5E Lesson Plan	EARTHQUAKES
Topic	Earthquake Resistant Structures
Grade Level/Subject	6th Grade Science
Time	7-8 Class Periods (40 minutes each)
NGSS and Common Core Standards	**MS-ESS3-2**. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2**. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **Science and Engineering Practice** Asking Questions and Defining Problems Analyzing and Interpreting Data Engaging in Argument from Evidence Constructing Explanations and Designing Solutions **Disciplinary Core Ideas** **ESS2.B**: Plate Tectonics and Large-Scale System Interactions **ESS3.B:** Natural Hazards **ETS1.A**: Defining and Delimiting Engineering Problems **ETS1.B**: Developing Possible Solutions **Crosscutting Concepts** Influence of Science, Engineering, and Technology on Society and the Natural World Cause and Effect

5E Lesson Plan	EARTHQUAKES
	Common Core State Standards Connections: **ELA/Literacy-** **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **WHST.6-8.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. **Mathematics –** **MP.2** Reason abstractly and quantitatively. **6.EE.B.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. **6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
Problem/Activity	Your task is to design an earthquake proof building for a Tokyo, Japan or San Francisco, USA (money is no object).
Background	These lessons will be at the end of the Plate Tectonics Unit. This short project will be using the student's prior knowledge on earthquakes. The students have been immersed in learning about Earth's Structure and Plate Tectonics. Up until this point, the students are aware that within the layer of the Earth there are convections currents that heat the Earth. They are familiar with Alfred Wegener and his theory of Continental Drift as well as Harry Hess's theory of Sea-floor Spreading. This all culminates with the theory of Plate Tectonics. Plate Tectonics is a very large unit that is taught in the 6th grade. The students are familiar

5E Lesson Plan	EARTHQUAKES
	with the concept that different plate movements cause various types of events especially what causes earthquakes and their effects. An Earthquake is a tremor of earth's surface that is triggered by the release of stress along the fault line of two transform boundaries. This movement causes results in energy waves that are released. There are some earthquakes that do not cause a lot of damage but there are others that have caused disastrous damage. Students have already learned about the impact of earthquakes and the resulting catastrophes that can occur.
Justification	The process of designing earthquake resistant buildings cannot be solved by using only one field of science, but rather integrating various scientific disciplines, such as science, math, technology and engineering to create creative and innovative problem solving. (Fitrani, et,al, 2017) I chose this lesson for the culmination of the Plate Tectonics unit because although most of the students in my class have never experienced earthquakes, (many if not all my students are native to the New York area), students have expressed interest in the fields of architecture and engineering. In an actual work environment architects and engineers need to be very knowledgeable about the infrastructure and the impact of natural disasters. They also need to be very well versed in structural design. Currently, much of the buildings and construction in many earthquake prone locations are not built with the natural hazards in mind. Even though scientists have developed very advanced equipment and have done a lot of research, it is nearly impossible to predict earthquakes. However, experts can estimate the areas where earthquakes are likely to occur. In earthquake prone areas, it is important to note that buildings should have clear earthquake evacuation procedures listed as well. Due to time and storage constraints, I will have the students design their buildings but not construct them. As a quick engineering challenge, I will have the students build a basic building out of everyday materials. They will do this prior to learning about the special design and architectural elements of earthquake proof structures. Teachers can extend these lessons by either using the Tinkercad to 3-D print designs or to utilize a variety of material to build their designs. Groups of students can create their models then test and retest them on a shake table to simulate a real earthquake. The students will have to be well versed in certain mathematical principles such as symmetry, geometrics, scale and proportion in order to design and/or build their structures. This is a perfect

