



TAYLOR'S UNIVERSITY

Wisdom • Integrity • Excellence

Building Structures [ARC2523] Project 1

FETTUCCHINE TRUSS BRIDGE

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7.1 First Case : Chia Wei Pin

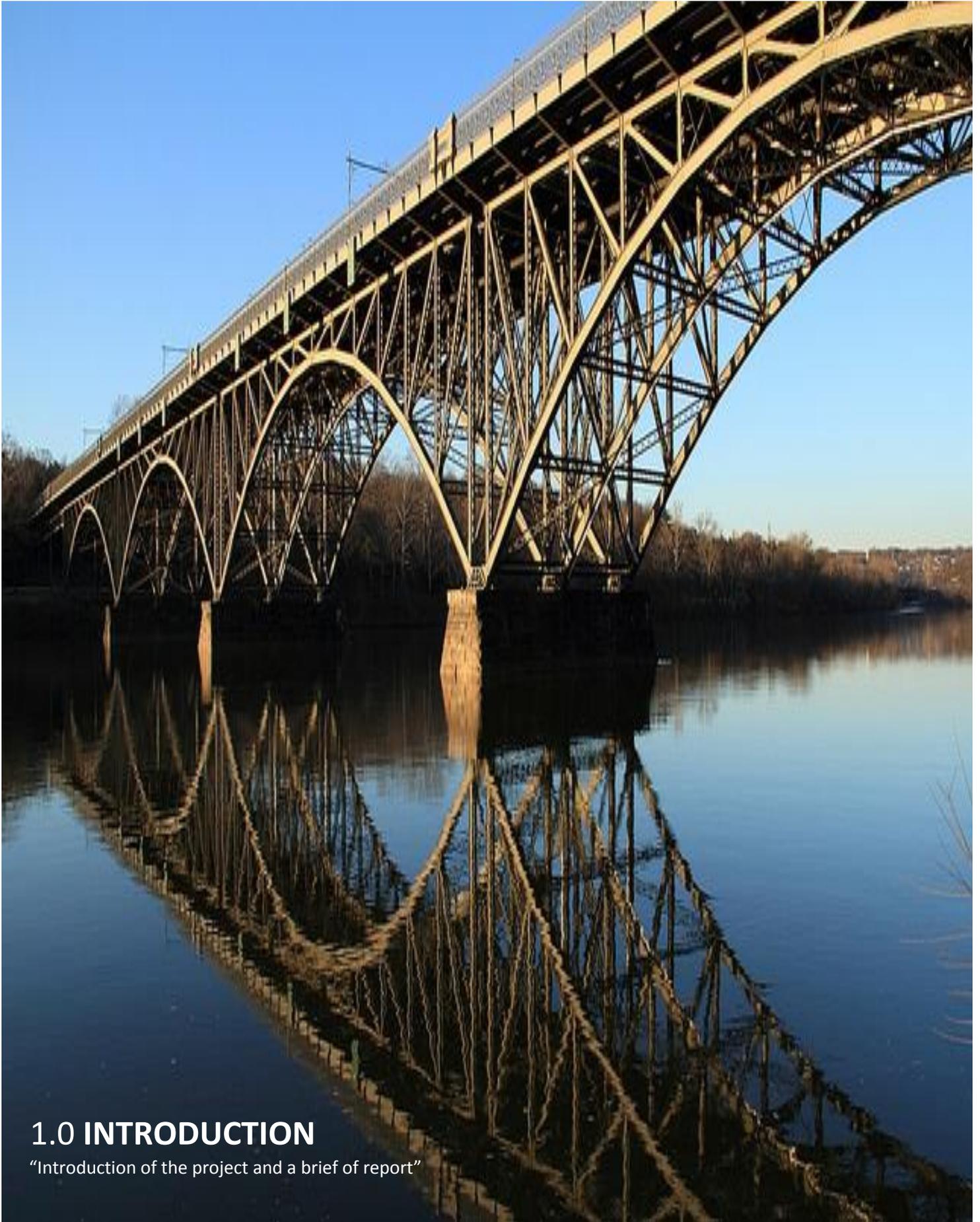
7.2 Second Case : Soh Wei Aun

7.3 Third Case : Yii Hong Gin

7.4 Fourth Case : Kee Yu Xuan

7.5 Fifth Case : Tommy Tan

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1.0 INTRODUCTION

“Introduction of the project and a brief of report”

1.0 Introduction

1.1 General purpose of study

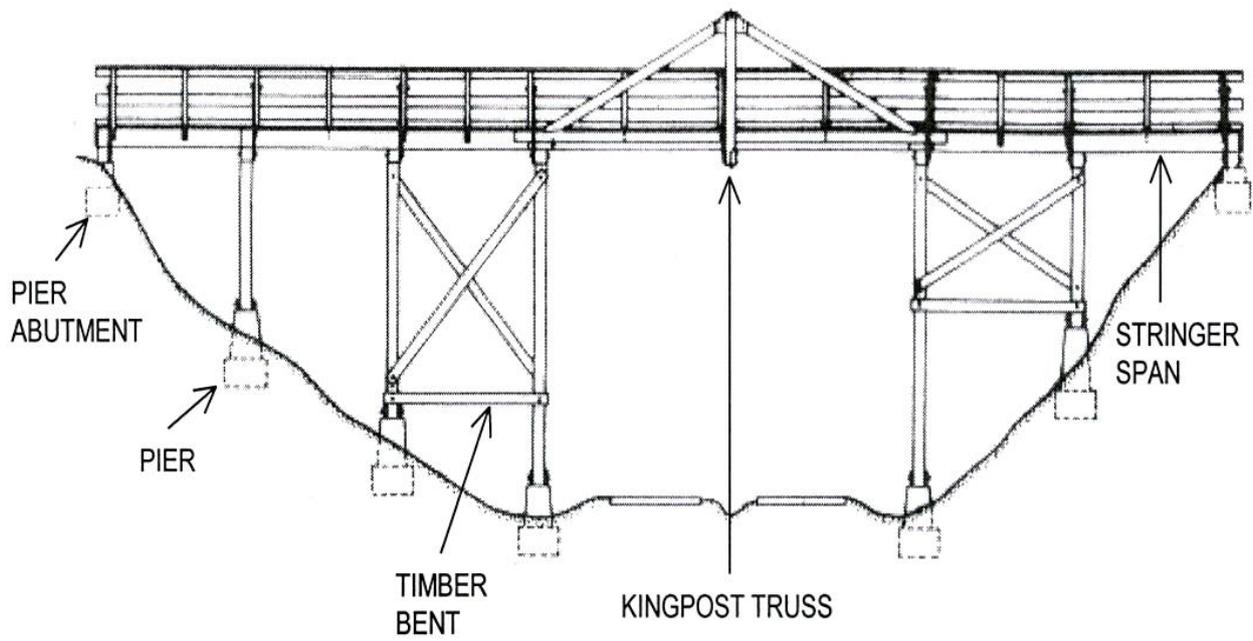
This project's aim is to develop our understanding of **tension** and **compressive** strength of construction materials. Through designing a perfect truss bridge, we explore truss members in different arrangements as well as apply the understanding of load distribution in a truss system. Besides, we're able to identify tension and compression members in a truss through performing structural analysis of the bridge.

1.2 Report preview

In a group of 5, we're required to construct a **truss bridge** of **750mm clear span and maximum weight of 200g** by using **fettuccine** as material. This report is a compilation of our understanding and analysis based on precedent studies conducted, construction materials and the design of our truss bridge.

2.0 METHODOLOGY

“Ways to do our model”



2.0 Methodology

Upon completing this project, the following methods are carried out:

- **Precedent Study**

To have better understanding of a truss bridge- connections and arrangements of members and truss type are focus on. Based on our precedent study, we adopted desire features into our bridge design.

- **Material and Adhesive Strength Testing**

Before we construct the bridge, we test all the materials used to find out its physical properties. These attributes are taken into consideration when designing our bridge.

- **Model Making**

Researches and sketches are done at the beginning of the design process. Once we decided our design, we generate it on AutoCAD with scale of 1 to 1. We then construct our bridge based on the CAD drawings.

- **Structural Analysis**

Throughout our whole making and design process, we analyse our bridge not only in terms of efficiency but also identifying each members to find out whether they are in compression or tension. Same method applied as the truss analysis exercise given by our lecturer.



3.0 PRECEDENT STUDY

“Reality bridge to study before designing”

3.0 Precedent Study

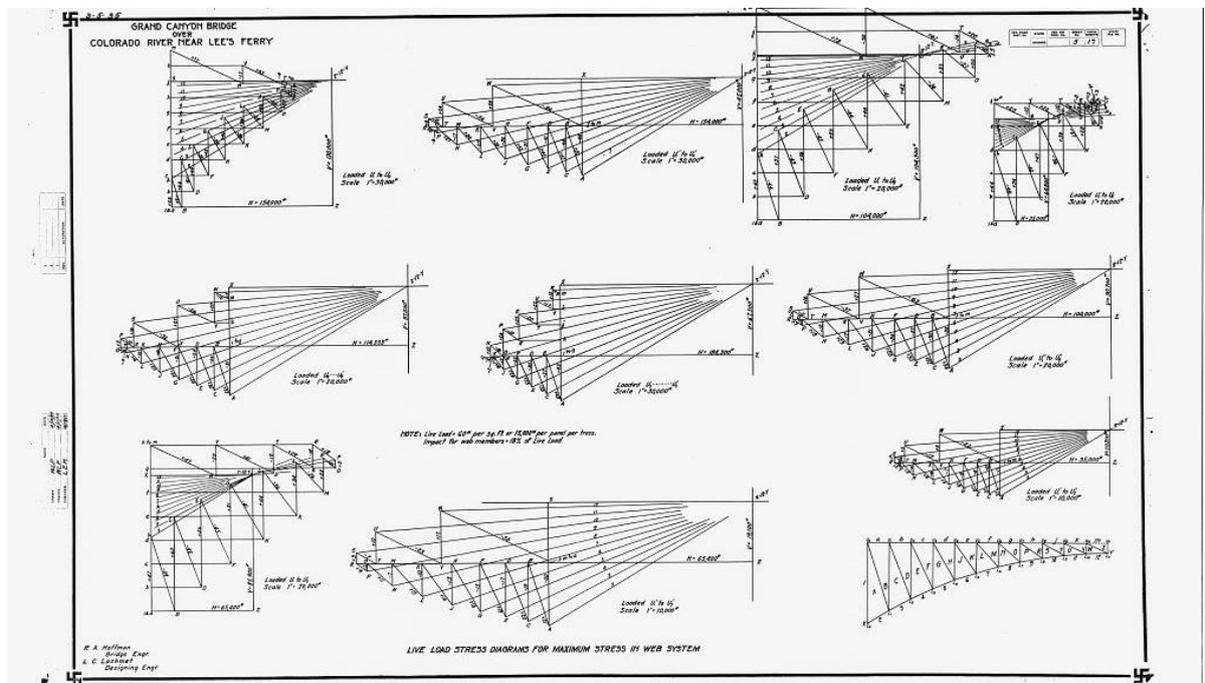
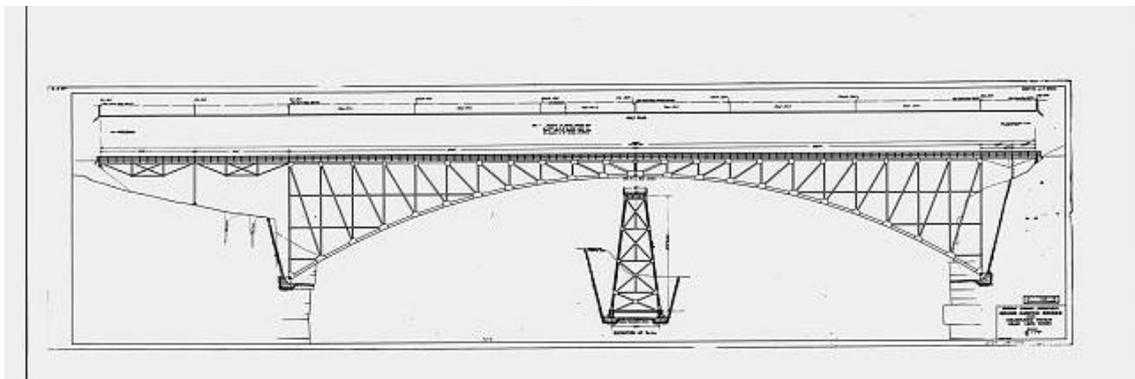
Navajo Bridge (1929)



The Navajo bridge, located at USA crosses the Colorado River's Marble Canyon. The bridge was built in 1927, and the bridge opened to traffic in 1929. The Steel spandrel bridge design was constructed by the Kansas City Structural Steel Company. The Bridge is 834 feet (254m) length, with a maximum height of 467 feet (142m) for canyon floor. The load capacity of the bridge is around 22.5 tons. In 1990, as automobiles and trucks became larger, wider, and heavier, the need for a stronger, and that a new solution was needed. A new bridge would be built immediately next to the original and have a similar design and structure appearance, but would conform to modern highway codes. As for the existing bridge has become pedestrian and equestrian use, and an interpretive centre has been constructed nearby to showcase the historical nature of the bridge.

