

Year 4 Design and Technology: Structures – Block D

Which shapes will give a structure stability?

- The outline and structure of the block is as follows:

Lesson 1	Lesson 2	Lesson 3
Exploration of the key question Exploration of materials and techniques	Conducting investigations relating to the key question	Application of knowledge and skills Evaluating and modifying




Roma Agrawal (born 1983)
The Shard (started 2009 – completed 2012)

At the end of this block, pupils will ...	
Know:	Be able to:
Triangles provide stability in a structure Structural engineers work with architects to ensure structures withstand forces	Make triangles to form and join trusses Identify the forces that affect structures

In this block, pupils will explore which shapes can be used to provide stability in structures.
They will use a range of materials to investigate 3D shapes and in Lesson 3 they will collaborate on a class geodesic dome structure.

CUSP Design & Technology Long term sequence	Block A	Block B	Block C	Block D	Block E	Block F
Year 1	Mechanisms	Structures	Food and Nutrition	Understanding Materials	Textiles	Food and Nutrition
Year 2	Textiles	Food and Nutrition	Mechanisms	Understanding Materials	Food and Nutrition	Structures
Year 3	Textiles	Food and Nutrition	Mechanisms	Food and Nutrition	Systems	Structures
Year 4	Food and Nutrition	Mechanisms	Textiles	Structures	Electrical Systems	Food and Nutrition
Year 5	Food and Nutrition	Systems	Textiles	Mechanisms	Structures	Food and Nutrition
Year 6	Food and Nutrition	Mechanisms	Food and Nutrition	Structures	Electrical Systems	Textiles

Point of reference:

Y4 Structures – Block D

Pupils will be able to:

- increase the rigidity and strength of paper by folding and creasing



Prior Learning

- name the properties of 2D and 3D shapes
- explain the difference between 2D and 3D shapes

Design or Technology History:

Roma Agrawal (born 1983)

Roma Agrawal is an Indian-British-American structural engineer. She is also an author and a diversity campaigner, championing women in engineering. She has worked on several major engineering projects, including the Shard which is a 72-storey skyscraper designed by the Italian architect Renzo Piano. Standing 309.6 metres high, the Shard is the tallest building in the United Kingdom and the seventh-tallest building in Europe.

Links to Literature:

How Was That Built? by Roma Agrawal

Built – The Hidden Stories Behind Our Structures by Roma Agrawal (teacher reference)

Working with Buildings and Structures by Izzi Howell

13 Buildings Children Should Know by Annette Roeder

13 Skyscrapers Children Should Know by Brad Finger

Materials:

Biodegradable straws, masking tape, rulers, scissors, weights (books, bricks or wooden blocks), craft sticks or tongue depressors, split pins, felt pens (optional), craft matchsticks, wooden dowels (3/8 inch diameter, 36 inches long, 225 – 250 per class of 30), 1000 elastic bands (NB dowels and elastic bands can be re-used)

Health and Safety:

This block requires pupils to use: scissors, weights, elastic bands and long pieces of wooden dowel which could pose injury to themselves or others if handled incorrectly. Teachers should ensure that they follow their own school's risk assessments and policies for using the necessary materials and equipment. Pupils should be taught about how to use equipment and materials safely and responsibly as part of these lessons.

Working as a Designer

Design	Make	Evaluate	Apply
The art or process of deciding how something will look or work.	Create something by combining materials or putting parts together.	Form an opinion of the value or quality of something after careful thought.	Use something or make something work in a particular situation.

Point of explanation:

Y4 Structures – Block D

Core Knowledge	Explanation
structural engineer	A structural engineer analyses and designs the gravity support and force resistance of buildings, bridges and other structures.
geodesic	Geodesic refers to curved surfaces made up of geometric shapes and straight lines.
gravity	Gravity is the force that attracts objects towards one another, especially the force that makes things fall to the ground.

Technical Vocabulary	Definition
truss	a rigid framework constructed from triangles
compression	the act of putting pressure on an object from different sides until it gets smaller
tension	the state of being stretched tight and stiff

Link to Video: https://vimeo.com/637412589/71d208e259
• Explanation and demonstration of taught content • Lesson by lesson guidance • Exemplification of techniques and outcomes

Point of delivery:

Y4 Structures – Block D

Revisiting prior learning 	Taught content 	Point of practice 	Point of reflection 
1. Paper can be made stronger by changing its shape	Identify and explain the forces that affect buildings (compression, gravity, tension) Describe the role of engineers and architects Conduct investigations to discover the load-bearing properties of cylinders made from a sheet of paper compared with cylindrical forms constructed from a series of smaller cylinders Record results and draw conclusions from findings	Introduce pupils to the key question for this unit: Which shapes will give a structure stability? Refer them to previous learning about how changing the shape of paper can make it stronger. Introduce the Knowledge Note and key vocabulary for this unit. Through questioning, find out what pupils already know about engineers and architects. Explain that a structural engineer focuses on the structural stability of a building, given the forces that are acting upon it. The forces of compression and tension can be demonstrated using the activity described in the teacher video. Pupils test the strength of a paper cylinder by increasing the weight of a load placed upon it. The test is repeated using two cylinders with the load distributed across both. Ask pupils to consider whether a series of cylinders would have greater strength. Pupils then conduct the same strength test using cylinders made from paper straws. Pupils should document their investigation, comparing the results achieved from the different tests carried out. Explain that cylinders play an important role in architecture because they are strong – dispersing the weight of any load throughout the whole shape. Share three types of columns found in architecture: Doric, Ionic and Corinthian. Pupils can draw and label these in their portfolios.	Can give a simple explanation of compression Can explain the roles of engineers and architects Can conduct a simple investigation, record and compare results and draw reasonable conclusions Can identify which cylinder was strongest and why cylinders are used in buildings
2. A column is strong because all parts of the cylinder share the load A series of cylinders is stronger than one Cylinders are regularly used in structures	Investigate the strength and stability of a range of geometric shapes Make a record of tests conducted and summarise outcomes Identify which shapes are strongest and most stable and their application in construction	Show pupils a picture of the Shard and introduce them to the structural engineer Roma Agrawal. Ask pupils to explain what they notice about the structure. Remind pupils that they have established that cylinders are shapes that give a building stability and strength. Challenge pupils to explore other geometric shapes to see which would be suitable to make a building strong and stable. Using craft matchsticks and modelling clay, pupils construct a range of 3D geometric shapes. Pupils then investigate which are most stable by applying pressure to them. Use questioning to draw out pupils' predictions and conclusions. Pupils then investigate 2D shapes which they construct from craft sticks and split pins. Pose the question, which shape will withstand the most compression? Through investigation and questioning, establish that a triangle is a strong and stable shape and can be joined with others to form a truss. Question pupils about where these might be used and why. Challenge pupils to devise a way to test the strength of a truss. Pupils can record their tests and results in their portfolio along with annotated drawings of the shapes they have constructed and the conclusions they have drawn. Pupils then complete Vocabulary Task 1.	Can construct a range of geometric shapes Can devise and conduct a strength test Can summarise and draw accurate conclusions from results Can identify the triangle as a strong and stable shape used in structures such as bridges

Point of delivery:

Y4 Structures – Block D

Revisiting prior learning 	Taught content 	Point of practice 	Point of reflection 
3. Triangles are strong and stable shapes Triangles joined together have stability and create a rigid structure	Apply knowledge and skills to a practical context Collaborate with others to create a structure from triangles Create, adapt and modify a design Evaluate results and suggest improvements	Refer pupils back to the original design question: Which shapes will give a structure stability? Invite them to share and discuss what they have learned so far that will help them answer this question. Explain that, in this final lesson, pupils will work in groups of five or six to construct and combine triangles to form structures. Ultimately, they will then collaborate as a class to create a geodesic dome under which they can all gather. Model joining dowel rods with elastic bands using the loop, twist, wrap, loop method. Initially, instruct pupils to form a triangle from the dowel rods. Challenge pupils to join a series of triangles together to form a structure that all their group can sit under or an arch they can walk through. Encourage pupils to draw out a design first but be prepared to make adjustments and modifications as they proceed. Use questioning to prompt pupils to think about which parts of their structure are most or least stable and what changes they could make to improve its stability. Take photographs throughout so that pupils have a record of their collaborative work which they can annotate with notes about the design decisions they made and any changes that were necessary. Provide opportunities for each group to share their work and evaluate their outcomes. Finally, challenge pupils to all work together to combine their triangles to form a geodesic dome. Discuss the skills they will need in order to work effectively as a group. Pupils then evaluate their completed structure and complete Vocabulary Task 2.	Can listen to others and share ideas effectively Can work collaboratively on a design and identify where changes need to be made to improve the stability of a structure Can negotiate with others and reach a compromise when opposing views are shared Can identify strengths and weaknesses in the finished structure

Questions for assessment

Does how tightly you roll the paper into a cylinder affect how strong it is?

Which is strongest: three cylinders made from one sheet of paper, or one cylinder made from lots of cylinders?

Does the positioning or size of the cylinders affect how much weight they can withstand?

What advantage does a truss have over solid wood or metal?

How do you know that a triangle is stronger and more stable than a square?

Where might trusses be used?

What part of your structure is most / least stable?

How can you ensure that everyone has a role in constructing the dome?

What changes did you have to make to your original design and why?

Oracy and Vocabulary: Y4 Structures – Block D

Task 1:

These adjectives are associated with stability. Order them according to their strength of meaning.

rigid				
stiff				
firm				

Write two words that mean the opposite of rigid.



