Structural integrity investigation of PV solar trackers support structure

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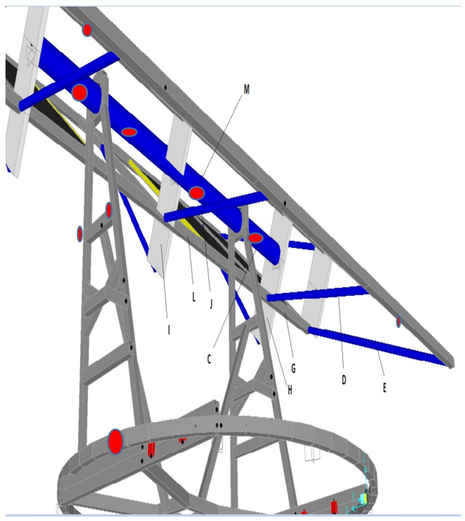
Introduction

The Photovoltaic (PV) solar trackers are very efficient in collecting the solar energy due to their ability to rotate and tilt so that the solar radiation exposure is maximized. This mobility, however, makes the PV solar trackers more vulnerable to wind effect compared to standard arrays of PV solar panels. The main objective of this project is performing an experiment on one of the frames which was supporting the PV solar tracker on the Mann Parking building, interpreting the experimental data obtained from the PV solar tracker, and establishing a conversion between the strain measurements and the corresponding forces applied on this structure.

Experimental Program

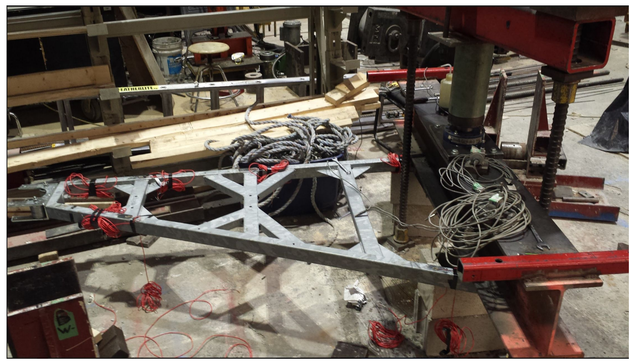
The experimental program was divided in three parts. The first part was the preparation of the experiment: the strain gauges were installed on the frame, following the layout of the site experiment performed on the PV solar tracker; the frame was tested under different loading scenarios, simulated in the laboratory by inducing certain displacements at the top of the frame. The second part was to perform the test and take measurements of the frame deformation, under different testing conditions. Finally, the third part consisted of gathering the measured data and converting the electric signal to strain.



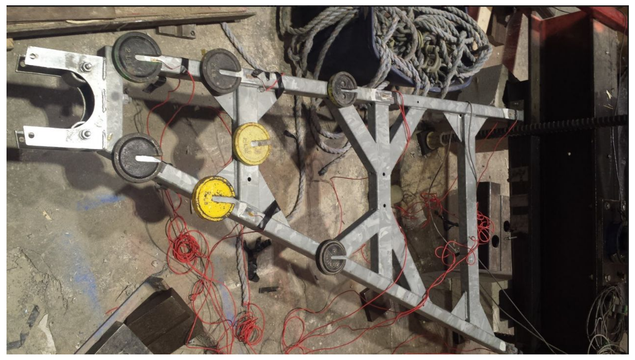
Frame Setup:

The setup consisted of the frame we needed to study, screwed on a metal bar that was supported upwards. The strain gauges were set up in the same location as the first experiment on the Mann Parking building.

The placement of the strain gauges. Four strain gages in each leg, on the top and bottom.



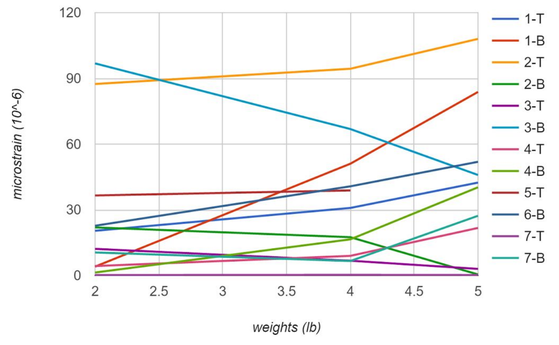
Photograph of Frame setup:
Four holes on a steel bar were drilled to fit the frame. That steel bar was then supported upwards.