Bridge Facts and Figures

Navajo Bridge	Historic Bridge	Modern Bridge
Total Length	834 feet (254 m)	909 feet (277 m)
Steel Arch Length	616 feet (188 m)	726 feet (221 m)
Arch Rise	90 feet (27.4 m)	90 feet (27.4 m)
Height Above River	467 feet (142 m)	470 feet (143 m)
Width of Roadway	18 feet (5.5 m)	44 feet (13.4 m)
Amount of Steel	2.4 million pounds (1.1 million kg)	3.9 million pounds (1.8 million kg)
Amount of Concrete	500 cubic yards (385 cubic m)	1790 cubic yards (1370 cubic m)
Steel Reinforcement	82,000 pounds (37,000 kg)	434,000 pounds (197,000 kg)
Construction Cost	\$390,000	\$14,700,000

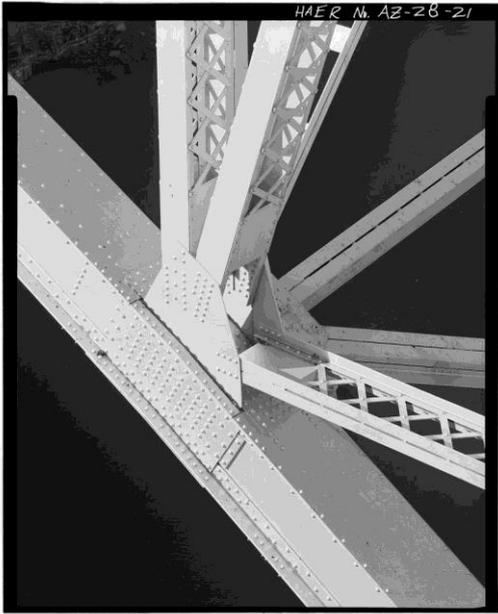


The Structure drawing of Navajo Bridge

Truss Connection and Member



Connections of truss web and Bottom chord connections



Detail of Lower chord connection on arch



Detail of Lateral connection on arch

4.0 EQUIPMENT INFO & MATERIALS ANALYSIS

“Analysing equipment & materials before we start our work as they’re important for model making ”



4.0 Equipment Info and Materials Analysis

4.1 Equipment Info

No.	Equipment and Materials	Description
1.	Fettuccine 	Main material to build the bridge. We differentiate those flats and deforms pieces before we used to ensure our work go efficiently.
2.	S Hook 	It is used to connect the bridge to the load (Plastic bags) at the centre of the bridge.
3.	Water Bucket 	It is used to test the strength of our bridge by filling up with water.
4.	3-second Super Glue 	To stick the fettuccine together. The reason we chose it rather than the other types of super glue is because it has higher adhesive strength.
5.	Electronic Balance 	To measure the weight of our materials as well as equipment used for weighing our bridge to ensure it does not exceed the allowed weight.
6.	Camera 	It is used to record all the testing progress and evidence.

4.2 Materials Analysis



San Remo Fettuccine



Kimball Fettuccine



Barilla Fettuccine

4.2.1 Types and strength of fettuccine

As stated in brief, fettuccine is the only material used for the model. Hence, different brands of fettuccine were studied and tested in order to find out which brand of fettuccine can withstand the highest amount of load acting on it.

To test the strength of fettuccine, we stick 4 layers of the same type of fettuccine instead of 1 layer itself in order to hold heavier load for more obvious result.

Results:

Types of fettuccine	Total load withstand (g)	Description(s)
San Remo Fettuccine (Chosen)	1508	<ul style="list-style-type: none"> - Carried most weight - Medium flexibility Medium rough surface
Kimball Fettuccine	1123	<ul style="list-style-type: none"> - Carried medium weight - Medium flexibility - Thinner surface
Barilla Fettuccine	1002	<ul style="list-style-type: none"> - Carried less weight - Very flexible - Lightest fettuccine



V-tech 502 Super Glue



UHU Ultra-fast Super Glue



Paper Mate Super Glue

4.2.2 Types and adhesion of super glue

Before testing the adhesion strength of the glue, we have do some research and know that only super glue works in sticking fettuccine for long term. Thus, we bought different brands of super glue to analyse their adhesive forces.

To test the adhesive force of super glue, we stick 4 layers of chosen fettuccine (San Remo's) by using different types of super glue and find out which of it can withstand higher load.

Results:

Types of super glue	Total load withstand (g)	Description(s)
V-tech 502 Super Glue (Chosen)	802	<ul style="list-style-type: none">- Highest efficiency- Dries the fastest
UHU Ultra-fast Super Glue	764	<ul style="list-style-type: none">- Moderate efficiency- Longer solidify time
Paper Mate Super Glue	758	<ul style="list-style-type: none">- Low efficiency- Longer solidify time

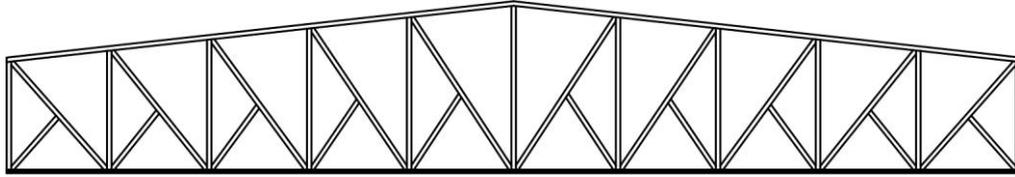
5.0 BRIDGE ANALYSIS

“A few mock up structure done to be analysed for our final bridge construction”



5.0 Bridge Analysis

5.1 BRIDGE TEST ONE



DETAILS OF BRIDGE

Height: 500mm

Width: 50mm

Length: 1000mm

Weight: 125g

Maximum Load: 520g

Efficiency: 3.38

Type of truss: Imperfect Truss

FAILURE ANALYSIS

Misinterpretation of compression and tension members

The structure failed by twisted due to wrong placement of compression members. There are too much compression members (X-bracings) at the bottom part of the bridge which are useless to support the structure while tension members are not enough to support the load.

Height of the structure

The structure is too high that it's not efficient enough to overcome the torsion force which also result in twisting of the structure.

IMPROVEMENT

We removed the X-bracing members at the bottom of the structure and also reduce the height of the bridge. However, we applied the same design which we design our bridge in a pyramidal form structure as it's harder to be toppled in compare to a squarish structure.

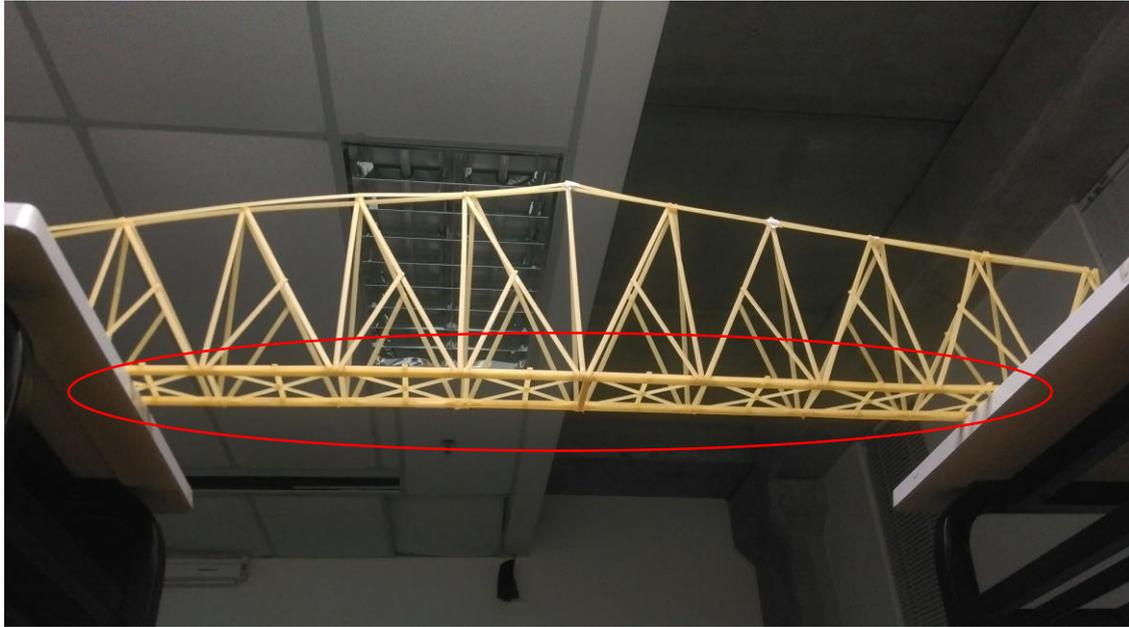


Figure 6.1 First Mock up Bridge

The red circle in the figure showing the bottom bracing we did for our very first bridge. It's not only useless in providing tension plus also reducing the efficiency of the bridge by adding more weight to it. Hence it's not strength enough in holding a heavy load.

