Bridges

_TEACHERS NOTES

RIBA KS3 | **Mathematics Activity**

INTRODUCTION + ACTIVITY /

The session is introduced with the power point presentation featuring Towncaster architects Sophie and Tomas and the Mayor of Greater Towncaster. The Mayor sets the scene and what she thinks the city needs. Sophie and Tomas narrate their approach to these needs and make a design solution for which they enlist the help of your students and their mathematical skills. In this activity, students work in groups of 4 or 5. Each group is provided with an activity sheet and materials which are listed on the worksheet to build model bridges for Towncaster.

One design is a road suspension bridge which is light, strong and flexible . The other design is a rail truss bridge which is heavy, strong and rigid. Each bridge has its strengths and weaknesses and needs a different mathematical approach to its design, in particular the power of formulae to provide solutions.

AIM /

"Through making two contrasting types of bridge structure, students can begin to understand how form is an important part of the structural strength. They will see the real-world value of mathematics, in particular volume and surface area."

_Curriculum Links

KS3 Maths:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/239058/SECONDARY_national_curriculum_-_Mathematics.pdf

'LET'S DO SOME MATHS!'

ALGEBRA /

- **substitute numerical values into formulae** and expressions, including scientific formulae
- **model situations or procedures** by translating them into algebraic expressions or formulae and by using graphs
- recognise, sketch and produce **graphs of linear and quadratic functions** of one variable with appropriate scaling, using equations in x and y and the Cartesian plane
- **interpret mathematical relationships** both algebraically and graphically

RATIO, PROPORTION + RATES OF CHANGE /

- **change freely between related standard units** [for example time, length, area, volume/capacity, mass]

GEOMETRY + MEASURES /

- **derive and apply formulae to calculate and solve problems** involving: perimeter and area of triangles, parallelograms, trapezia, volume of cuboids (including cubes) and other prisms (including cylinders)
- **describe, sketch and draw using conventional terms and notations**: points, lines, parallel lines, perpendicular lines, right angles, regular polygons, and other polygons that are reflectively and rotationally symmetric
- **use the properties of faces, surfaces, edges and vertices** of cubes, cuboids, prisms, cylinders, pyramids, cones and spheres to solve problems in 3-D
- **interpret mathematical relationships both algebraically and geometrically**

SUBJECT CONTENT /

Maths: Algebra; Ratio, proportion and rates of change; Geometry and measures.

Architecture & Design: Shape-making possibilities of materials; energy performance; pollution & recycling; model making; structure; sustainability

KS2 / Learning Aims

- **Numbers**
- **Units**
- **Decimals**
- **Operations**

Students will carry out addition, multiplication and division calculations involving decimal places. These can be done long hand or with a calculator where recommended.

- **Measurement**
- **Perabolas**
- **Formulae**
- **Plotting Curves**

For the suspension bridge, students will plot a curve to an advanced formula which will require careful measurement and calculation using units of measurement. For the truss bridge we will use an engineering formula to predict how much material they will need. The triangles in the truss form a very rigid structure.

ARCHITECTURE + DESIGN / Learning Aims

Students will gain an insight through application of: structures and materials; different approaches in design to a similar problem; transport and the environment; teamwork and planning; careful measurement, drawing and making.

In principle, suspension bridges are light and strong, enabling transport infrastructure to span large distances with little material. However they are also flexible and roll badly if carrying heavy trains. Train bridges need to be very rigid and this means they end up as a heavier construction, but rail transport has environmental advantages over road transport.

NOTES/

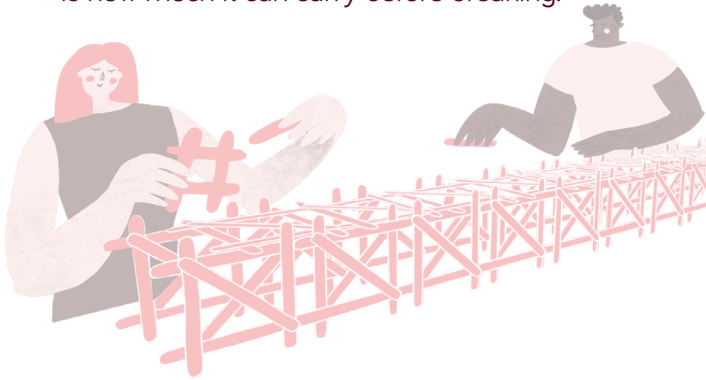
For this activity it is recommended that each group tackles one type of bridge with some making the suspension bridge and other smaking the truss bridge. If there is time and enthusiasm (or if you want a longer session) then each group can make both bridges. You can decide how groups are assigned to bridge type.

The corrugated cardboard should be as thick as possible e.g. 6mm. If you can only source thinner board then it could be doubled up. Depending on the skills of your students you can decide how they can cut the corrugated cardboard such as with scissors or a craft knife (with a metal straight edge on a cutting mat and a degree of supervision) if deemed appropriate. Alternatively, you can provide the cardboard components ready cut.

A glue gun is recommend for making strong joints quickly but this can be substituted for sticky tape or other glues.

Due to time lost when students try to find the end of the tape, it's recommended that sticky tape should be provided on dispensers. Alternatively, you can provide a supply of ready cut lengths.

If both types of bridge have been successfully constructed then an experimental comparison of their performance can form a valuable part of the session. The strength and rigidity can tested with weights such as toy cars. Flexibility is how much it bends before breaking; strength is how much it can carry before breaking.



MATERIALS / Suspension Bridge

MATERIAL	SIZE	QUANTITY
Large Sheet of Paper	A2/Flip Chart Sheet	1
Ruler	30cm (or longer)	2
Marker Pens		2
Sticky Tape (on dispenser)	10/15mm Wide	2
Corrugated Card/6mm Thick	A2 sheet or bigger	1
Scissors	To cut the card	4

Notes:

It is recommended that a calculator is permitted to help plot the quadratic curve. However, if you feel that your students will benefit from the challenge, this can be done long hand or using a spreadsheet could be an alternative approach.

It is important that the corrugated cardboard for the uprights is cut from the sheet so that the grain is lengthways, otherwise it will just buckle. If the uprights don't reach the floor they can be extended with some extra card or propped with a book.

Paper is surprisingly strong in tension but if there is a tear this is where it will break. It can easily be repaired with some tape. For the suspension bridge to work the ends of the cables need to be taped to the chair.

MATERIALS / Truss Bridge

MATERIAL	SIZE	QUANTITY
Lolly Pop Sticks	115mm x 10mm	200
Glue Gun		4 or 5
Glue Sticks		10
Sticky Tape (on dispenser)	10/15mm Wide	1
Corrugated Card/6mm Thick	A2 sheet	1
Scissors	To cut the card	4

Notes:

For each truss to work the lolly pop sticks need to be very well stuck together.