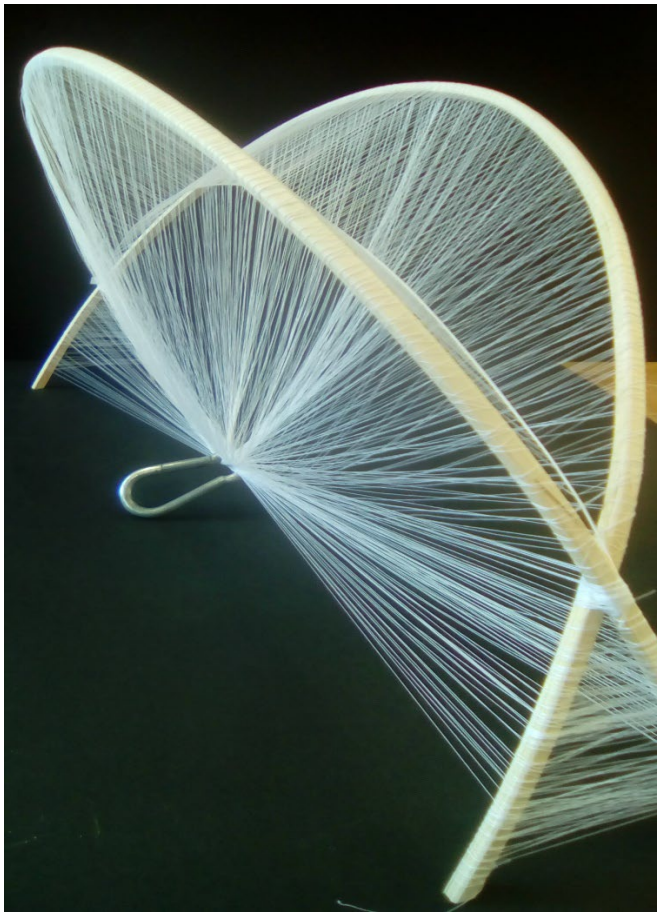
ARCH5112 Design Studio 1 2023

SEMESTER 2

Project 2 STRUCTURE

Weeks 1 - 3 **STRUCTURE** **28%**



Student Exemplar (1): popsicle stick bridge with cotton bracing

"I believe that the material doesn't need to be strong to be used to build a strong structure. The strength of the structure has nothing to do with the strength of the material."

Shigeru Ban

The strength of a structure is defined by the physical principles manifested and the quality of the connections made ……

structure **Hangatanga - *(noun) construction, building, structure***
a stable assembly of material elements designed and constructed to function as a whole to support and transmit loads and forces to the ground

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AIMS

- To generate and test a structural model to assess its efficiency and aesthetic merit

- To start to understand basic structural principles

- To analyse a structure to identify the structural principles manifested

- To improve on an intuitive model having understood more clearly the structural system to be employed

- To redesign and retest a structural model to improve structural efficiency

STRUCTURE ASSESSMENT EVENTS
(Associated Learning Outcomes 1,2,3,5 – see Studio Introduction on Moodle page)

Week 2	Monday 31 July	**Structure** Bridge 1 Testing	8%
Week 4	Monday 15 August	**Structure** Bridge 2 Testing	8%
	Thursday 17 August	**Structure** Booklet + Drawings	12%

TASKS

WEEK 1
Build a Bridge 1

You will construct a bridge made from ice block sticks, string or cotton, glue and/or pins.

The aim is to explore the principle of greatest structural capacity for least structural weight.
This is called a '**strength-to-weight ratio'**, where **'strength'** is the load/weight that the bridge is able to carry and **'weight'** measures the weight of the bridge itself.
The higher this number, the greater the bridge's efficiency or the better its 'strength-to-weight' ratio.
Most real bridges have a 'strength-to-weight' ratio of about 1:1.
This means they can carry a load equal to their own weight before they fail.
The modelling technique that we are using is usually much more efficient because the materials are so light.

Your bridge will be **approximately 825mm long** spanning the length of a testing rig.
It must **NOT** be attached in any way to the rig when being tested.
It is a free-standing structure.
NOTE: The bridge should be made longer than the rig span. When placed under stress from loading the structure often bends decreasing in length, which can result in the bridge falling off the rig.

Your bridge will weigh a maximum of **300 grams**.

First, weigh the material to be utilised to the maximum weight allowed, then explore the arrangement of possible elements to span the testing rig.

This will be an intuitive exercise as you measure and construct a model using ice block sticks and string, cotton and glue.

Consider carefully the number of layers of sticks in a beam, double or triple thickness may be used with separate elements being glued together and/or bound with string or cotton. Experiment with connections and the binding of joints, as this is most often where bridges fail.

Photograph the various stages of the construction of your bridge.
This photographic record of the fabrication of your bridge is important material to be included in a Final Report Booklet to be produced at the end of Week 3 of the Structure project.

CONSTRUCT A BRIDGE

Approximate Length = 825mm
Maximum weight = 300 grams

MATERIALS

- popsicle sticks
- glue
- string and cotton
- pins

Bridge 1 Testing - Monday 31st July 8:00 - 12:00 pm

NOTE: Testing will take place in Building 48 in Rooms 1070 and 1043.
PPE gear is required for testing: safety glasses and safety boots

- BRIDGE NUMBERING

Each bridge will be laid out in tutor groups and assigned, at random, a number to identify the bridge.

