TAYLOR'S UNIVERSITY

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SCHOOL OF ARCHITECTURE, BUILDING AND DESIGN
BACHELOR OF SCIENCE (HONOURS) (ARCHITECTURE)

BUILDING STRUCTURES [ARC 2523)
RESEARCH STUDY REPORT

PROJECT 1
FETTUCCINE TRUSS BRIDGE

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CONTENT

1. Introduction

1.1. Introduction to Project

In groups 5 – 6 we were required to carry out research on a precedent of a truss bridge. Using the information obtained from the precedent study as a program, we were required to design and construct our own truss bridge, with the span of 600mm, made from Fettuccine (ribbon pasta).

We were to be graded according to a series of assessments, which include; testing whether the bridge we constructed would be able to withstand a point load of 5kgs, initially to the bridges failure. Later we were to create a report that would demonstrate the findings of the study for evaluation.

1.2. Reason for Study

The general purpose of this study is to construct, evaluate and improve elements of a truss construction. By constructing the truss bridge out of fettuccine, we are to explore the truss members based on the arrangement system chosen and apply the knowledge gained of load distribution. Being able to understand and apply the knowledge of calculating; internal forces, reaction forces and conclude by identifying members in compression and tension within a truss system.

1.3. Definition of Truss

It is a structure that comprises of one or more triangular components, constructed with members, which can either be fastened or hinged at joints called nodes. Trusses are composed of triangles because of the structural stability of that shape and design. A triangle is the simplest geometric figure that will not alter shape when the stretches of the hypotenuse are secured in place.

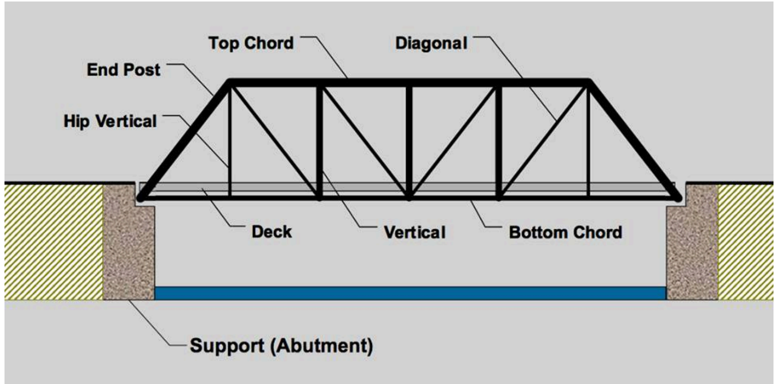


Diagram 1: Components of a Truss Bridge.

1.4. Truss System types and Designs

There are many types of truss bridge designs, bellow are some of the more common types of designs:

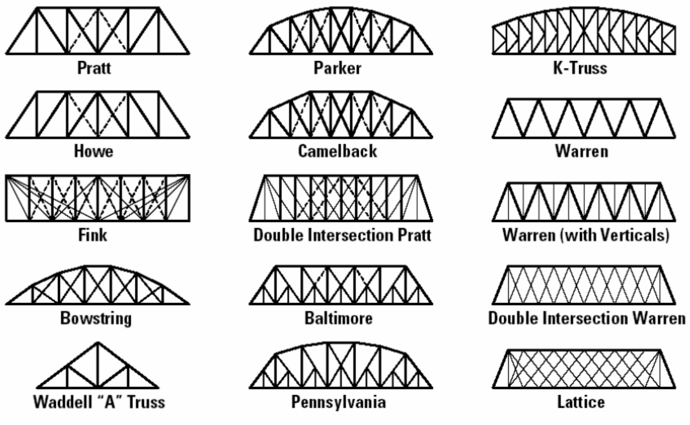


Diagram 2: Types of truss designs

There are several different arrays of trusses. Loads applied to these arrangements are transferred to the connections (joints) and each individual support within the system will either be in tension or compression. A truss bridge has to be straight due to the fact that is designed to handle stretching and pushing forces – a bending moment could cause the bridge to fail. There are mainly two types of trusses:

a. Through Truss

Is designed so that the road deck is suspended bellow the trusses that make up part of the load bearing structure of the bridge assembly. The road passes through the trusses.

