STRUCTURES - BRIDGES

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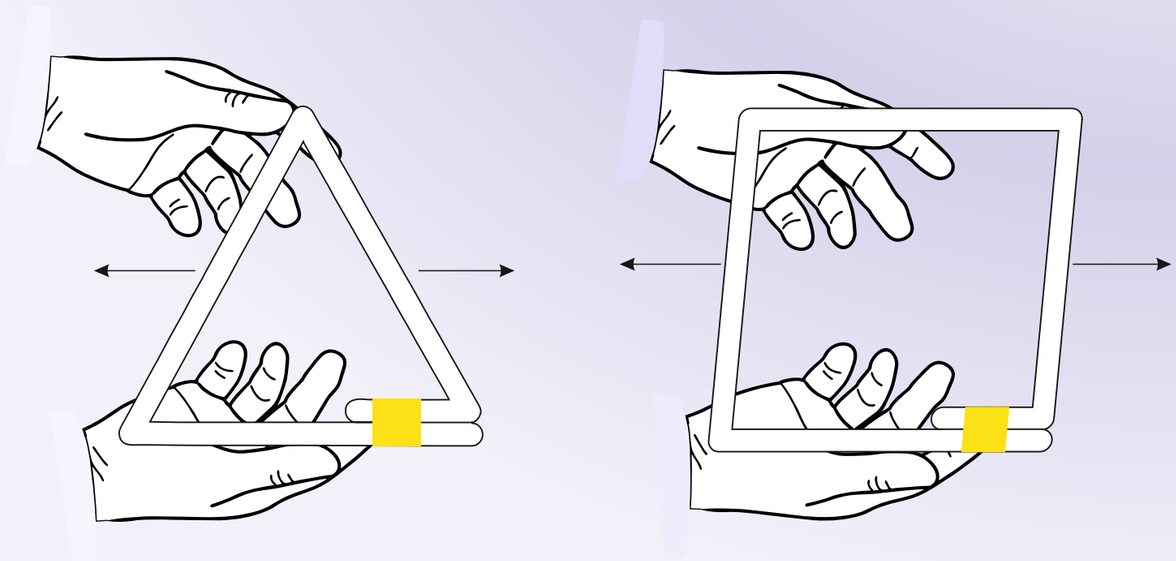
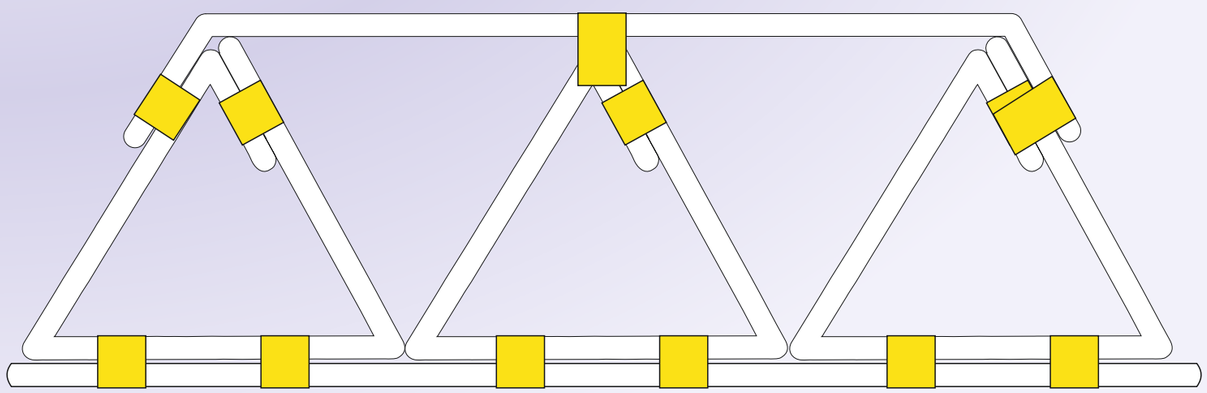
SQUARE AND TRIANGULAR FRAMES
INTRODUCING TRIANGULATION
BUILDING A TRIANGULATED BRIDGE
BRIDGE TESTING AND DATA COLLECTION
ROMAN ARCH and BOX GIRDER BRIDGES
THE RIBBLEHEAD VIADUCT - NORTH YORKSHIRE
THE MILLAU BRIDGE - SOUTHERN FRANCE
FURTHER EXERCISES
SEVEN MAJOR BRIDGE TYPES





STRUCTURES PROJECT - SQUARE AND TRIANGULAR FRAMES

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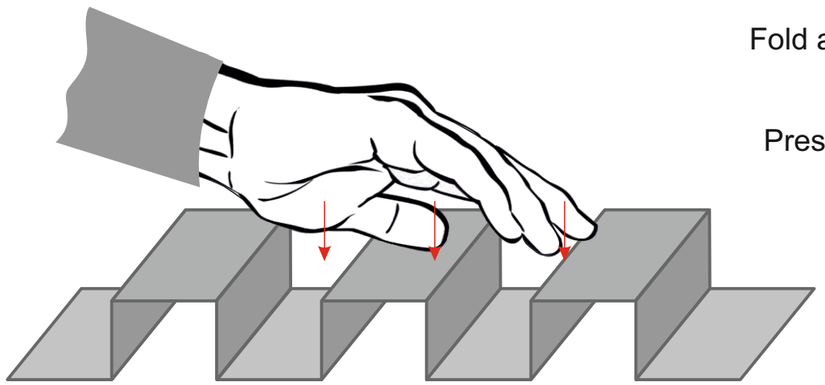
LINK FOR DETAIL ON SQUARE AND TRIANGULAR FRAMES

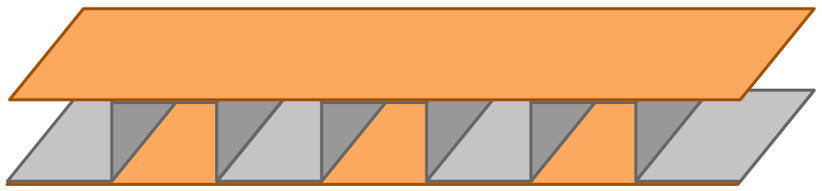
https://technologystudent.com/struct1/frame1.htm



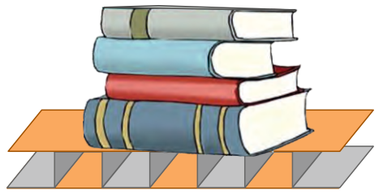
Fold an A4 piece of card to form a '**square frame**'. Place it on a table top.

Press downwards with one hand, 'gently testing its strength.

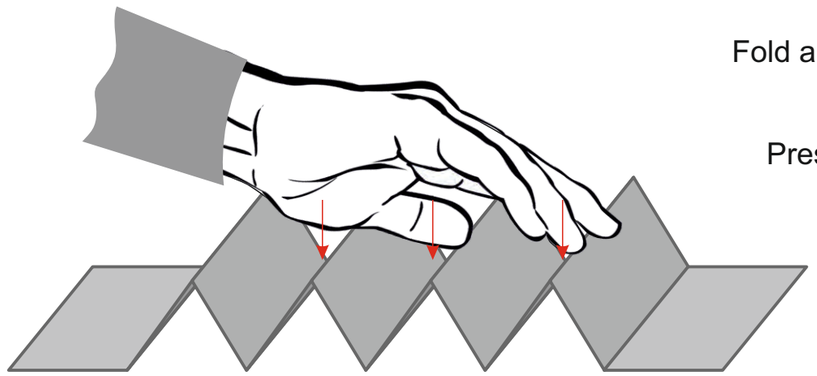
When you pressed down with one hand, how strong did you find the card **square frame**? Did it move side to side?



Glue card to the top and base and test with books, adding one at a time.



How many text books / weights did square frame (reinforced with a top and base) successfully hold? Describe what happened when the square frame failed?

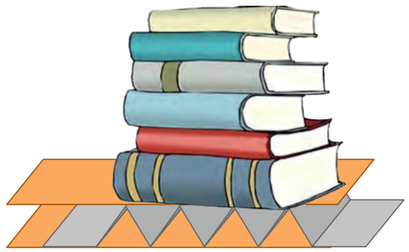


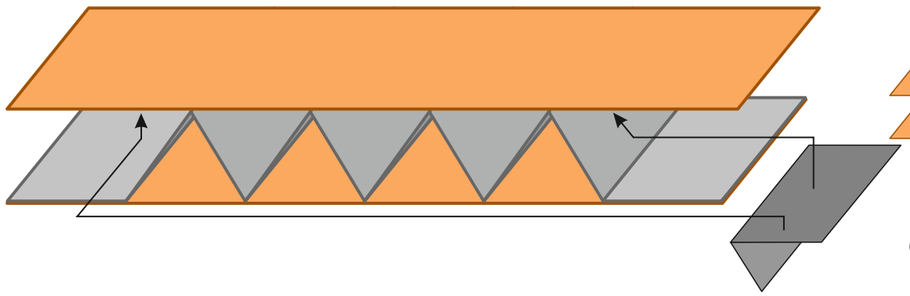
Fold an A4 piece of card to form a '**triangular frame**'. Place it on a table top.

Press downwards with one hand, 'gently testing its strength.

When you pressed down with one hand, how strong did you find the card **triangular frame**? Did it move side to side?

Glue card to the top and base and test with books, adding one at a time.





You will need to add / glue a piece of folded card at each end, to help hold the frame in together.

How many text books / weights did triangular frame successfully hold? Describe what happened when the triangular frame failed?

STRUCTURES PROJECT - INTRODUCING TRIANGULATION

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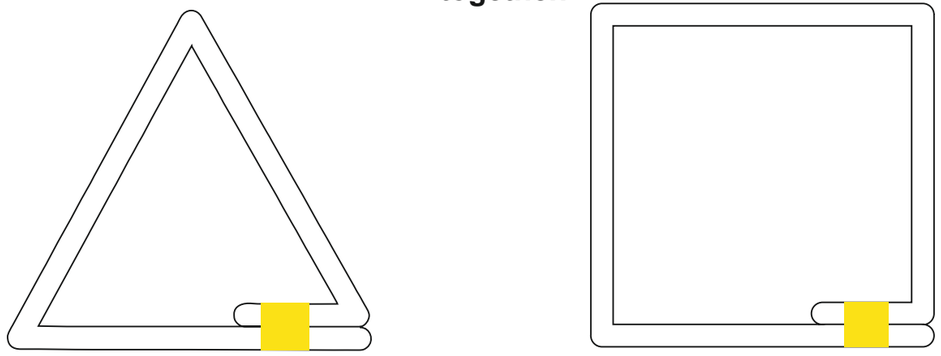
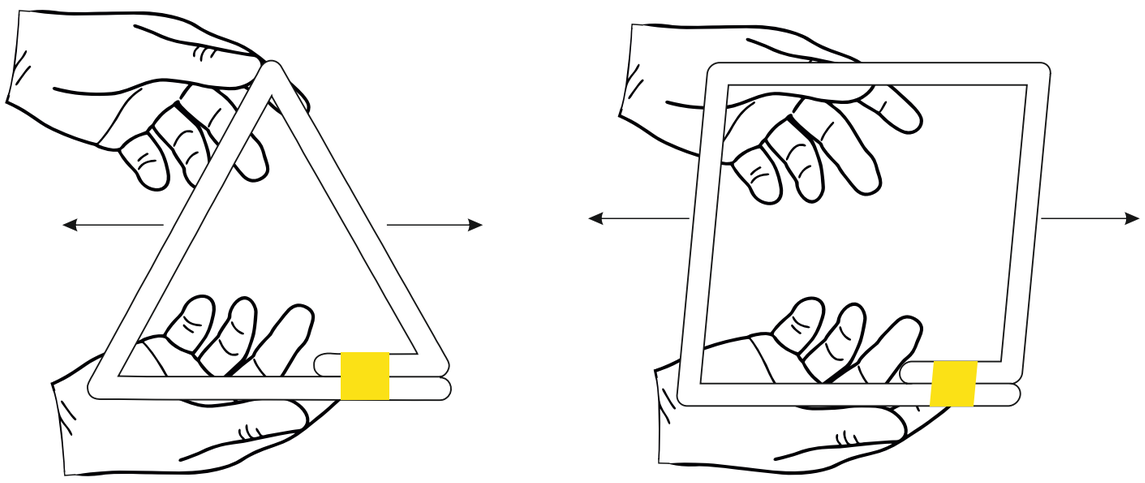
Using art straws, make a triangle and a square. Use sellotape to hold the shapes together.