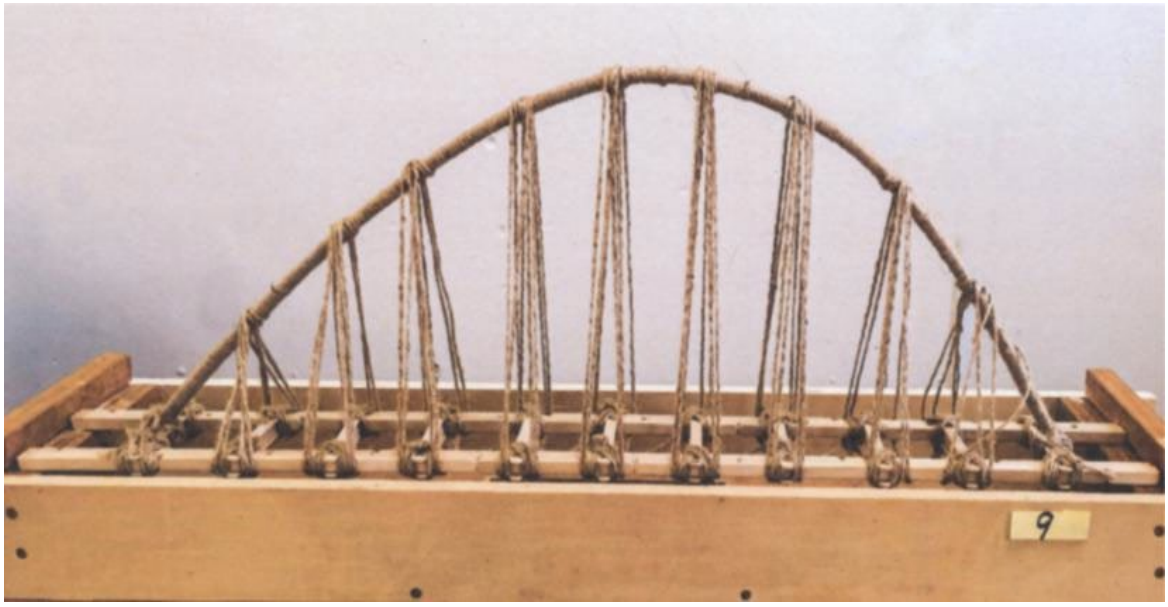
- WEIGH THE BRIDGE

Each bridge will be weighed, in grams, to establish the **'W'** value

- PHOTOGRAPH YOUR BRIDGE

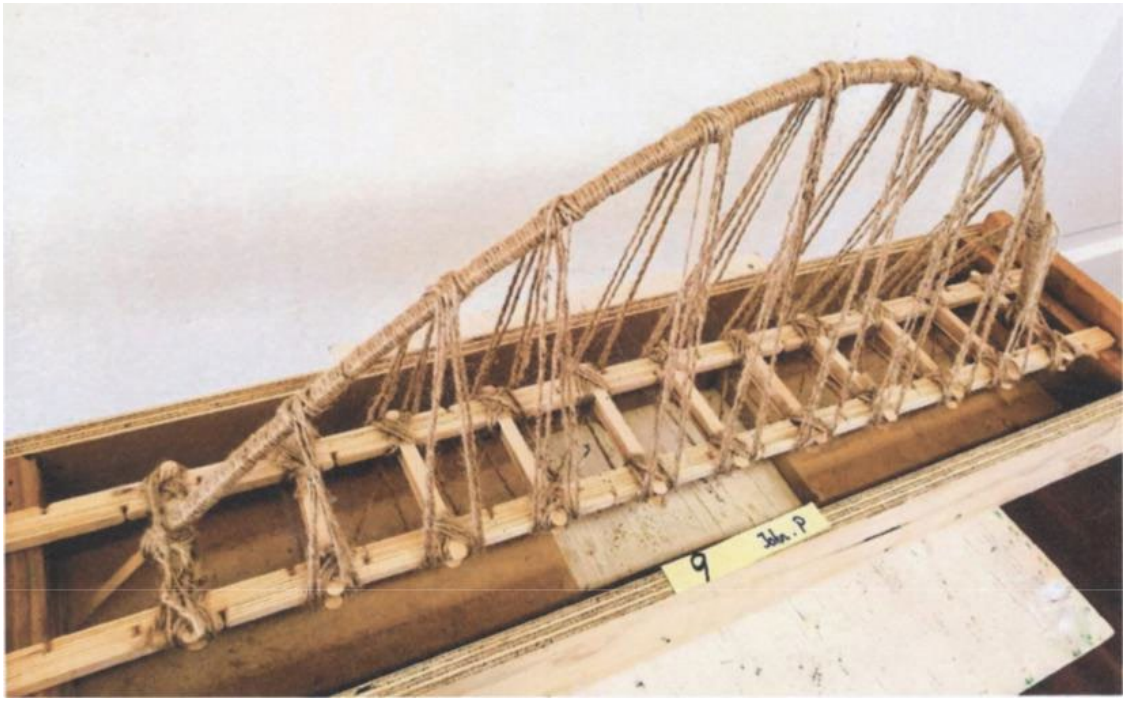
Take 2 quality photographs of your bridge.

One image is an **'ELEVATION'** of the bridge side on, in position in the test rig.



Student Exemplar (2): elevational image of bridge in rig

One will be a **'BIRD'S EYE' PERSPECTIVE** of the bridge in position on the test rig.



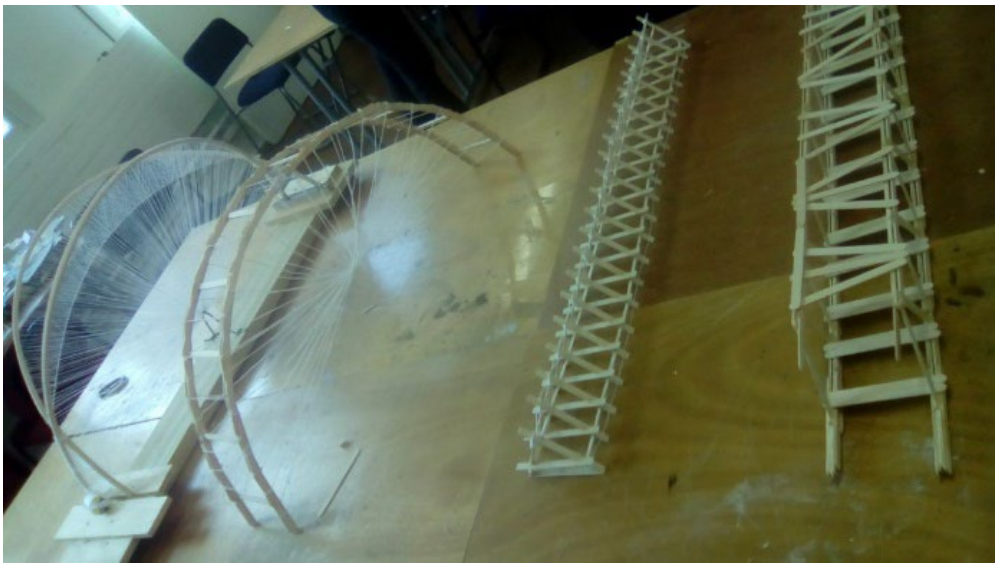
Student Exemplar (3): bird's eye image of bridge in rig

IMPORTANT: These photographs of your bridge are an important record of your model as we will now be weighing the bridges and testing them to breaking point in the test rig.

The photographs MUST be included in the Bridge Report Booklet to be handed in at the end of Week 3 of the Structure project.