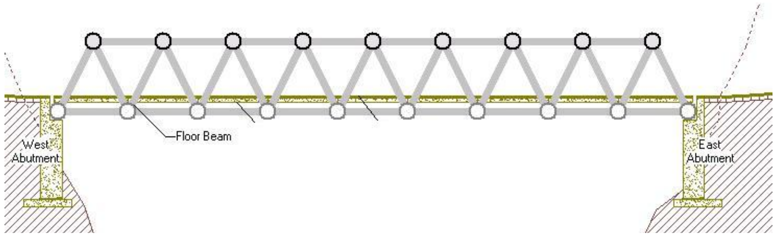


Diagram 3: Through truss bridge arrangement

b. Deck truss

A type of bridge, which has the road deck, lay above the structure. The support members are arranged in triangular patters to distribute loads and provide stability.

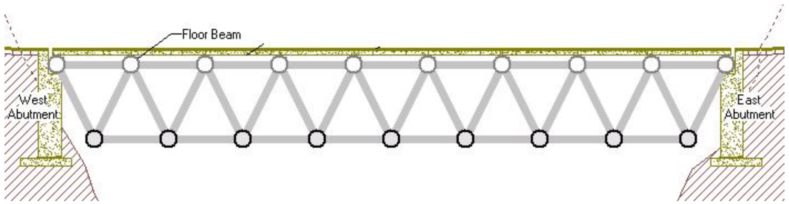


Diagram 4: Deck truss bridge arrangement

1.5. Forces on Truss Bridges

There are mainly two types of forces that apply to the truss bridges. The members in a truss arrangement will either be in compression or tension. Compression forces bear down on the object, whilst the tension directly opposes the force that lengthens the object.

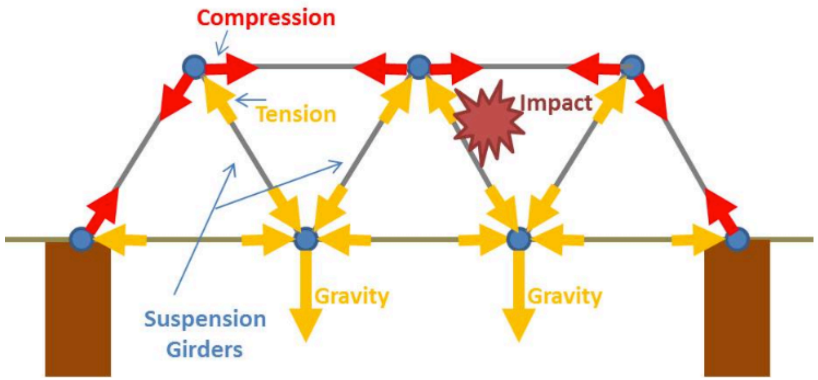


Diagram 5: Forces applied on a truss bridge

A spring is a good example of a mechanism that works with both forces. Tension pulls the coils further apart lengthening the spring and compression pushes the coil together, shortening the spring.

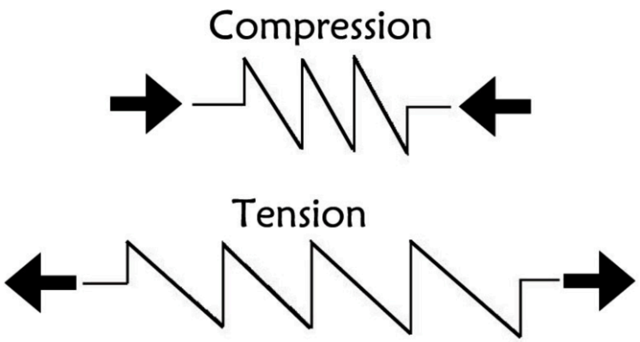


Diagram 6: tension and compression forces on a bridge

2. Precedent Study

Nanticoke Bridge

Diagram 7: Front elevation view of the bridge

Built in 1987, the construction is located in Luzerne Country Pennsylvania over Susquehanna River on Market Street in Nanticoke.

