gives. Below is a force diagram for this condition.

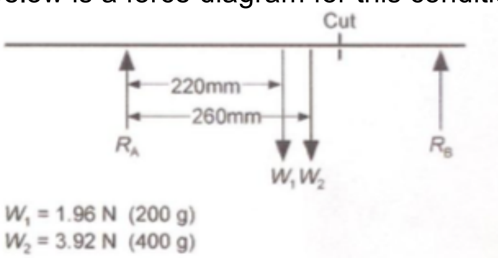


Figure 3 – force diagram of experiment 2, second condition.

The third condition gives two weights, one on each side of the cut. Weight 1 is 4.91N and 0.24m away from R_a. The second weight, Weight 2, was 3.92N and 0.4m away from R_a, from this I calculated the moments around R_a using equation 5 and then using equations 2 and 3 I calculated the shear force acting on the cut, theoretically. I then compared this to the experimental value. Below is a force diagram of the third condition.

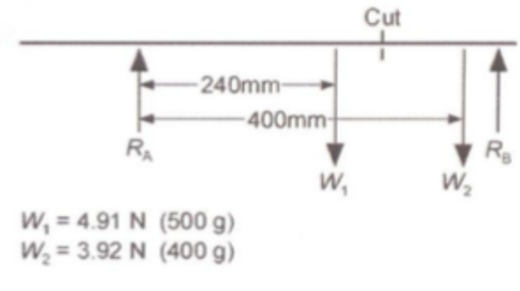
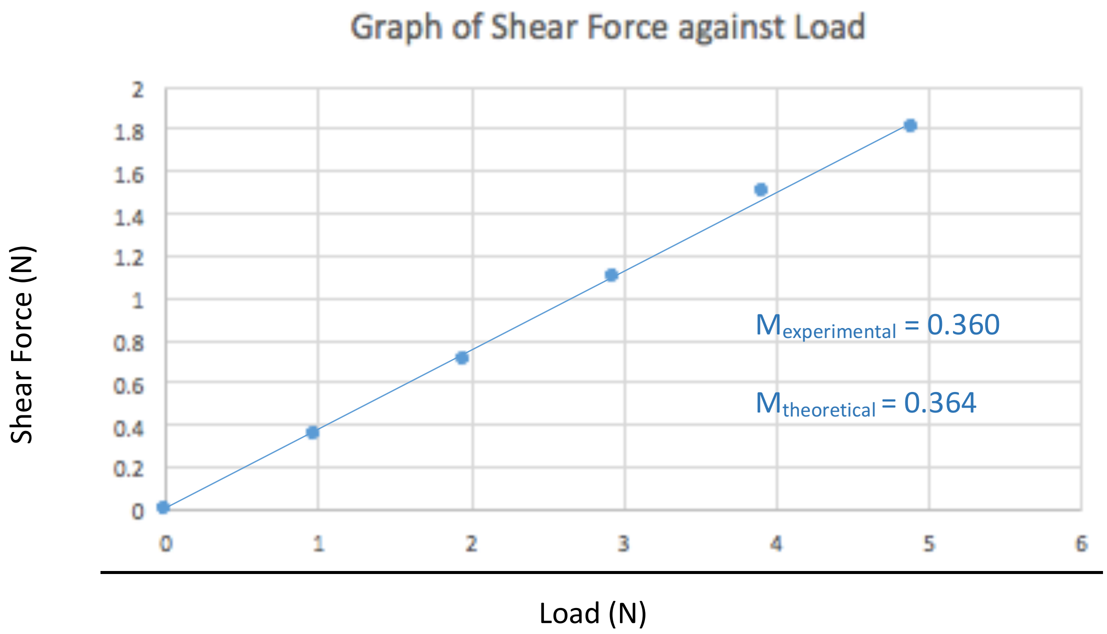


Figure 4 – force diagram of experiment 2, third condition.