- AESTHETIC RANKING

All the bridges have been laid out on a row and numbered.
Each student will rank **every** bridge for their aesthetic qualities, from most appealing to least compelling, on a named Aesthetic Ranking Sheet.



Student Exemplars (4): bridges lined up in preparation for Aesthetic Grading

Make sure that you rank every single bridge in your group - check and then double check that you have ranked them all.

This ranking will count for 50% of the assessment for Bridge 1.

The remaining 50% will be based on the measured performance

– **S/W** ratio of your bridge **(S:W)**

BRIDGE 1 TESTING

Your bridge will be tested in the test rig to assess its performance to calculating the **S/W ratio.**

You have already weighed your bridge before testing to record the **WEIGHT = W**.
You will now test your bridge to breaking point, recording the weight of load it can sustain without breaking **STRENGTH = S**.

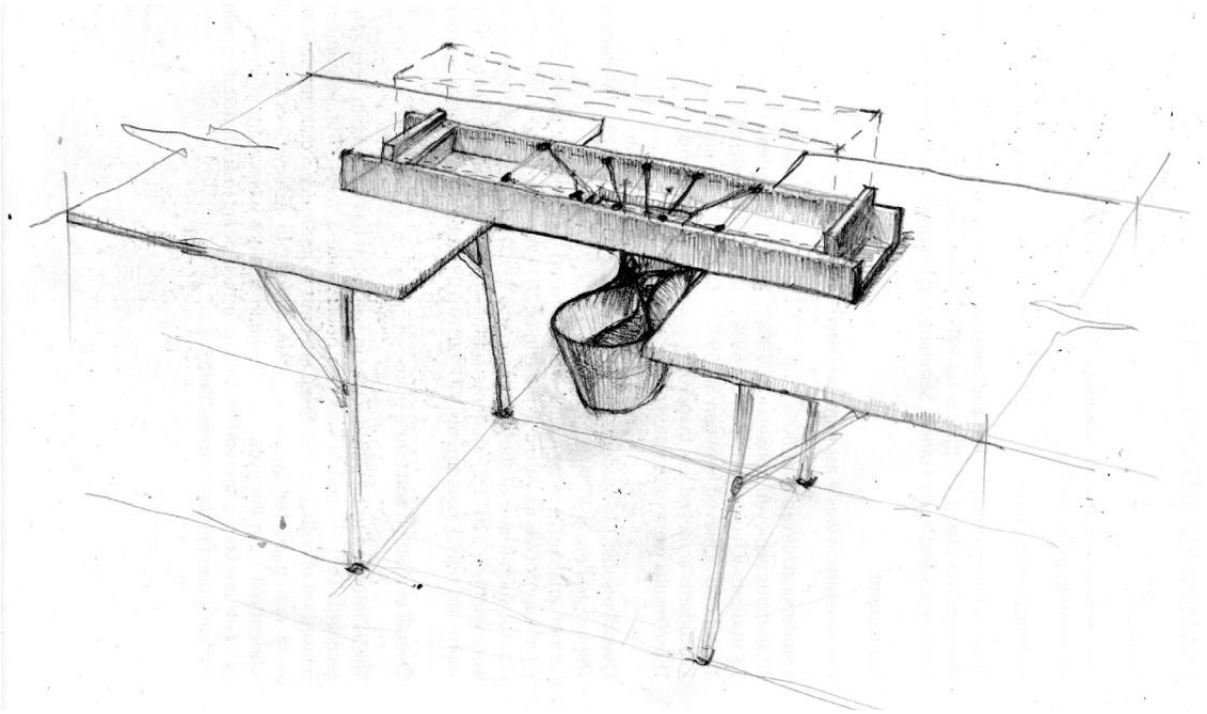


Image (5): Sketch of rig and bridge testing station

When testing your bridge for strength take care to distribute the weight applied as evenly as possible along the length of the bridge.
The strings distributed along the bridge must not touch the rig, running clear of the rig to hold the bag/bucket suspended below where extra weights are gradually applied.

The bridge is deemed to have failed when it collapses or any part of the bridge distorts so as to touch the rig.

IMPORTANT: Make a video of the collapse of your bridge.

The video can be studied afterwards, enabling you to analyse your bridge's performance and understand where it failed. The observation of its collapse will provide clues to how to improve your model for the construction of Bridge 2.
Stills from the video of the moment of collapse MUST be included in the final Bridge Report Booklet.

GRADING FOR BRIDGE 1 TESTING

Bridge 1 Performance		**8%**
The grade is calculated in the following manner:		
- Student aesthetic grading of bridge	50%	4%
- S/W ratio – performance graded Relative to class outcomes	50%	4%

TASK – BRIDGE REPORT DATA GATHERING

You need to have gathered information for your Bridge Report Booklet to be handed in to your tutor in the studio rooms at 1:30pm on Thursday 17th August.

A paragraph describing the form and conceptual idea behind your bridge project (100 words max.)
You should have clear Elevation and Bird's Eye Photographs of your Bridge 1 model in the rig.
You should have a series of 5/6 images recording the various stages of the bridge construction process.
A paragraph analysing the Bridge 1 performance, why it failed and strategies for improvement in Bridge 2 (150 words max.).

WEEK 2
Analysing Bridge 1 Performance

Having tested Bridge 1, you will have seen how it performed.
What was its performance defined by the S/W Ratio?

Your Bridge 1 Project was principally generated by a 'sense' of structure, an intuitive fabrication of your materials.

You are going to redesign and improve your bridge construction, after being introduced to Structural concepts.