2.1. Bridge Description and Analysis

The bride has two large pin-connected Pennsylvania through truss spans and a slightly smaller truss that is a combination of a Pennsylvania and a parker truss with multiple different connections. The original formation of the bridge was demolished a number of years ago and replaced with modern pre-stressed concrete spans – hence the original spans are no longer historically significant. The current bridge spans are all at the northernmost end of the bridge.

This bridge is significant and rare surviving example of a large pin-connected truss bridge. Pennsylvania was at one time carrying many pin-connected bridges one of the few states with a sizable amount of these type bridges crossing large bridges. Nearly all pin-connected bridges have been destroyed due to or are in danger of being demolished.

Hence the bridges being a rare truss system today. Such configurations are uncommon due to the wide spread demolition. The bridge carries a large volume of traffic, as it retains historic integrity with no major alterations to the design or materials.

2.2. Truss System of Bridge

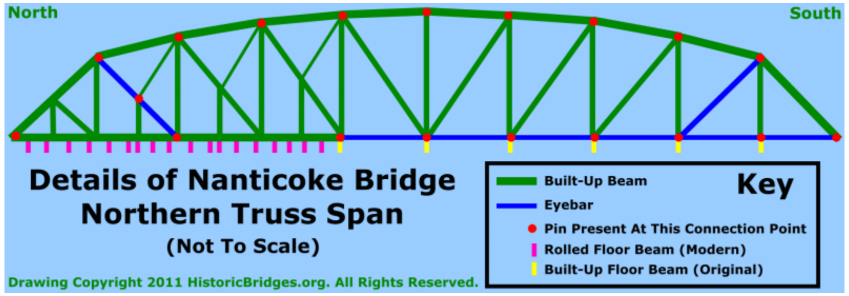


Diagram 8: Truss Design

The truss spans are large and highly significant, the smaller truss spans at the northern end of the bridge is singled out due to its having one of the most unique designs encountered in a truss bridge system and may be the only one of its kind in existence.

What is unique about this bridge is its asymmetrical arrangement of members where normal truss bridges are usually symmetrical. It appears that the primary panels of the north end of the design are subdivided following the Pennsylvania truss configuration – the south half is not subdivided hence following a parker truss configuration.

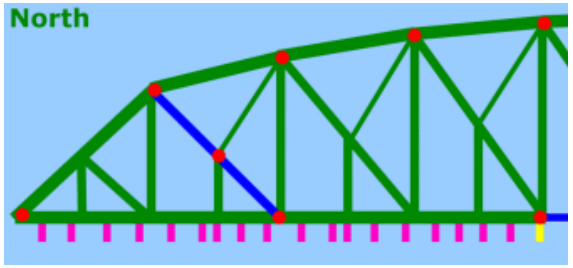


Diagram 9: Northern end of bridge

Only four of the northernmost panels are subdivided following the parker truss configuration. In addition only those same panels get additional support with the addition of a vertical and diagonal support that connect to the mid-point of the end post, which is not seen in the southern end.

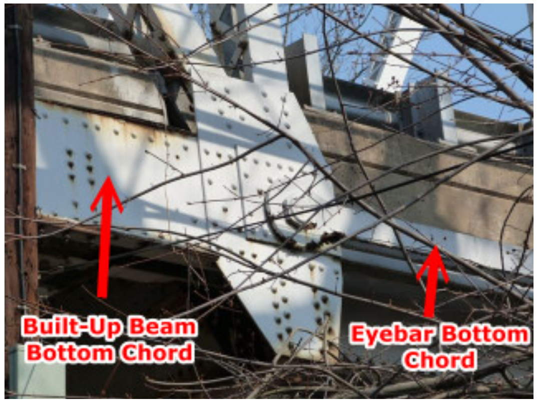


Diagram 10: Bridge connections Southern end

The beam at the southern end of the truss has a bottom cord that is known as an eye bar and the northern end of the truss there is an unusual massive riveted beam configuration known as a built up box beam.

The southern spans have traditional pin connections and the northern truss spans have a hybrid of pinned and riveted connections, hence adding on to the asymmetry of the design.

