Co-Human Equilibrium

Minster

ABSTRACT

This experiment is designed to analyze bending moment of “co-human” structure. The objective of this lab is an understanding the balance mechanism with various building materials and participants. Students will be able to analyze forces and bending moments of the entire structure and also they can calculate maximum stress, center of masses, pressure point, moment diagram, etc. This experiment was successful because bending moments were bigger when the structure had longer moment arm as the formula of momentum. Students also analyzed data and actual calculations and moreover, they analyzed errors.

INTRODUCTION

The purpose of this lab is to design and implement a “co-human” structure and to analyze bending moments of the structure. The objective of this lab is to understand building materials are transmitted through contact with the force platform with two colleagues. Thus, students can measure values to analytically predicted weights and center of pressure, and to evaluate changes in results that occur with a change in positioning. Students create mechanically stable structures that consist of available building materials. Then two colleagues complete student’s co-human structure with assembled and mounted on the force platform in the lab. Students take pictures and analyze the structure for the center of pressure and evaluate changes in results with different positioning. In normal living environments, human bodies are exposed to momentum balance, for example, walking, holding boxes, exercising, etc. Therefore, it is very important to understand how momentum balance works and students to measure and to evaluate it with data. Students are going to mainly focus on total forces and bending moments with x, y, and z axis. The formula for moment is force times moment arm. There are more detail explanation will be in the method section.

METHOD

The structure has two iron disks (2 pounds per a disk) on each side of the force platform in the middle, on the top of that, a piece of wood along the x-axis in the middle and a board on the top of the disks. After participants tried to make a balance, the student took pictures of all structure include participants. Then the picture shows how participants made balance with their bodies and provides overall image information. All measurement in length is done by a tape ruler, weights of disks are written on them.

At the beginning, the student designed a structure with bigger disks (5 pounds per a disk). However, the shape of the bigger disk is not flat at the top, so that it causes an unsafe structure. Therefore, the students changed to smaller disks which have flat tops. Two participants were standing on the board with only one foot. Thus, it causes unpredicted movements with x, y, and z axis.

The uniqueness of the structure is having another piece of wood on the top of disks which is different size from the board. Most students have two bases and a board but this structure has three parts. The student predicted that adding a piece of wood would cause different pressure point for different center of mass than common structure.

Participants: Tim (196 pounds), Heesup (144 pounds)
Shoe size: Tim (width: 4 inches, length: 11 ¾ inches), Heesup (width: 4 inches, length: 11 1/2inches)
Board: 96.25 inches X 9.25 inches
Disks: 5 inches of diameter, 2 pounds
Wood: 47.5 inches X 3.5 inches

Please see the attachments for detailed diagram and pictures.

Please see the attachment for calculating moments, forces, pressure point, center of mass, etc.

RESULT

	Predicted values (Calculation) #1, #2	Results from Experiment#1	Results from Experiment#2
Mx (Total momentum in x axis)	0 lb inch	-35 lb inch	-10 lb inch
My(Total momentum in y axis)	0 lb inch	-90 lb inch	-5 lb inch
Mz(Total momentum in z axis)	0 lb inch	0	0.3 lb inch
Fx (Total force in x axis)	0 lb	0 lb	0 lb
Fy (Total force in y axis)	0 lb	0 lb	2 lb
Fz (Total force in z axis)	0 lb	273.8 lb	331.4 lb

	Predicted values (Calculation) #1	Predicted values (Calculation) #2	Results from Experiment#1	Results from Experiment#2
r(cx)	-0.056 inche	-0.668 inch	-0.1 inch	-0.029 inch
r(cy)	0 inch	0 inch	-0.265 inch	-0.0147 inch
r(cz)	0 inch	0 inch	0 inch	-8.8 X 10^-4 inch

	Predicted values (Calculation) #1	Predicted values (Calculation) #2	Results from Experiment#1	Results from Experiment#2
σ(max)	4500 lb/inch^2	3924 lb/inch^2	70.35 lb/inch^2	66.7 lb/inch^2
h(tension)	0.308 inch	0.301 inch	0 inch	-0.008 inch
h(compression)	-0.308 inch	-0.301 inch	0 inch	-0.008 inch

Safety factor = σ(max) Estimated value / σ(max) actual value

Safety factor (experiment #1) = 4500lb/inch^2/70.35lb/inch^2 = 63.97
Safety factor (experiment #2) = 3924lb/inch^2/66.7lb/inch^2 = 58.83

DISCUSSION

This structure has a piece of wood and a board, which have different masses, dimensions, shapes, materials, etc. However, when the student evaluates results, a piece of wood and a board are one system. Also student assumed participants and disks are point masses. During the lab performance, participants moved with x, y, z axis to balance their bodies. However, in the calculation and the analysis of results, the student assumed that there is no such a movement during "co-human equilibrium" is developing. Finally, the student made an assumption that weights of participants are acting on the exact middle of their feet. Analysis also needs to consider human errors, measurement errors, and other various factors. Therefore there is about plus and minus 10% of variation of estimated values.

Waxed forced platform created a lot of movement of disks which can effect movement of participants, board, and a wood. Also, the piece of wood and the board are not one object but the student treated as one system. Students collected data for only 30 seconds which is not enough time to balance the system and measure forces and moments. First data do not have a lot of information because about 15 seconds participants were not on the board. This can give off set of average momentum of x, y, and z axis. Strangely, the second experiment shows more weight of participants than the first experiment even though the condition was not changed. This can be in the variation range of the platform's performance.

Factor of safety is the actual stress over the estimated stress. The safety factors of both experiments are huge with over 55. This result shows that the structure was very safe. Also the student estimated that the maximum tension and compression occurs on the top and the bottom of the board. However, actual calculation shows very little number of heights that tension and compression of the board occurred.

In this experiment, the structure is the static equilibrium. All summation of force and summation momentum should be zero with theories. The formula of momentum is force times moment arm. Thus, if the structure has longer moment arm, then there is

greater moment occurs. In the results, the second experiment showed less bending momentum which exactly supports the prediction from the theory. Because the second experiment had shorter distances from middle of the board to each participant. However, in theory, weight should not be changed unless gravity changed. Nevertheless, the result shows different weight of participants which can be an error from the platform. Also because of the less bending moment, participants were more stable than the first experiment according to print outs. The first experiment shows a lot of vibrations during participants try to be balanced. The second experiment shows fewer vibrations during participants try to be balanced.

CONCLUSION

The lab was successful because students understood the objectives of this lab and the results support theories of static mechanism. Even though there is an error which shows different weight of experiment #1 and #2, the bending moment is less when the structure has shorter moment arm. Safety factor of both experiment #1 and #2 showed more than 55 which explains the structure was safe. The maximum stress of the board was bigger when the structure has greater bending moment. Center of pressure also show the maximum difference of 0.5 inch in one dimension.

There are not many different selection of building materials which did not provide various structure forms. The platform was waxed which can create a lot of vibration of the structure. That might effect the bending moment of x, y, and z- axis. Also students could not measure the center of pressure while participants are balancing. Students never know where participants put more weight on their feet.

In the further experiment, the student wants to test what happen with participants are balancing with both feet. The prediction is that will not show much differences from balancing with one foot.