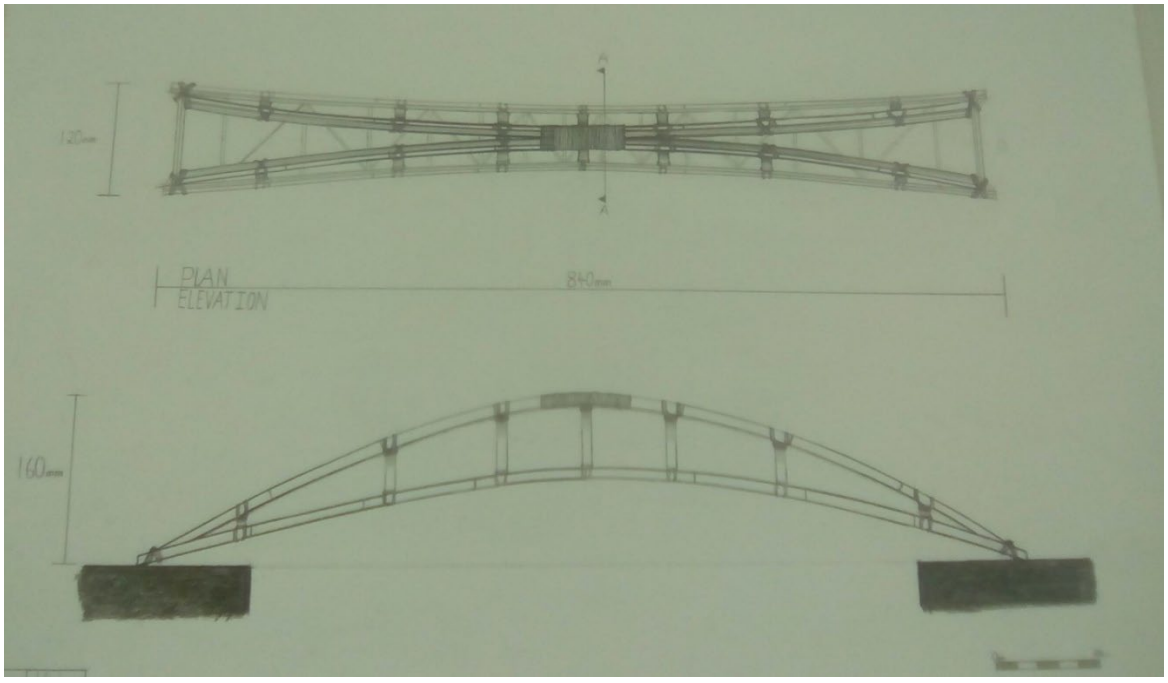
There are more detailed **STRUCTURAL PRINCIPLES** to be understood.
- Tension, Compression, Shear, Torsion

These **Structural Principles** generate **STRUCTURAL ELEMENTS**.
- beam, horizontal cantilever, column-vertical cantilever

These **Structural Elements** are combined to generate **STRUCTURAL SYSTEMS**.
- column and beam, cantilevered beam, braced system –column/brace/beam/brace/column
- truss, arch, gothic structure

These **Structural Systems** are the drivers which generate different **BRIDGE TYPOLOGIES**.
- beam, cantilever, arch, suspension, cable-stayed and truss bridges

You will now draw the project for an improved bridge design.



Student Exemplar (6): Proposed Bridge 2 drawings – plan and elevation at scale 1:2

Draw your improved Bridge 2 Project 6%

You will produce detailed drawings of your Bridge 2 design.
There will be a pinup of the drawings in progress, in class to get feedback, before the final submission of the drawings. The submission of the completed drawings will be done by including them in the Bridge Report.
A final grade will be assigned to the drawings when the report is marked.

On 2 x A2 sheets of cartridge paper you will draw:

- 1 x Plan **Scale 1:2**

- 2 x Sections **Scale 1:2**

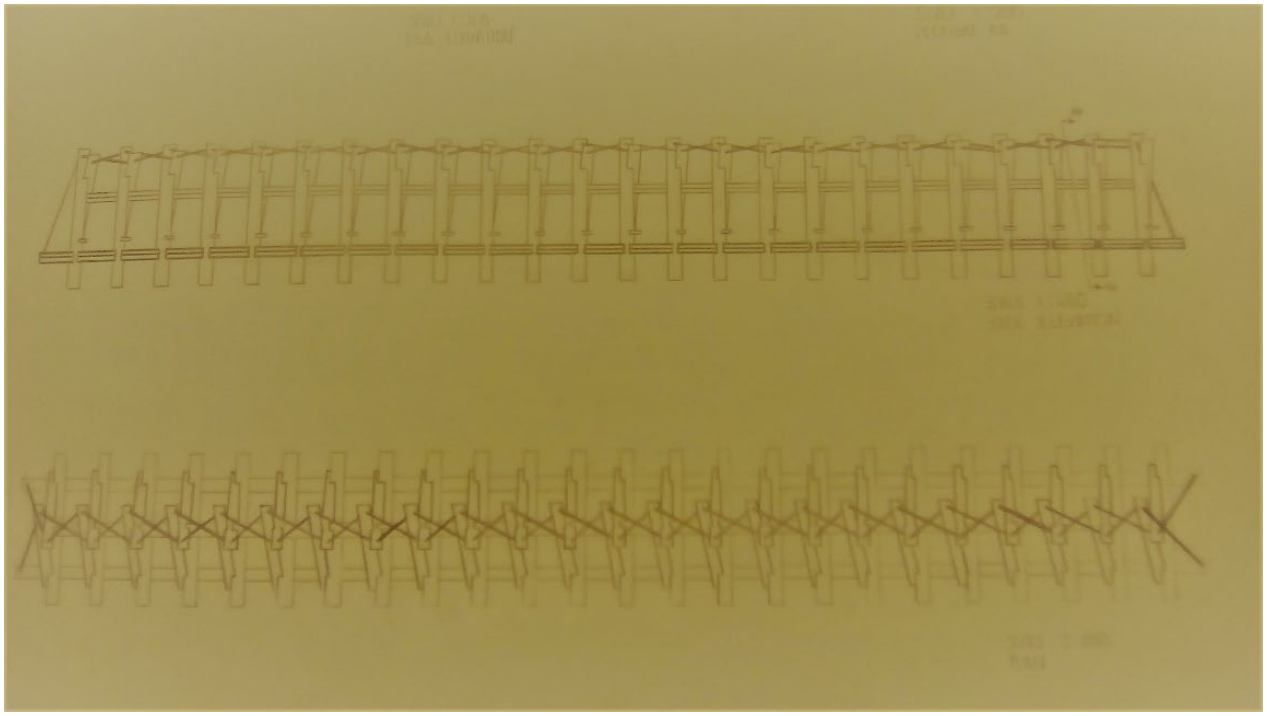
- 2 x Elevations **Scale 1:2**

- 2 x Details **Scale 1:1**

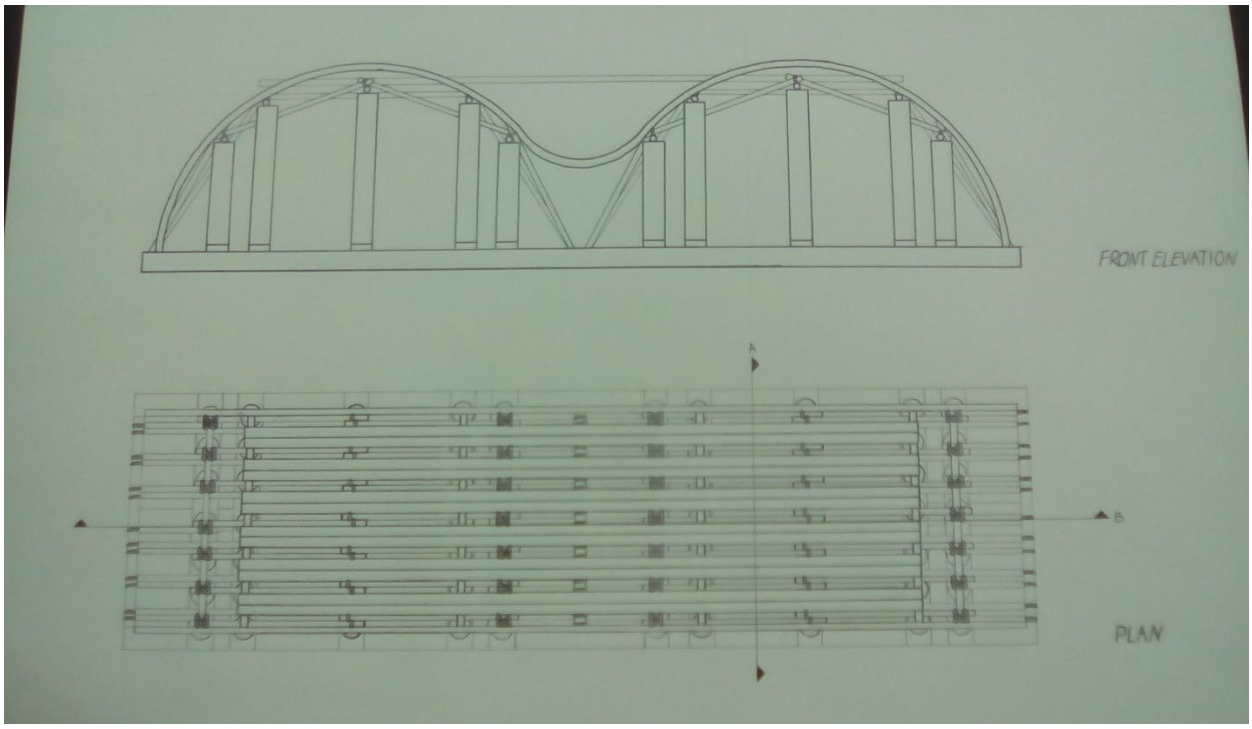
- a diagram of the structural principles and forces at work in your bridge

These drawings will be clear and finely detailed, communicating the qualities and texture of materials, together with the binding or fabrication of joints and connections.

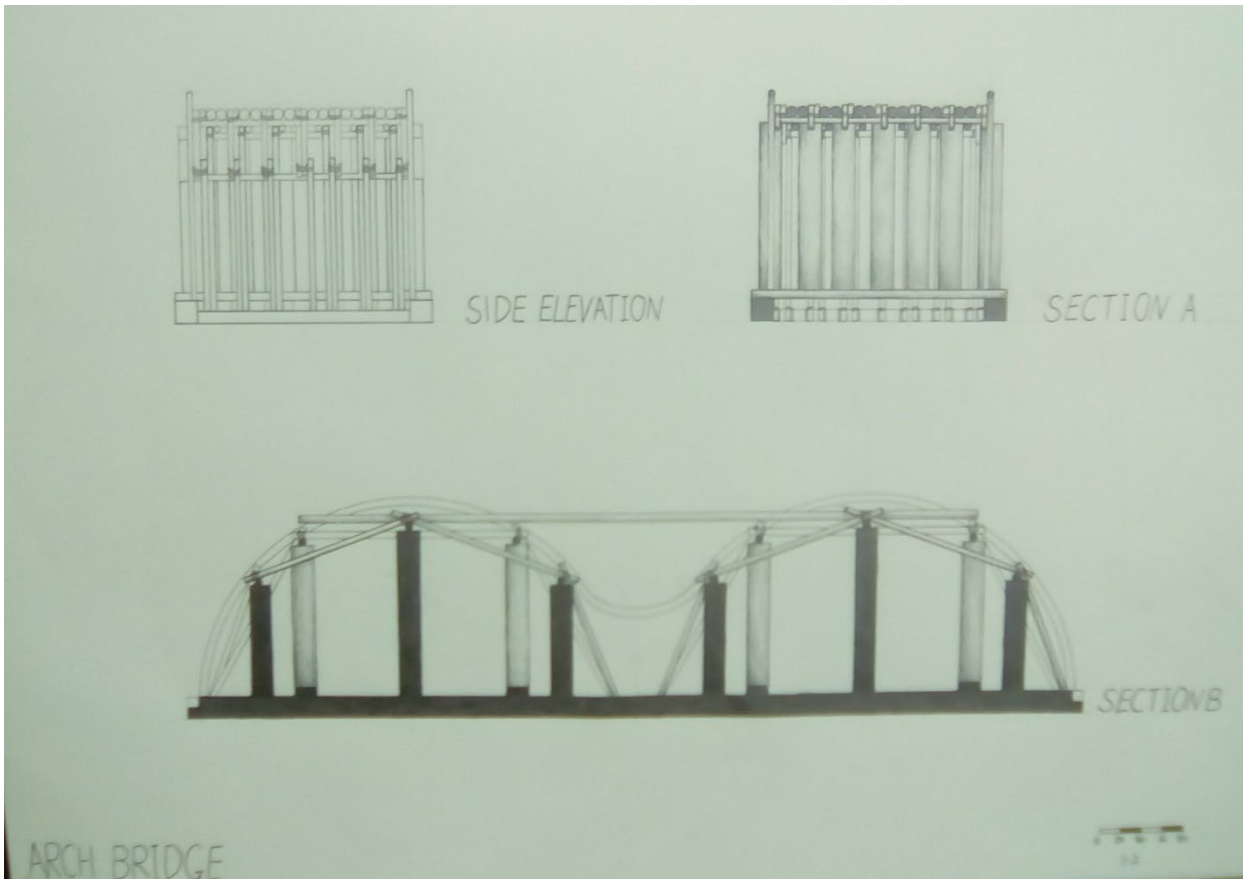
Bridge 2 drawings will be pinned up on Thursday 10th August in class groups. Each student will present their project to their class group, discussing, and getting feedback, regarding the proposed bridge structural diagram and revisions to their Bridge 1 design.