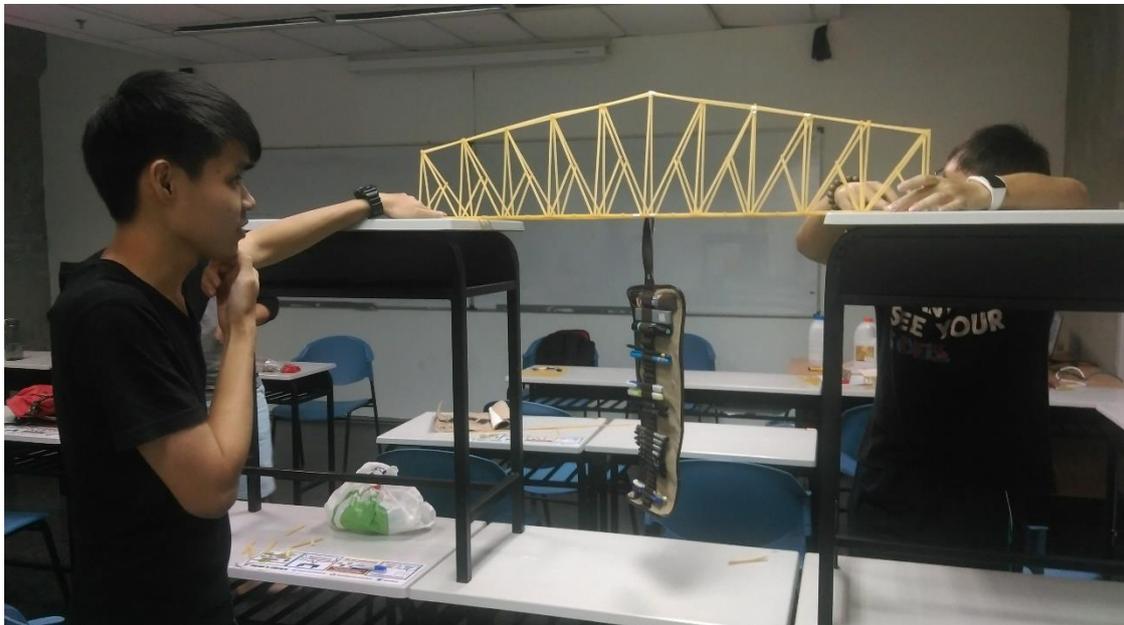
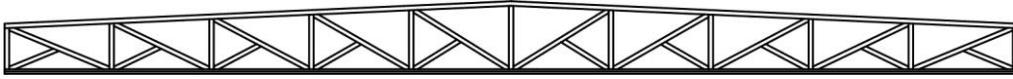


Figure 6.2 Testing of first bridge

We used pencil case instead of water bucket to test the bridge as we knew that it couldn't hold heavy load.

5.2 BRIDGE TEST TWO



DETAILS OF BRIDGE

Height: 866mm

Width: 100mm

Length: 1000mm

Weight: 102g

Maximum Load: 677g

Efficiency: 4.5

Type of truss: Imperfect Truss

FAILURE ANALYSIS

Poor Workmanship

The structure toppled instead of breaking apart due to our poor craftsmanship of structure. Some members protruded out as the glue applied not evenly and most of the members didn't cut perfectly to fit in to their respective place.

Lack of applying Materials

We used the same amount of fettuccine as in the first bridge which result in poor sufficient of both tension and compressive force that cause the bridge to topple easily. (1 member of fettuccine applied for all the bracings while 4 members of fettuccine used in both the main horizontal structure.)

IMPROVEMENT

We apply more materials in each members and we change the design of the main horizontal structure from 4 simple laminated layers of fettuccine to an i-beam shaped which 2 layers of fettuccine covering 3 laminated layers of fettuccine in the middle. Also, we reduced the size of the whole structure as we realized that the smaller the size, the harder the structure. To further improve it, we decided to add in curve design at the bottom of the bridge to strengthen its compressive force and thus making the whole structure to be more stabilize.

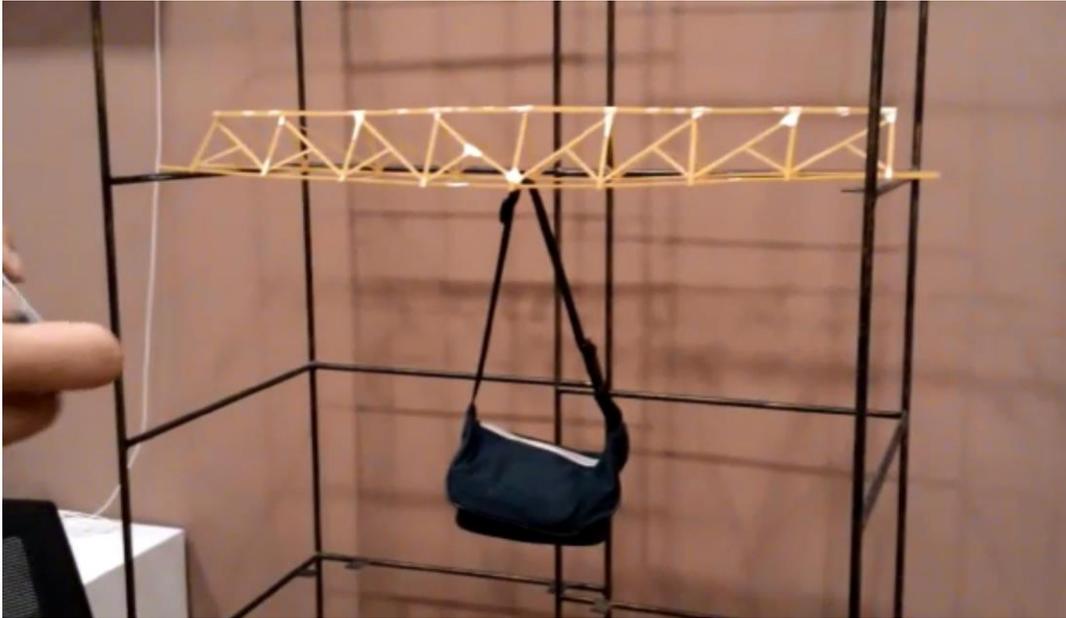


Figure 6.3 Testing of Second Mock up Bridge

Due to some problem, we rush our work and that's how you see our bridge this time is like "scrap metal". In this figure, we're trying to test whether this bridge works better than the previous one or not, and hence we used the maximum load- 520g that the first bridge can handle to start our testing. It works!

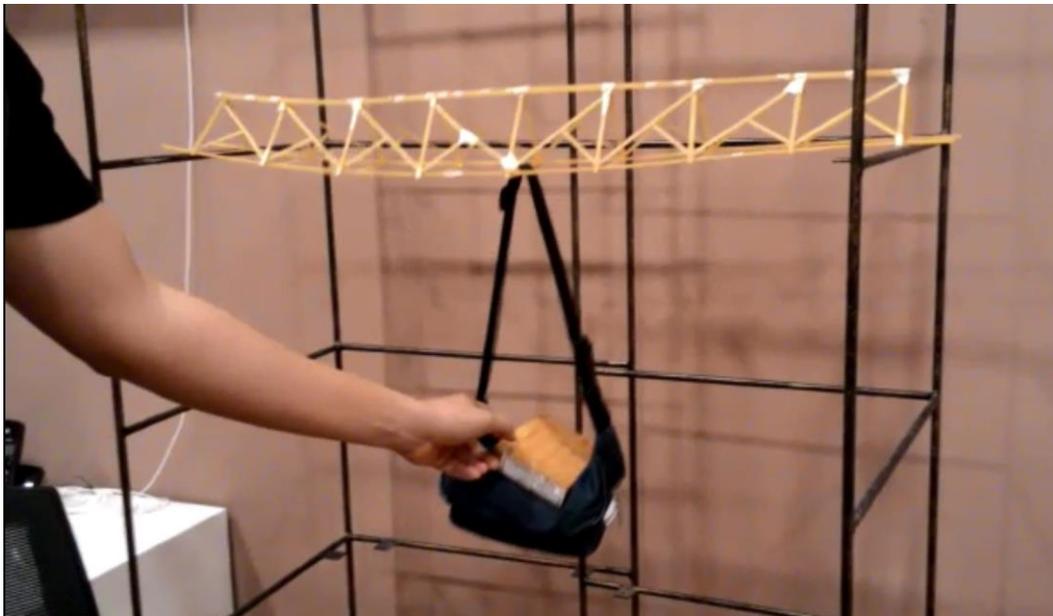
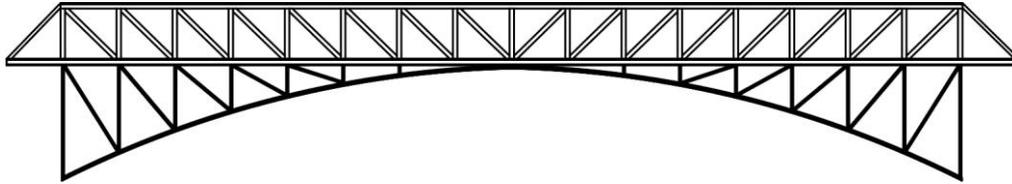


Figure 6.4 Further Test of Second Mock up Bridge

After we add up another load on it, the bridge collapsed due to our poor workmanship.

5.3 BRIDGE TEST THREE



DETAILS OF BRIDGE

Height: 65- 1650mm

Width: 550mm

Length: 1000mm

Weight: 217g

Maximum Load: 3850g

Efficiency: 68.31

Type of truss: Redundant Truss

FAILURE ANALYSIS

Wrong Modelling Skills

After the failure of second design, we add in additional structure to improve the load capacity. But due to wrong modeling method since we first encountered to bend design of modelling with fettuccine, many mistakes made during the process. The main mistake was we paste the bracing member behind the vertical member which is not strong enough to transfer to the vertical forces perfectly.

Wrong Placing of Beam

We decided to hold the whole structure with 2 layers of laminated fettuccine stick at both side of the top corners of the triangles. Nevertheless, this design is not efficient enough to hold the whole structure.

IMPROVEMENT

We change the beam from sticking it both side to just sticking it right on top of the triangles' corner with 2 laminated fettuccine.



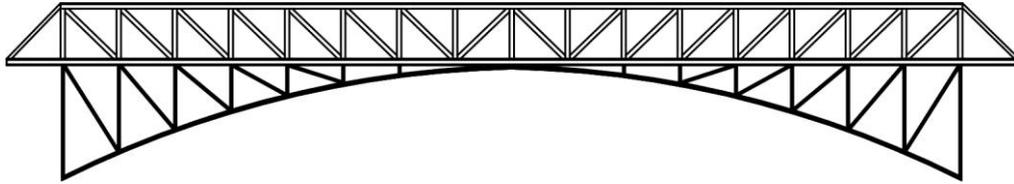
Figure 6.5 Showing the construction of mock up bridge 3

In this stage, we're almost finish by sticking the final part- the beams that stick at both side of the top corner of the triangulars.



Figure 6.6 Mock up bridge 3 Broke

5.4 BRIDGE TEST FOUR



DETAILS OF BRIDGE

Height: 65- 1650mm

Width: 550mm

Length: 1000mm

Weight: 228g

Maximum Load: 3670g

Efficiency: 59.07

Type of truss: Redundant Truss

FAILURE ANALYSIS

Weak of Glue Adhesion

The beam we modified from the previous one is work actually but it fails as one of the members of the beam flick out during testing. The flicked members weaken the stability of the whole structure, making it imbalance and finally the bridge collapsed.

Poor Compression at the Central Part

Besides the beam member, we still noticed that the central part of the bridge is not that firm, which will easily lead to torsion.

IMPROVEMENT

We strengthen the central part of the structure by adding more tension members. We even doubled the layer of the bracings, making it hard to hold heavier load. Plus, we renovated our upper beam by joining both the idea from third and fourth structure, which we now locked the upper corner of all the triangle by sticking the 2 layers fettuccine above it as well as at the both sides of the corner.