Test both the triangular and square frame. To do this, hold each frame with one hand and push it side to side with the other hand, at the top.



What happened when you 'pushed' each structure at the top? Which one was the strongest?

LINK FOR MORE DETAIL ON TRIANGULATION

https://technologystudent.com/struct1/triag1.htm

Examples of triangulation are seen all around us, especially in the construction industry (building and civil engineering). Folding a simple art straw into a triangular shape and then applying pressure, gives us some idea of the strength of triangulation. This is why it is popular when building structures, both permanent to temporary.

A triangular form is one of the strongest shapes known to man. It is not surprising that 'triangulation' is used in the construction of buildings and structures.

In the space below, paste images of structures that are / include examples of triangulation.

The link above leads to some examples of triangulation.

STRUCTURES PROJECT - BUILDING A TRIANGULATED BRIDGE

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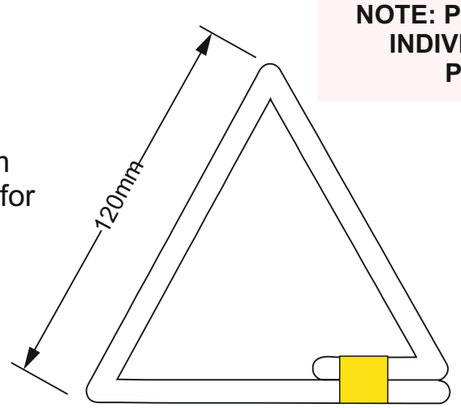
LINK FOR MORE DETAIL ON BUILDING THE STRUCTURE

https://technologystudent.com/struct1/freehnd1.html

NOTE: PUPILS CAN WORK IN PAIRS OR AS INDIVIDUALS. YOUNGER PUPILS MAY PREFER TO WORK IN PAIRS.

1.

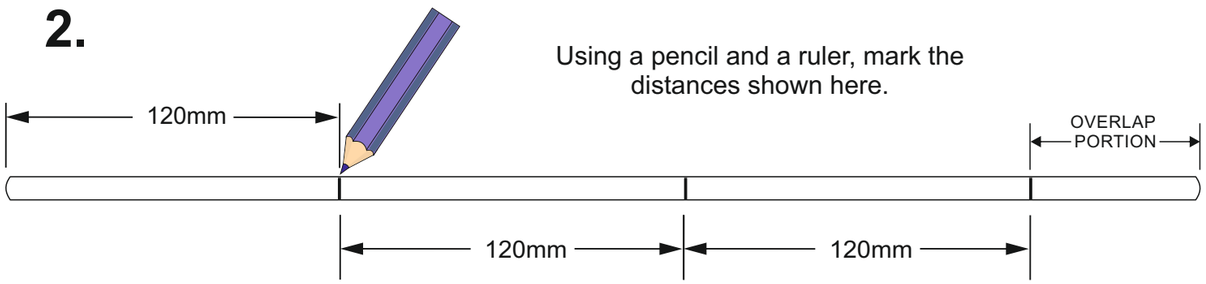
You will be using 300mm long, 6mm diameter art straws for this project.



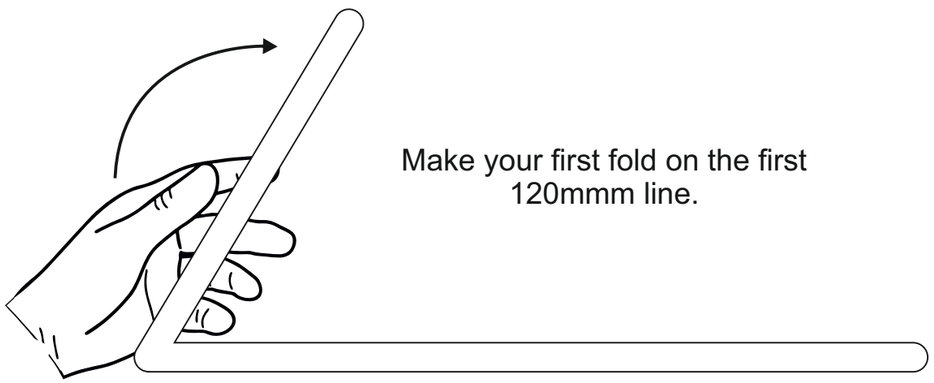
You are going to make six triangles from artstraws.

2.

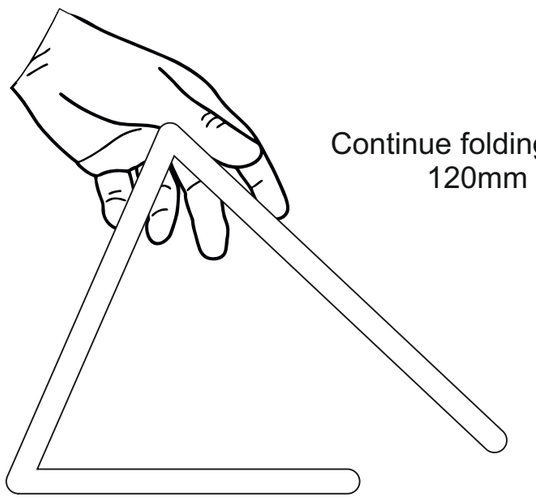
Using a pencil and a ruler, mark the distances shown here.



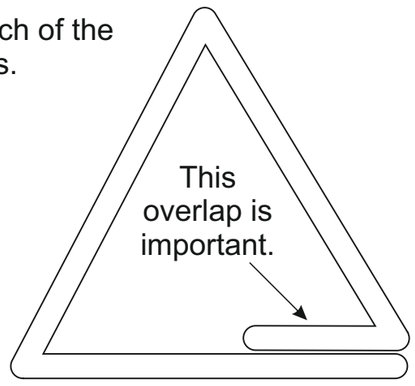
3.



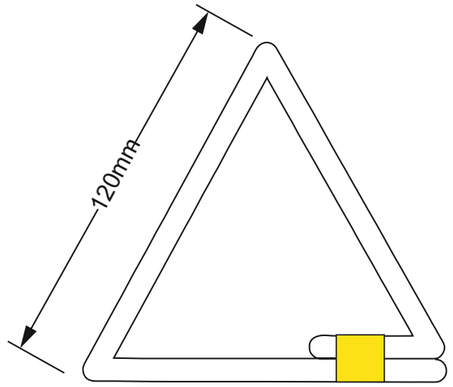
Make your first fold on the first 120mmm line.



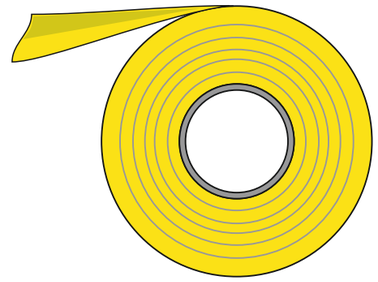
Continue folding on each of the 120mm markers.



4.

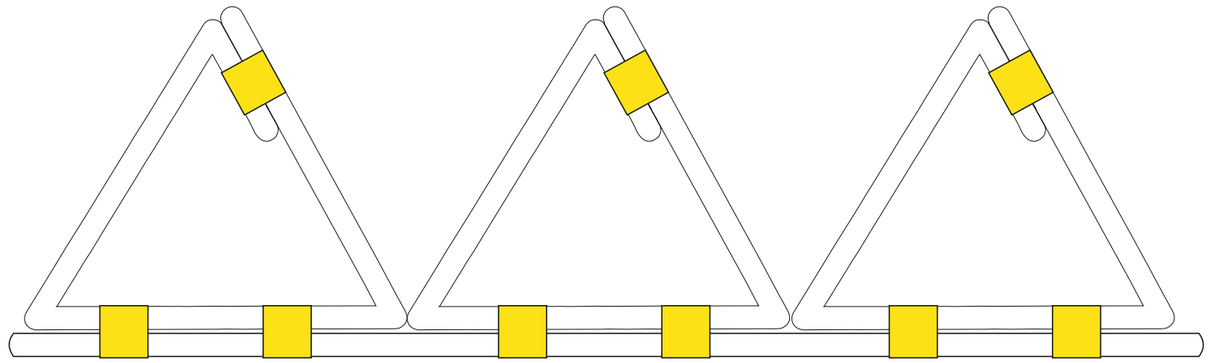


Sellotape the overlap to the base of the art straw.



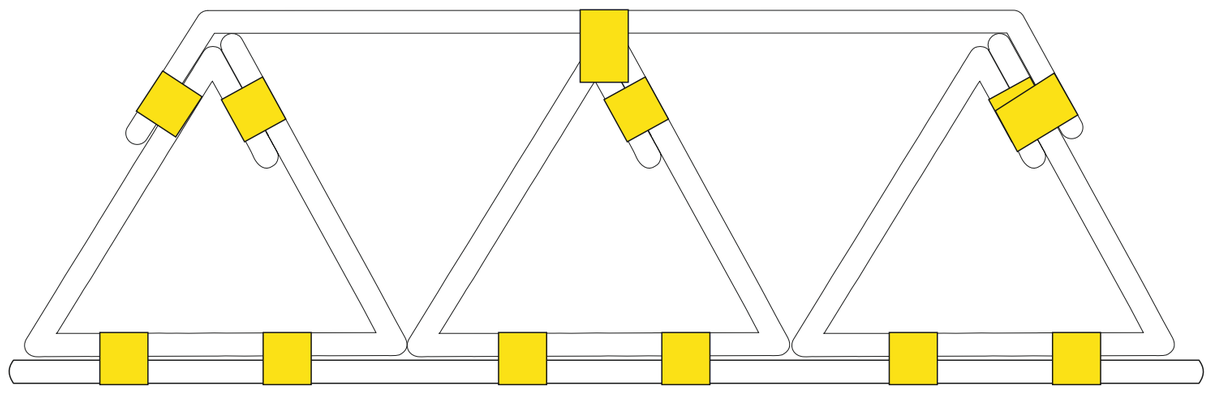
5.

Sellotape the three triangles to a straw, as shown in the diagram.



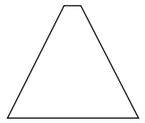
6.

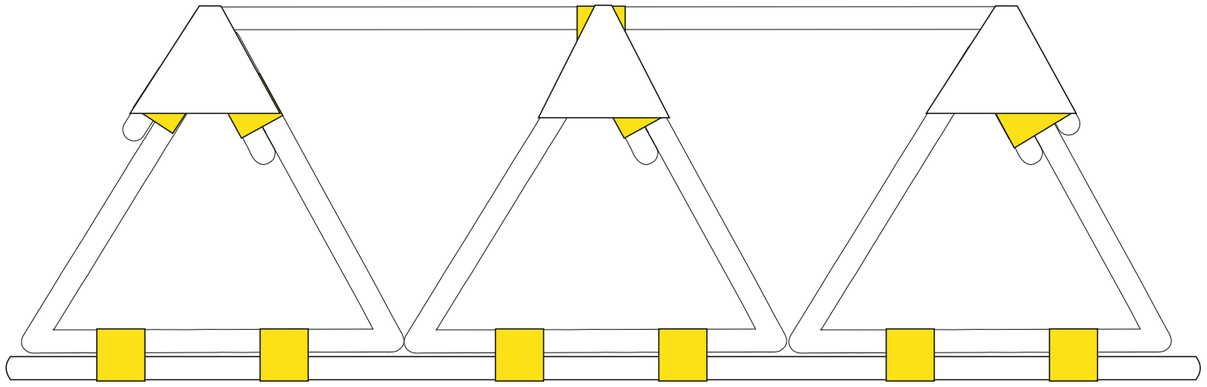
Sellotape another straw to the top of the triangles, as shown below.