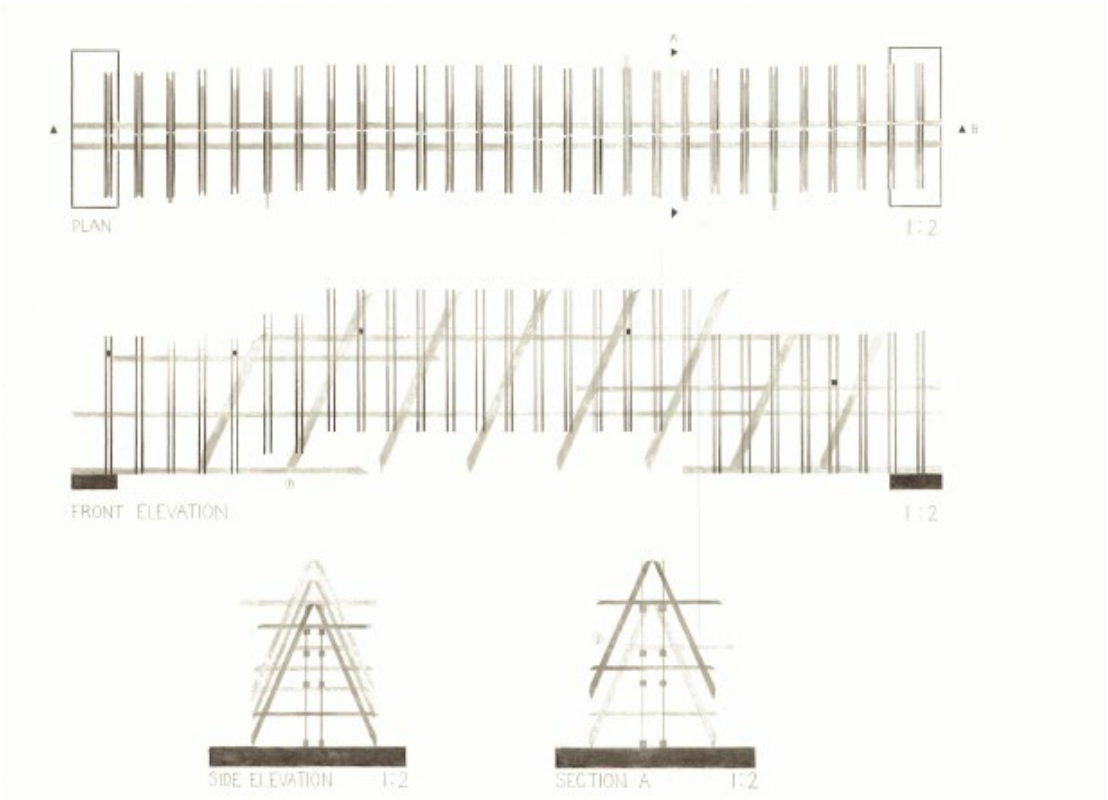
Student Exemplar (7): Proposed Bridge 2 drawings – plan and elevation at scale 1:2



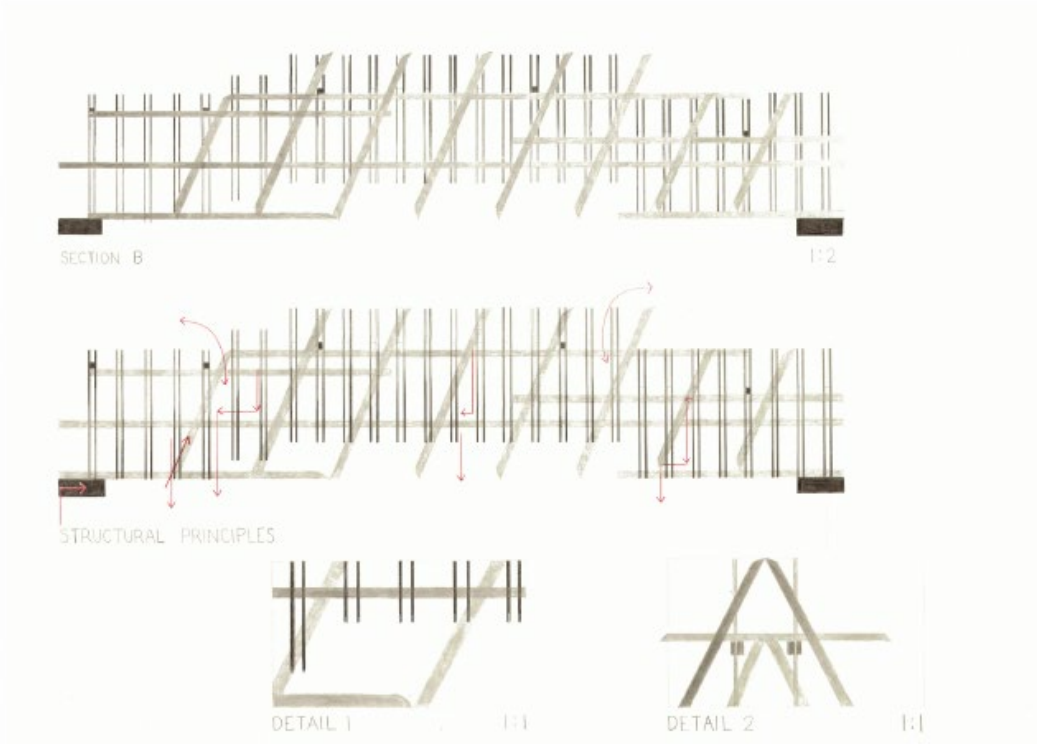
Student Exemplar (8): Proposed Bridge 2 drawings – plan and elevation at scale 1:2