5E Lesson Plan	EARTHQUAKES
	example that will explain to students the real-word application of mathematical concepts. These mathematical concepts will integrate well with the technology of designing their buildings. After doing the quick engineering challenge of building a structure out of basic materials, students will come to realize that architects and engineers need to spend a lot of time planning their designs prior to building them. These designs need to be well thought out and drawn out precisely, in order to stay structurally sound during an earthquake. These careers require extensive knowledge of technology and the use of computers to design buildings. This lesson integrates many aspects of STEM as well as geography and art. Science – Plate Tectonics and Earthquakes Technology – Chromebooks, Smartboard, Google Classroom, Forms and Docs, TinkerCad Engineering – Designing an Earthquake proof using 3D software Math – Scale and Proportion Geography – Tokyo, Japan and San Francisco, California Arts – Designing a building using architectural elements
Objectives	Students will be able to: • Analyze and interpret photographic data and write a creative journal entry based on photographic data. • Build a 3-foot-tall building using straws, tape and a piece of cardboard. • Explore different materials, shapes, and design options that affect the durability of a building and identify which building materials work best in designing an earthquake proof structure • Recognize and apply the different types of architectural design elements to their designs. • Design an earthquake proof building based on the geography and geology of chosen earthquake prone location. (San Francisco or Tokyo, Japan) • Justify their choice of design and building characteristics in a written statement. • Integrate technical Earthquake evacuation procedures for their building. • Use Tinkercad or another design software to design their Earthquake Resistant Buildings • Describe ratio, scale and proportion properly in their designs

5E Lesson Plan	EARTHQUAKES
Materials	Chromebooks Internet access Pens Pencils Markers Earthquake Planning Sheet Smartboard Cardboard Scissors Straws Masking table
Vocabulary	Earthquake resistant Rubber bearings Tuned mass damper X Bracing Base Isolator
Engage The purpose for the ENGAGE stage is to pique student interest and get them	Day 1: (40 Min) All students will come into class and take their Chromebook from the cart. As there are logging in, I will show them the following video of the Loma Prieta Earthquake on October 17, 1989 in San Francisco, California Video - Loma Prieta Earthquake (2:33)

5E Lesson Plan	EARTHQUAKES
personally involved in the lesson, while pre-assessing prior understanding.	Students will then follow a link on their Google Classroom that leads to the USGS Photographic Data on the Loma Prieta Earthquake. USGS Photographic Data - Loma Prieta Earthquake This large repository of photographs will allow the students to experience what it must have been like to be part of this Earthquake.
Explore The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.	**Day 1** Based on the video and the photographs, I will tell each student: "Imagine you were a part of the Loma Prieta earthquake. Based on the video you saw, write a journal entry from October 18, 1989, and add a link or copy and paste one of the photographs in the data set that describes your experience from the day after the earthquake, and think about the following aspects." "Where were you during the earthquake?" "How did the earthquake affect you and your loved ones?" "What are the effects on your home, community and possessions?" "Once you knew it was an earthquake what precautions did you follow in order to stay safe?" Students will have 25 minutes to write a short journal entry on a Google Doc. Students will share their journal entries for the last 5-10 minutes of class. Students will submit their entries via Google Classroom. This will be a formative assessment that will allow me to see if the students are able to use the data from the photographs to write a personal journal entry. **Day 2 (40 min)** Activity: Quick Design Challenge Students will be grouped into 2-3. Students will receive a piece of cardboard or a file folder 12 straws 1 meter of masking tape.

5E Lesson Plan	EARTHQUAKES
	Students will have 10 minutes to plan and 20 minutes to build the tallest structure that can withstand 10 seconds on a shaking table After building and testing, students will log into google classroom and fill out the following questions on a google form 1. To what level did your members work as a team? 2. To what level did your tower meet the criteria? 3. To what degree was your tower able to withstand the forces exerted by the earthquake? a. What was your innovation? 4. What would you have done differently if you had more time to plan? 5. What role to architects and engineers play in designing and building earthquake resistant structures? 6. Based on your building what structural characteristics worked and which ones did not. Be specific as you will need it at a later lesson. **Day 3 (40 min)** As class begins, I will tell the students to keep the photographic data from Day 1 in their minds and I will have the students watch the following video. Ted-Ed Why do buildings fall in Earthquakes? After watching the video, students will be directed to log onto their Chromebooks and complete a quick formative assessment and complete the questions associated with the video. https://ed.ted.com/lessons/why-do-buildings-fall-in-earthquakes-vicki-v-may/review_open#question-1 (review questions) As a class we will go over the answers. I will then conduct a whole group discussion on how engineers and architects design and create buildings that can withstand the impact of an earthquake. Students will be directed back to Google Classroom to read the following article on Earthquake hazards and safe structures Earthquake Safe Structures and discuss with their partners, the design elements of the structures

