Sidney Lam - 9STEA Paper Bridge Folio

Statement of Intent

We are required to construct a paper bridge with an A4 piece of paper, 300mm of masking tape, a pair of scissors, ruler and other materials,(provided by the school) and then test it, recording the amount of weight and deflection inflicted by the bridge when weight is put on it. The school will provide all materials, including paper, masking tape, and other equipment. We will then need to test the bridge and record the load and the deflection in a table format. This project will provide me with some insights into the details of how a bridge works.

Criteria for Success

The criteria for success that I will refer to to assess the success of the bridge that my group has made:

- It can hold a certain amount of weight for a reasonable time,
- It is aesthetically pleasing,
- It only uses the materials provided,
- It meets the marking criteria
- It is sturdy enough
- It is not messy

This project is characterized by a series of critical constraints. These are a limited timescale, restrictions on the amount and type of available materials, and the problem of using prior knowledge to develop the most effective build.

Research (Bridge designs, strength, materials, load Vs deflection)

Types of bridges with a diagram of its type, and a brief description. At least 5 to 7 types of bridge are required.

To build a strong paper bridge we need to study existing designs.
The beam bridge is simple and cost-effective, though limited in span length.
The truss bridge, with its triangular patterns, offers a great strength-to-weight ratio but is more complex.
The arch bridge is excellent for distributing weight but requires precise construction.
These designs can inspire the creative use of paper folds and layering.

Key design principles include even load distribution, balancing tension and compression, material efficiency, and combining strength with aesthetic appeal.

Design Principles

1. Material Efficiency: Using paper effectively to balance strength and weight is very important. By folding, layering, or rolling the paper, you can greater its load-bearing capacity without using excess material.
2. Structural Integrity: The bridge's structure, such as trusses or arches, is crucial. These forms distribute weight evenly, reducing stress points and preventing collapse under a load.
3. Stability and Balance: Ensuring the bridge remains stable involves maintaining even weight distribution. Symmetry in the design helps to keep the bridge balanced and functional.
4. Aesthetics and Functionality: A good design balances visual appeal with functionality.
5. Testing and Iteration: A good design comes from trial and error. Testing the paper bridge with load, recording the results and improving the design are key aspects of the engineering process.

Types of bridges

Type of Bridge	Description
Beam Bridge	The simplest form; a flat deck supported at both ends. Strong for short spans but limited in length and weight.
Arch Bridge	Curved structure distributes load evenly into abutments. Strong but requires precision.
Truss Bridge	Triangles spread load efficiently; lightweight but strong. Great for small materials.
Suspension Bridge	Strong over long distances; not practical for paper, but interesting concept.
Cable-Stayed Bridge	Similar to suspension bridges cables go directly to the deck; more rigid.
Cantilever Bridge	Balanced arms extending from supports; great for moderate lengths.

Tied Arch Bridge	Combines the strength of arches with tension to stop spreading forces.

Each offers unique strengths and weaknesses that can guide the creation of a sturdy and effective paper bridge.

Bridge Design

In real life, these are the most common materials used in the designing of bridges.

Steel: Used in structural beams, trusses, and cables due to its high tensile strength and ductility.
Reinforced Concrete: A composite material combining concrete's compressive strength with steel's tensile strength, used in bridge decks, piers, and abutments.
Prestressed Concrete: Concrete subjected to intentional compressive forces to enhance its tensile capacity, used in long-span bridges.
Timber: Used in smaller bridges or temporary structures, offering a renewable and aesthetically pleasing option.
Stone: Used in older bridges, and when long term durability is required, and is very good at handling compressive forces.

Designs

PMI Table

Bridge 1 - Truss Bridge

Plus	Minus	Interesting
It uses a triangular base design which makes it slightly more stable.	It does not hold as much weight as expected.	Due to the shape of the bridge, it is slightly harder to tape on.
The two layers of paper offer a slight reinforcement.	It can be weak especially when there is more weight used	A decision has to be made whether to place the weights on the flat surface or the trussed surface.