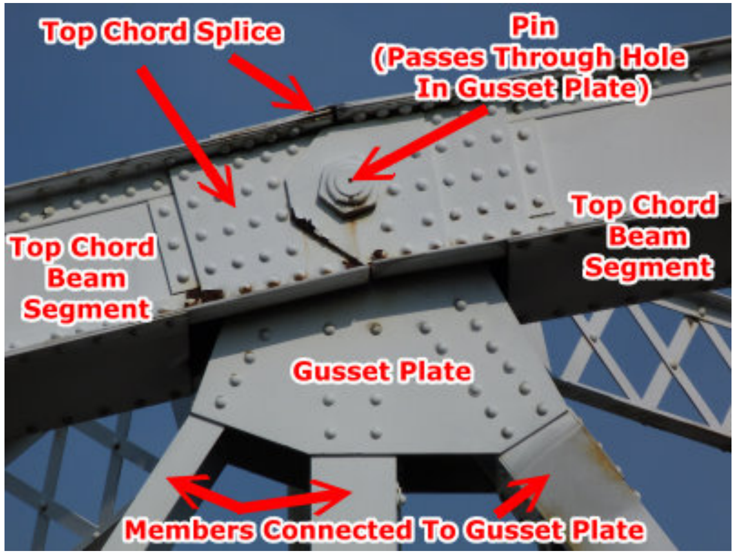


Diagram 11: Bridge connections Northern end


Diagram 12: Southern Span


Diagram 13: Northern Span

3. Preliminary Analysis

3.1. Materials and Equipment Used

Weights

The weight was an important factor in determining how much weight the fettuccine bridge could handle; the strength of the fettuccine through applying it as a point load on one of the member of the bridge.

Diagram 14: Type of Weights

Fettuccine

Based on the requirements of the project, this was the vital material used in the entire project, which was used to build the bridge. Strengthening the material through lamination was against the rules of construction, hence not to be used. We tested out two different brands of fettuccine: Buitoni and San Remo Fettuccine. We picked the most appropriate type based on the strengths.

Diagram 15: Buitoni Fettuccine

Diagram 16: San Remo Fettuccine

Super Glue (3 second)

We used this adhesive to hold the fettuccine together. We specifically used this because it rapidly holds the material together and helps strengthen it instantaneously.

Diagram 17: 3 second super glue

3.2. Strength and Testing of Fettuccine

The testing method we carried out allowed us to understand the material better, we carried out standard tests to determine the strength:

The first one was the basic bend-test, which determines the plasticity and ductility of the fettuccine. When the density of the material is higher, the least the material is able to bend hence the fettuccine is lacking in flexibility.

The second test was a bit more advanced where a lever converted into a machine that would assist the testing of the fettuccine. The two different brands of fettuccine strips are placed on the lever to analyze the compression and tension of the material.

Figure 1: represents the testing of tensional strength. The material is supported at the edge of the lever and a water bucket is hung on the opposite side of the lever. The bucket is then filled with water at intervals until the fettuccine breaks.

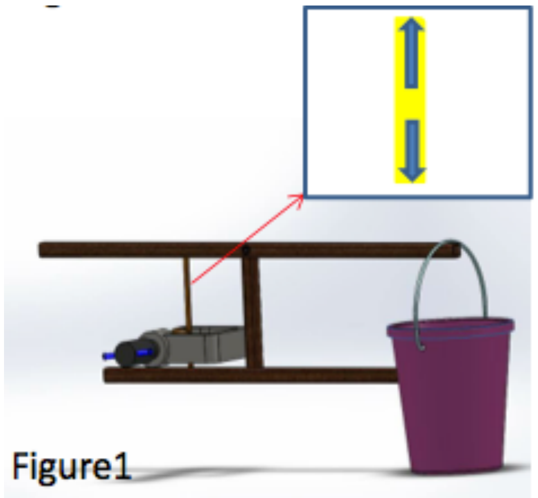


Diagram 18: Testing Tensional Strength

Figure two on the other hand shows the testing for compressional strength. The fettuccine is then placed underneath the plank of the lever and the water bucket is then hung on the same edge of the plank. Similar to testing tensional strength – water is poured into the bucket until the fettuccine strip breaks.