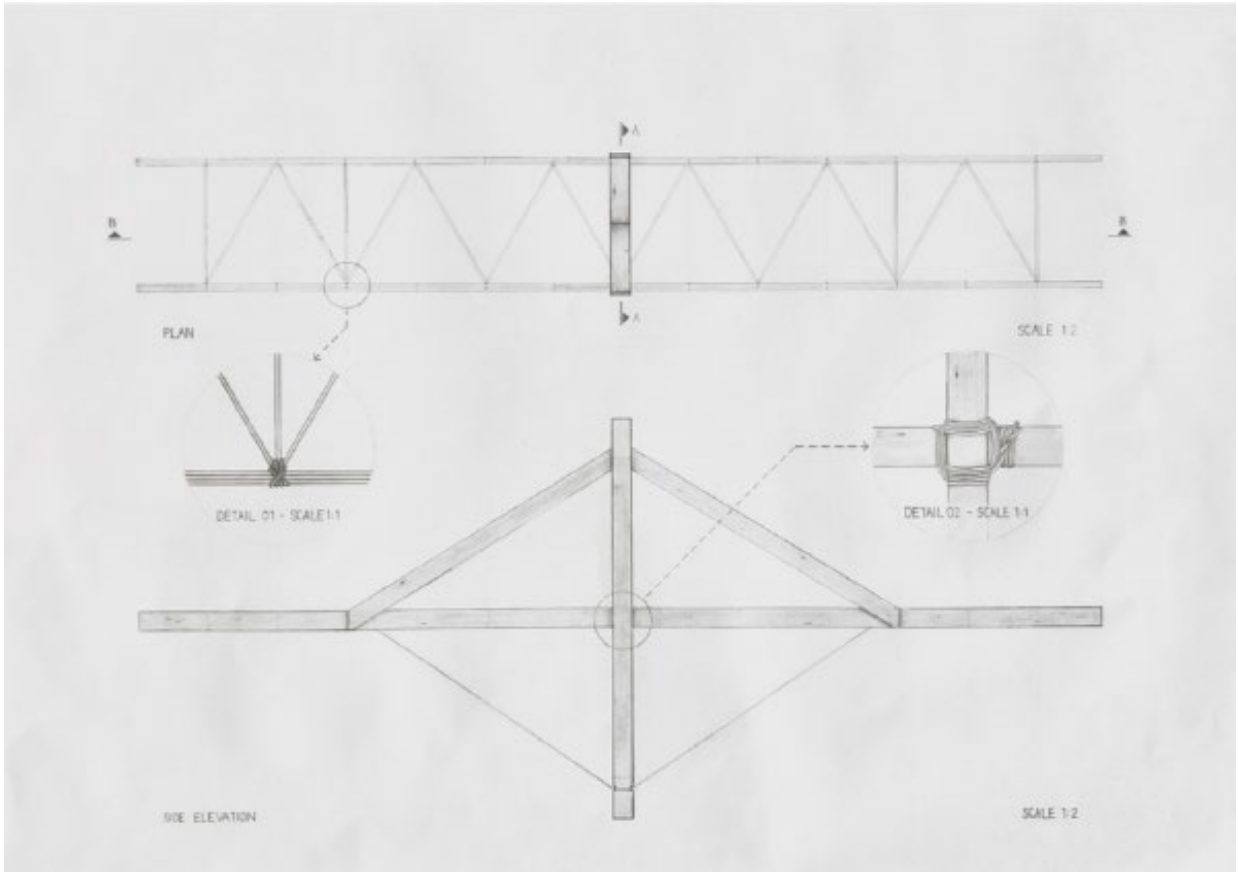
Student Exemplar (9): Proposed Bridge 2 drawings – 2 x sections and elevation at scale 1:2



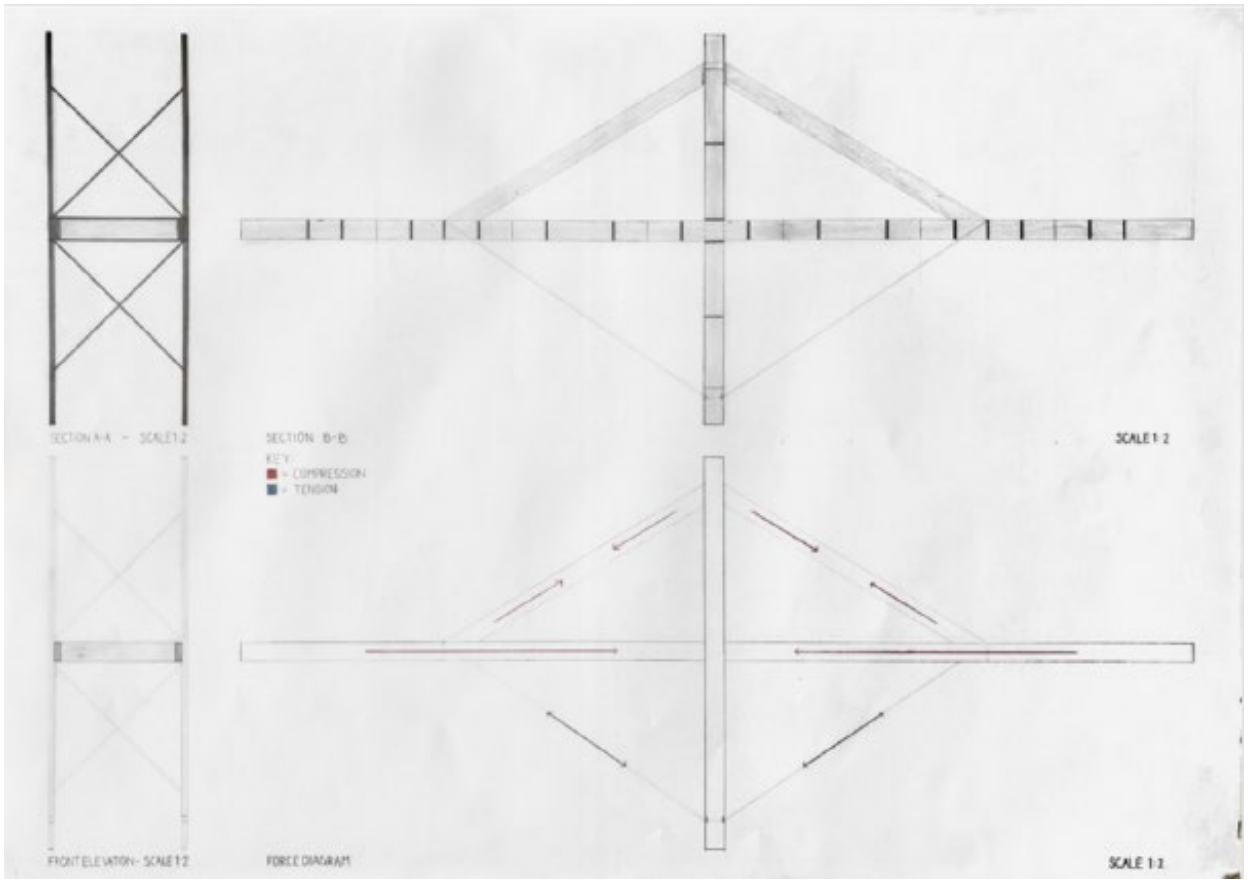
Student Exemplar (10): Proposed Bridge 2 drawings – plan, section and elevations at scale 1:2



Student Exemplar (11): Proposed Bridge 2 drawings – section, structural diagram and details at scale 1:2



Student Exemplar (12): Proposed Bridge 2 drawings – plan and elevation at scale 1:2 and details at scale 1:1



Student Exemplar (13): Proposed Bridge 2 drawings – sections, elevation and structural diagram at scale 1:2

TASKS

WEEK 3

CONSTRUCTION AND TESTING – BRIDGE 2

You will build Bridge 2, based on a revised bridge design, as indicated in your Bridge Drawings, and improvements made following testing Bridge 1.