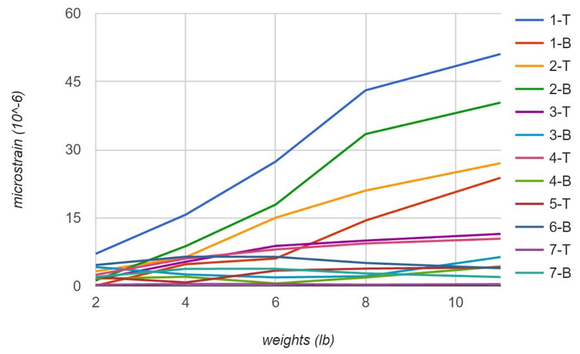


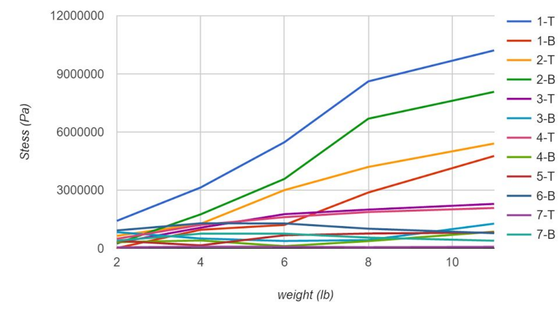
Uniform placement of weights.
The first test consisted of placing the weights in two locations: on the top of each leg.
The second test consisted of placing three weights on each leg and one in between.
Putting the weights on the frame instead of hanging them slightly reduces final data errors.

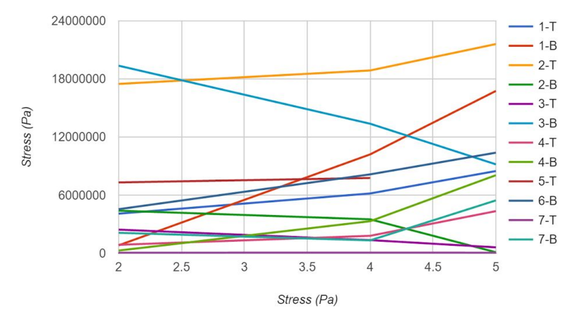
Data Analysis and Comparison

1-T signifies the strain gauge at the top of position 1, and 1-B the strain gauge on the bottom of position 1. The odd numbered positions are the strain gauges on the angled leg, while the even numbered positions are the ones on the straight leg, both ascending from the bottom to the top.









The strain was converted to stress using Hooke's law, with the, Young's modulus of elasticity E= 200GPa for the frame's steel.

$$\sigma = E\varepsilon$$

Strain Gauges	1	2	3	4	5	6	7	8
Average strain (Pa)	7.78E+07	7.73E+07	7.72E+07	7.71E+07	7.69E+07	7.69E+07	2.65E+07	2.64E+07

Comparing the average stress for each sensor of the first experiment on the Mann Parking building, and our own results, it can be deduced that the effect of wind is approximate to a uniformly distributed weight of barely 2 lbs if both magnitudes are analysed.

Conclusion

In conclusion, during this experiment, we simulated the effect of wind on a frame that supported a PV solar panel, by measuring the strain in multiple positions of the frame, while uniformly distributing different weight values. Despite two non-functioning strain gauges, the strain data was collected for the support frame and a comparison with the experimental results obtained from the solar tracker installed on the Mann Parking building roof was performed. It could be concluded that for the critical cases, the wind-induced load on the support frame is equivalent to a weight of around 2 lbs.
However, in the laboratory, the wind direction and the wind gust could not be simulated for the investigated frame. Therefore, dynamic wind loading should also be simulated in the laboratory for a better comparison with the experimental results.