Bridge 2 - Cylindrical Bridge

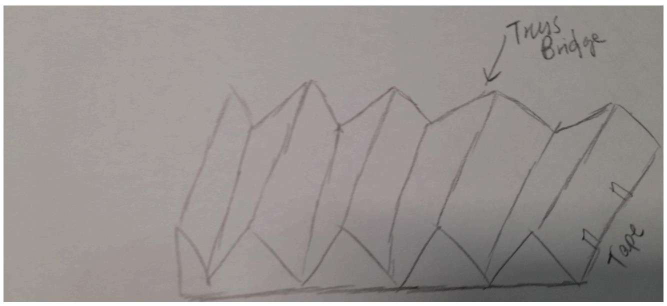
Plus	Minus	Interesting
It uses a cylindrical base which can be slightly more stable.	The cylindrical base resulted in the weights slipping off a little if there weren't any flat weights.	It might be hard to place the objects/weights on the bridge as the surface is curved.
It could hold much more weight when compared to Bridge 1.	The cylindrical base made it so that it would break as soon as too much load was put on it instead of deflection.	The bridge couldn't be reused.

Bridge 3 - Flat Bridge

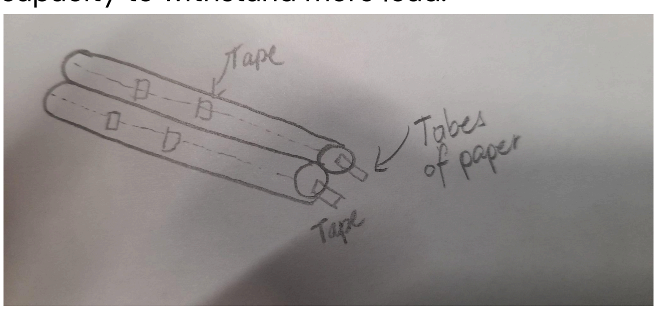
Plus	Minus	Interesting
It has a stable base, where you can put all types of weights on there.	The bridge does not support much weight as compared to the others.	Easier to build and test.
It is easier to build and reuse.	The tape detaches from the books/surface when there is a little bit of weight on it.	Reliable for multiple trials.

Idea Generation and Development

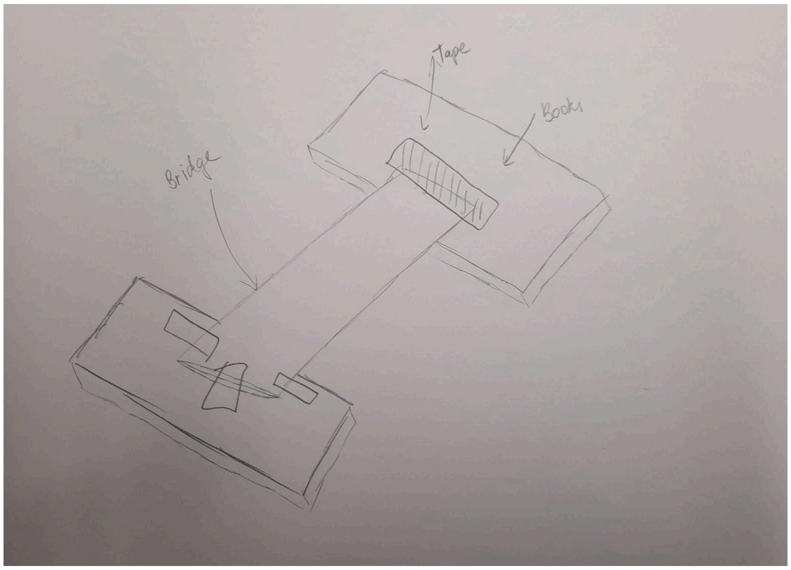
Hand-drawn design



Truss Bridge - The sketch shows a truss bridge made by folding a piece of A4 Paper. Paper is folded back and forth so that it forms a truss shape. Adhesive tape is strategically applied at various points along the edge, to provide reinforcement and maintain structural integrity. This use of tape balances out the weakness of paper in resisting collapsing, expanding the capacity to withstand more load.