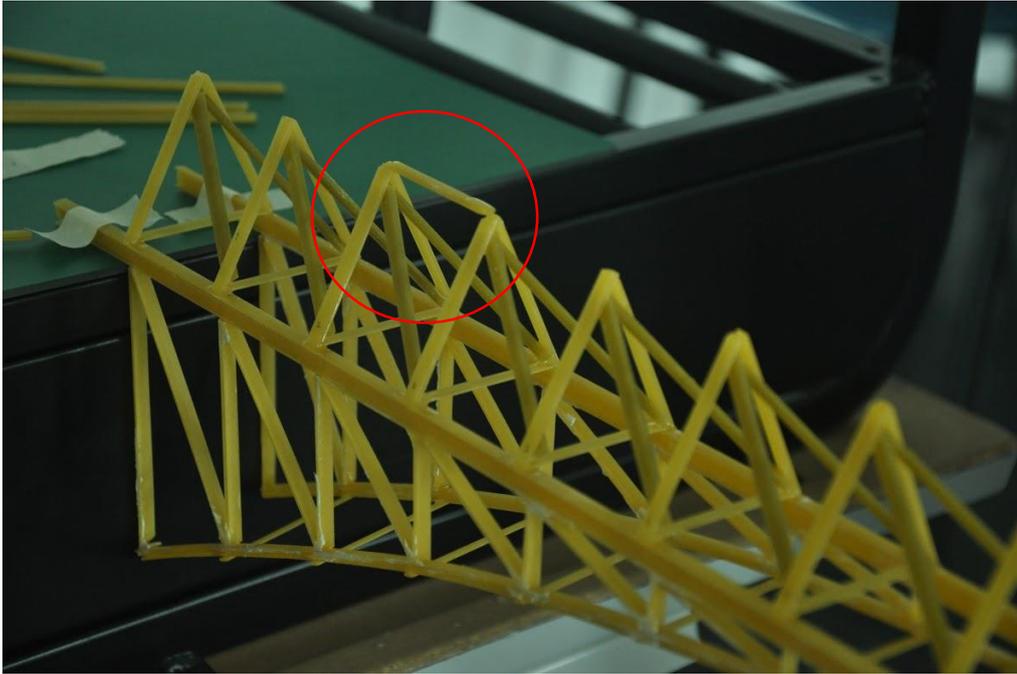


Figure 6.7 Showing the construction details of the structure

From the red circled part can see we joint the triangle together with a fettuccine in between the distance of triangle.

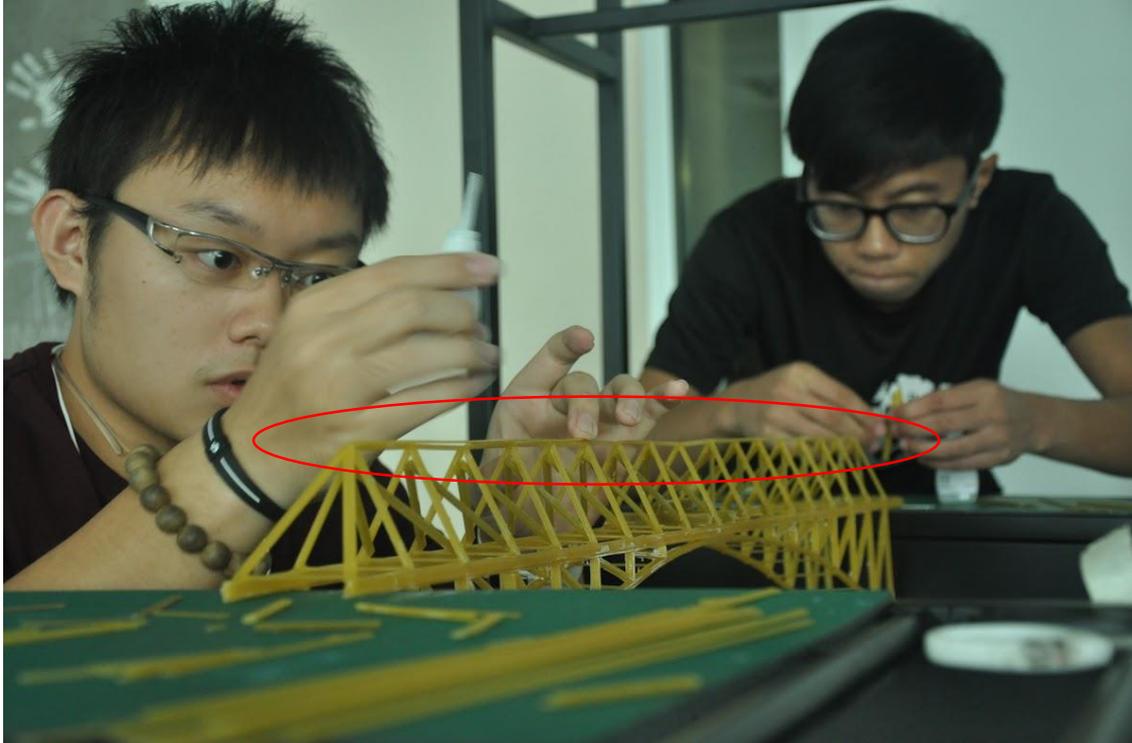
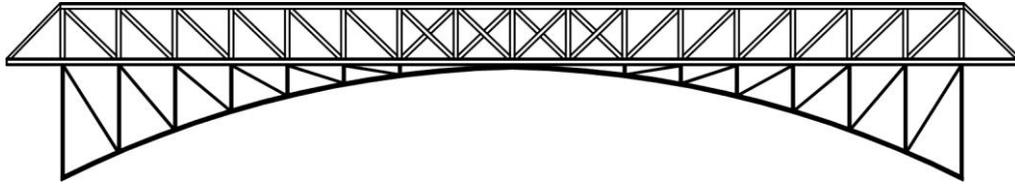


Figure 6.8 Showing the construction details of the structure

From this figure can see we're strengthening the beam by adding one layer of fettuccine again above the fettuccine just now.

5.5 BRIDGE TEST FIVE [FINAL BRIDGE]



DETAILS OF BRIDGE

Height: 65- 1650mm

Width: 550mm

Length: 1000mm

Weight: 223g

Maximum Load: 4650g

Efficiency: 96.96

Type of truss: Redundant Truss

FAILURE ANALYSIS

Weak Central Load Holders

The central H-beam broke although it is modeled in the form of I-beam. Meanwhile, bridge structure remain stable and unchanged.

IMPROVEMENT for future development

Strengthen the central H beam in order to have provide ample time for carrying load before the whole structure collapse.

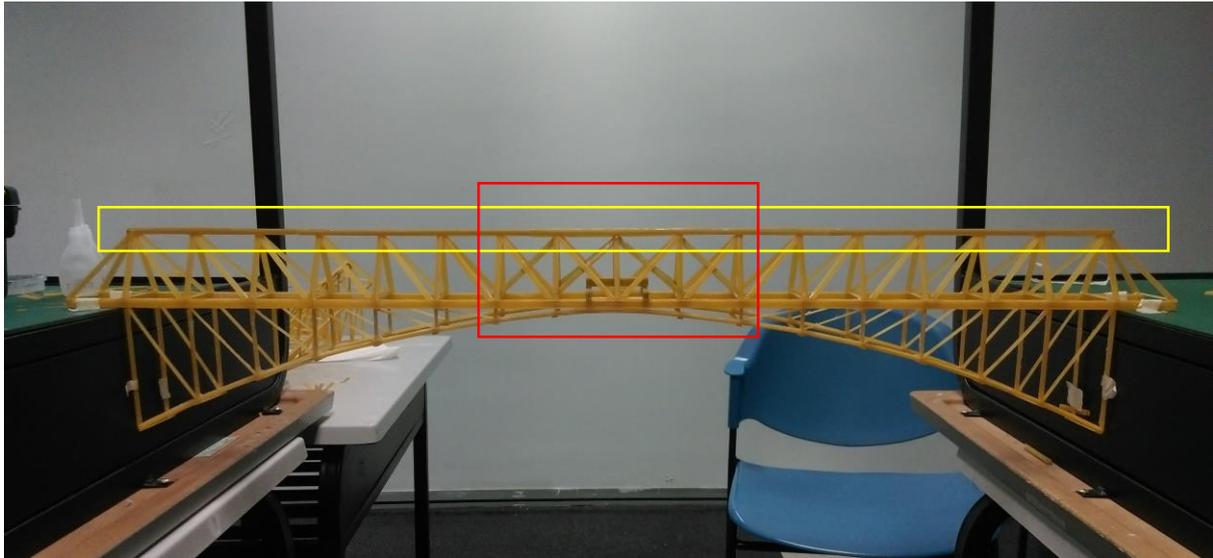


Figure 6.9 FINAL BRIDGE STRUCTURE

From this figure can see we strengthen the upper beam as well as adding more bracings at the central part of the structure to let it to have enough strength to withstand heavier load.

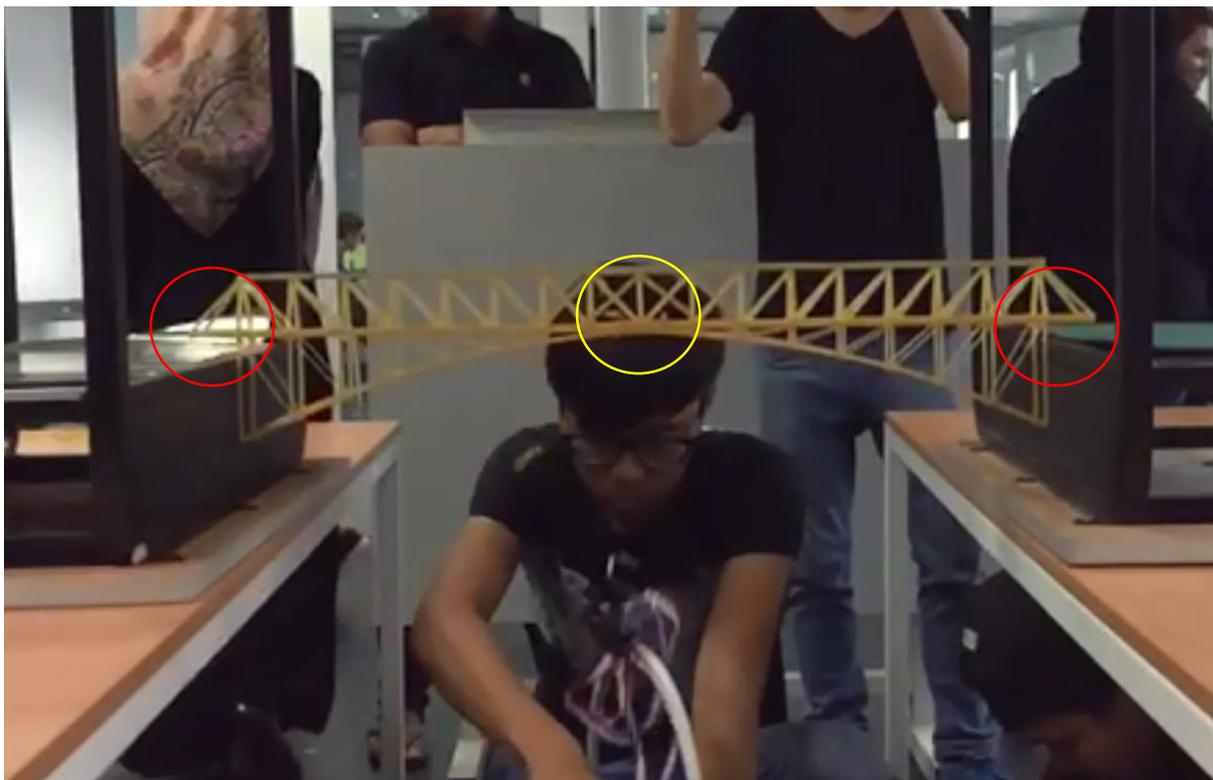
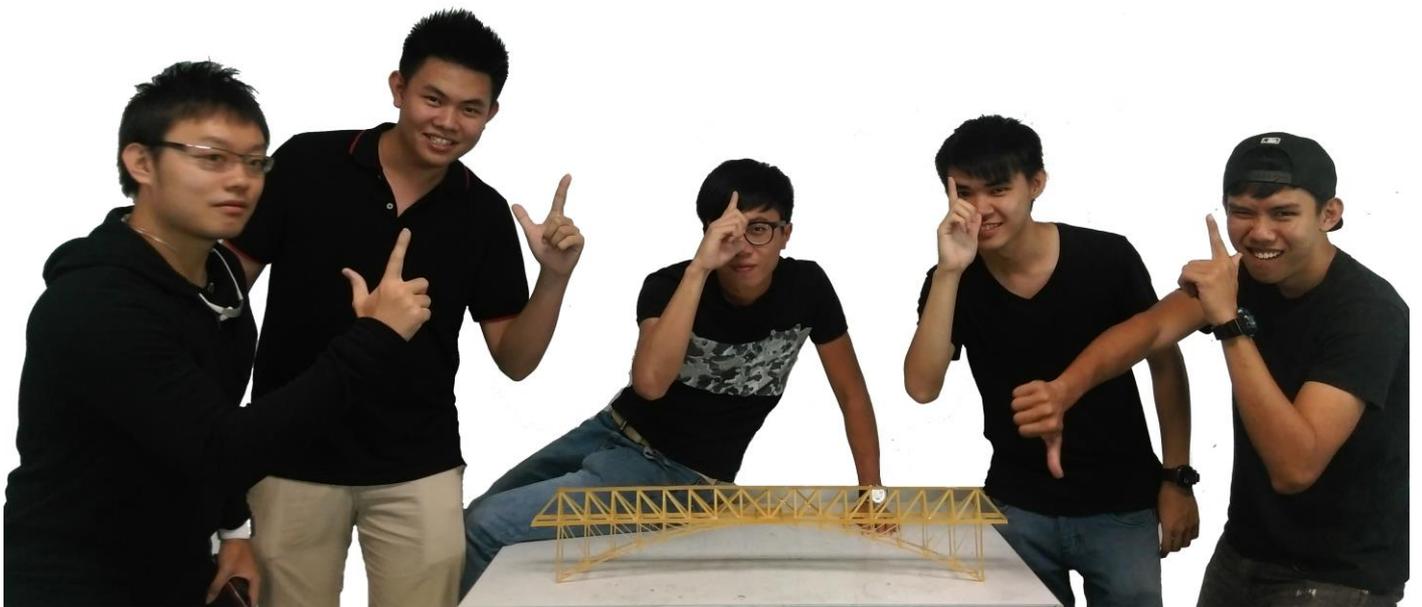