5E Lesson Plan	EARTHQUAKES
	discussed. I will introduce the Design Task. “As the head of an Architectural and Engineering Firm, you have been tasked with designing a building in either Tokyo, Japan or San Francisco, California. The building must take into consideration design, construction and geology of the area. The building must be aesthetically pleasing as well.” Students will work in pairs. One student can act as the architect and the other can take the role of engineer or they may both have these roles interchangeably. They will receive the guidelines and the associated rubric. Students will return to Google Classroom and review the two websites that are provided. I would like to students to really understand the geology of where their building will be built. Students will be grouped into pairs and they will brainstorm how they would build their structure. Students should write down the elements they would like to use and the location where their building will be built (either Tokyo or San Francisco). They need to research and be able to explain the answers to the following questions. • What does your building need to be built upon to help withstand or limit the shaking? Think about rock type and landscape. Japan's Explosive Geology Explained San Francisco Bay Region Geology If time permits students can look for other websites on their own.
Explain The purpose for the EXPLAIN stage is to provide students with an opportunity to	**Day 4 (40 min)** After the students review the geographic information provided and they have decided where they would like to design their building, I will show them a PowerPoint (resource below) that reviews some current earthquake resistant structures. I will review some earthquake resistant construction techniques such as rubber bearings, base isolation, tuned mass dampers and x-bracing.

5E Lesson Plan	EARTHQUAKES
communicate what they have learned so far and figure out what it means.	I will them show the students the following video that explains a famous building Tokyo and a few other technologies and techniques that can be used. Earthquake proof: Japan building made quake-safe by curtain of cables anchoring it down - TomoNews
Explore The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.	Students will return to their Chromebooks and review and further research any technique that interested them. I will review and explain the guidelines and rubric for the project (see below) The students will receive a planning worksheet that will help them plan their designs. Using this worksheet, they will be required to name their building, add the special elements of the top, middle and lower part of the building. (resource below) They will have to explain the purpose of the parts in their structures. All buildings must have clear earthquake evacuation procedures. Students must formulate their ideas and be able to explain the following features. • DESIGN: What design features will help your building to stay standing in an earthquake? Think about shape and size in particular. • CONSTRUCTION: What type of materials are likely to stay strong and stay together in an earthquake? Think about what your building will be made from This worksheet and its planning will be handed in as part of the final grade.
Explain The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means	I will circulate around the room and go to each group and review their designs. It is imperative that the students can explain their ideas and the reasons behind their designs. All elements of the building must be approved prior to online designing. I will ask the students: “How tall will your structure be?” “What design elements have you put in place in order for your building to withstand an earthquake?” “What materials will your building be made out of?” • All students must write a supporting statement about their design describing the features included, explaining their choices and if they can justify their decision making. • All students must choose between 5-10 characteristics to include in their design (see Resource below) It is understandable that some students may research and browse online and get similar ideas. However, in discussion amongst groups, creativity and ideas may be unique.