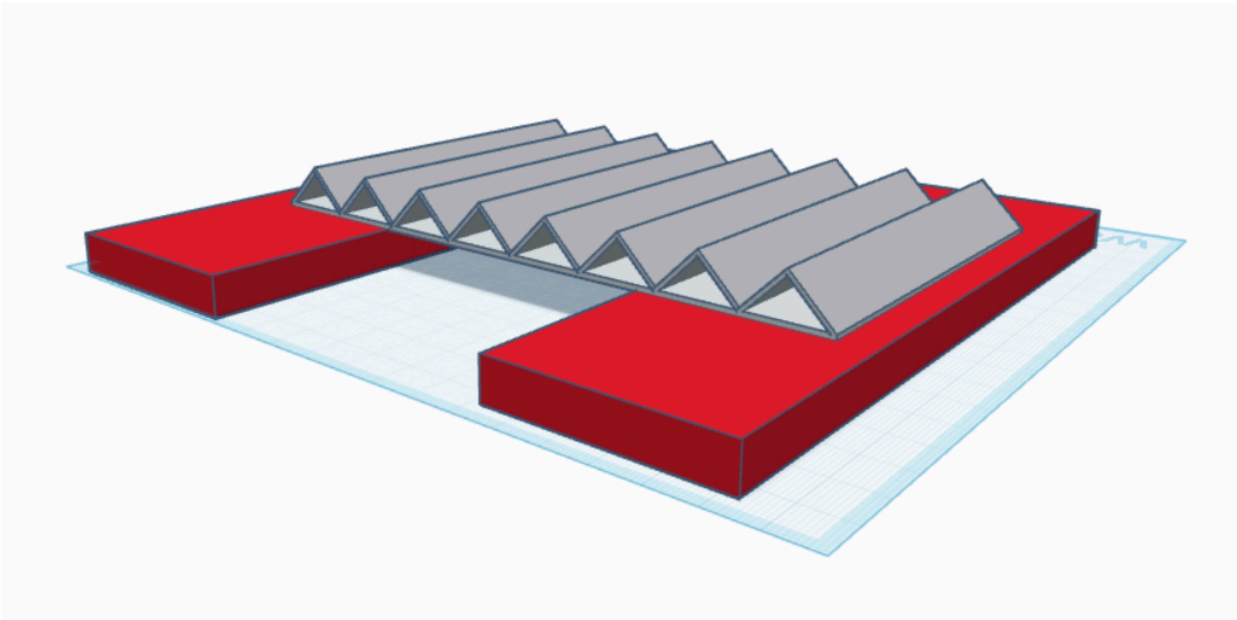


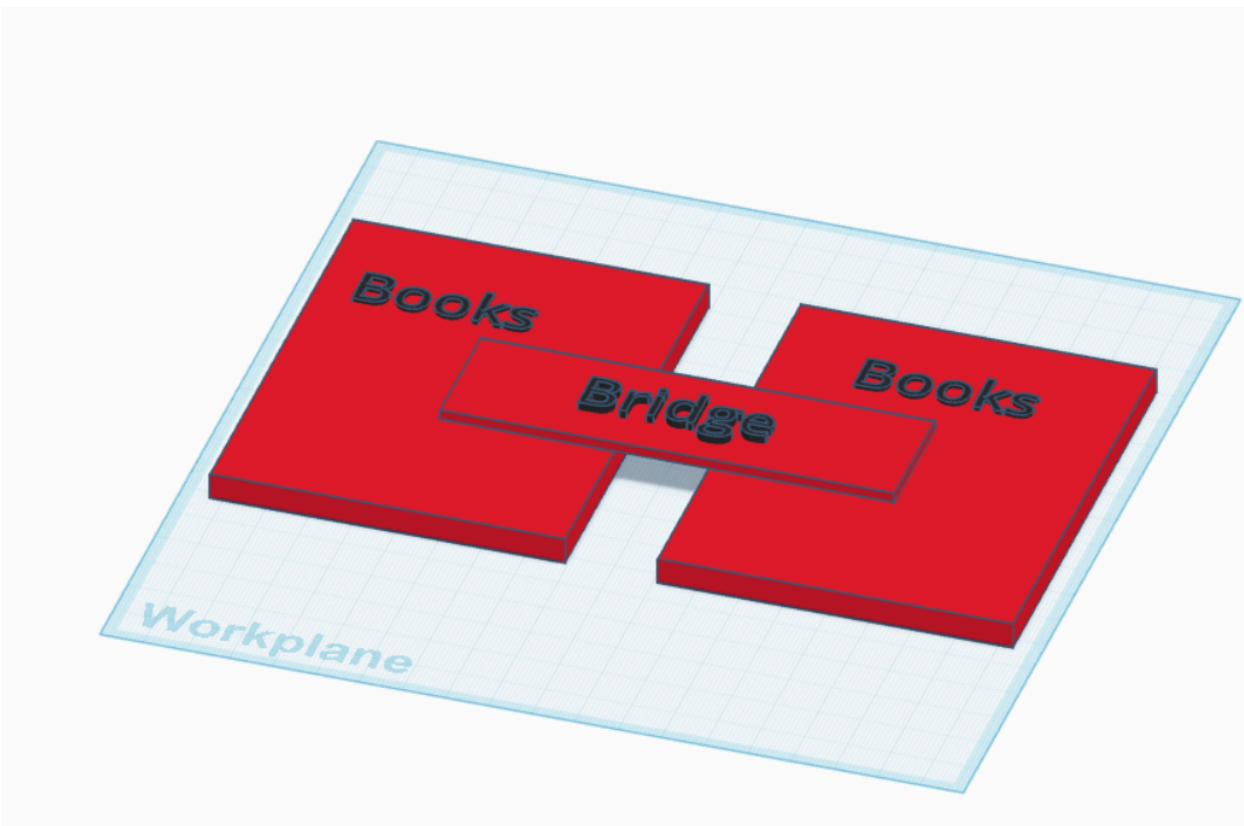
Cylindrical Bridge - A taped and rolled paper cylinder, built with torn paper, is strengthened by the cylinders ability to distribute the weight evening across its bearings. Taping torn edges keeps the structure intact but unsecure joints potentially weaken stability. This model mimics real structures like columns, showing how design makes weak materials become strong support systems.



Flat Bridge - The sketch features a flat bridge constructed by folding an A4 sheet of paper four times along its shorter side, resulting in overall dimensions of 55mm x 297mm. To maximize the strength, there is tape each side four times, applying tape between every fold and layer of the paper. Additionally, the top of the bridge is reinforced by using the remaining tape on each side, providing extra support and stability.