STRUCTURES PROJECT - BUILDING A TRIANGULATED BRIDGE

7. Consider adding triangular card reinforcements to each 'corner'.

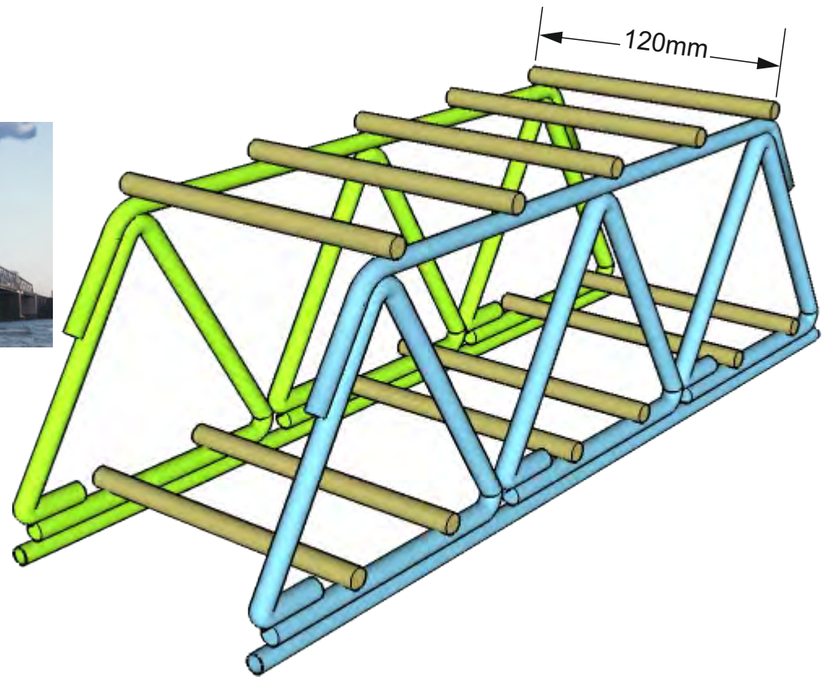




8. Make a second side and join both together with straws (120mm in length).

The diagram below, shows the straws as different colours. This is to make it easier to distinguish between the various parts of the bridge.

This type of bridge is also called a **Truss Bridge**.

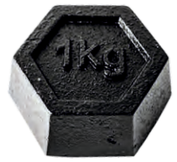


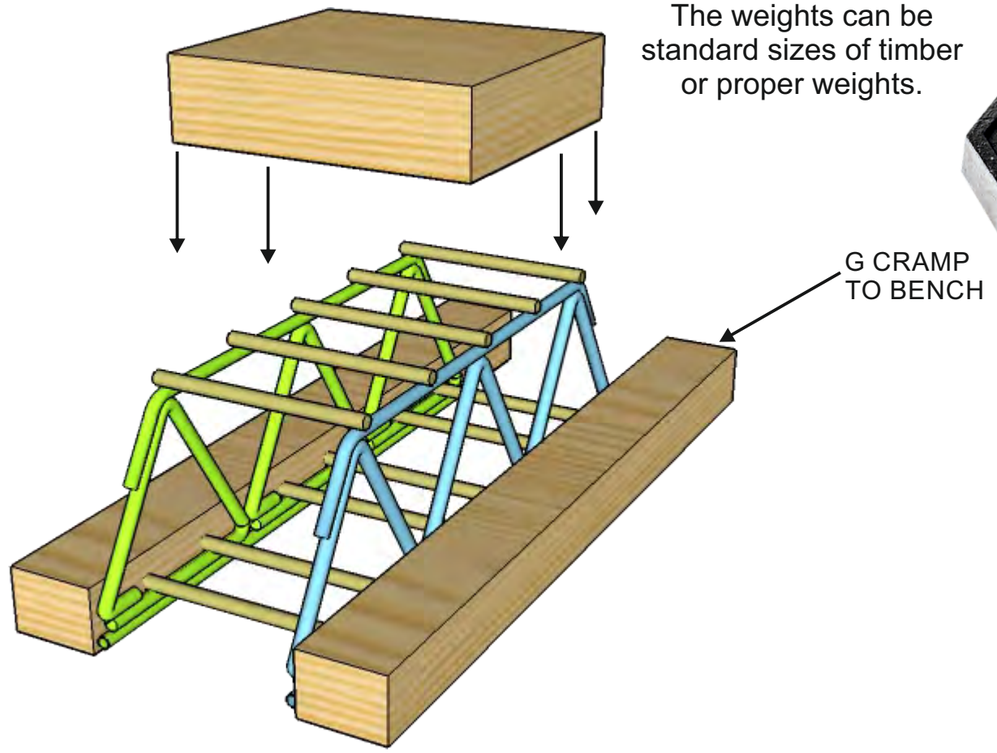
LINK FOR MORE DETAIL ON TESTING THE STRUCTURE

https://technologystudent.com/struct1/freehnd2.html

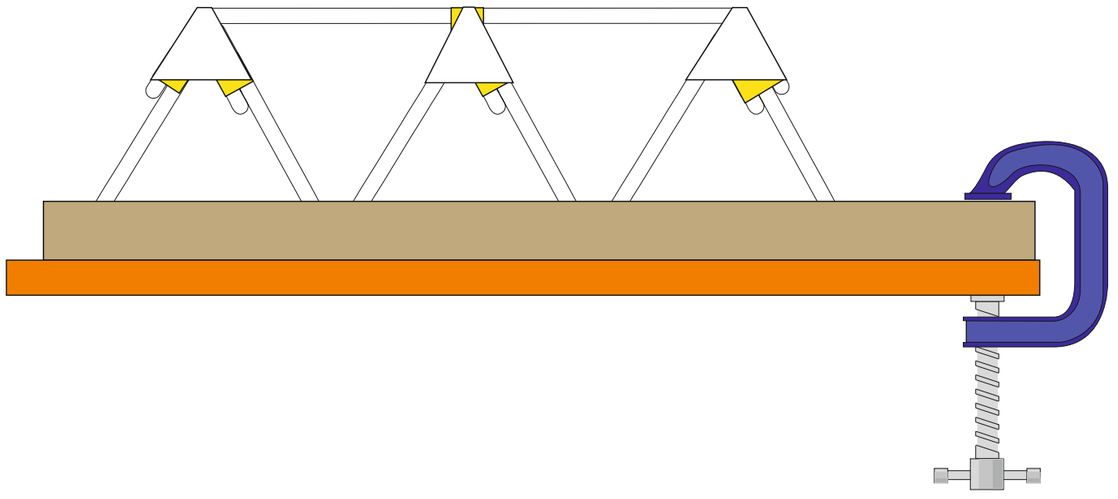
To test the bridge, place two straight pieces of wood on either side and G-cramp them to the bench. Weights can then be added to the top, one at a time, until it collapses.

The weights can be standard sizes of timber or proper weights.





The two g-cramped pieces of wood hold keep the bridge in a vertical position.

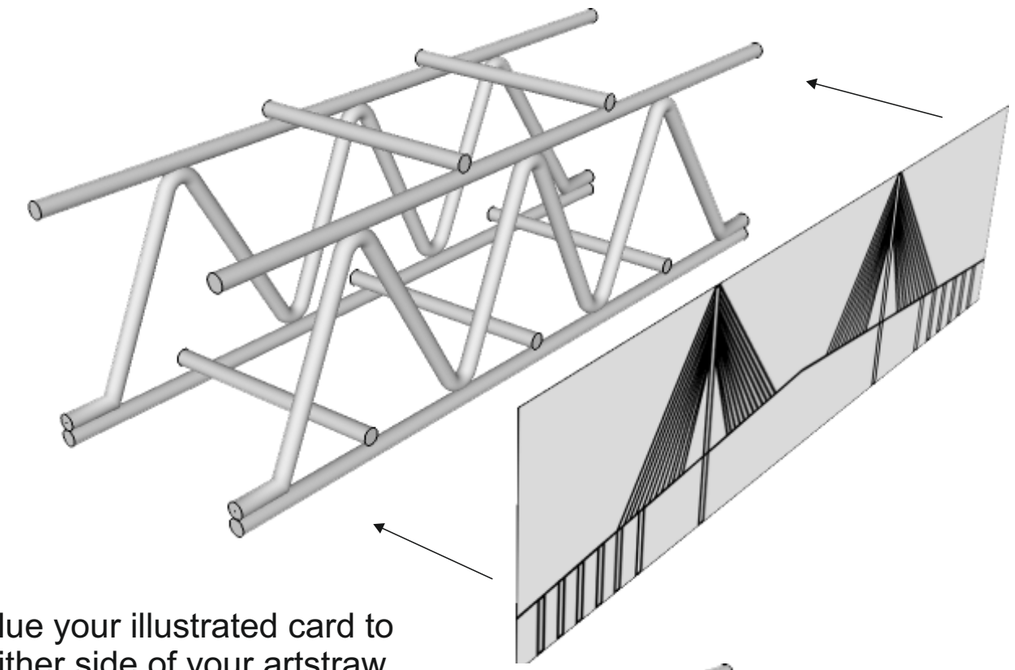


STRUCTURES PROJECT - BRIDGE EMBELLISHMENT

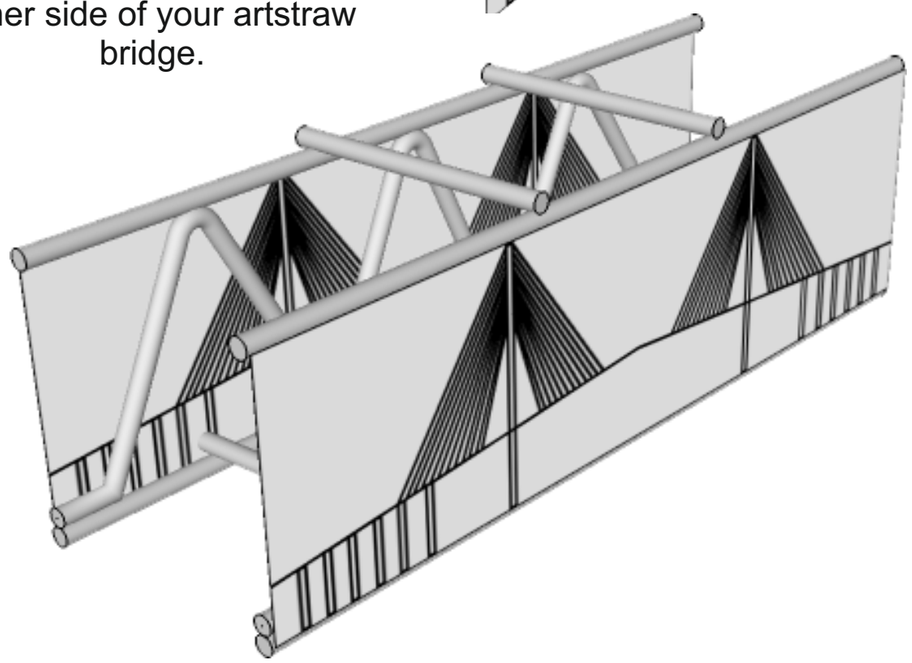
LINK FOR MORE DETAIL ON EMBELLISHING YOUR BRIDGE

https://technologystudent.com/struct1/bridgemb1.html

Consider embellishing your straw bridge with card sides, before 'testing with weights'. The sides could be decorated to look like common bridge types (three common bridge types are shown opposite).



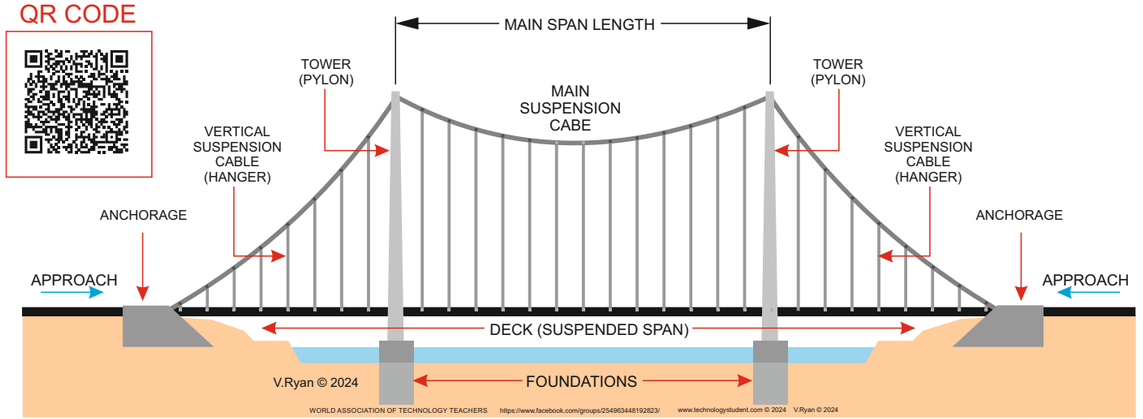
Glue your illustrated card to either side of your artstraw bridge.