Figure 6.9 FINAL STRUCTURE TESTING

Those colored circle pointed out the result of the testing which red circle noticing the whole structure jump up due to sudden break of the central part of the H-Beam load holders. The yellow color circle shows the broken pieces of the H-Beam.



6.0 CONCLUSION

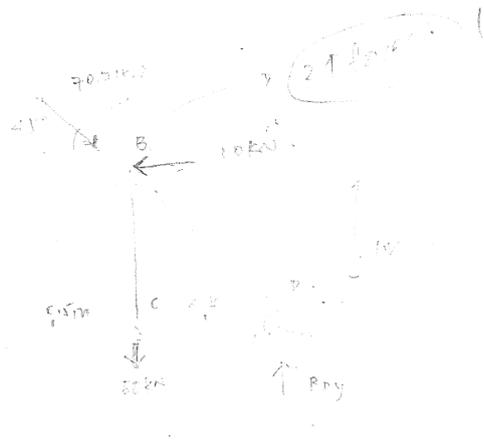
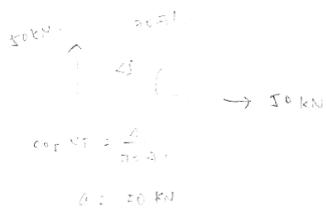
“A final review of our project”

6.0 Conclusion

From this project we knew that it's actually not easy to design a bridge as many things need to be considered before constructing a bridge. It's glad that we are given a chance to learn and to construct a bridge although we just allow to use fettuccine as the material. It's fun in terms of the overall project but it's also annoying during the process of bridge construction as fettuccine is really very fragile to be used especially in sticking moment. It took most of the time just to joint all the fettuccine together. Besides, in order to design the bridge to be more efficient, we learnt a lot not only designing in terms of aesthetic, but also designing in terms of weight; considerations taken for all the load distribution in the bridge as to make the bridge can carry more load with only a tiny and lighter weight itself. In conclusion, forces and loads play an important role in designing a bridge. It must come before aesthetic and has to be clearly understood before a bridge is designed.



"Sigh, it broke..."



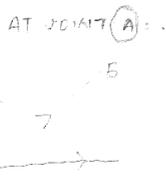
$\sum F_x = 0$
 $R_{Ax} - 10 + 40 = 0$
 $R_{Ax} = -40 \text{ kN}$

$\sum F_y = 0$
 $R_{Ay} - 50 - 50 + R_{Cy} = 0$
 $R_{Ay} + R_{Cy} = 100 \text{ kN} \quad \text{--- (1)}$

$\sum M_A = 0$
 $(50 \times 0.5) + (150 \times 0.5) - R_{Cy} = 0$
 $R_{Cy} = 90 \text{ kN}$

$R_{Ay} + R_{Cy} = 100 \text{ kN}$
 $R_{Ay} = 10 \text{ kN}$

ASSUME ALL MEMBERS IN TENSION.



AT JOINT (A):
 $\sum F_x = 0$
 $R_{Ax} + \left(\frac{0.5}{1.118}\right) AB + AC = 0$
 $-40 - 0.447 AB + AC = 0 \quad \text{--- (2)}$
 $-40 - 0.447(-11.98) + AC = 0$
 $-40 + 5.35 + AC = 0$

$\sum F_y = 0$
 $R_{Ay} + \left(\frac{1.0}{1.118}\right) AB = 0$
 $10 + 0.894 AB = 0$
 $AB = -11.98 \text{ kN}$
 TENSION

$AC = 35 \text{ kN}$
 TENSION

AT JOINT (B):



$\sum F_x = 0$
 $-\left(\frac{0.5}{1.118}\right) BD + CD = 0 \quad \text{--- (3)}$
 $0.447(100.67) = CD$
 $CD = 44.7 \text{ kN}$
 TENSION

$\sum F_y = 0$
 $R_{By} - \left(\frac{1.0}{1.118}\right) BD = 0$
 $90 - 0.894 BD = 0$
 $BD = 100.67 \text{ kN}$
 TENSION

AT JOINT (C):

$\sum F_y = 0$
 $-50 - \left(\frac{1.0}{1.118}\right) BC = 0$
 $-0.894 BC = 50$
 $BC = -55.9 \text{ kN}$
 COMPRESSION

seepehang.edu.my

seepehang.ann@loyans.edu.my

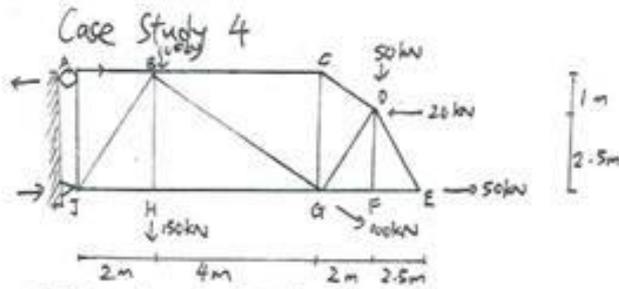
7.0 APPENDIX

"Case Studies"

7.0 Appendix: Truss Analysis Case Studies

7.1 CASE STUDY 1 by Chia Wei Pink 0316971

7.2 CASE STUDY 2 by Kee Yu Xuan 0315041



KEE YU XUAN
0315042

① Determine Perfect Truss

$$2J = m + 3$$

$$2J = 2(9) = 18 \quad m + 3 = 18$$

$\therefore 2J = m + 3$, it is a perfect truss.

② Calculate the reaction forces.

100 kN at point A let y-axis component be y, x-axis be X.

$$\tan \theta = \frac{y}{x}$$

$$\theta = 36.52'$$

$$\sin 36.52' = \frac{y}{100} \quad y = 59.99$$

$$\cos 36.52' = \frac{x}{100} \quad x = 80 \text{ kN}$$

\therefore

$$\sum X = 0$$

$$-F_{AX} + F_{JX} + (-20) + 50 + 80 = 0$$

$$-F_{AX} + F_{JX} + 110 = 0 \quad \text{--- ①}$$

$$\sum Y = 0$$

$$F_{JY} + (-100) + (-150) + (-50) + (-60) = 0$$

$$F_{JY} = 360 \text{ kN} \quad \text{--- ②}$$

Calculate moment at Joint J.

$$-R_{AX}(3.5) + 100(2) + 150(2) + 60(6) + 50(8) - 20(2.5) = 0$$

$$-R_{AX}(3.5) + 1260 - 50 = 0$$

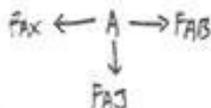
$$R_{AX} = 345.71 \text{ kN} \quad \text{--- ③}$$

③ sub into ①: $(-345.7142) + F_{JX} + 110 = 0$

$$R_{JX} = 235.7142 \text{ kN} \quad \text{--- ④}$$

Determine internal forces

1) Point A



$$\sum X = 0$$

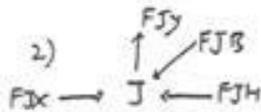
$$F_{AB} - F_{AX} = 0$$

$$F_{AB} = 345.7142 \text{ kN}$$

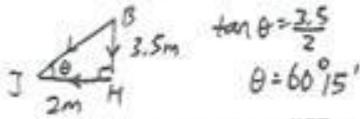
$$\sum Y = 0$$

$$-F_{AJ} = 0$$

$$F_{AJ} = 0$$



Resolve FjB



$$\tan \theta = \frac{3.5}{2}$$

$$\theta = 60^{\circ}15'$$

$$\sin 60^{\circ}15' = \frac{F_{jBy}}{F_{jB}}$$

$$F_{jBy} = 0.8682 F_{jB}$$

$$\cos 60^{\circ}15' = \frac{F_{jBx}}{F_{jB}}$$

$$F_{jBx} = 0.4962 F_{jB}$$

$$\sum y = 0$$

$$F_{jy} - F_{jBy} = 0$$

$$360 - 0.8682 F_{jB} = 0$$

$$F_{jB} = 414.6510 \text{ kN}$$

$$F_{jBy} = (0.8682)(414.6510)$$

$$= 359.9999 \text{ kN}$$

$$F_{jDy} \approx 360 \text{ kN}$$

$$F_{jBx} = (0.4962)(414.6510)$$

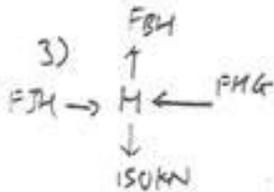
$$F_{jBx} = 205.7498 \text{ kN}$$

$$\sum x = 0$$

$$F_{jx} - F_{jH} - F_{jBx} = 0$$

$$235.7142 - 205.7498 - F_{jH} = 0$$

$$F_{jH} = 29.9644 \text{ kN}$$



$$\sum y = 0$$

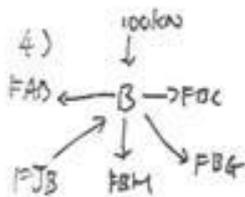
$$F_{jB} - 150 = 0$$

$$F_{jB} = 150 \text{ kN}$$

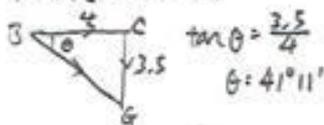
$$\sum x = 0$$

$$F_{jH} - F_{jG} = 0$$

$$F_{jG} = 29.9644 \text{ kN}$$



Resolve FjG



$$\sin 41^{\circ}11' = \frac{F_{jGy}}{F_{jG}}$$

$$F_{jGy} = 0.6585 F_{jG}$$

$$\cos 41^{\circ}11' = \frac{F_{jGx}}{F_{jG}}$$

$$F_{jGx} = 0.7526 F_{jG}$$

$$\sum y = 0$$

$$-100 \text{ kN} + F_{jBy} - F_{jH} - F_{jGy} = 0$$

$$-100 + 360 - 150 - F_{jGy} = 0$$

$$F_{jGy} = 110 \text{ kN}$$

$$F_{jGy} = 0.6585 F_{jG}$$

$$F_{jG} = 167.0463 \text{ kN}$$

$$F_{jGx} = 0.7526 F_{jG}$$

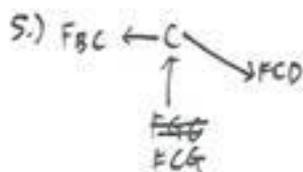
$$F_{jGx} = 125.7190 \text{ kN}$$

$$\sum x = 0$$

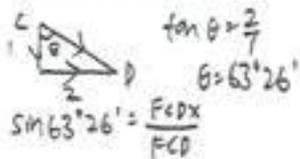
$$-F_{jB} + F_{jC} + F_{jBx} + F_{jGx} = 0$$