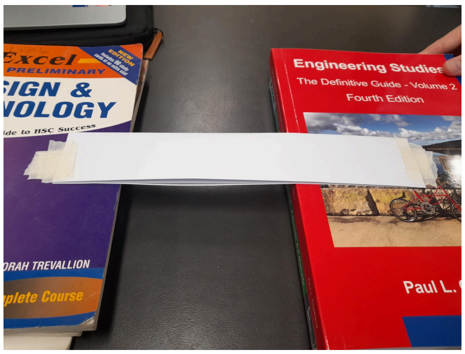
CAD Drawings



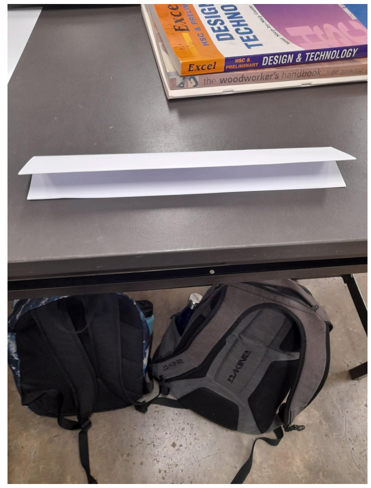
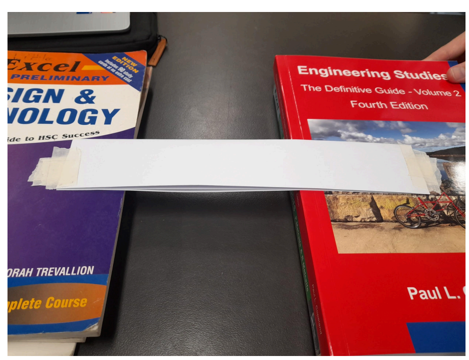


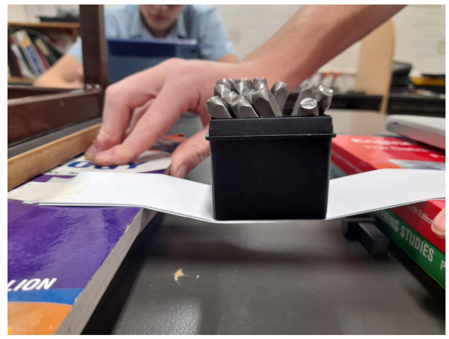
Final Design

Our final design features a flat bridge constructed by folding an A4 sheet of paper four times along its shorter side, resulting in overall dimensions of 55mm x 297mm. To maximize strength, we securely tape each side four times, applying tape between every fold and layer of the paper. Additionally, we reinforce the top of the bridge by using the remaining tape on each side, providing extra support and stability.



Procedure Table + Progress Photos

1. Plan the type of bridge that you will be making.	
2. Fold the piece of paper according to the design that you have decided to try out.	
3. Tape down any parts that need taping down.	
4. Place it so that it hangs between two books.	
5. Tape the bridge to the books if needed.	

6. Gradually place weights and record the deflection (how far down it drops depending on the weight).	
7. Place weights until it collapses.	
8. Record final weight.	

Production

Procedure

Design a paper bridge:
Materials:

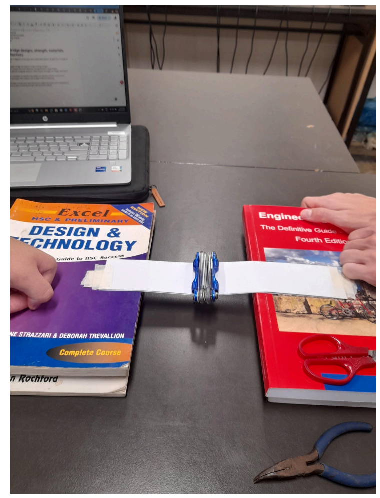
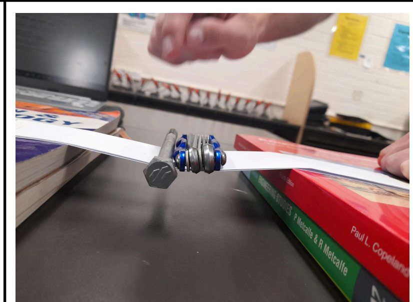
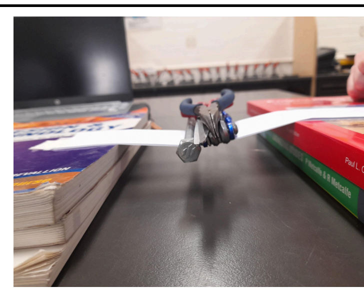
- 1 A4 paper
- 300mm of masking tape
- Weights

Method:

1. Plan the type of bridge that you will be making.
2. Fold the piece of paper according to the design that you have decided to try out.
3. Tape down any parts that need taping down.
4. Place it so that it hangs between two books.
5. Tape the bridge to the books if needed.
6. Gradually place weights and record the deflection (how far down it drops depending on the weight).
7. Place weights until it collapses.
8. Record the final weight.