LINK FOR MORE SEVEN BRIDGE TYPES

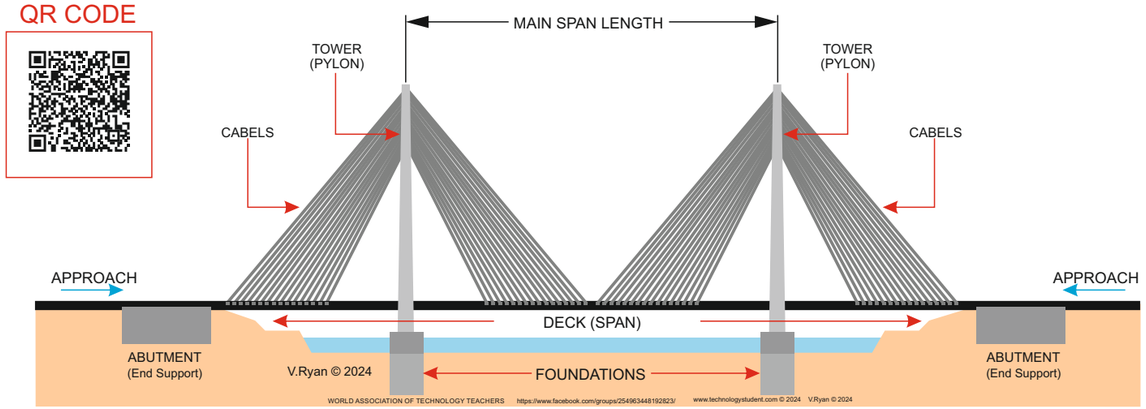
https://technologystudent.com/struct1/struindex.htm

QR CODE



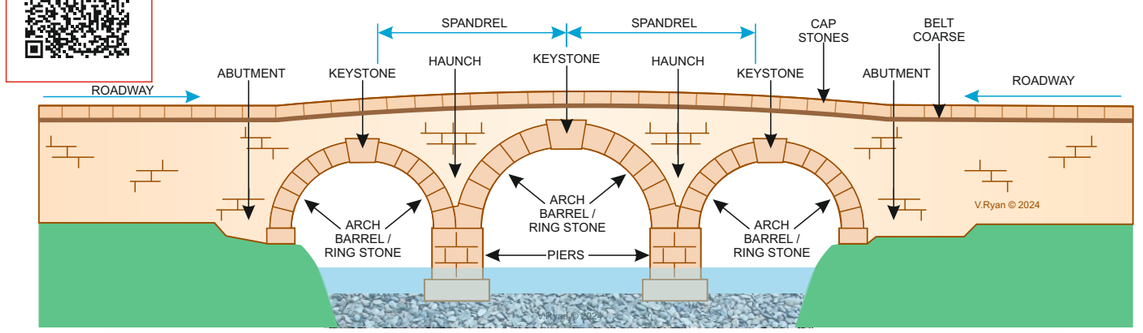
USEFUL LINK: https://technologystudent.com/struct1/suspen1.htm

QR CODE



USEFUL LINK: https://technologystudent.com/struct1/cable1.htm

QR CODE



USEFUL LINK: https://technologystudent.com/struct1/roman1.htm

BRIDGE TESTING

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LINKS FOR MORE DETAIL

https://technologystudent.com/struct1/model4.htm

https://technologystudent.com/designpro/quest1.htm

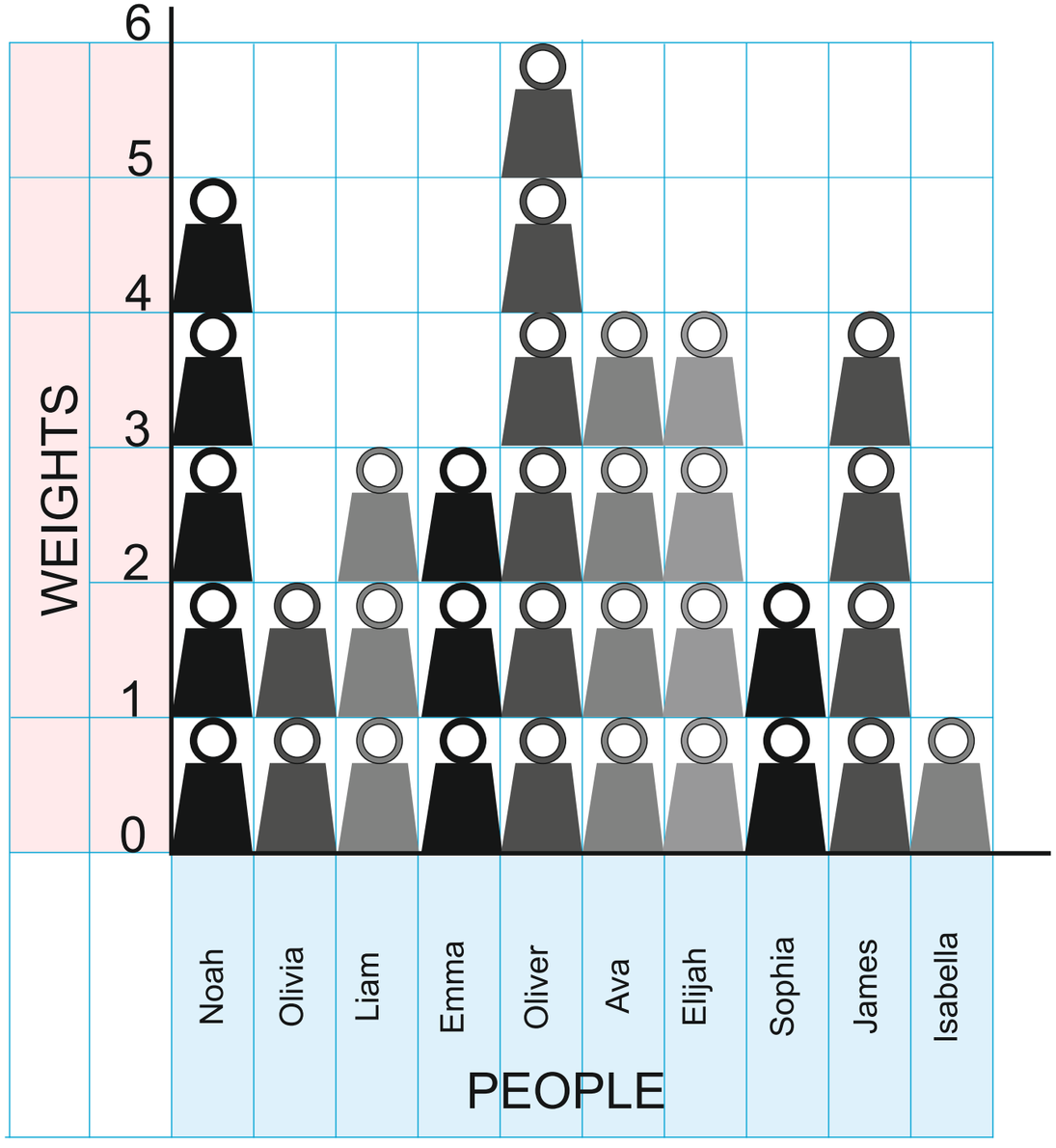
Test each art straw bridges constructed by a class and record the data (number of weights supported successfully by each bridge) . This can be presented in the form of a table and a graph or pictogram.

ARRANGE THE NAMES OF EACH MEMBER OF THE CLASS

LIST EACH RESULT AGAINST THE CORRECT NAME

NAMES	Nº OF WEIGHTS
Noah	5
Olivia	2
Liam	3
Emma	3
Oliver	6
Ava	4
Elijah	3
Sophia	2
James	1
Isabella	4
William	3
Mia	3
Benjamin	4
Amelia	5
Lucas	2
Harper	5
Henry	2
Evelyn	3
Alexander	3
Abigail	6
Mason	4
Ella	3
Michael	2
Elizabeth	1
Ethan	4
Camilla	3
Daniel	3
Luna	4
Jacob	5
Sofia	2
TOTAL	100
AVERAGE	3.33

Take the first ten people from the table of results. Draw a Pictogram of the results. Use the ‘link’ above for information and examples on pictograms.



WORKING OUT THE ‘MEAN’ AVERAGE

CALCULATION FOR AVERAGE NUMBER OF WEIGHTS TAKEN BY THE STRUCTURES

$$\frac{\text{Total}}{\text{No of people}} = \frac{100\text{mm}}{30} = 3.33\text{mm (AVERAGE)}$$

BRIDGE TESTING

WORLD ASSOCIATION OF TECHNOLOGY TEACHERS https://www.facebook.com/groups/254963448192823/

LINKS FOR MORE DETAIL
https://technologystudent.com/struct1/model4.htm
https://technologystudent.com/designpro/quest1.htm

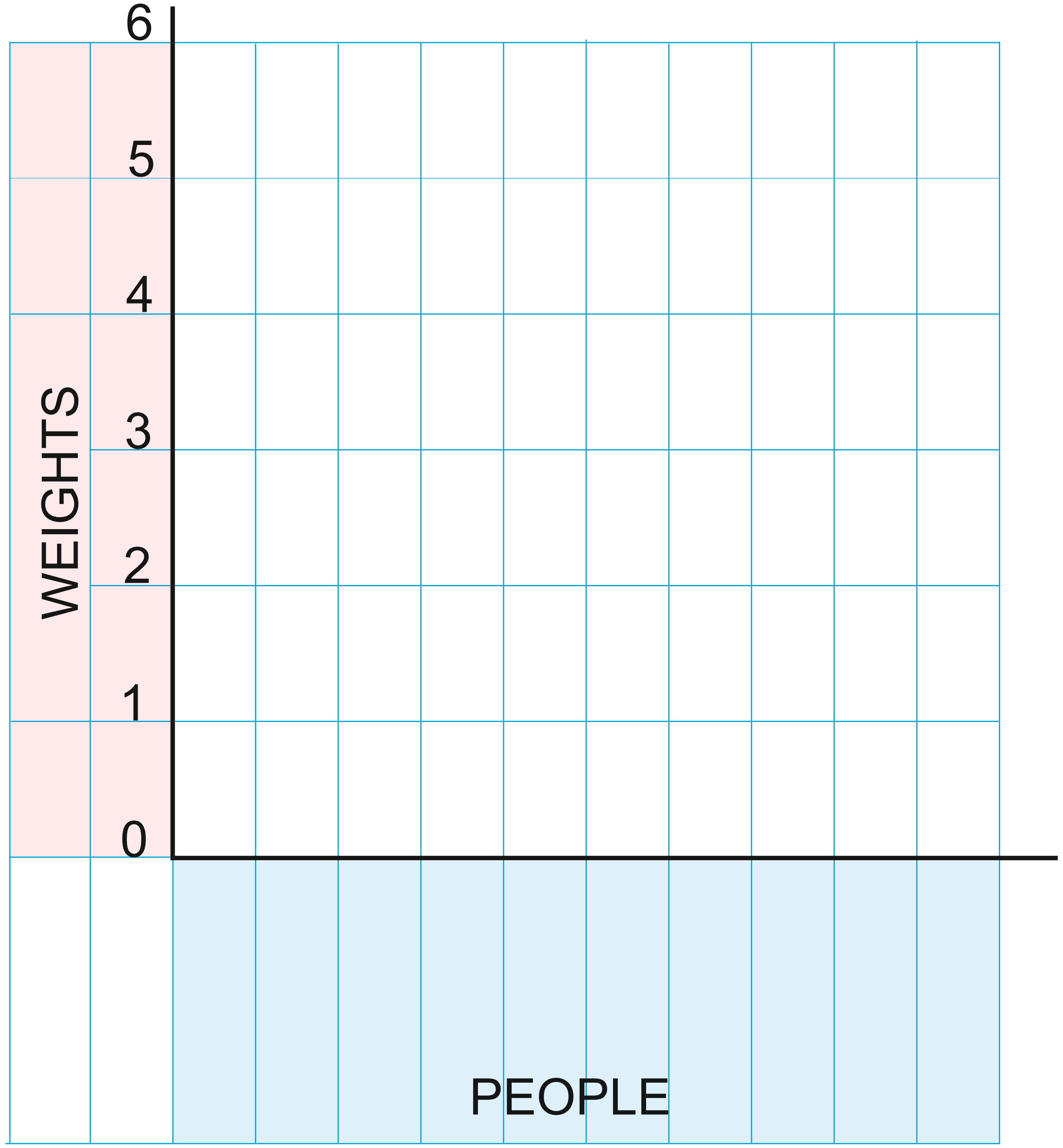
Test each art straw bridges constructed by a class and record the data (number of weights supported successfully by each bridge) . This can be presented in the form of a table and a graph or pictogram.