$$-345.7142 + 205.7498 + 125.7190 + F_{jC} = 0$$

$$F_{jC} = 14.2454 \text{ kN}$$



Resolve FCD



$$F_{CDx} = 0.8944 F_{CD}$$

$$F_{CDx} = 0.8944 F_{CD}$$

$$\cos 63.26^\circ = \frac{F_{CDy}}{F_{CD}}$$

$$F_{CDy} = 0.4472 F_{CD}$$

$$\sum X = 0$$

$$-F_{BC} + F_{CDx} = 0$$

$$-14.2454 + F_{CDx} = 0$$

$$F_{CDx} = 14.2454 \text{ kN}$$

$$F_{CDx} = 0.8944 F_{CD}$$

$$F_{CD} = 15.9273 \text{ kN}$$

$$F_{CDy} = 0.4472 F_{CD}$$

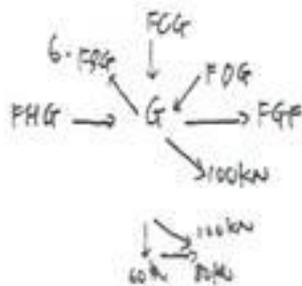
$$F_{CDy} = 7.1227 \text{ kN}$$

$$\sum Y = 0$$

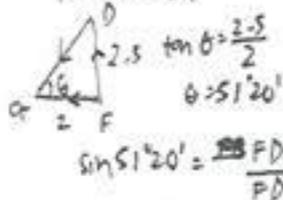
$$-F_{CDy} + F_{CG} = 0$$

$$-7.1227 + F_{CG} = 0$$

$$F_{CG} = 7.1227 \text{ kN}$$



Resolve FDG



$$F_{DGy} = 0.7808 F_{DG}$$

$$\cos 51.20^\circ = \frac{F_{DGx}}{F_{DG}}$$

$$F_{DGx} = 0.6248 F_{DG}$$

$$\sum Y = 0$$

$$-F_{CG} + F_{DGy} - 60 - F_{DGy} = 0$$

$$-7.1227 + 110 - 60 - F_{DGy} = 0$$

$$F_{DGy} = 42.8773 \text{ kN}$$

$$F_{DGy} = 0.7808 F_{DG}$$

$$F_{DG} = 54.9146 \text{ kN}$$

$$F_{DGx} = 0.6248 F_{DG}$$

$$F_{DGx} = 34.3106 \text{ kN}$$

$$\sum X = 0$$

$$-F_{BGx} + F_{HG} + 80 \text{ kN} + F_{GF} - F_{DGx} = 0$$

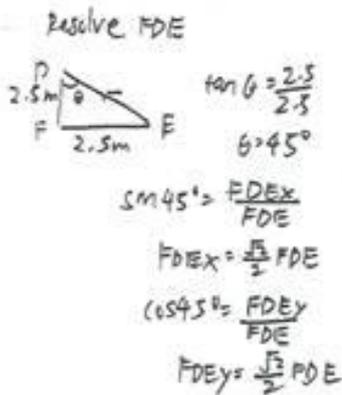
$$-125.7190 + 29.9644 + 80 + F_{GF} - 34.3106 = 0$$

$$F_{GF} = 50.0652 \text{ kN}$$

7) $\sum F_x = 0$
 $F_{GF} + F \rightarrow F_{FE}$
 $-F_{GF} + F_{FE} = 0$
 $F_{FE} = 50.0652 \text{ kN}$

$\sum F_y = 0$
 $F_{DF} = 0 \text{ kN}$

8) $\sum F_x = 0$
 $-F_{CDx} + F_{GDx} - F_{DEx} - 20 = 0$
 $-14.2454 + 34.3106 - F_{DEx} - 20 = 0$
 $F_{DEx} = 0.0652 \text{ kN}$



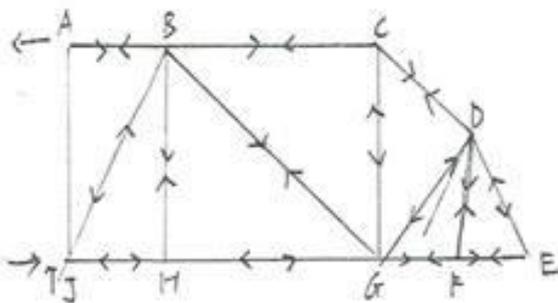
$F_{DEx} = \frac{\sqrt{2}}{2} F_{DE}$
 $F_{DE} = 0.0922 \text{ kN}$

$F_{DEy} = \frac{\sqrt{2}}{2} F_{DE}$
 $F_{DEy} = 0.0652 \text{ kN}$
 $\approx 0 \text{ kN}$

$\sum F_y = 0$
 $-50 + F_{CDy} + F_{GDy} - F_{DF} + F_{DEy} = 0$
 $-50 + 7.1227 + 42.8773 - 0 + F_{DEy} = 0$
 $F_{DEy} = 0 \text{ kN}$ \therefore Proved that F_{DEy} is correct.

9. $\sum F_x = 0$
 $F_{FE} - 50 \text{ kN} + F_{DEx} = 0$
 $F_{DEx} = 50.0652 - 50$
 $F_{DEx} = 0.0652 \text{ kN}$
 \therefore Proved that F_{DEx} is correct.

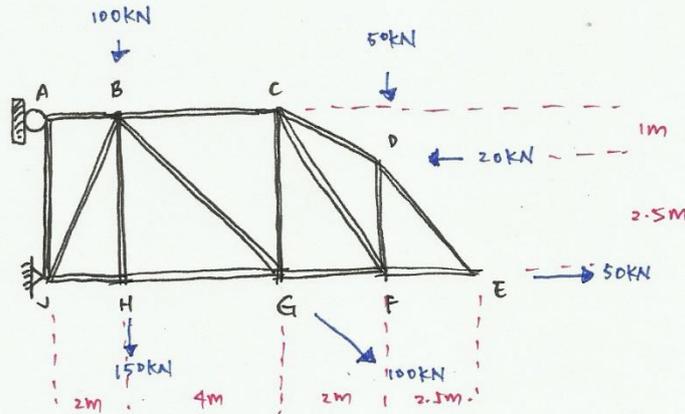
$\sum F_y = 0$
 $F_{DEy} = 0 \text{ kN}$



\therefore AB is in highest tension
 345.71 kN

\therefore BJ is in highest compression
 414.65 kN

7.3 CASE STUDY 3 by Yii Hong Gin 0316120



① DETERMINE TYPE OF TRUSS

$$2J = m + 3$$

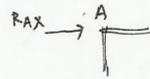
$$2(9) = 15 + 3$$

$$18 = 18$$

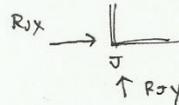
[PERFECT TRUSS]

② DETERMINE REACTION FORCES

AT JOINT A; THERE IS ONE REACTION FORCE AS IT IS ROLLER SUPPORTED.



AT JOINT J, THERE ARE TWO REACTION FORCE EXERTED ON IT AS IT IS SUPPORTED BY PIN.



③ CALCULATE REACTION FORCES

$$\sum F_x = 0$$

$$R_{Ax} + R_{Jx} + 100 \left(\frac{4}{5}\right) + 50 - 20 = 0$$

$$R_{Ax} + R_{Jx} + 100 \left(\frac{2}{2.5}\right) + 30 = 0$$

$$R_{Ax} + R_{Jx} = -110 \text{ kN} \quad \text{--- (1)}$$

$$\sum F_y = 0$$

$$R_{Jy} - 100 - 150 - 100 \left(\frac{3}{5}\right) - 50 = 0$$

$$R_{Jy} - 300 - 100 \left(\frac{1.5}{2.5}\right) = 0$$

$$R_{Jy} = 360 \text{ kN}$$

$$\sum M_A = 0$$

$$100(2) + 150(2) + \left[100 \left(\frac{1.5}{2.5}\right)\right](6) + 50(8) + 20(1) - 50(3.5) - R_{Jx}(3.5) + (-80)(3.5) = 0$$

$$200 + 300 + 360 + 400 + 20 - 175 - 3.5R_{Jx} - 280 = 0$$

$$-3.5R_{Jx} = -825$$

$$R_{Jx} = 235.71 \text{ kN}$$

sub into (1)

FROM (1) $R_{Ax} + R_{Jx} = -110 \text{ kN}$

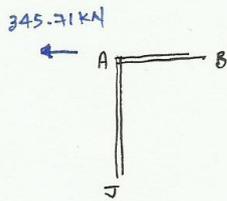
$$R_{Ax} + 235.71 = -110$$

$$R_{Ax} = -345.71 \text{ kN}$$

~~PROB~~

④ CALCULATE INTERNAL FORCES [ASSUME ALL TRUSSES IN TENSION].

AT JOINT A :



$$\sum F_x = 0$$

$$F_{AB} + R_{AX} = 0$$

$$F_{AB} - 345.71 = 0$$

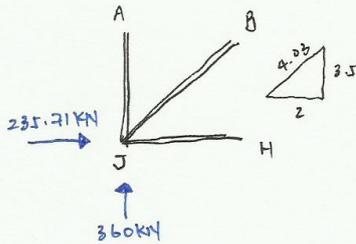
$$F_{AB} = 345.71 \text{ kN}$$

TENSION

$$\sum F_y = 0$$

$$F_{AJ} = 0 \text{ kN}$$

AT JOINT J :



$$\sum F_x = 0$$

$$235.71 + F_{JH} + \left(\frac{2}{4.03}\right)F_{JB} = 0$$

$$F_{JH} + 0.5 F_{JB} = -235.71 \text{ kN} \quad (1)$$

$$\sum F_y = 0$$

$$360 + F_{AJ} + \left(\frac{3.5}{4.03}\right)F_{JB} = 0$$

$$360 + 0 + 0.868 F_{JB} = 0$$

$$0.868 F_{JB} = -360$$

$$F_{JB} = -414.75 \text{ kN}$$

COMPRESSION

sub into (1)

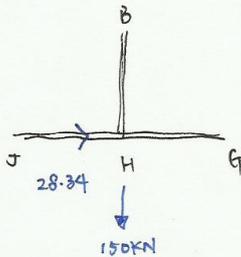
$$\text{FROM (1), } F_{JH} + 0.5 F_{JB} = -235.71 \text{ kN}$$

$$F_{JH} + 0.5(-414.75) = -235.71$$

$$F_{JH} = -28.34 \text{ kN}$$

COMPRESSION

AT JOINT H :



$$\sum F_x = 0$$

$$F_{JH} + F_{HG} = 0$$

$$28.34 + F_{HG} = 0$$

$$F_{HG} = -28.34 \text{ kN}$$

COMPRESSION

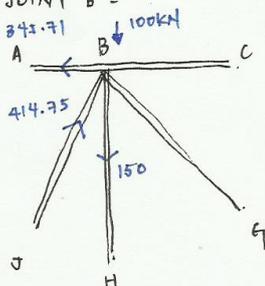
$$\sum F_y = 0$$

$$F_{HB} - 150 = 0$$

$$F_{HB} = 150 \text{ kN}$$

TENSION

AT JOINT B :



$$\sum F_x = 0$$

$$-F_{AB} + \left(\frac{2}{4.03}\right)(414.75) + \left(\frac{4}{5.315}\right)F_{BG} + F_{BC} = 0$$

$$0.75 F_{BG} + F_{BC} = 139.88 \text{ kN} \quad (2)$$

$$\sum F_y = 0$$

$$-100 + \left(\frac{3.5}{4.03}\right)(414.75) - 150 - \left(\frac{3.5}{5.315}\right)F_{BG} = 0$$

$$-0.66 F_{BG} = -110.2$$

$$F_{BG} = 167 \text{ kN}$$

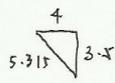
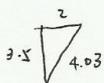
TENSION

sub into (2)