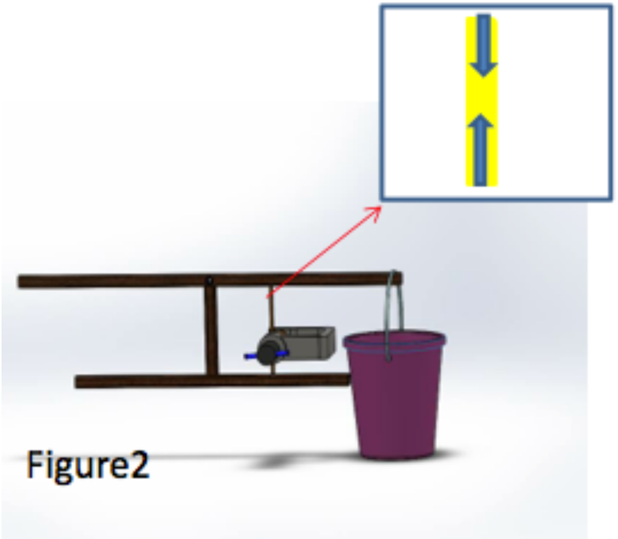


Diagram 19: Testing Compressional Strength

Throughout the testing process we were then able to conclude that the fettuccine is more capable in withstanding tensional force that it is in withstanding compressional force; fettuccine is much weaker in compression.

3.3. Preliminary Design and Testing

Baltimore Bridge

Diagram 20: Preliminary bridge design

Before we assembled the final bridge, we came up with preliminary designs of truss bridges based on the precedent study, so as to figure out which design we would find most suitable to be able to withstand the load.

Apart from selecting a design for the final testing process we tested the preliminary bridge to analyze the efficiency of the model before selecting the final design.

Diagram 21: Weighing of the bridge

3.4. Analysis of Initial Bridge Design

A typical Baltimore Truss was selected as a preliminary fettuccine bridge test design. The members of the bridge carry different weights and act differently depending on their positioning, i.e. the smallest members act as additional supports to the primary lateral members.