ARRANGE THE NAMES OF EACH MEMBER OF THE CLASS

LIST EACH RESULT AGAINST THE CORRECT NAME

NAMES	Nº OF WEIGHTS
TOTAL	
AVERAGE	

Take the first ten people from the table of results. Draw a Pictogram of the results. Use the ‘link’ above for information and examples on pictograms.



WORKING OUT THE ‘MEAN’ AVERAGE

CALCULATION FOR AVERAGE NUMBER OF WEIGHTS TAKEN BY THE STRUCTURES

$\frac{\text{Total}}{\text{No of people}} = \underline{\qquad} =$ (AVERAGE)

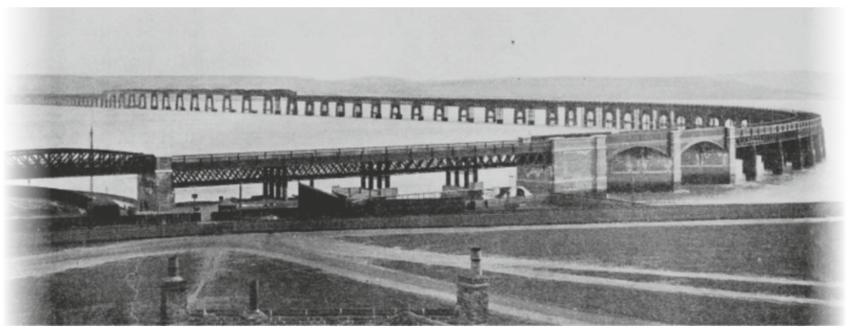
BRIDGE TESTING - WHY IS IT IMPORTANT?

WORLD ASSOCIATION OF TECHNOLOGY TEACHERS https://www.facebook.com/groups/254963448192823/

Briefly describe the two 'famous' bridge disasters (Tacoma Narrows and Tay Bridge)

THE TACOMA NARROWS SUSPENSION BRIDGE DISASTER - 1940

THE TAY BRIDGE DISASTER - 1879



LINKS FOR MORE DETAIL

https://technologystudent.com/struct1/tacoma1.htm

https://technologystudent.com/struct1/taybrd1.htm

Testing a scale model of bridge / building before it is built and in use, is very important. Why do you think this is?

Name and describe a famous / significant bridge. Include an image of the bridge

LINKS FOR SOME EXAMPLES

https://technologystudent.com/struct1/struindex.htm

ROMAN ARCH and BOX GIRDER BRIDGES

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LINK FOR DETAIL STONE ARCH BRIDGES

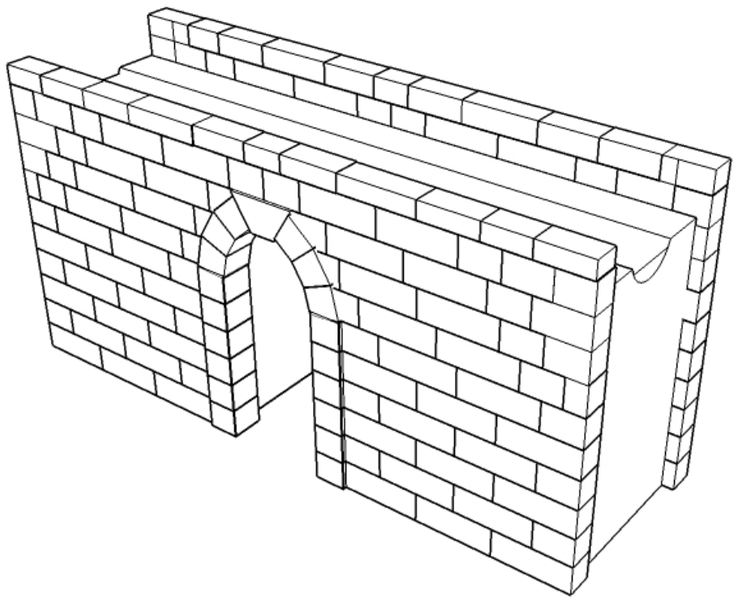
https://technologystudent.com/struct1/roman1.htm

https://technologystudent.com/struct1/roman2.htm

STONE ARCH BRIDGE

1. The following 'parts' of a Roman stone arch bridge are listed below. Identify the position of each part on the diagram, using labels and arrows.

1. KEYSTONE
2. ROMAN ARCH
3. EXTERNAL STONEWORK
4. WATER RUNNING DOWN HILL
5. GRAVEL/SAND/ ROUGH STONE FILLING - IN CAVITIES.
6. CAVITY
7. INTERNAL ARCH STONEWORK



2. Why did the Romans use gravel, sand and rough stone to fill all cavities of an arch bridge?

3. Name a famous Roman arch bridge and its location.

NAME: LOCATION:

LINK FOR DETAIL BOX GIRDER BRIDGES

https://technologystudent.com/struct1/boxg1.htm

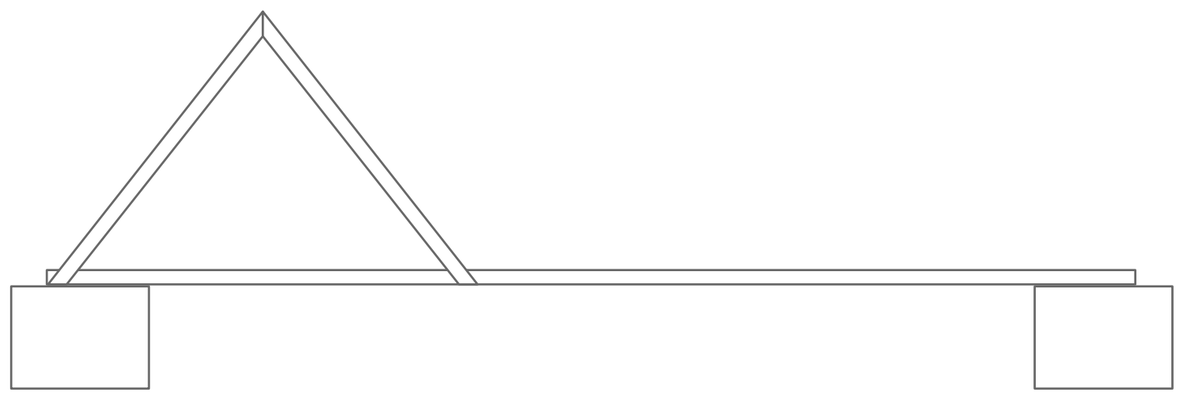
TRUSS BRIDGE

1. A description of truss bridge is written below. Complete the paragraph by adding the missing words, in the correct places.

"Truss bridges are quite common and they are usually manufactured from _____ steel girders. This means that the girders are _____ in a factory and _____ to the location of the bridge, where they are fixed together. One of the best examples of a prefabricated structure is the _____ _____. All its parts were manufactured in a factory, transported to _____ and then fixed together to form the worlds most famous tower. The steel girders of a bridge are normally fixed together with large _____ and _____. Sometimes _____ are used, although these are seen on older structures".

bolts	Eiffel Tower	nuts	manufactured	transported
	rivets	Paris	prefabricated	

2. Below is an incomplete drawing of a truss bridge. Complete the drawing by adding the missing parts. Add appropriate colour and shade.

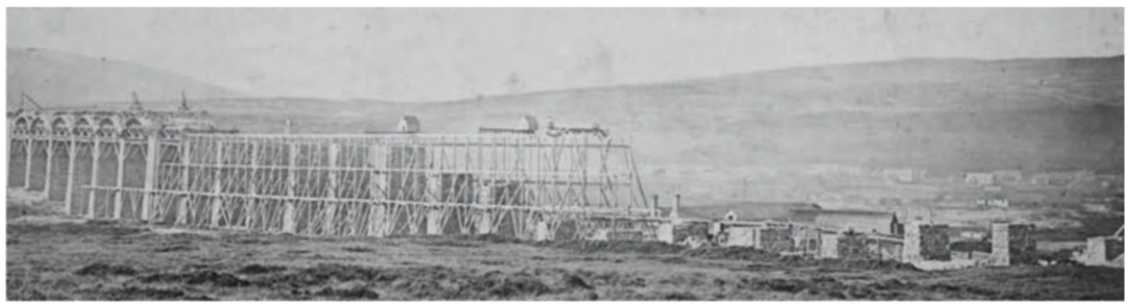


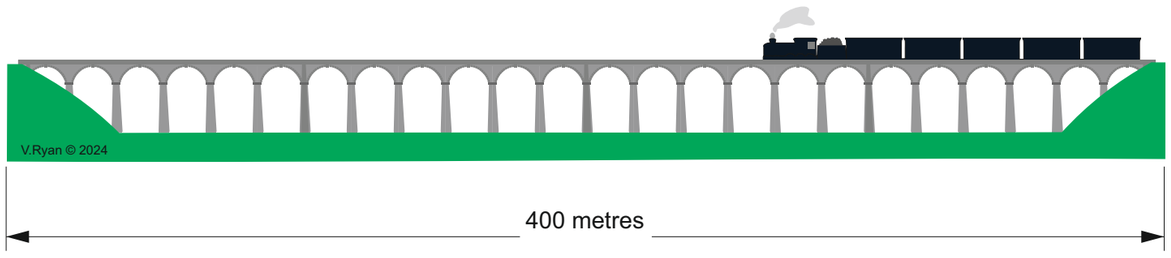
LINK FOR DETAIL RIBBLEHEAD VIADUCT

https://technologystudent.com/struct1/ribble1.html

THE RIBBLEHEAD VIADUCT - NORTH YORKSHIRE

THE VIADUCT UNDER CONSTRUCTION





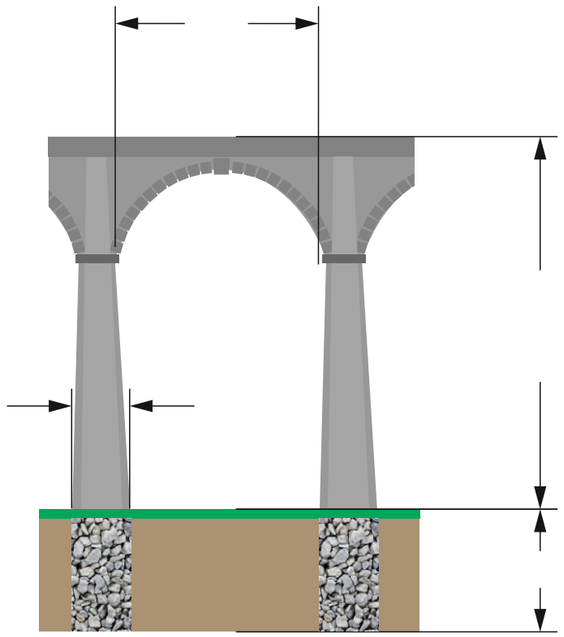
THE RIBBLEHEAD VIADUCT - NORTH YORKSHIRE

1. When was the Ribblehead Viaduct completed, for passenger trains to cross?

2. Name the railway that runs along its length.

3. Who was the designer of the viaduct?

4. Add the missing measurements to the diagram.



5. Write a brief description of the viaduct, concentrating on the method of construction.

THE MILLAU BRIDGE - SOUTHERN FRANCE

LINK FOR DETAIL - MILLAU BRIDGE

https://technologystudent.com/struct1/millau1.htm

1. Who was the main architect / designer of the Millau Bridge?

2. Describe the Millau Bridge and its location.

3. With the aid of a sketch / diagram, describe the construction techniques, especially the way the deck was rolled into position.

Use the website / internet, to help you name and describe the bridges.