Results

		Shear force (N)		
Mass (kg)	Load (N)	Experimental	Theoretical	Error %
0	0	0	0	0
0.1	0.981	0.35	0.36	2.78
0.2	1.96	0.7	0.71	1.41
0.3	2.94	1.1	1.07	2.8
0.4	3.92	1.5	1.43	4.9
0.5	4.9	1.8	1.78	1.12

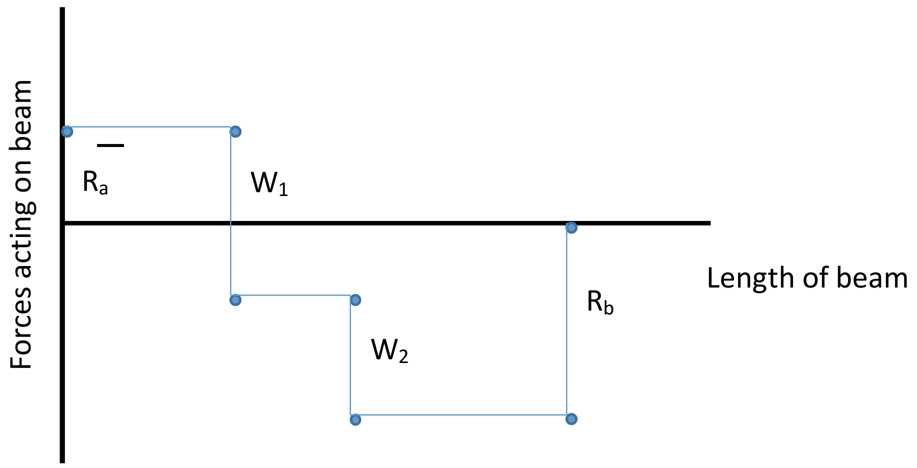
Table 1- results from experiment 1



Graph 1 – Shear Force against Load.

Condition	W1 (N)	W2 (N)	Experimental	Ra (N)	Rb (N)	Theoretical	Error %
1	3.92		-1.4	2.67	1.25	-1.25	12
2	1.96	3.92	3.4	2.58	3.3	3.3	3.03
3	4.91	3.92	2.4	2.58	6.24	2.32	3.45

Table 2 – results form experiment 2



Graph 2 – Graph of shear force for experiment 2 condition 3.

Discussion
By looking at table 1 with reference to graph 1 we can conclude that the mechanism measuring the shear force is very accurate as the highest percentage error is only 4.9%. By looking at the graph 1 for the first experiment we can evaluate the experimental gradient of the line which is 0.36. Looking at it theoretically and by looking at equation 1 the gradient will give the ratio of a to L. Theoretically this gives a value of 0.364, the error here is very small and probably insignificant being the only error could be that the weights did wobble during the experiment and this caused the shear force given by the mechanism to fluctuate slightly.

The percentage error for the second experiment is much higher with a highest value of 12%, this could be because there were more masses thus the swinging causes a greater percentage error. The mechanism measuring the shear forces only gave it to one decimal place this means the shear forces given by the mechanism were not very precise and thus the calculations using them may not be accurate.

Conclusion
I conclude that the shear force increases with the moments around a pivot, so if a mass is further away from the pivot the shear force on the cut will be greater. I also conclude that the shear force only depends upon one side of the cut.

References

Birmingham, U. o. (2016). *Shear force in a simply supported beam.* Birmingham: School of engineering.

Appendix

Using equation 1 to calculate the theoretical shear force in the first experiment.

Shear force = (W.a)/L
Shear force = (0.981 x 0.16)/0.44
Shear force = 0.36 N

Using equation 5 to calculate the moments around R_a.

Moments around R_a = W x a
Moments around R_a = 3.92 x 0.14
Moments around R_a = 0.5488 NM

Using equation 2 to calculate the force R_b.

R_b = 0.5488 / 0.44
R_b = 1.25 N

Using equation 3 to find R_a.

$R_a = \Sigma W - R_b$
R_a = 3.92 – 1.25
R_a = 2.67 N

Using equation 4 to find the shear force.

Shear force = $R_a - \Sigma W_a$
Shear force = 2.67 – 3.92
Shear force = -1.25 N