5E Lesson Plan	EARTHQUAKES
	All ideas for designs and building must be approved prior to completing their full design.
Elaborate/Extend The purpose for the EXTEND stage is to allow students to use their new knowledge and continue to explore its implications.	**Day 5-6 (40 min/day)** After their designs are approved, students have the opportunity to design their buildings online with Tinkercad. Tinkercad is a simple, online 3D design and 3D printing app. Students have been using this website in their technology classes so they are familiar with this format. https://www.tinkercad.com/ If there is a 3D printer in the class, students can 3D print their designs. Some students may be more familiar with Sketch Up or Minecraft. They can use these websites as well. If there is limited internet access or lack of devices students can draw their designs by hand.
Evaluate The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place.	**Day 7-8 (40 min/day)** Students will present their project designs to the class using the class computer and the Smartboard. They will explain their designs and all the elements that go along with it. They will be graded using the attached rubric. In order to keep all students engaged, each group will have to peer review 2 other designs. They are required to give one positive comment and either ask a question or give a suggestion for improvement for both of their reviews.
Extend	If time permits, Students can play the following video game from the International Strategy for Disaster Reduction (ISDR). This game requires the player to plan and construct a safer environment for a population. The player must assess the disaster risk and try to limit the damage when natural hazards strike. Can use this game for many different natural disasters. Stop Disasters Game

Journal Activity

Day 1 – Engage/Explore

1. Students will log into Chromebooks and turn attention to Smartboard
2. Teacher will show video on the the Loma Prieta Earthquake on October 17, 1989 in San Francisco, California
   Video - Loma Prieta Earthquake (2:33)
3. Students will then be directed to Google Classroom and follow the link to the photographic data and associated assignment
4. Photographic Data - USGS Photographic Data - Loma Prieta Earthquake
   This large repository of photographs will allow the students to experience what it must have been like to be part of this Earthquake.
5. Assignment/Assessment - Based on the video and the photographs, each student will:
   a. Imagine you were a part of the Loma Prieta earthquake. Based on the video you observed.
      i. **Write a journal entry** from October 18, 1989, and **copy and paste one of the photographs** in the data set that describes your experience from the day after the earthquake, and think about the following aspects.

      "Where were you during the earthquake?"

      "How did the earthquake affect you and your loved ones?"

      "What are the effects on your home, community and possessions?"

      "Once you knew it was an earthquake what precautions did you follow in order to stay safe?"
6. Students will have 25-30 minutes to write in their Google Docs
7. Submit assignment via Google Classroom
8. Selected Students will share their experiences in class. (5 min)

This will be a formative assessment that will allow me to see if the students are able to use the data from the photographs to write a personal journal entry.

Mini Engineering Challenge - Activity

Day 2: Engage/Explore/Explain
Challenge: Create a tower that can survive the waves created on the Earth's surface during an earthquake

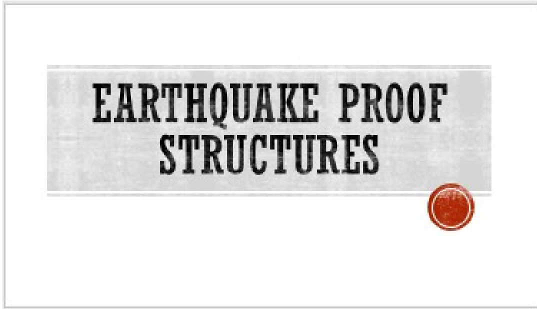
Criteria:
Brainstorm with your team of 2-3 and drawn out a plan
Building must remain standing for 10 seconds, on a moving table
Building must be at a height of 3 feet or more

Materials:
1 file folder
1-meter masking tape
12 straws
Scissors

You will have 10 minutes to plan and 20 minutes to build the tallest structure that can withstand 10 seconds on a shaking table

After building and testing, you will log into google classroom and fill out the following questions on a google form

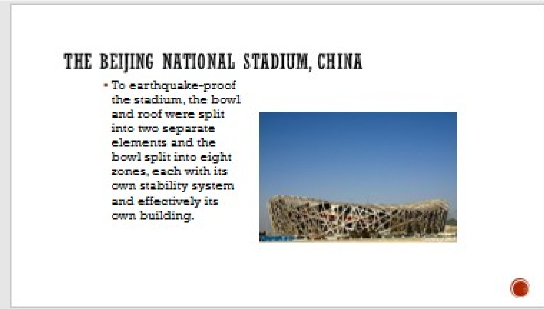
1. To what level did your members work as a team?
2. To what level did your tower meet the criteria?
3. To what degree was your tower able to withstand the forces exerted by the earthquake?
   a. What was your innovation?
4. What would you have done differently if you had more time to plan?
5. What role to architects and engineers play in designing and building earthquake resistant structures?
6. Based on your building what structural characteristics worked and which ones did not. Be specific as you will need it at a later lesson.


