BANANA CRANE

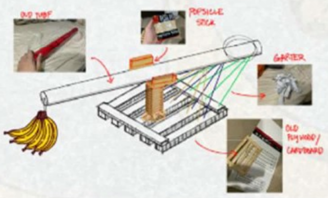
DESIGN CONCEPT BALANCE + FORM

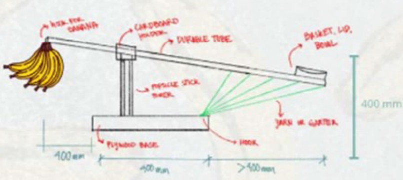
The final project for Ar171 calls us to design and construct a rather unconventional banana stand, capable of carrying at least **5 bananas**. The stand's peculiarity lies in the design parameters given: the loading point of the bananas shall be **cantilevered** at **height of 400mm** from the base, and **400mm horizontally** from a reference foot print not exceeding **400mm x 400mm**.

Due to its cantilevered design, the banana stand has to embody a strong sense of **stability, structural integrity,** and **balance**. Additionally, it was logical to reference real-world objects that fit the criteria for these parameters as design precedents.

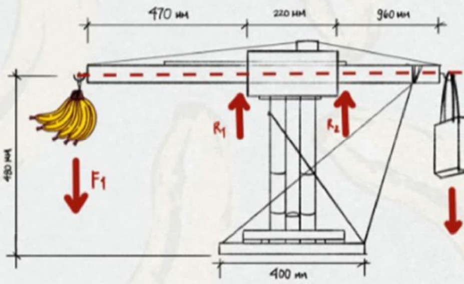
I discovered that the a **tower crane** used in construction follows the most optimal form factor for this project, given its innate cantilevered design in how it carries heavy loads. Along with this, properties of a **weighing scale** can also be incorporated in order to balance heavier loads to be applied later on. Through the primary concept of **balance**, the economical design of the **"banana crane"** integrates a variety of structural theories and techniques that aim to help support its loads in the most efficient and effective way possible.

PRELIMINARY SCHEMATIC DESIGN





FINAL SCHEMATIC ELEVATION DIMENSIONS



FINAL BANANA CRANE FEATURES

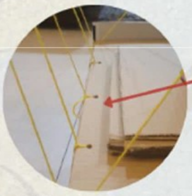
HOLLOW BOX ATTACHED TO DOUBLE MAST SUPPORTS

2ND LAYER OF ELEVATED CARDBOARD BASE FOR "FOUNDATIONAL" SUPPORT

HOOK FOR COUNTER-WEIGHT

HOOK FOR BANANA

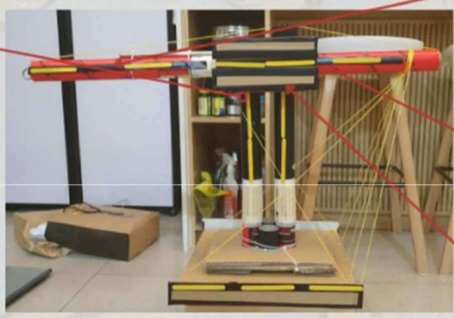
HOOKS AS AREAS FOR LOAD APPLICATION ATTATCHED TO BOTH ENDS OF CANTELIEVERED TUBE



STRINGS TIED TO BASE ACTING AS TENSION CHORDS ATTACHED TO COUNTERWIEIGHT SIDE OF CRANE SYSTEM

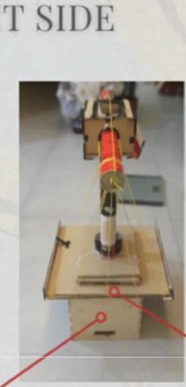
ELEVATIONS

FRONT



RIGHT SIDE

LEFT SIDE



REAR

WOODEN BASKET USED ONLY AS ADDT'L ELEVATION

LEGEND:

1. 1st Base Layer
2. 2nd Base Layer (Elevated)
3. Strings (6 total) attached to base and cantilevered tube
4. Vertical carboard tubes acting as double mast support ziptied with 2 additional 1/6 tubes as footing
5. Hollow cardboard box attached to double mast support
6. Cantilevered tube w/ metal hooks on both ends
7. Black cardboard box with string attached to both hooks (aesthetic design)
8. Stainless steel pipe zip-tied to cantilevered tube