USEFUL LINK

https://technologystudent.com/struct1/struindex.htm

NAME AND DESCRIBE THE BRIDGES

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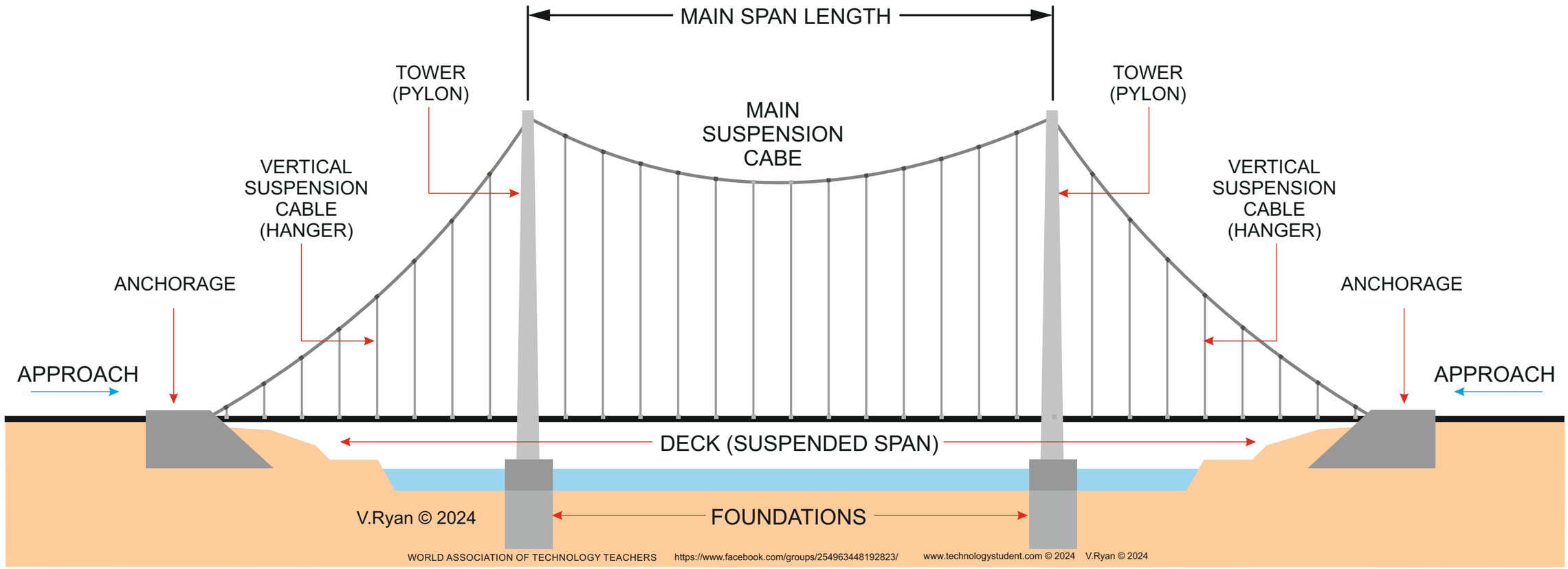
USEFUL LINK

https://technologystudent.com/struct1/suspen1.htm

THE SUSPENSION BRIDGE



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FACTS

The deck is held by suspension cables (hangers). The main cables extend over the towers and are held securely at each anchorage. The main suspension cables are a single length, spanning the length of the bridge (anchorage to anchorage). The vertical suspensions cables hold the deck in position.

The main suspension cables carry the weight of the deck, with the aid of the towers. The anchorages hold the structure in place.

Suspension bridges tend to be more expensive and time consuming to build, when compared to other cable systems. They need more cables that tend to be longer and heavier anchorages.

Suspension Bridges are ideal when a wide span is to be crossed.

Suspension bridges and cable stay bridges have their admirers, with the aesthetics of each type being appealing. The Suspension Bridge is regarded as more 'graceful and elegant' than the modern Cable Stay Bridge.

FAMOUS SUSPENSION BRIDGES

Golden Gate Bridge (USA) - Located in San Francisco, California, spans 1.7 miles.

Brooklyn Bridge (USA) - Connecting Manhattan and Brooklyn in New York City, completed in 1883.

Akashi Kaikyō Bridge (Japan) - is the longest suspension bridge in the world, main span of 1,991 metres (6,532 feet).

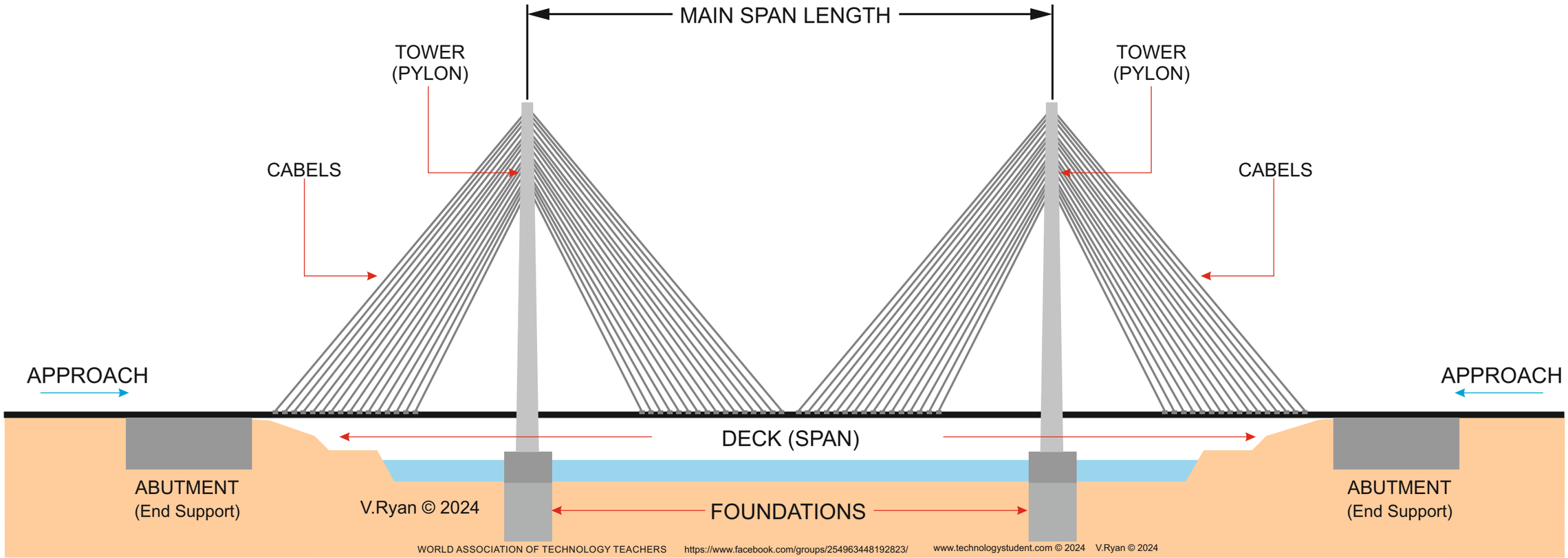
Humber Bridge (UK) - spans the Humber Estuary in England.

Tower Bridge (UK) - Located in London, a combined bascule and suspension bridge.

USEFUL LINK

https://technologystudent.com/struct1/cable1.htm

THE CABLE STAY BRIDGE



FACTS

A Cable Stay Bridge has a deck that is directly supported by the cables, each fixed to the towers at a slightly different angle. Each cable transfers the vertical loads to the towers, produced when supporting the deck.
The weight of the deck is held initially by the towers, with the weight distributed through the cables. The 'abutments' at each end of the bridge hold the entire structure in position, transferring the 'loads' from the bridge to the ground.
Cable Stay Bridges are usually less expensive to manufacture and construct than suspension bridges. Their cantilever design requires less material, but it does have one disadvantage (see next point).
Due to the nature of their design, cable stay bridges are suited to small to medium spans, rather than long spans.
The Cable Stay design is regarded as more modern looking, due to its straight lines and angles.

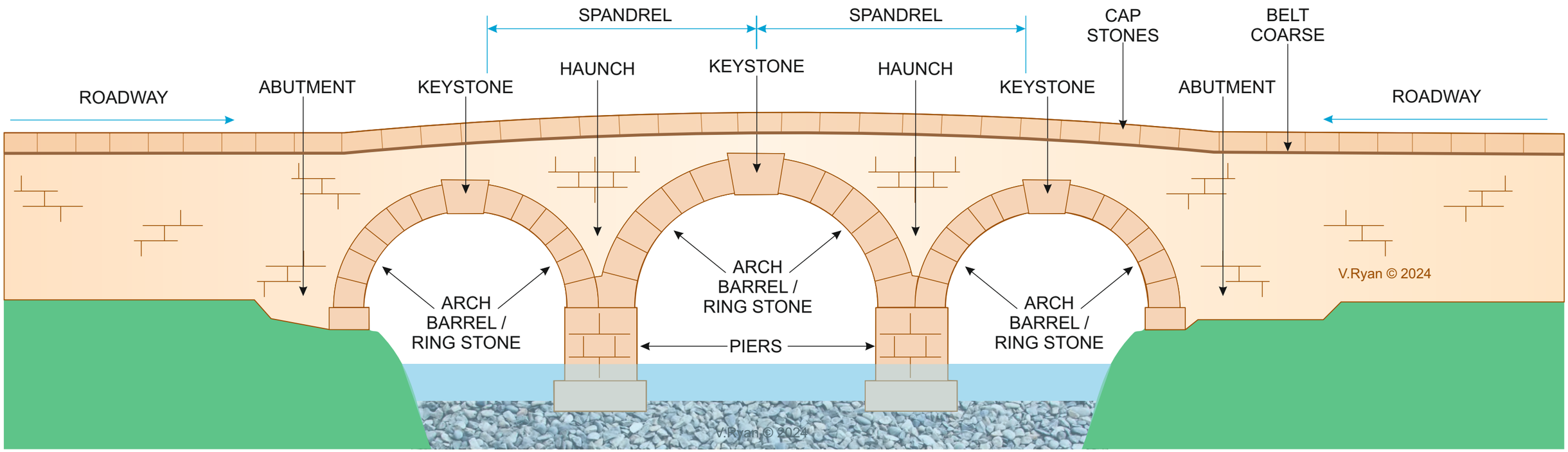
FAMOUS CABLE STAY BRIDGES

Russky Bridge (Russia) - Spanning 1,104 metres.
Sutong Yangtze River Bridge (China) - With a main span of 1,088 metres
Stonecutters Bridge (Hong Kong) - This bridge has a main span of 1,018 metres
Tatara Bridge (Japan) - Spanning 890 metres,
Normandy Bridge (France) - With a main span of 856 metres.

USEFUL LINK

https://technologystudent.com/struct1/roman1.htm

THE STONE ARCH BRIDGE



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FACTS

Stone arch bridges were introduced by the Romans, thousands of years ago. Some of the finest examples are aqueducts (E.G. Ponde du Gard - France), carrying water to towns and settlements. Stone arch bridges are very strong, because the weight is transferred through the arch, down to the abutments, into the ground. They were (and often still are) manufactured from local materials such as limestone, sandstone and granite, by skilled crafts people. These materials are ideal, because they withstand compressive forces. Arch bridges are the longest lasting of all bridges, due to the choice of materials and construction techniques. Stone arch bridges are aesthetically appealing, as they fit into the natural landscape perfectly and they look elegant and permanent. In the past, the construction of this type of bridge started with a wooden frame. Each stone arch was built around the frame, with the keystone preventing the finished arch from collapsing.

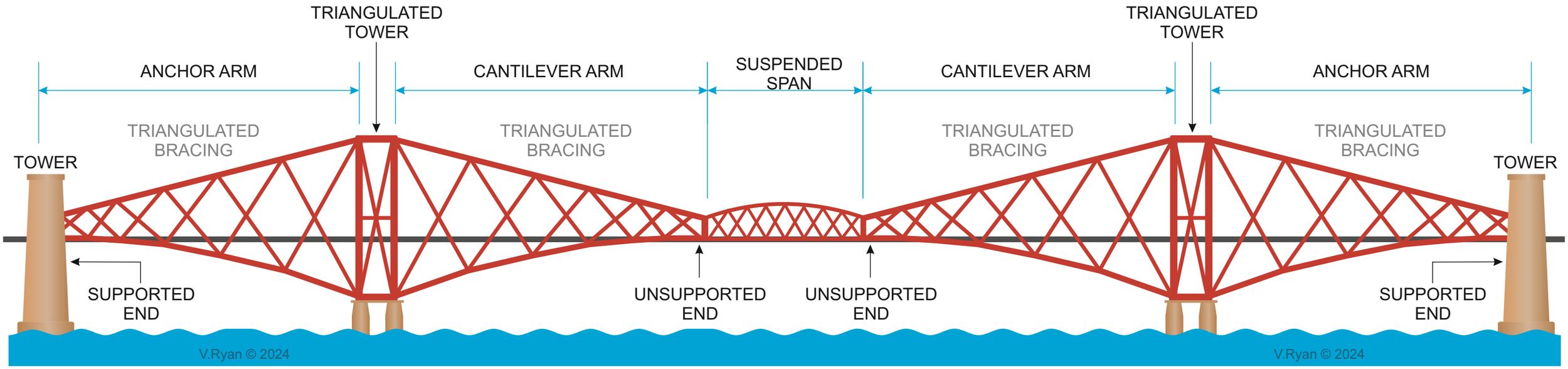
FAMOUS STONE ARCH BRIDGES

Pont du Gard - France- Roman aqueduct bridge.
Charles Bridge - Prague, Czech Republic.
Ponte Vecchio - Florence, Italy.
Stone Arch Bridge - Minnesota, USA.
Roman Aqueduct of Segovia - Spain.
Pontcysyllte Aqueduct - Wales: Completed in 1805, longest and highest aqueduct in Britain.
Aqueduct of Valens - Istanbul, Turkey. Roman aqueduct.