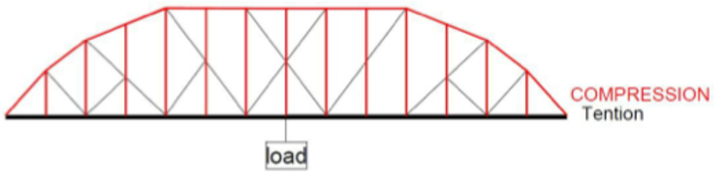


Diagram 22: Design of bridge with load

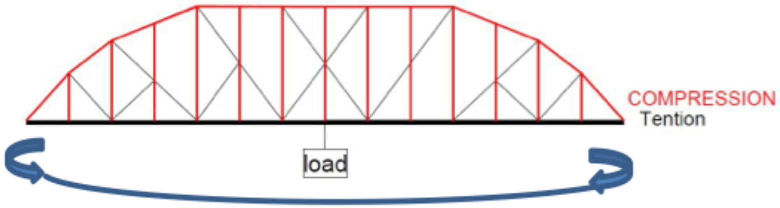


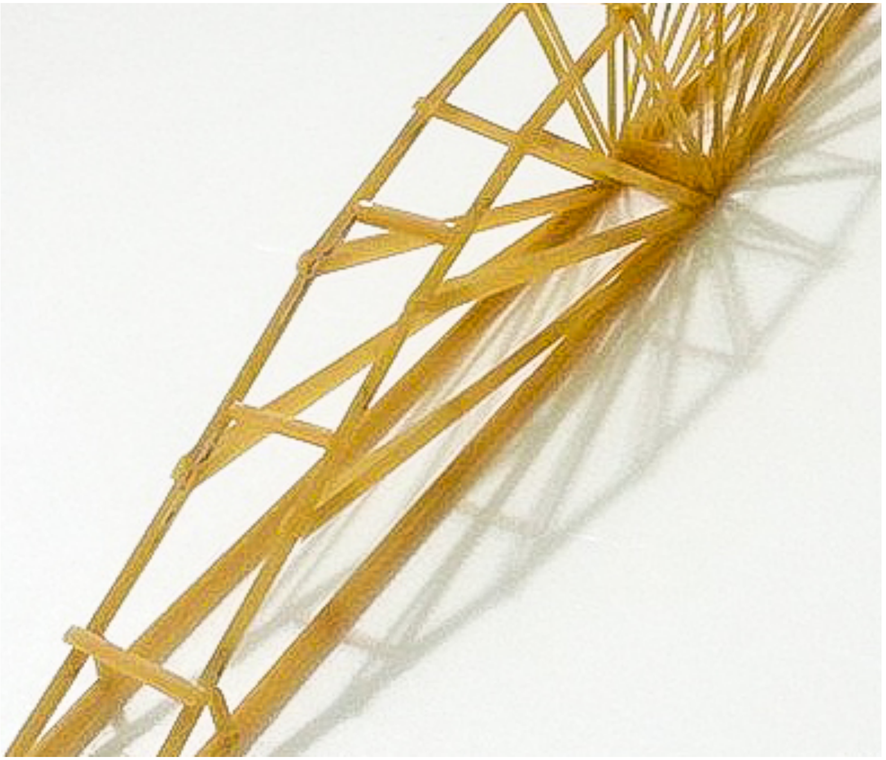
Diagram 23: Members in compression and tension

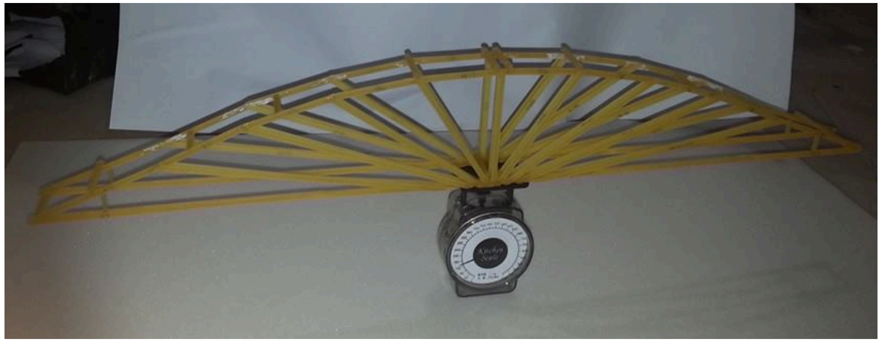
The initial bridge was tested with a load of 2.5kg. The bottom truss deflected downwards when more weight was added onto the bridge.

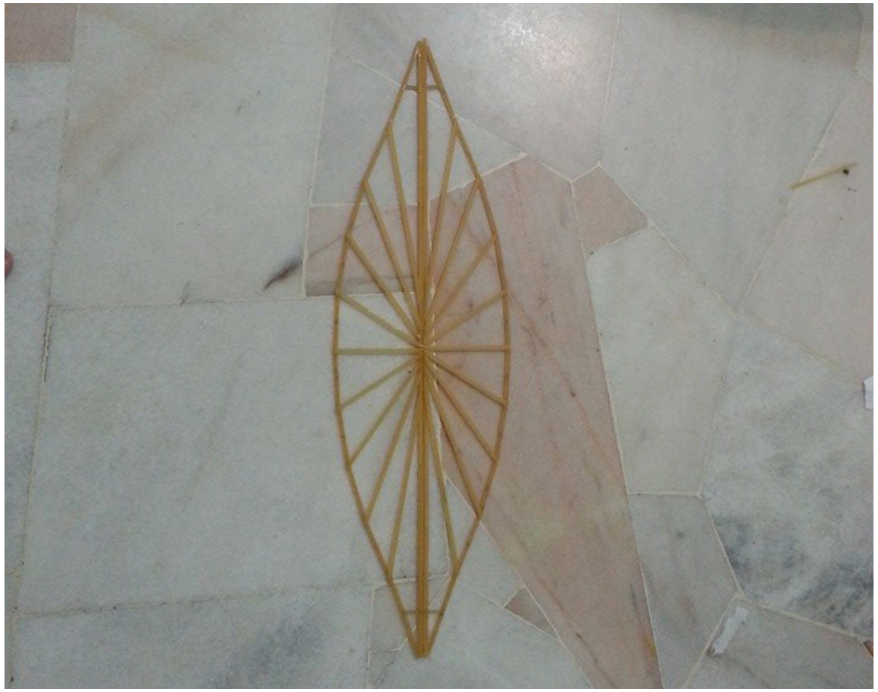
The reason as to why we chose to change the design of the bridge was because we wanted to lower that arc of the initial design and stack enough fettuccine to achieve good efficiency without the structure becoming overweight based on the weight requirements.