CANTELIEVERED CARDBOARD TUBE WITH ZIP-TIED STAINLESS STEEL PIPE REINFORCEMENT

OTHER END OF STAINLESS STEEL PIPE REINFORCEMENT

CANTELIEVERED CARDBOARD TUBE THOUGH HOLLOW BOX

HOLLOW CARDBOARD BOX ACTING AS ATTACHMENT FOR VERTICAL DOUBLE MAST SUPPORT

DOUBLE LAYERED, CORRUGATED CARDBOARD ELEVATED BASE AND "FOUNDATION" FOR DOUBLE MAST SYSTEM

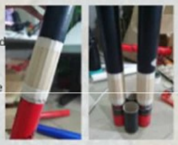
MATERIALS & PROCEDURE

1 Step 1: Attach 2 cardboard tubes together with masking tape. This will act as your cantilevered beam. Then, glue and tape together large popsicle sticks around the taped area for further reinforcement.

2 Step 2: For the hollow box attachment, cut out circle holes on both ends of the box. This is where the tube will be inserted.

3 Step 3: For each vertical mast support, attach 4 popsicle sticks within the interior (near its opening) for more reinforcement. Stuff the opening with crumpled paper to further secure the sticks in place.

4 Step 4: Use the excess tube covers from the first cardboard tube pair and tape them to the ends of each vertical mast support. Then, glue and tape together large popsicle sticks around the taped area for further reinforcement. Using zip-ties, secure the last pair of excess tube covers together at the base. These will create more surface area for better and easier base attachment.



5 Step 5: Cut out five 400mmx400mm cardboard squares. Stacking and gluing these together creates the first base layer. Then, cut out 5 300mmx220mm cardboard rectangles. Stacking and gluing these together creates the second base layer. Afterwards, trace and cut out the outline of the mast footing from each cardboard square/rectangle.

6 Step 6: Cut and stack 4 piles of the rectangular pieces of layered cardboard. These will act as the pedestals. Glue them together and attach each pile to the underside corners of the second base layer.

7 Step 7: Glue the second base layer with attached pedestals onto the 1st base layer, making sure to line up the mast support cut-out outlines together.

8 Step 8: To secure the two mast supports, cut two cardboard rectangles and two circles from them. Afterwards, layer them on top of each other and fit the 2 ends of the mast through the holes.

9 Step 9: Hammer a hole through each metal end of the tube being used as the cantilevered beam. Then, screw a metal hook on each of the holes.

10 Step 10: Glue a flat solid piece of cardboard on top of the cardboard layer from Step 9. Then, glue the hollow box onto the newly attached cardboard piece. Slide the cantilever tube into the holes of the hollow box.

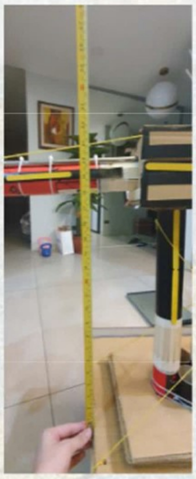
11 Step 11: Attach strings from the base to the counterweight-end of the cantilever tube. Then, attach the stainless steel pipe on top of the tube and secure it in place with zip-ties (these will also prevent the tube sliding off)

12 Step 12: Continue detailing the banana crane by using extra pieces of yellow yarn, popsicle sticks, cardboard, and electric tape for further securing the pieces together, as well as for aesthetic purposes.

13 Step 13: Finish the project by moving on to Load Testing.

LOAD TESTING RESULTS & OBSERVATIONS

1 SUPPORTING ONE HAND OF BANANAS



BANANA CRANE PROTOTYPE

ONE HAND OF BANANAS (6 PCS.)