USEFUL LINK

https://technologystudent.com/struct1/canti1.html

THE CANTILEVER BRIDGE



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FACTS

A cantilever is a structure that extends over a gap / space. It is supported at one end and unsupported at the other. When a force / weight is applied at the unsupported end, the 'stress' is carried back to the supported end. When this principle is applied to a cantilever bridge, the anchor arm and cantilever arm act as a balance.
The bridge above has two cantilever structures that meet in the middle (based on the Forth Rail Bridge in Scotland). A design like this means that cantilever bridges can span long distances, without additional support in the centre. In addition, many cantilever bridges are composed of triangulated structures which give additional strength. They are capable of supporting heavy loads (traffic).
The ideal building materials are steel for the main triangulated structure and stone / concrete for the towers.

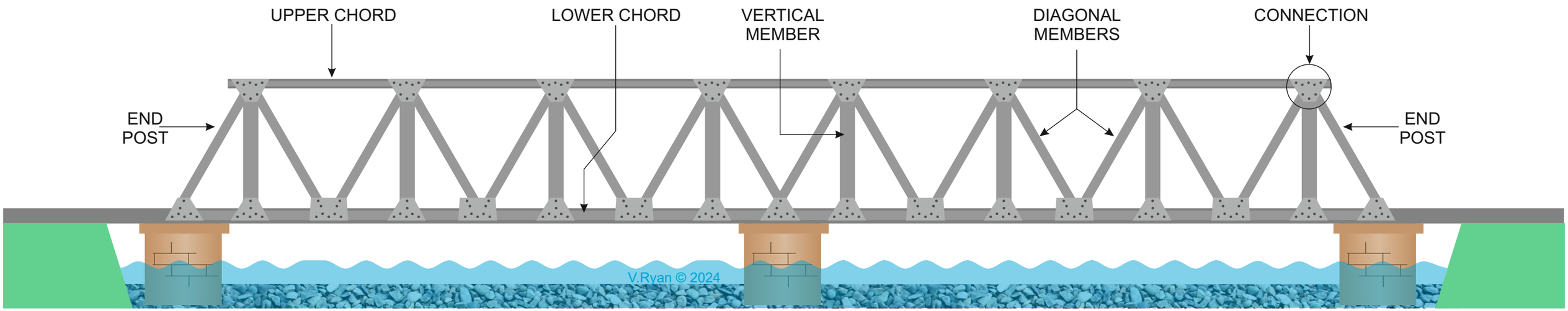
FAMOUS CANTILEVER BRIDGES

Forth Bridge - Scotland - 1890 - total length 2467 metres.
Quebec Bridge - Canada - 1919 - total length 987 metres.
Howrah Bridge (Rabindra Setu) - total length 705 metres.
Minato Bridge - Japan - total length - 983 metres.
Sanguantang Bridge - China - total length 2200 metres.
Tokyo Gate Bridge - Japan- 2618 metres

USEFUL LINK

https://technologystudent.com/struct1/boxg1.htm

THE TRUSS BRIDGE



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FACTS

A Truss Bridge is composed of triangular modules (triangulation) connected in a line, making it comparatively easier to build. This design is often adopted if a quick construction is required. When the Anglesey Bridge (Wales) burned down in 1970, it was replaced within two years by the Britannia Bridge (1972), an steel truss arch bridge.

The triangle is a very strong shape because of its stability and the way it distributes weight, making it ideal for a truss bridge. This type of bridge has a very good strength to weight ratio. They are functional and efficient, rather than being aesthetically pleasing. Modern truss bridges are manufactured from steel, although before the advent of steel, wood was used, especially on bridges with a short span.

An early form of cast iron truss bridge, the Tay Bridge in Scotland (the longest bridge in the world at the time), collapsed in 1879 after the truss structure failed. This was due to the inflexibility of cast iron. However, steel is able to absorb vibration, making it suitable for this type of construction.

FAMOUS TRUSS BRIDGES

Ikitsuki Bridge- 1991 - Japan
Taylor Southgate Bridge - 1995 - USA
Kingston-Rhinecliff Bridge - 1957 - USA
Minato Bridge - 1974 - Japan
Astoria-Megler Bridge - 1966 - USA
Yoshima Bridge - 1988 - Japan
Britannia Bridge - 1972 - Wales

USEFUL LINK

https://technologystudent.com/struct1/boxgirder1.html

THE BOX GIRDER BRIDGE

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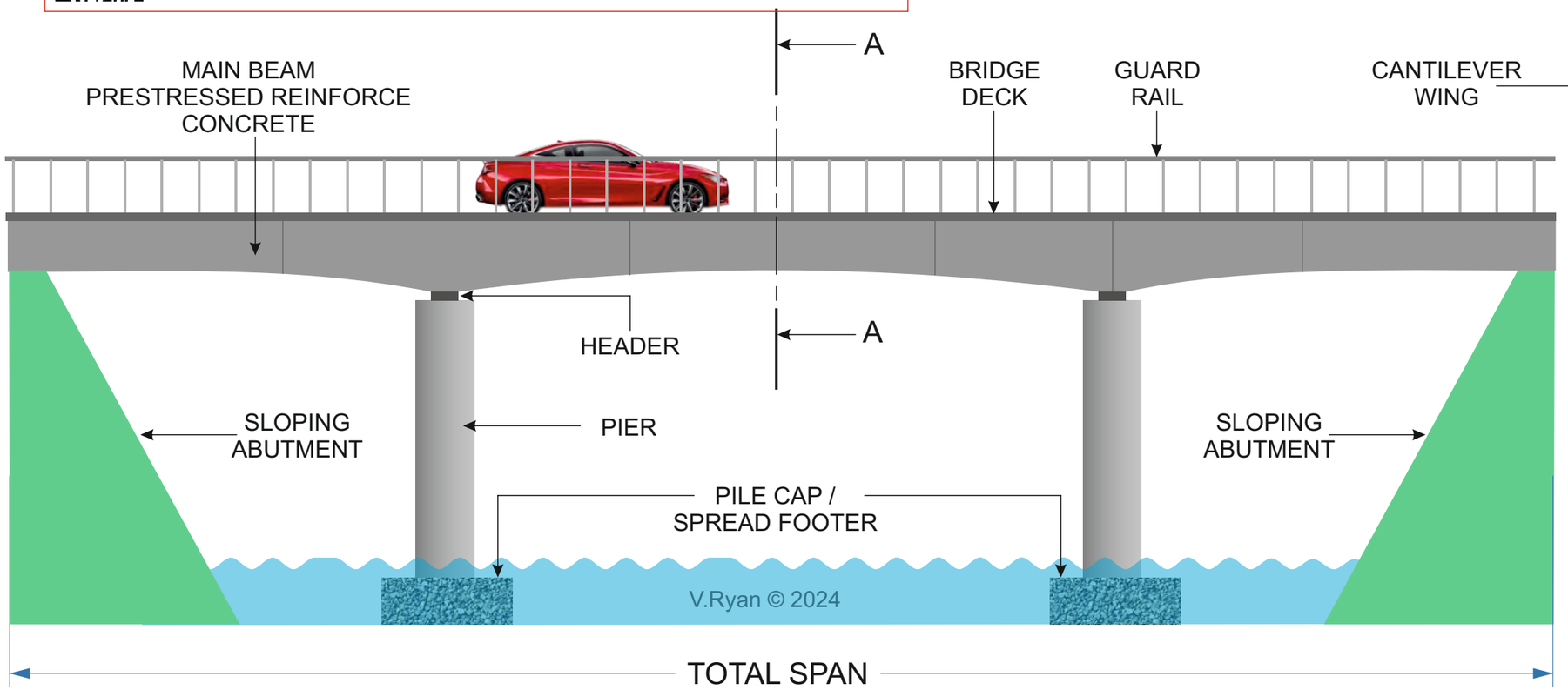
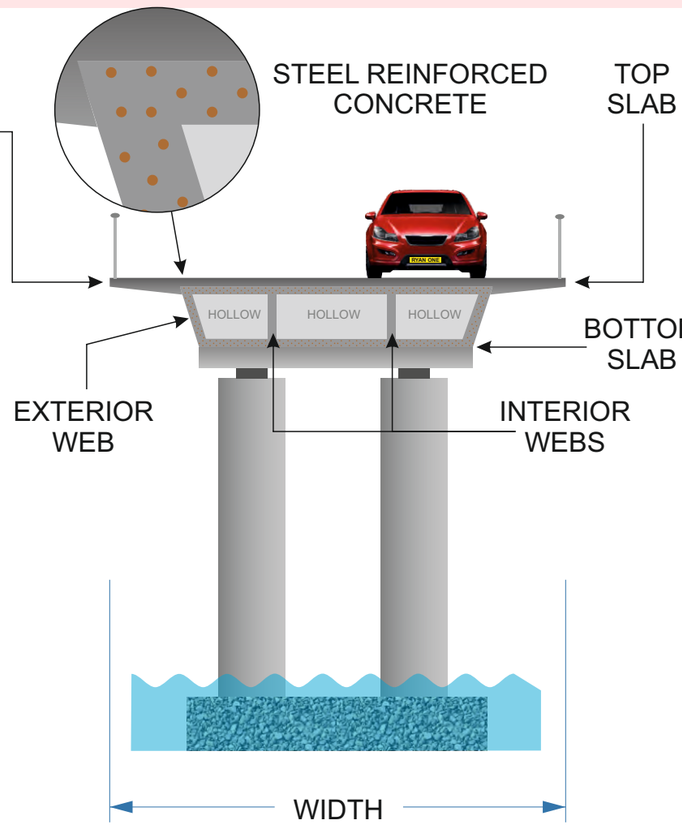


SIDE ELEVATION



SECTIONAL FRONT SELEVATION ON 'AA'

FACTS

A Box Girder Bridge is basically a hollow, long box, composed of several sections, manufactured from reinforced, prestressed concrete. The sectional front elevation (above), shows the hollow box, with interior webs that strengthen it. The box girder sections are manufactured in a factory and transported to the construction site, where they are assembled forming the bridge.
This type of bridge can be very long, made up of several box girder sections, bolted together. They are ideal for motorway flyovers and even pedestrian walkways.
They have a modernist appearance, ensuring that they fit in with urban architecture. They have a reputation of requiring little maintenance and are therefore, a cost effective alternative to other types of bridges.