Monday 14th AUGUST 8:00am - 12:00pm

Bridge 2 will be tested in exactly the same way that we tested Bridge 1.

- NUMBER ASSIGNED TO YOUR BRIDGE

- WEIGH YOUR BRIDGE

Weigh your bridge, in grams **WEIGHT = W**

- PHOTOGRAPH YOUR BRIDGE

Take two quality photographs of your model – one in elevation and one a bird's eye view – sitting in the rig before testing

- AESTHETIC RANKING

Rank the bridges in the group from most to least aesthetically appealing.

- BRIDGE TESTING

Test to breaking point recording the maximum load supported **STRENGTH = S.**

Calculate the S/W Ratio (S:W)

S (strength = weight supported) is divided by W (weight of bridge)

Eg. Where the bridge weighed 250gms (W) and supported 45kgs (S) before collapsing.
45000gms divided by 250gms = 180 S/W Ratio

GRADING FOR BRIDGE 2 TESTING

Bridge 2 Performance 8%

The grade is calculated in the following manner:

- Student aesthetic grading of bridge	50%	4%
- S/W ratio – performance graded Relative to class outcomes	50%	4%

BRIDGE REPORT BOOKLET 6%

The writing of reports is an essential and frequent requirement in architectural practice. Reports are an important tool to clearly communicate the ideas behind projects and a project's content and performance criteria.

The final grade for Bridge 2 is derived from a **Bridge Report Booklet**.

The Report will be an A4 landscape format booklet.
This is a design/communication project.
The success of this booklet is in the details:
How are you going crop your photographs?
How are you going to lay them out in a clear sequence with captions under them?
You are communicating important information about your project.

- Prepare a cover page with your name; ID number; Title "Structure: Building Bridges".

Put your BRIDGE 2 elevation photograph, with the S/W ratio below it, on this cover sheet

- Write an Introduction (100 words) that explains the *structural idea* behind your bridge design to communicate what you were trying to achieve.

- Show 6 - 8 photographs of the BRIDGE 1 construction process. Each photograph has a caption under it explaining what is seen in the photograph. You need to decide how to lay these out in a clear and compelling way. Scan any design process sketches that explain the development of your design. Present these carefully to make a beguiling presentation of the design work. Add captions to explain what the sketches are showing.

- Show the two photographs of the finished BRIDGE 1 in the test rig, i.e. the elevation and the bird's eye perspective. Each must have a caption.

- Show 1 - 4 photographs showing the collapse of your bridge. Choose stills from your video that capture the failure.

- Write an analysis (100-150 words) of your understanding of why your bridge failed.

- Write a proposal (100-150 words) that suggests how to improve the structural efficiency of your bridge.

- Include images of your drawn BRIDGE 2 proposal.
These are worth half of the grade for the Booklet i.e. 6%.

- Show the two photographs of the finished BRIDGE 2 in the test rig, i.e. the elevation and the bird's eye perspective.

- Show 1 - 4 photographs showing the collapse of BRIDGE 2. Choose stills from your video that capture the failure.
- State clearly the S/W Ratio achieved by BRIDGE 2.
- Write a final analysis of the performance of BRIDGE 2 (max 150 words)**.**

Pay careful attention to the graphic organisation of images on each page.
Clearly label every illustration, image and photograph.

A hardcopy of the document is to be handed in to your tutor in your studio class, by 1:30pm on Thursday 17th August.

A digital copy of the booklet to be submitted to the Structure Booklet hand-in folder in Moodle by **2pm on Thursday 17th August.**

The report will be assessed on the completeness of all tasks requested, clarity of layout and effective communication of the conceptual idea, and analysis, of your bridge models.

DATES of Studio

BRIDGE 1

Week 1

Monday 24th July **8:00am – 12:00pm**
Semester 2: General Introduction
Project 2 – Weeks 1-3 Structure Brief - presentation
Content – Building bridges - weighing material – ice block sticks/glue/string/pins
- Connection Methods - lamination-glue-joints-lashing-string as structure

Wednesday 26th July **8:00am - 10:00am**
Joseph, Rimo and Scarlett – self-directed studio session – workshops and Q&A

Thursday 27th July **1:00pm - 5:00pm**
Building Bridge 1 – workshop and modelling
Content – student bridge exemplars and videos of testing procedure

Week 2

Monday 31st July **8:00am - 12:00 pm**
Bridge 1 TESTING – **In Building 48 – PPE Gear required**
- aesthetic ranking and performance testing to breaking point
- calculating the strength/weight ratio results

BRIDGE 2 - Drawings, Testing, Booklet

Wednesday 3rd August **8:00am - 10:00am**
Joseph, Rimo and Scarlett – self-directed studio session – workshops and Q&A

Thursday 4th August **1:00pm - 5:00pm**

Presentation of BRIDGE 2 Project work

Content – structural principles, structural elements, structural systems
- Bridge typologies - beam, cantilever, arch, suspension, cable-stayed and truss bridges

Content – Booklet layout principles – compositional strategies and examples

Analysis of Bridge 1 – understanding your bridge performance and designing improvements

Week 3

Monday 7th August **8:00am - 12:00pm**

Content – drawing exemplars and how to draw details and represent materials

Bridge 2 – construction improvements – drawing your bridge project

Wednesday 9th August **8:00am - 10:00am**

Rimo + Kahu – self-directed studio session – workshops and Q&A

Thursday 10th August **1:00 - 5:00pm**

1-3pm - **Bridge 2 Drawings pin-up and crit**

PINUP in Class GROUPS (not graded) but feedback essential

3-5pm – feedback and desk crits – building your final model

Week 4

Monday 14th August **8:00am - 12:00 pm**

Bridge 2 TESTING – **In Building 48 – PPE Gear required**

– aesthetic ranking and performance testing to breaking point

- calculating the strength/weight ratio results

Wednesday 16th August **8:00am - 10:00am**

Joseph, Rimo and Scarlett – self-directed studio session – workshops and Q&A

Thursday 17th August **1:00pm - 5:00pm**

1:30pm – Bridge Report Booklet – hardcopy hand-in + digital submission to Moodle by 2pm

2pm - Introduction **MATERIALITY Brief**