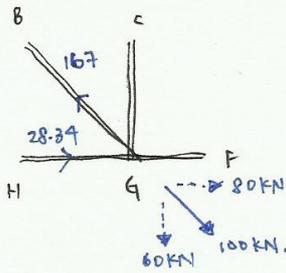
$$\text{FROM (2), } 0.75(167) + F_{BC} = 139.88$$

$$F_{BC} = 14.63 \text{ kN}$$

TENSION



AT JOINT G:



$$\sum F_x = 0$$

$$28.34 + 80 + F_{GF} + \left(\frac{4}{5.315}\right)(-167) = 0$$

$$F_{GF} = 17.34 \text{ kN}$$

TENSION

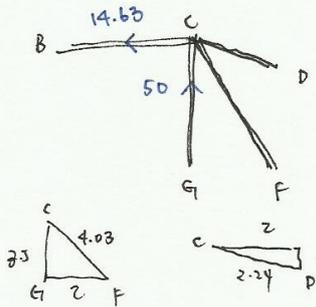
$$\sum F_y = 0$$

$$F_{CG} - 60 + \left(\frac{3.5}{5.315}\right)(167) = 0$$

$$F_{CG} = -50 \text{ kN}$$

COMPRESSION

AT JOINT C:



$$\sum F_x = 0$$

$$-F_{BC} + \left(\frac{2}{4.03}\right)F_{CF} + \left(\frac{2}{2.24}\right)F_{CD} = 0$$

$$0.5 F_{CF} + 0.9 F_{CD} = 14.63 \text{ kN} \quad \text{--- (4)}$$

$$\sum F_y = 0$$

$$F_{CG} - \left(\frac{3.5}{4.03}\right)F_{CF} - \left(\frac{2}{2.24}\right)F_{CD} = 0$$

$$0.868 F_{CF} + 0.89 F_{CD} = 50 \text{ kN} \quad \text{--- (5)}$$

$$\text{(5)} \times 2, 1.74 F_{CF} + 0.9 F_{CD} = 100 \text{ kN} \quad \text{--- (6) sub with (4)}$$

$$\text{(6)} - \text{(4)}, 1.74 F_{CF} - 0.5 F_{CF} = 100 - 14.63$$

$$1.24 F_{CF} = 85.37$$

$$F_{CF} = 68.85 \text{ kN}$$

TENSION

sub into (4)

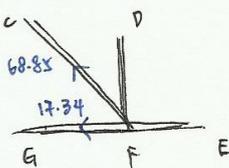
$$\text{FROM (4)}, 0.5(68.85) + 0.9 F_{CD} = 14.63$$

$$0.9 F_{CD} = -19.8$$

$$F_{CD} = -22 \text{ kN}$$

COMPRESSION

AT JOINT F:



$$\sum F_x = 0$$

$$-F_{GF} + F_{FE} + \left(\frac{2}{4.03}\right)(-68.85) = 0$$

$$-17.34 + F_{FE} - 34.17 = 0$$

$$F_{FE} = 51.5 \text{ kN}$$

TENSION

~~APPROX~~

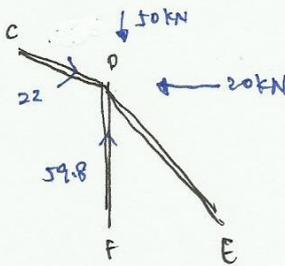
$$\sum F_y = 0$$

$$\left(\frac{3.5}{4.03}\right)(68.85) + F_{FD} = 0$$

$$F_{FD} = -59.8 \text{ kN}$$

COMPRESSION

AT JOINT D :



$$\sum F_x = 0$$

$$\left(\frac{2}{2.24}\right)(22) - 20 + \left(\frac{2.5}{3.54}\right) F_{DE} = 0$$

$$20 - 20 + 0.71 F_{DE} = 0$$

$$0.71 F_{DE} = 0$$

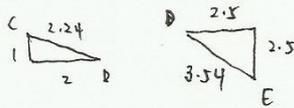
$$F_{DE} = 0 \text{ kN}$$

$$\sum F_y = 0$$

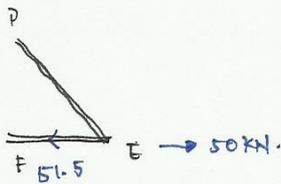
$$\left(\frac{1}{2.24}\right)(-22) - 50 + 59.8 - \left(\frac{2.5}{3.54}\right) F_{DE} = 0$$

$$-10 - 50 + 60 - 0.71 F_{DE} = 0$$

$$F_{DE} = 0 \text{ kN. } \boxed{\text{PROVED}}$$



AT JOINT F :



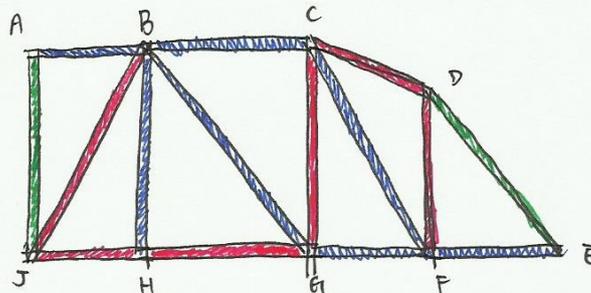
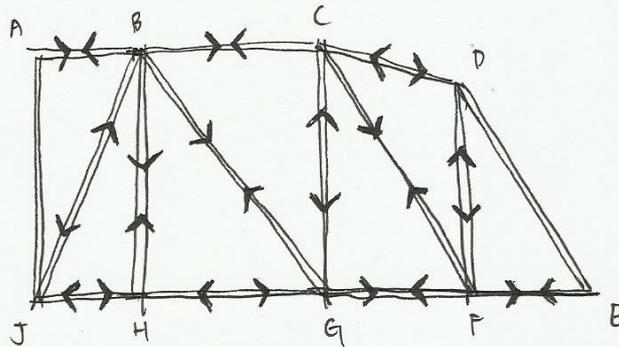
$$\sum F_x = 0$$

$$50 - 50 = 0 \text{ kN.}$$

(APPROXIMATELY)

PROVED

IN CONCLUSION :



■ TENSION
 ■ COMPRESSION
 ■ FREE MEMBER

7.4 CASE STUDY 4 by Soh Wei Aun 0316887

$\curvearrowright (+)$ Moment = $F \times \text{distance}$
 $\curvearrowleft (-)$

① Determine Deflection times

$\Delta J = M \times 3$
 $\Delta (9) = 15 + 3$
 $12 = 18$

② Reaction force:

$\tan \theta = \frac{4}{3}$
 $\theta = 53.13^\circ$

$G_x = 100 \sin \theta$
 $= 80 \text{ kN}$
 $G_y = 100 \cos \theta$
 $= 60 \text{ kN}$

Reaction force:

a) $\sum F_x = 0$

$-R_{Ax} - R_{Dx} - 50 + 20 - 80 = 0$
 $-R_{Ax} - R_{Dx} = 110 \text{ kN}$

b) $\sum F_y = 0$

$-100 - 50 - 60 - 150 + R_{Dy} = 0$
 $R_{Dy} = 360 \text{ kN}$

$\sum M = 0$

$R_{Ax}(3.5) + 100(2) + 150(2) + 50(8) + 60(6) - 20(2.5) = 0$
 $R_{Ax}(3.5) = -200 - 300 - 400 - 360 + 50$
 $= -1210$
 $R_{Ax} = \frac{-1210}{3.5}$
 $= -345.71 \text{ kN}$

$-R_{Ax} - R_{Dx} = 110$
 $345.71 - R_{Dx} = 110$
 $R_{Dx} = -110 + 345.71$
 $= 235.71 \text{ kN}$

JOINT J

$\sum F_x = 0$
 $235.71 - F_{JH} = 0$
 $F_{JH} = 235.71 \text{ kN (C)}$

$\sum F_y = 0$
 $360 - F_{JA} = 0$
 $F_{JA} = 360 \text{ kN (C)}$

JOINT H

$\sum F_x = 0$
 $235.71 - 305.67 - F_{HG} = 0$
 $F_{HG} = -235.71 + 305.67$
 $F_{HG} = 69.96 \text{ kN (C)}$

$\sum F_y = 0$
 $360 - F_{HA} - 150 = 0$
 $F_{HA} = 210 \text{ kN (C)}$

JOINT A

$\sum F_x = 0$
 $-348.71 + F_{AB} + F_{AH} \cos \theta = 0$
 $F_{AB} + 105.67 + 345.71$
 $F_{AB} = 140.04 \text{ kN (C)}$

$\sum F_y = 0$
 $360 - F_{AH} \sin \theta = 0$
 $F_{AH} \sin \theta = 360$
 $F_{AH} = 414.61 \text{ kN (C)}$

JOINT B

$\sum F_x = 0$
 $-140.04 + F_{BC} + F_{BD} \cos \theta = 0$
 $F_{BC} + F_{BD} \cos \theta = 140.04$
 $F_{BC} = 14.34 \text{ kN (C)}$

$\sum F_y = 0$
 $-100 + F_{BE} - F_{BD} \sin \theta = 0$
 $-100 + 210 - F_{BD} \sin \theta = 0$
 $-F_{BD} \sin \theta = -110$
 $F_{BD} \sin \theta = 110$
 $F_{BD} = 167.03 \text{ kN (C)}$

JOINT G

$\sum F_x = 0$
 $304.20.03 + F_{GF} = 125.70 = 0$
 $F_{GF} = 15.47 \text{ kN (C)}$

$\sum F_y = 0$
 $F_{GB} + F_{GC} + 60 = 0$
 $-110.18 + F_{GC} + 60 = 0$
 $F_{GC} = 50.18 \text{ kN (C)}$

JOINT C

$\sum F_x = 0$
 $-F_{CB} + F_{CD} + F_{CF} = 0$
 $-14.34 + F_{CD} + F_{CF} = 0$
 $F_{CD} + F_{CF} = 14.34$
 $F_{CF} = 14.34 - F_{CD}$

$\sum F_y = 0$
 $-F_{CB} + F_{CD} + F_{CE} = 0$
 $-50.18 + F_{CD} + F_{CE} = 0$
 $F_{CD} = 50.18 - F_{CE}$
 $50.18 - 0.2623(14.34 - F_{CD})$
 $= 37.73 + 0.2623 F_{CD}$

JOINT D

$\sum F_x = 0$
 $-F_{DC} - 20 + F_{DE} = 0$
 $-256.22 - 20 + F_{DE} = 0$
 $F_{DE} = 276.22 \text{ kN (C)}$

$\sum F_y = 0$
 $-50 + F_{DD} + 195.32 = 0$
 $F_{DD} = -145.32$

JOINT E

$\sum F_x = 0$
 $-F_{ED} + F_{EC} + 50 = 0$
 $-185.47 + F_{EC} = -50$
 $F_{EC} = 135.47$
 $F_{ED} = 191.27 \text{ kN (C)}$