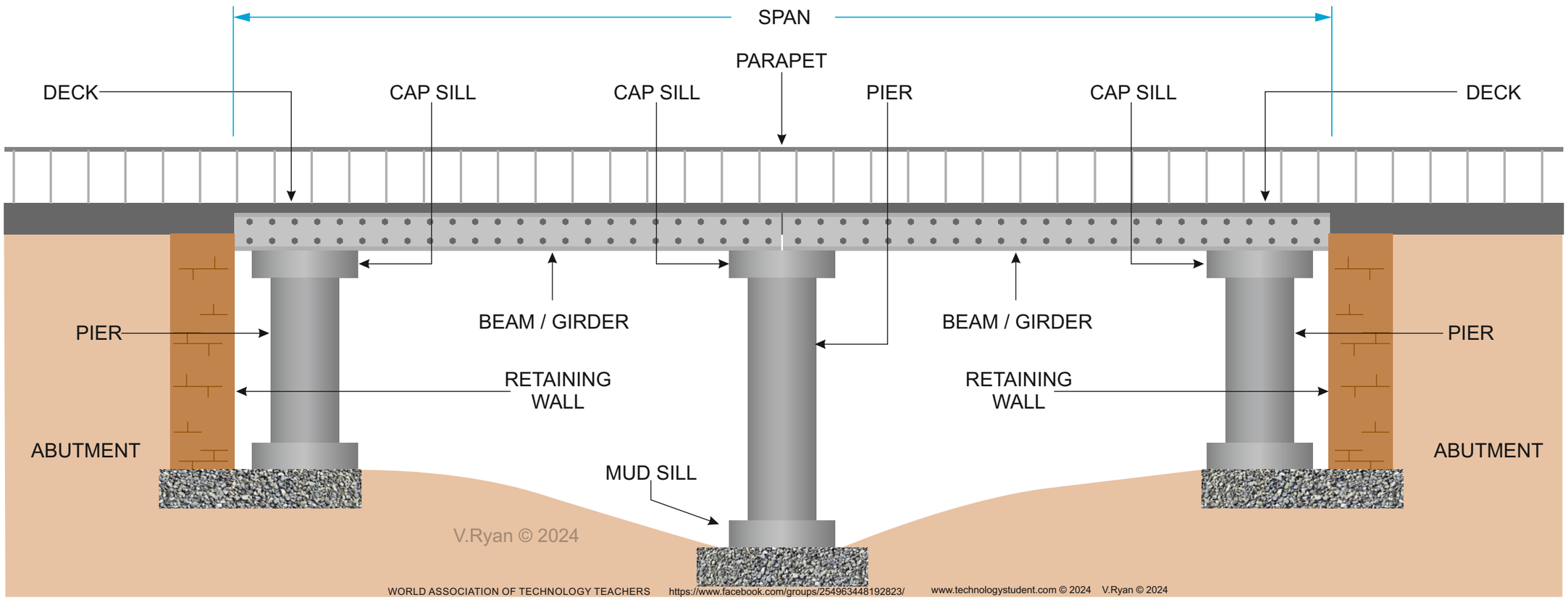
FAMOUS BOX GIRDER BRIDGES

Oresund Bridge - 2000 - Denmark / Sweden.
Confederation Bridge - 1997 - Canada
Rio-Niterói Bridge - 1974 - Brazil
Bang Na Expressway - 2000 - Thailand
General Douglas MacArthur Causeway - updated 1990s - Miami, USA

USEFUL LINK

https://technologystudent.com/struct1/sntbrd1.htm

MODERN BEAM BRIDGE



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FACTS

A modern beam bridge is a rudimentary structure, with a roadway and beams supported by piers. They are generally constructed from steel and reinforced concrete, which gives the bridge a long working life, durability and strength. A typical beam bridge can be seen above. However, there are various types including, girder bridges (above), box girder and those made from steel plate. The components for this type of bridge are manufactured in a factory and transported to the site's location, where they are assembled, forming the bridge. The weight of the bridge and transport travelling across it, is transferred by compressive forces, through the piers and into the ground. The span (distance between supports) of a typical beam bridge, should not exceed 76 metres.

This type of bridge is popular for crossing motorways and highways (including pedestrian bridges). They are also common as railway bridges.

WELL KNOWN BEAM BRIDGES

Donghai Bridge - 2005 - China
Chesapeake Bay Bridge-Tunnel - 1964 - United States
Tianjin Grand Bridge - 2010 - China
Confederation Bridge - 1997 - Canada

ANSWER THE QUESTIONS ON THE THREE BRIDGE TYPES SHOWN BELOW.

QUESTIONS ON BRIDGE TYPES

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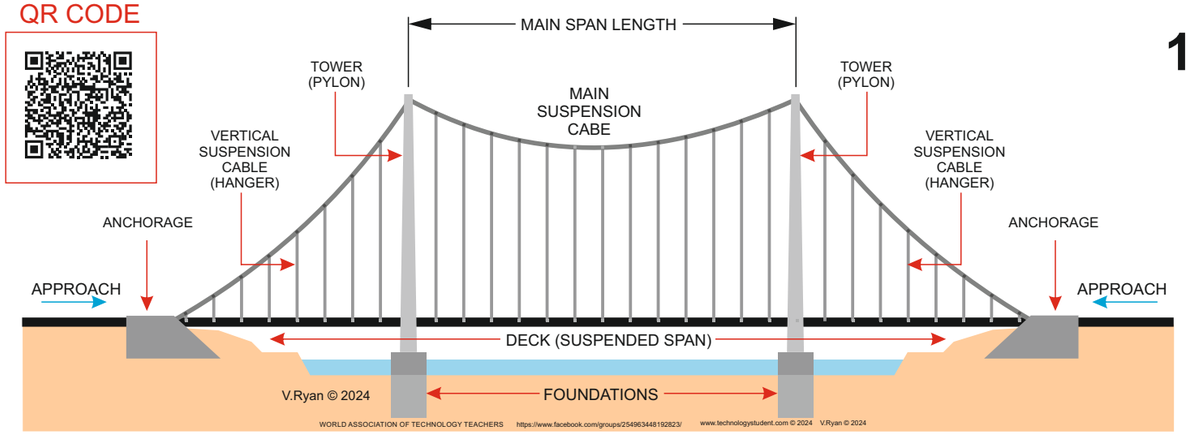

USEFUL LINK: https://technologystudent.com/struct1/suspen1.htm

1. Bridge type: _____

Three facts: _____

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_____

Name two famous Bridges of this type: _____

_____

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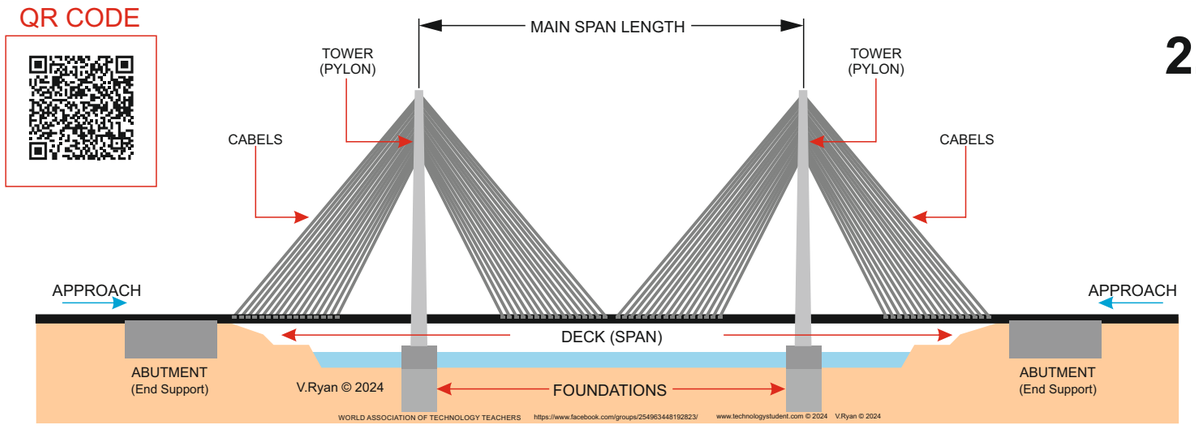

USEFUL LINK: https://technologystudent.com/struct1/cable1.htm

2. Bridge type: _____

Three facts: _____

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Name two famous Bridges of this type: _____

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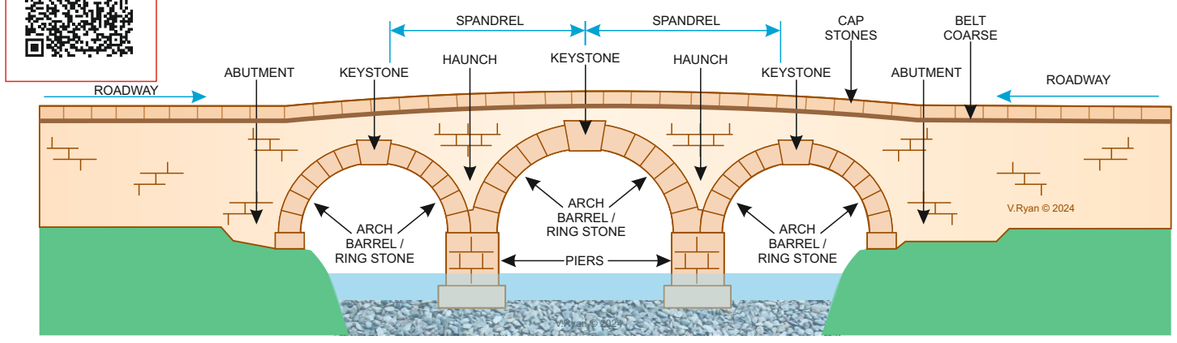


USEFUL LINK: https://technologystudent.com/struct1/roman1.htm

3. Bridge type: _____

Three facts: _____

_____

_____

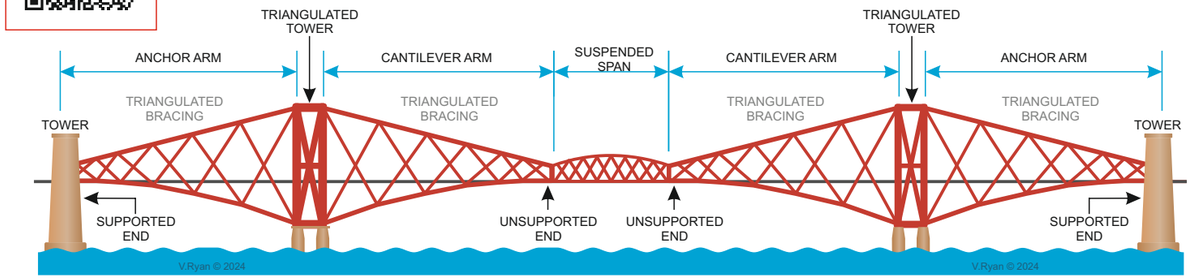
Name two famous Bridges of this type: _____

_____

ANSWER THE QUESTIONS ON THE THREE BRIDGE TYPES SHOWN BELOW.

QUESTIONS ON BRIDGE TYPES

QR CODE



USEFUL LINK: https://technologystudent.com/struct1/canti1.html

4. Bridge type: _____

Three facts: _____

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Name two famous Bridges of this type: _____

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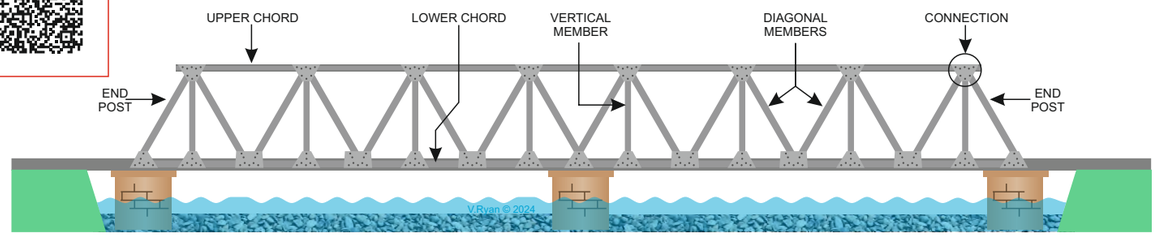

USEFUL LINK: https://technologystudent.com/struct1/boxg1.htm

5. Bridge type: _____

Three facts: _____

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Name two famous Bridges of this type: _____

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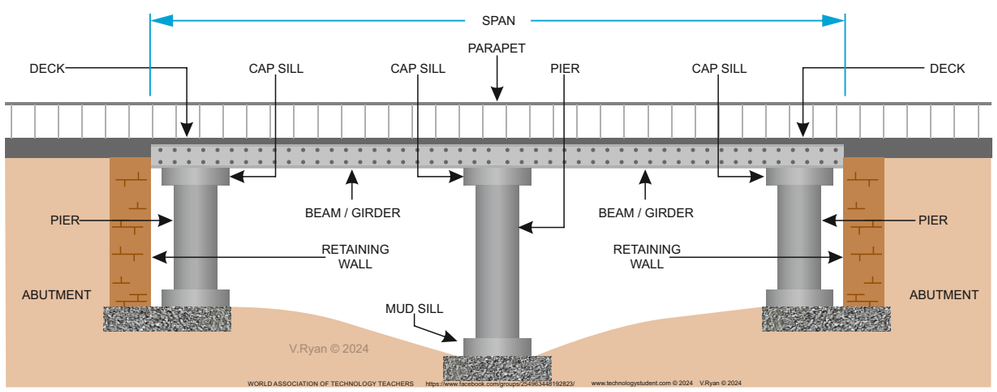

USEFUL LINK: https://technologystudent.com/struct1/sntbrd1.htm

6. Bridge type: _____

Three facts: _____

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Name two famous Bridges of this type: _____

_____