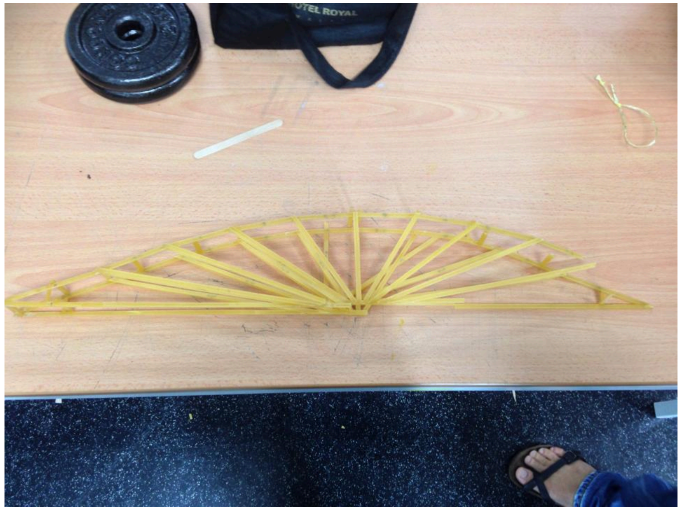
We also wanted a design where instead of the weight being distributed amongst the members we wanted the point load to focus more on the middle member of the bridge.

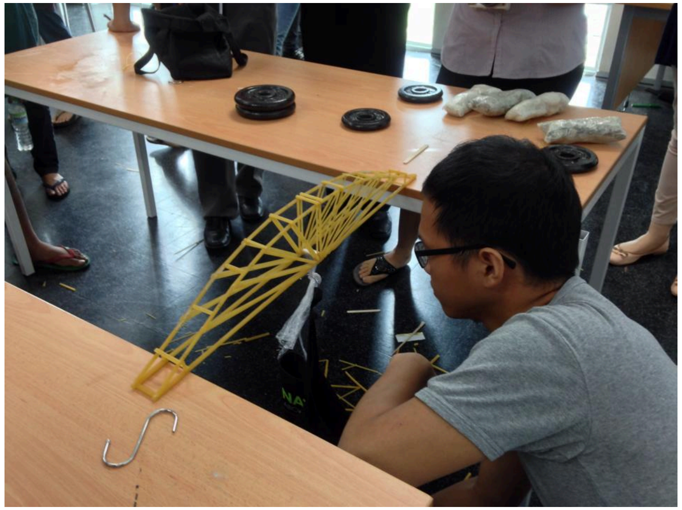
Calculation of Bridge











4. Conclusion

Within the process of testing the model testing the structure we built was able to withstand the required load of 5kgs. We tested the model to failure and saw that it carried a total weight of 6kgs.

We came up with a few reasons as to why the bridge collapsed so and at that weight. One of the main reasons why the structure failed as it did could have been due to the lack of internal bracing on the bottom of the bridge. If it were braced it could have provided enough rigidity and support to prevent the structure from collapsing as it did.

From the results of the calculation, the top members of the Fettuccini Bridge are under compression hence will have the most internal force, distributing the load to the two edges of the bridge. With the top most members (EF) having the highest compression force. The compression force on the members decreases towards the lower members near the base.

For the members under tension, the force decreases as it gets to the higher members with member AG under the highest tension force

There fore from this analysis we know that the members under compression should be made thicker than the members under tension as they handle larger forces. And the compression members at the top should be thicker than those at the bottom while tensional members at the top should be lighter than those at the bottom

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