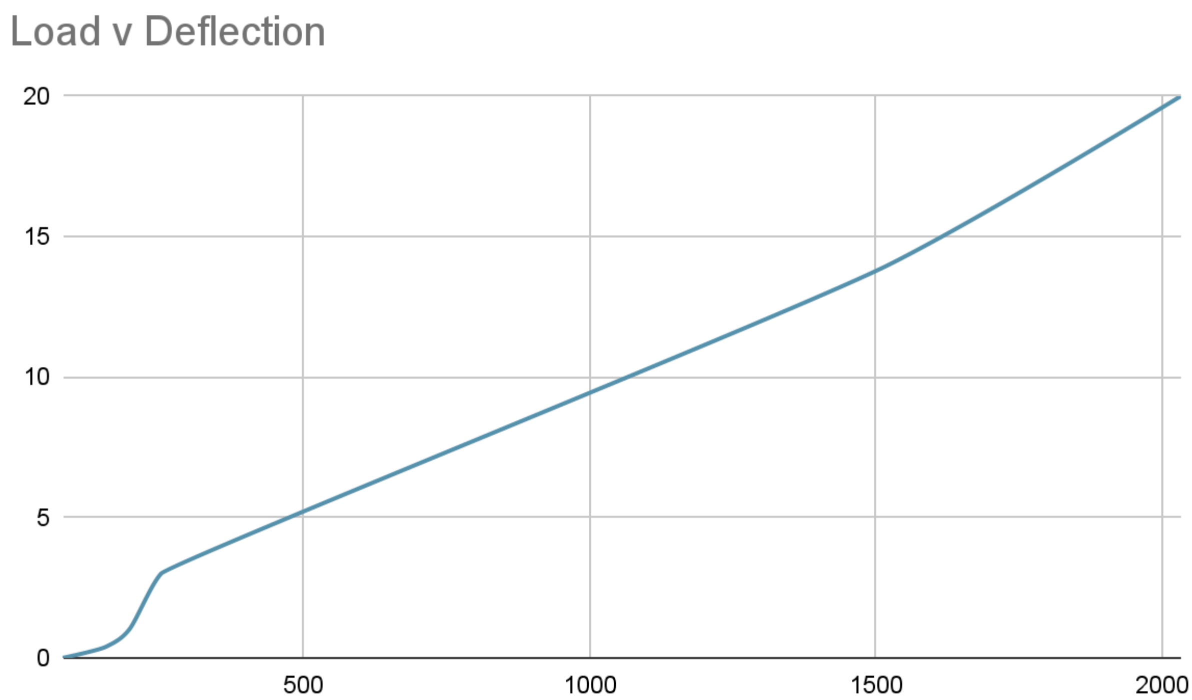
Statistical Data (Graphing of your data obtained when testing)

Table

Load g	Deflection mm	
79	0	
155	0.4	
195	1	

251	3	
1523	14	
2033	20	
2050	BREAK	
Mean:	Deflection: 6.4	Weight: 706
Range:	Deflection: 20	Weight: 2033

Graph



Ongoing and Final Evaluation

Compare with the statement of intent, success criteria, research and planning.

Compared to my Statement of Intent: We successfully built and tested a bridge using only the provided materials.

Criteria for Success:

- It held a decent load (max 1875g).
- It was neatly constructed, though taping could have been cleaner.
- All materials used were from the provided set.
- Our data was recorded and graphed.

What worked well: Using triangular trusses made the structure more stable than a flat bridge alone.

What could be improved: The tape wasn't strong enough in some places, and weight placement could have been more controlled.

What I learned: Simple materials can handle surprising loads with the right design. Load distribution and structural shapes are key. Deflection is a good indicator of when a bridge is about to fail.