Structures for Strength
God is a powerful protector
God is our refuge and strength

Supporting devotional resource
Themes for Christian Studies 4, (Powerful) - God's power is the greatest
Themes for Christian Studies 3, (Powerful) - God is great, strong and mighty

Biblical references
Bible stories about God our strength
Exodus 7-14 - God set the Israelites free, and by His strength He held back the Red Sea.
Judges 6-8 - Through His power God used Gideon to set the Israelites free.
Judges 13-16 – Samson could have used his God-given strength for the glory of God and the support of his nation, but his sin caused him to lose God's protection
Joshua 6 - The walls of Jericho. God's power is greater than man's strength.
Joshua 10 - By His strength and power God caused the sun to stand still.

Verses
Psalm 46:1 - God is our refuge and our strength, an ever-present help in the time of trouble.
2 Samuel 22:2 & 32; Psalm 18:30-36; Psalm 31:3; Psalm 71:3; Psalm 89:26; Psalm 91:5 - God is a rock
2 Samuel 22:33 - It is God who arms me with strength
Proverbs 18:10; Psalm 61:13 - God is a strong tower
Luke 1:37 - Nothing is impossible with God.
Phil 4:13 – I can do all things through Christ who strengthens me.

Buildings in the Bible
Tower of Babel (Genesis 11)
Noah's Ark (Genesis 6-8)
The tabernacle (Exodus 26 & 27)
The temple (1 Kings 6 & 2 Chron. 3 & 4)
The house on the rock (Matt 7:26)
Image of Christ the cornerstone (Ephesians 2:20)
Image of the body of Christ as living stones (1 Peter 2:5)

Key Questions
Why does a rock remind us of strength?
What does the Bible tell us about God's power and strength?
Which miracles in the Bible show God's strength?
Who is in charge of the universe?
Is God's power great enough to do anything?

Outcomes
Students will
Knowledge

- understand that the stability of a structure is affected by the type of force and where that force impacts the structure
- design structures to produce maximum strength
- asses strength of bridge and tower construction, using engineering features such as arch, dome, cylinder, cantilever, buttress
- discover rigid and non-rigid shapes
- test materials and structures for strength and ability to support weight
- explain why some shapes will support weights better than others
- change the shape of a piece of paper or card to support a weight more successfully
- explain the two types of support used in buildings: tension and compression
- explain how laying patterns can affect the strength of a brick wall
- predict the ability of a beam to span between two supports

Skills

- plan, experiment, appraise
- identify design features discovered in nature

Values

- use team work
- show patience in construction work

Activities

- Make and test the strength of mud bricks with different kinds or reinforcement, e.g. stones, straw. Drop from waist height.
- Make spaghetti or drinking straw towers and bridges.
- Investigate the strength of fresh eggs by applying loads to different parts.
- Take a sheet of A4 paper and predict its possibilities to support a weight, unaided. Pleat the paper using 4-5 cm pleats. Make a column from the piece of paper and try to support a cassette case.
- Test the column with other weights. Find out how much weight the column will actually support. Make a table showing results.
- Make a bridge from the pleated paper using two supports. Find out how much weight the paper will support when placed as such. Compare results with those of the single support.
- Take another piece of A4 paper and make a column by rolling. Compare the supporting ability of the column with the above.
- Suspend a rock on a piece of string or rubber band to show the principle of suspension.
- Place a rock on top of a pillar to show the principle of compression.
- Look for use of these two principles in existing structures.
- Use a strip of card to form a bridge between two pillars (or wooden blocks). Find out how to stop the card collapsing in the middle by - a) moving the pillars closer together, b) using wider card, c) using a stronger material. Draw conclusions.
- Experiment with building blocks to show the stability of different laying patterns similar to those used in bricklaying.
- Form groups and hold a competition to see which group can make the tallest structure using only - a packet of straws, a roll of sticky tape, scissors and newspapers.

- Observe structural features in famous buildings around the world e.g. Egyptian pyramids, leaning tower of Pisa, Eiffel Tower, The Beehive (Wellington N.Z.).
- Describe some of the structural developments of Greek and Roman times such as columns, arches, stone arch bridges (aqueducts).
- Investigate the strength of triangles and arches. Make a model aqueduct using scored cardboard for arches. Use plastic straws or cardboard strips to make a construction of triangles. *(See 'Shelter' unit for diagrams).*
- Compare bridges designed on suspension or compression principles e.g. Golden Gate Bridge demonstrates suspension; Roman stone arch bridges demonstrate compression.
- Make models of historical examples.
- Explore the local environment comparing old and new buildings. Assess stability of buildings, taking into account building materials and methods.

Link with Australian Curriculum

Science Year 4: Physical sciences – Forces can be exerted by one object on another through direct contact or from a distance

Learning Connections:

English:
Use imagination to construct stories of the past, involving buildings and structures from the past
Science: forces used in building construction
Social studies: buildings in the community
History: History of shelter
Mathematics:
Research strength of shapes and prisms.
Measure heights of structures.
Estimate, measure, and record length, height, and distance, using standard units (i.e., centimetre, metre, kilometre)
Estimate, measure and record the mass of the load that the structures can support.
Art: Construct models of buildings; Draw building designs
Thinking skills: See the *Creative Thinking Skills* section of this website – *"Structures for Strength" (Middle/Upper Primary).*

Assessment

1. Design a building that is strong and stable. Make a model and explain why your building is a strong structure.

2. What have I learned from the study of mini-beasts…
    - about God?
    - about doing what God wants me to do?
    - about the Bible?