EARTHQUAKE PROOF STRUCTURES

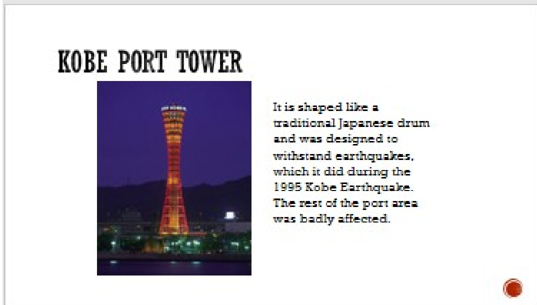
1


THE TRANSAMERICA PYRAMID, SAN FRANSISCO
It has been build pyramid shaped as this is hard to topple over.
http://Footage of the transamerica pyramid/

2


THE BEIJING NATIONAL STADIUM, CHINA
To earthquake-proof the stadium, the bowl and roof were split into two separate elements and the bowl split into eight zones, each with its own stability system and effectively its own building.

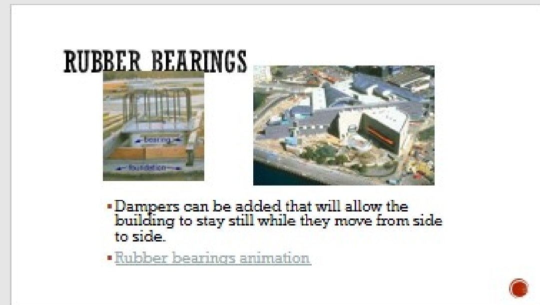
3


KOBE PORT TOWER
It is shaped like a traditional Japanese drum and was designed to withstand earthquakes, which it did during the 1995 Kobe Earthquake. The rest of the port area was badly affected.

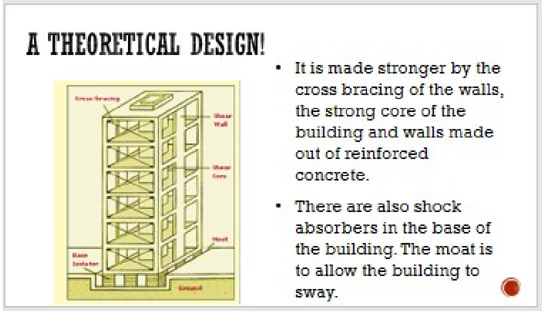
4


CENTREPORT BUILDING, WELLINGTON, NEW ZEALAND
In the event of an earthquake, the three piers can move independently of one another without destroying the bridges, which link the piers together

5


RUBBER BEARINGS
Dampers can be added that will allow the building to stay still while they move from side to side.
Rubber bearings animation

6



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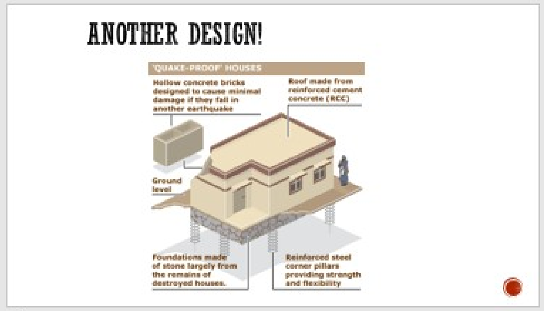