PAPER COUNTER WEIGHT

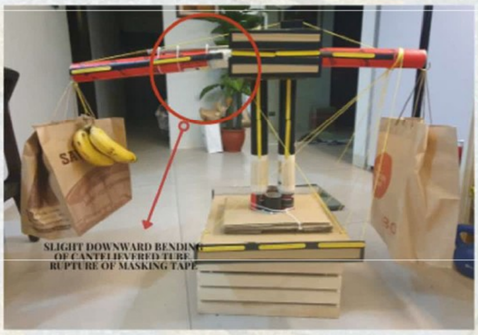
		Weight of Load (lbs)
	Prototye	3.2
Left-side Load	Hand of Bananas	1
Right-side Load	Paper Counterwight	0.8
	Total Weight carried by Prototype	1.8

Current Structural Efficency (Total Weight carried by Prototype / Weight of Prototype x 100%)	56.25%

OBSERVATIONS & NOTES

- Weights were measured using digital weighing scale
- Prototype was able to easily carry 6 bananas with paper counterweight
- No major deformations in the prototype
- Tension strings not under major stress due to paper counter-weight
- Overall stable and balanced system

2 WEIGHT OF INITIAL DEFORMATION & RUPTURE



SLIGHT DOWNWARD BENDING OF CANTILEVERED TUBE
RUPTURE OF MASKING TAPE

TAPE RUPTURE

ADDT'L LEFT-SIDE WEIGHT

ADDT'L RIGHT-SIDE WEIGHT

		Weight of Load (lbs)
	Prototype	3.2
Left-side Load	Hand of Bananas + Pink Jug + Bottle	1
Right-side Load	5lbs Weight	4.2
	Total Weight carried by Prototype	5.3

Current Structural Efficency (Total Weight carried by Prototype / Weight of Prototype x 100%)	165.63%

OBSERVATIONS & NOTES

- Additional weights were added on both sides of the prototype
- All water jugs used as weights were filled with water
- Paper bags were used to hold the weights
- Slight bending deformation was observed on the left side of the cantilevered tube
- Rupture of the masking tape holding the popsickle sticks of the cantilievered tube is visible
- Overall the prototype was still stable

3 WEIGHT OF PROTOTYPE COLLAPSE

FINAL STABLE POSITION MOMENTS BEFORE COLLAPSE

REAR OF MAST SUPPORTS

ALL OBJECTS USED AS WEIGHTS

		Weight of Load (lbs)
	Prototye	3.2
Left-side Load	-5 Coke Swakto Bottles -5 lbs. weight -10 lbs. weight -Zim Cleaner Spray Bottle -1 Absolute Bottle -1 Blue Water Jug -2 C2 bottles -1 Calamansi Juice Bottle	23
Right-side Load	-1 Hand of Bananas -7 Coke Swakto Bottles -2 Real Leaft Bottles -1 Pink Jug -1 Light Blue Jug -1 Gray Jug -1 Mr. Muscle -1 Lysel Spray Bottle	16.8
	Total Weight carried by Prototype	39.8

Final Structural Efficency (Maximum Weight carried by Prototype / Weight of Prototype x 100%)
1243.75%

OBSERVATIONS & NOTES

- Additional weights were added on both sides of the prototype
- All water jugs used as weights were filled with water
- Significant bending deformation was observed on both sides of the cantilevered tube
- Metal hooks on both sides were significantly bent
- Vertical Mast supports were bending significantly
- Structural collapse can be mainly attributed to the rupture of the left vertical mast support. Internal tearing of tape holding together the tube and red tube cover was seen. Because of this, the whole system became unbalanced and leaned more towards the left-side load.

OVERALL OBSERVATIONS

- The Prototype Banana Crane was able to successfully fulfill its goal of carrying a handful of bananas.
- The prototype was able to go beyond what was expected, and was able to carry a maximum weight of 39.8 lbs, which is more than 12 times its own weight!
- Areas where tube ends were attached were the primary points of failure, most often leading to bending deformation as more weights were added to the system.
- The stainless steel pipe and popsicle stick reinforcements played a big role in providing additional support to the cantilevered tube and mast supports
- Zip-ties are very strong and effective in securing and attaching parts together.
- Although the strings contributed to the aesthetic of the crane, they were not able to optimally fulfill their role of providing tensive force to counter the left-side load. This is because the hanging right-side load was more than enough to react to most of the force applied by the right-side load

RECOMMENDATIONS FOR IMPROVEMENT

- Using stronger methods of attachment, such as super glue or duct tape, instead of masking tape to significantly prevent the deformation of tubes and parts used.
- When load testing, use solid objects as weights instead of objects containing liquid, as liquid tends to move.
- If available, use more light stainless steel pipes as internal or external reinforcement bars for the cantilevered tube and double mast support
- Utilize load application systems that are stronger than the metal hooks used, as they bend easily carrying a lot of force