Additional Beacon Media resource

'Shelter' – See **Science and Social Studies Students Activities**; **Science and Social Studies Research Cards**

Related Building Blocks units: Shelter; Gravity and pendulums

Sample Lesson Plan: Canadian Monuments:

How structures are designed and created to be strong and stable

http://www.tvdsb.ca/uploads/S&TDVD/Appendix%20N%20-%20Canadian%20Monuments%20Lesson%20Plan%20Pkg%20(Grade%203).pdf

Understanding: The stability of a structure is affected by the type of force and where that force impacts the structure.

Keywords:
structure
force
buttress
supports
pillars
columns
stability

Prior Knowledge:
Students should have prior knowledge about: how forces affect the stability of structures; how the strength of different materials affects structural stability; and how balance, symmetry, and gravity affect the stability of a structure?

Specific Expectations Covered in this Lesson:

- investigate, through experimentation, how various materials and construction techniques can be used to add strength to structures
- investigate, through experimentation, the effects of pushing, pulling, and other forces on the shape and stability of simple structures use technological problem-solving skills, and knowledge acquired from previous investigations, to design and build a strong and stable structure that serves a purpose
- use appropriate science and technology vocabulary, including compression, tension, strut, ties, strength, and stability, in oral and written communication
- define a structure as a supporting framework, with a definite size, shape, and purpose, that holds a load
- identify structures in the natural environment and in the built environment
- identify the strength of a structure as its ability to support a load
- describe ways to improve a structure's strength and stability
- explain how strength and stability enable a structure to perform a specific function
- describe ways in which different forces can affect the shape, balance, or position of structure

1. Engage:

- Have 2 students form an arch by placing their palms together and leaning toward each other, sliding their feet as far back as they can. Caution them not to lose their balance. Ask: Where do you feel a push or a pull? (pushing on their hands)
- Have another student pull down on their hands in the middle to test the strength of the arch. (It will not be difficult to break the arch. Their hands will be forced downward.)
- Have the group brainstorm ways for two more students to join the arch and make it stronger, but without breaking up the space beneath the arch. Guide them to the idea of adding support by asking the arch-makers how stable their legs feel. Then repeat Step 2 and compare the results. (The buttresses exert an inward force on the sides of the arch that balances the outward force created by the load pressing down on the top of the arch.) (Building Big - PBS http://www.pbs.org)

- Have 2 more students join hands, like in the game “London Bridge”. (This time the students should stand tall, with feet directly under them so they are not leaning into each other. Arms should be straight with elbows locked.)
- Have another student pull down on their hands. Again it should not be difficult to force their hands down.)
- Gather 10 more students (5 on each side) to provide force to the 2 students with their hands together. (These students should push on the backs of the pair forming a bridge.)
- Have a student pull down on their hands again. Their hands will be stronger, and therefore more difficult to pull down.

2. Explore:

Invite questions and discussions. Encourage higher level thinking skills and “deeper levels” of observations by prompting and questioning students accordingly.

Examples:

- What happened? What provided strength?
- What was different in the two scenarios? What was the same?
- What would happen if....?
- How could you design a sound structure?
- Have students write a question about the event in their science journals and have a peer write a well thought out answer.

The Big Idea:

Structures are affected by forces acting on them.
Structures need to be strong and stable to be useful.

Materials and Resources:

1. Coins
2. Straws
3. Modeling clay

4. Plastic cup

3. Explain:

- Explain that in both scenarios the structures were supported by "buttresses" that counteracted the outward pushing force or thrust. In the second scenario (the "London Bridge" model), the supporting students acted as "flying buttresses" (free standing buttresses).
- Emphasize that providing outward force on the vertical pillars (buttresses) increases the strength of the structure.

4. Elaborate:

- Provide students with straws and modeling clay. You may choose to have students work individually, partners or small groups (no more than 4).
- The challenge: To design and build a Canadian Monument with a restaurant at the top.
- Structures will have to support a plastic cup of pennies (representing the load of restaurant). Who can build the tallest structure that can support the most coins?
- Students should draw design prior to constructing.

5. Evaluate:

Teacher observations and anecdotal comments regarding student's oral and written responses - Consider:

1. Did students ask questions of increasing complexity?
2. Were they able to provide some thought to the answer in their peer's journal?
3. Does their structure have reinforced sides?

Background Information for the Teacher

- A buttress is a support -- usually brick or stone -- built against a wall to support or reinforce it. It is a side support that counteracts an outward pushing force, the way bookends keep books on a shelf from sliding sideways. Buttresses are often used to support the sides of arches and tall cathedral walls, where they counteract the outward thrust.
- A flying buttress is a free-standing buttress attached to the main structure by an arch or a half-arch. They are called "flying buttresses" because they are no longer attached to the sides of the cathedrals. The invention of flying buttresses allowed the cathedrals to be built taller since the buttresses would transfer the loads to supports on the sides.
- An arch is a curved structure that converts the downward compression force of its own weight, and of any weight pressing down on top of it, into a force along its curve. This results in an outward and downward force along the sides and base of the arch.

Safety Considerations:

When testing the strength of the structures created by students' arms (during the "Engage" portion of the lesson), students should be reminded to carefully apply force to pull the arms down, so not to hurt their classmates.

References / Websites: http://www.pbs.org/wgbh/buildingbig/index.html)