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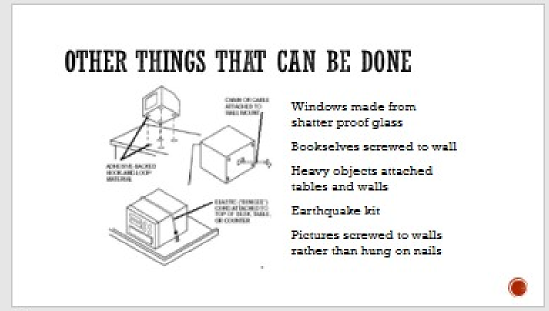

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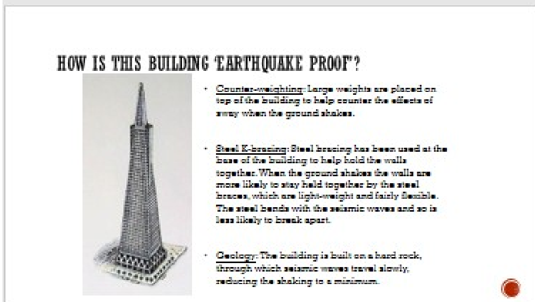

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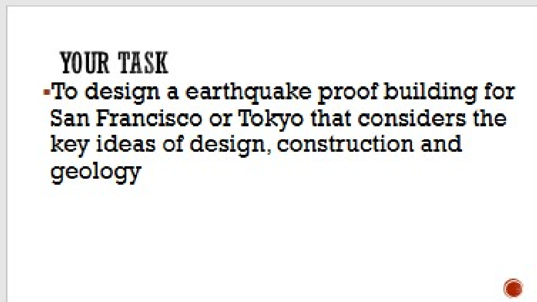

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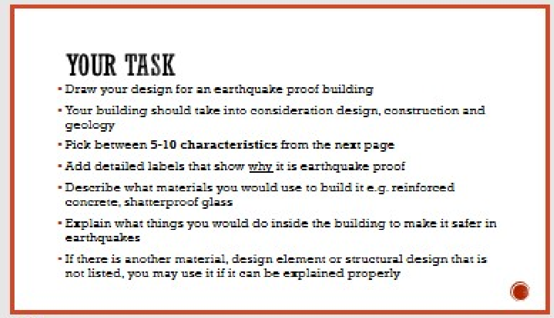

12

Triangular shape	Square shape	Circular shape	X bracing
Short building	Tall building	Base isolators	K bracing
Counter-weights	Shock absorbers	Fixed base	No bracing
Steel	Concrete	Paper	Wood
Glass	Bricks	Plastic	Tiles
Sand	Soft mud	Hard bedrock	Reclaimed land
Steep Slope	Flat land	Near a fault line	Away from a fault

6th Grade: Earthquake Proof Buildings

Your task is to design an earthquake proof building for a Tokyo, Japan or San Francisco, USA (meaning money is no object).

Each pair of students:
- Write a supporting statement about your design describing the features included, explaining your choices and if you can justify your decision making.
- Choose between 7-10 characteristics to include in your design

You may:
- Include other design features and materials that you find that are not listed
- Draw your design on Tinkercad
- Draw the building to scale by hand

You could:
- Include maps showing where you would build your building
- Include photographs of real life buildings to support your decision

Please consider:
- DESIGN: What design features will help your building to stay standing in an earthquake? Think about shape and size.
- CONSTUCTION: What type of materials are likely to stay strong and stay together in an earthquake? Think about what your building will be made from.
- GEOLOGY: What does your building need to be built upon to help withstand or limit the shaking? Think about rock type and landscape in particular.

All students:

- All students will have to present their designs to the class.
- Must justify their use of all their design elements
- Must have clear evacuation procedures for their buildings
- Must submit design planning page to teacher
- As a team write and submit a supporting statement justifying the design and its elements.

Construction company name

Building name:

Building location:

Building features - Top
This needs to give details of how the top of your building is designed to prevent collapse in the event of an earthquake.