JOINT F

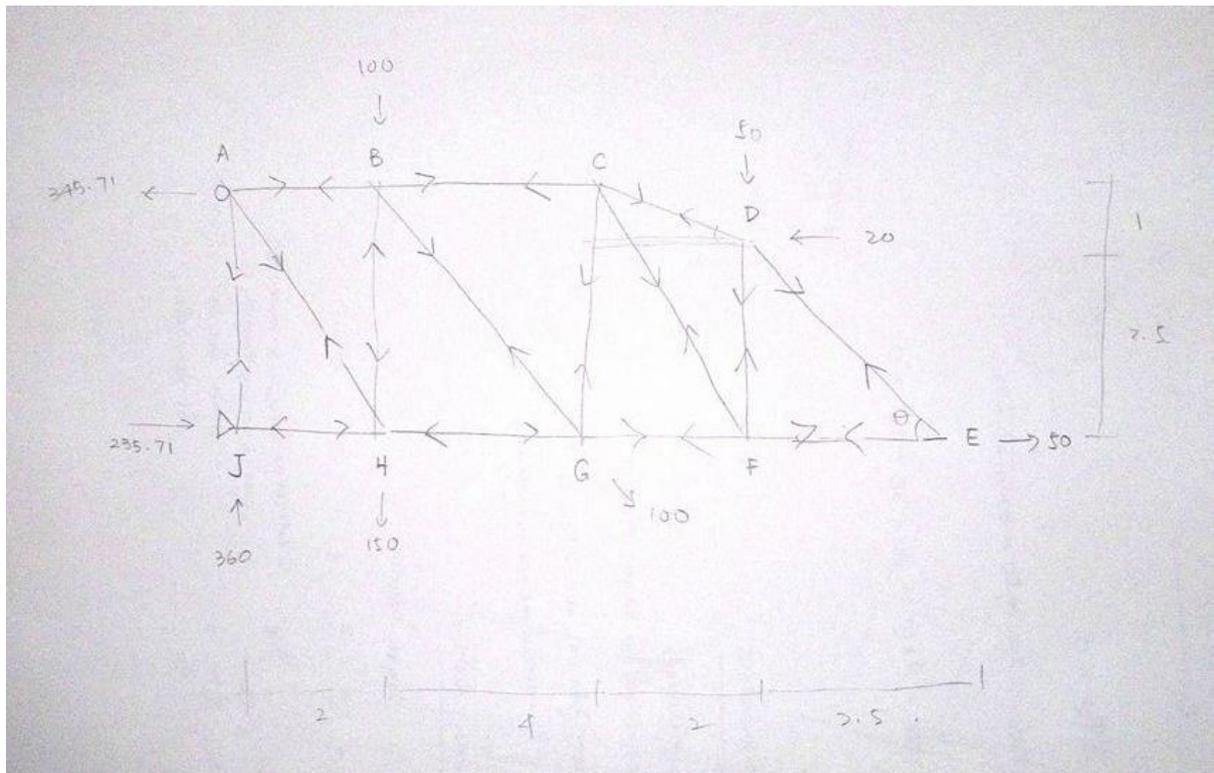
$\sum F_x = 0$
 $-15.47 - 170 + F_{FE} = 0$
 $F_{FE} = 185.47 \text{ kN (C)}$

$\sum F_y = 0$
 $-212.5 + (-145.32) = 0$
 $67.18 \text{ kN} = 0$

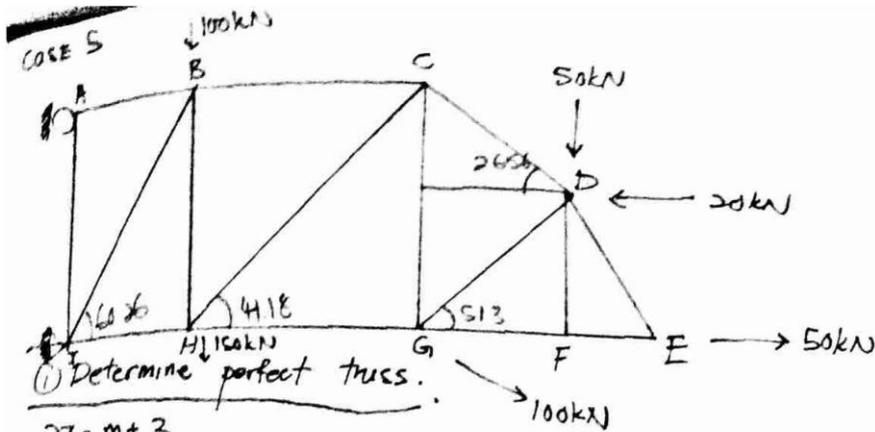
JOINT C (cont)

$0.2623(14.34 - F_{CD}) = 12.45 = 0.2623 F_{CD}$
 $F_{CD} = 0.2623 F_{CD} = 0.1317 F_{CD}$
 $0.2623 F_{CD} - 0.2623 F_{CD} = 0$
 $0.1317 F_{CD} = 37.73$
 $F_{CD} = 286.42$

$F_{CF} = 14.34 - F_{CD}$
 $= 14.34 - 286.42$
 $= -272.08$



7.5 CASE STUDY 5 by Tommy Tan 0310004



① Determine perfect truss.

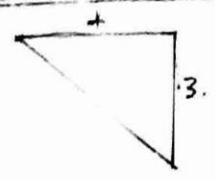
$$2J = m + 3$$

$$2(9) = 15 + 3$$

$$18 = 18$$

∴ It is a perfect truss.

② Determine Reaction force.



$$\tan \theta = \frac{4}{3}$$

$$\theta = 56.13^\circ$$

$$\begin{aligned} \therefore G_x &= 100 \sin \theta \\ &= 80 \text{ kN} \end{aligned}$$

$$\begin{aligned} G_y &= 100 \cos \theta \\ &= 60 \text{ kN} \end{aligned}$$

$$\sum F_x = 0$$

$$-R_{Ax} - R_{jx} - 50 - 80 + 20 = 0$$

$$R_{Ax} + R_{jx} = -110 \text{ kN} \quad \text{--- (1)}$$

$$\sum F_y = 0$$

$$-100 - 50 - 60 - 150 + R_{jy} = 0$$

$$R_{jy} = 360 \text{ kN}$$

$$\sum M = 0$$

$$3.5 R_{Ax} + 100(2) + (150)(2) + (50)(8) + (60)(6) + (-20)(2.5)$$

$$R_{Ax} = -345.71 \text{ kN}$$

$$\therefore R_{Ax} + R_{jx} = -110 \text{ kN}$$

$$R_{jx} = -110 + 345.71$$

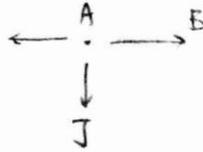
$$= 235.71 \text{ kN}$$

Joint A

$$\sum F_x = 0$$

$$-F_{Ax} + F_{AB} = 0$$

$$F_{AB} = 325.71 \text{ kN (Tension)}$$



Joint J

$$\sum F_y = 0$$

$$F_{JA} + F_{Jy} + F_{BJ} \sin \theta = 0$$

$$F_{BJ} \sin \theta = -360$$

$$F_{BJ} = -414.6 \text{ kN (compression)}$$

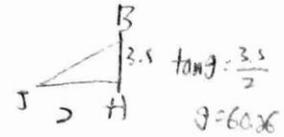
$$\sum F_x = 0$$

$$F_{Jx} + F_{JA} + F_{JB} \cos \theta = 0$$

$$F_{JH} = -F_{Jx} - F_{JB} \cos \theta$$

$$= -235.71 + 205.67$$

$$= -30.04 \text{ kN (compression)}$$



Joint B

$$\sum F_x = 0$$

$$-F_{AB} + F_{Bc} + F_{BJ} \cos \theta = 0$$

$$-325.71 + F_{Bc} + 205.67 = 0$$

$$F_{Bc} = 140.04 \text{ kN (Tension)}$$

$$\sum F_y = 0$$

$$-100 - F_{BH} + F_{BJ} \sin \theta = 0$$

$$-F_{BH} = 100 - F_{BJ} \sin \theta$$

$$= 100 - 360$$

$$F_{BH} = 260 \text{ kN (Tension)}$$



Joint H

$$\sum F_x = 0$$

$$F_{JH} + F_{HG} + F_{HC} \cos \theta = 0$$

$$30.04 + F_{HG} + F_{HC} \cos \theta = 0$$

$$F_{HG} + F_{HC} \cos \theta = -30.04$$

$$\therefore F_{HG} = -30.04 + 125.74$$

$$= 95.704 \text{ (tension)}$$

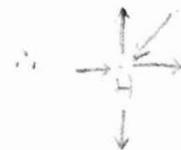
$$\sum F_y = 0$$

$$F_{BH} - 100 + F_{CH} \sin \theta = 0$$

$$260 - 100 + F_{CH} \sin \theta = 0$$

$$F_{CH} \sin \theta = -160$$

$$F_{CH} = -167.07 \text{ (compression)}$$



Joint C

$$\sum F_x = 0$$

$$-F_{BC} + F_{CD} \cos \theta + F_{CH} \cos \theta = 0$$

$$-140.04 + F_{CD} \cos \theta + 125.74 = 0$$

$$F_{CD} \cos \theta = 14.3$$

$$F_{CD} = \frac{14.3}{\cos 26.56^\circ}$$

$$= 15.99 \text{ kN (Tension)}$$

$$\sum F_y = 0$$

$$F_{CH} \sin \theta - F_{CG} - F_{CD} \sin \theta = 0$$

$$-F_{CG} = -F_{CH} \sin \theta + F_{CD} \sin \theta$$

$$= -110 + 7.149$$

$$F_{CG} = 102.85 \text{ (tension)}$$


Joint G

$$\sum F_x = 0$$

$$F_{GH} + F_{GF} + 80 \text{ kN} + F_{GD} \cos \theta$$

$$-95.7 + F_{GF} + 80 + F_{GD} \cos \theta = 0$$

$$F_{GF} + F_{GD} \cos \theta = -15.7 \text{ kN} \text{ --- } \odot$$

$$\therefore F_{GF} = -49.98 \text{ kN (tension)}$$

$$\sum F_y = 0$$

$$-60 + F_{CG} + F_{GD} \sin \theta = 0$$

$$F_{GD} \sin \theta = 60 - 102.85$$

$$F_{GD} \sin \theta = -42.85$$

$$F_{GD} = -54.87 \text{ kN (compression)}$$


Joint F

$$\sum F_x = 0$$

$$-F_{GF} + F_{FE} = 0$$

$$F_{FE} = F_{GF}$$

$$= 50 \text{ (tension)}$$

$$\therefore \leftarrow \begin{array}{c} | \\ F \end{array} \rightarrow$$

Joint E

$$\sum F_x = 0$$

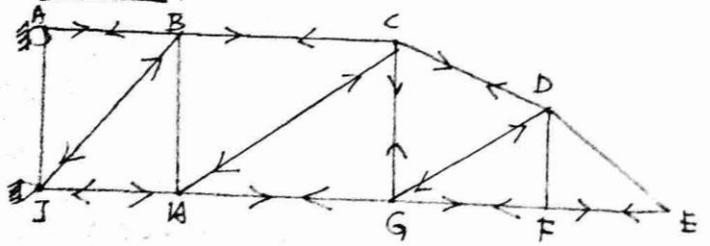
$$-50 + F_{FE} - F_{ED} \cos \theta = 0$$

$$-F_{ED} \cos \theta = -F_{FE} + 50$$

$$= 0 \text{ (in equilibrium)}$$

$$\therefore \leftarrow \begin{array}{c} | \\ E \end{array} \rightarrow$$

Conclusion



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8.0 References

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03. <https://www.youtube.com/watch?v=2rpyCDKuyFI>