Exploration: 

Is stability the same as strength?	Which are stronger, pentagons or hexagons?	Are shapes with an odd number of sides more stable than shapes with an even number of sides?
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Task 2:

Work with a partner to answer these questions about what you have learned in this unit.

How did you find out which shapes are the strongest and most stable?



Write some sentences to explain why triangles and cylinders are used so much in buildings.



Was your group successful in making a structure that you could sit under or walk through?

What changes did you have to make to your original design and why?



What would you do differently next time?

Write about what you have learned from making a geodesic dome as a class.



Vocabulary: Y4 Structures – Block D

OWN-it	Analyse 
Underline the part of the word that means to build.	
structural	
Change this word to the past tense.	
engineer - _____	
Change this word to a verb.	
compression - _____	

KNOW-it	Define 				
Tick true or false.					
An object that is under <i>tension</i> is being stretched.					
<table border="1"> <tr> <td>true</td> <td></td> <td>false</td> <td></td> </tr> </table>	true		false		
true		false			
Tick the correct answer.					
What is a <i>truss</i> ?					
☐ a frame for growing plants ☐ a triangular frame ☐ a triangular building					
Match the word to the most accurate definition.					
structural	relating to buildings relating to architects				

LINK-it	Connect 
Write a different word that also contains the root <i>press</i> .	
compression - _____	
Write two different words that contain the root word <i>force</i> .	
1. _____	
2. _____	
Write two words that contain the prefix <i>geo</i> .	

USE-it	Use in context 
Select the correct word to complete this sentence.	
Compression is a _____ that affects buildings.	
structure	force material
Tick the box if the word <i>tension</i> has been used correctly in this sentence.	
We need more <i>tension</i> in the ropes so loosen them.	
Use these words to write a sentence explaining <i>gravity</i> .	

force	objects attracts

Knowledge Note:

Y4 Structures – Block D

Year 4: Structures

Which shapes give a structure stability?



Core content:

Explore which shapes can be used to ensure stability in structures.

Use a range of materials to investigate 3D shapes.

Collaborate on a class geodesic dome structure.

Technical vocabulary:

Structural engineer – designs the force resistance of buildings, bridges and other structures.



Geodesic – curved surfaces made up of geometric shapes and straight lines.



Gravity – the force that attracts objects towards one another, especially the force that makes things fall to the ground.



Truss – a rigid framework constructed from triangles.



Compression – the act of putting pressure on an object from different sides until it gets smaller.



Tension – the state of being stretched tight and stiff.



Connections:

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(born 1983)
Indian-British-American
structural engineer



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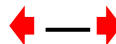
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Exemplification: Y4 Structures – Block D

Which shapes will give a structure stability?

Y4 Structures

Which shapes will give a structure stability?

- Create cylinders out of paper
- Test the strength by putting a weight on top (Books are ideal)
- Compare length of cylinders – does this affect the strength?

Identify styles of columns

Weights gently applied

Does it matter how many cylinders are used? Why?

Compression

Create cylinders from smaller tubes (Use paper straws and tape)

Are these stronger? Why is that?

Identify the three forces that engineers work with:

- Compression
- Gravity
- Tension

Apply gentle pressure on top of head – feel the force travel down through the body

pull

tension

pull

tension

Identify forces that engineers need to consider when designing buildings

Demonstrate these forces using the activity described in the teachers' video

Join smaller cylinders (paper straws) together to form larger cylinders

Pose questions to pupils: How stable are they?

Are they stronger than cylinders made from single sheets of paper?

Test the strength of cylinders

Use cardboard tubes and then make cylinders from paper

Pose questions to pupils:

What weight will the cylinders withstand before bending and giving way?

Does the size of the cylinder affect how much weight it can hold?

Are three cylinders stronger than one?

Does the positioning of the cylinders affect how much weight they can hold?

Exemplification: Y4 Structures – Block D

Which shapes will give a structure stability?

Establish that parallelograms are not able to withstand compression or tension

Triangles can provide strength and stability to a structure

Form trusses by joining triangles together

Pose the question to pupils: What is the advantage of using a truss rather than a solid piece of wood or steel?

Wrap, twist, loop.

Used to make holes in the craft sticks split pins join the sticks together

Use matchsticks and modelling clay to create 3D shapes and structures

modelling clay

matchstick

How stable are these structures?

Use matchsticks and modelling clay to create a range of 3D shapes

Explore the strength of these and record results

Join the triangles to create large 3D structures

Make arches and domes

Geodesic dome has triangles that are structurally rigid and distribute stress throughout the

Join craftsticks to form triangles - these can then form trusses

Ask pupils to identify shapes that can withstand compression

Make shapes using craft sticks and split pins

Make triangles using dowels and elastic bands

Create large geodesic structures