Building features - Middle
This needs to give details of how the middle of your building is designed to prevent collapse in the event of an earthquake.

Building features - Lower section/ base
This needs to give details of how the lower section of your building is designed to prevent collapse in the event of an earthquake.

Earthquake procedures
This would take the form of a poster throughout the building, like the fire procedure posters we have around the Academy.

Which of these would you incorporate into your building and why?

1. Shock absorbers
2. X bracing
3. Counter weights

Give details of your own genius ideas to make your building able to withstand an earthquake.

Supporting Statement

On a shared Google doc with your partners:

Please write a supporting statement about your design and describe the features you have used in your building. Be sure to explain your choices and justify your decision in using these elements. Please be as detailed as possible.

Please share this document with me as well.

PICK BETWEEN 7-10 CHARACTERISTICS FROM THE LIST BELOW

Triangular shape	Square shape	Circular shape	X bracing
Short building	Tall building	Base isolators	K bracing
Counter-weights	Shock absorbers	Fixed base	No bracing
Steel	Concrete	Paper	Wood
Glass	Bricks	Plastic	Tiles
Sand	Soft mud	Hard bedrock	Reclaimed land
Steep Slope	Flat land	Near a fault line	Away from a fault

Grading Rubric

	1	2	3	4
Teamwork	Only one of the team members did the planning and design	Both of the team members worked together on the planning but only one worked on the design	Both members participated in planning and design but they did not work equally	Both members of the team participated and worked equally in planning and the designing and worked well together.
Comprehension	Students did not comprehend the goal of the activity.	With guidance students began to comprehend how to build a tall, strong, safe structure.	Students comprehended the goal of the activity and could plan and design a structure that was safe, tall and strong.	Students met the goal of the activity and went beyond expectations in planning and designing a tall, strong, safe structure.
Planning	Designs were not planned on worksheet and not well thought out.	Designs were somewhat planned on worksheet but specific design elements were haphazardly planned	Designs were mostly planned on worksheet and some design elements were somewhat specific and well thought out	Designs were well planned on worksheet and design elements were specific and well thought out
Geology	Students did not take into consideration the geology of the location they chose	Students took into consideration some geology of the locations they chose	Students took into consideration the specific geology of the location they chose but did not provide maps	Students took into consideration the specific geology of the location they chose and added maps as well

	1	2	3	4
Justification Support Statement	Students did not write a statement justifying their design ideas	Students did not write a clear justification statement supporting their design	Students wrote a clear justification statement supporting their design describing the features but did not explain their choices	Students wrote a clear justification statement supporting their design describing the features included, explaining their choices
Construction Elements	Groups used 1-2 characteristics in their designs	Groups used 3-4 characteristics in their designs	Groups used 5-6 characteristics in their designs	Groups used 7-10 characteristics in their designs
Earthquake Evacuation Procedures	Evacuation procedures were not listed or explained	Evacuation procedures were listed but not explained	Evacuation procedures were listed and explained, however they were not creative and or realistic.	Evacuation procedures were creative, realistic and explained properly
Scale and Proportion	Buildings are not designed to scale	Buildings have some scaled design elements but it is mostly not designed to scale	Buildings are mostly designed to scale	Buildings are designed to scale
Presentations	Groups gave a poor description of designs	Groups gave some details but otherwise did not explain their reasoning	Groups gave many details and had some explanations for their reasons they chose those elements	Groups gave a rich and detailed explanation of their designs and the reasons they chose those elements

Design Activity: _______/40
Peer Review: 5 points each ____/10

Total Points _______/50

Resources

1. Earthquakes & Volcanoes. (n.d.). Retrieved from http://www.geographypods.com/earthquakes--volcanoes.html
2. Loma Prieta Earthquake
3. USGS Photographic Data - Loma Prieta Earthquake
4. https://webnew.ped.state.nm.us/wp-content/uploads/2017/12/55_Are-You-STEM-Ready.pdf
5. Ted-Ed Why do buildings fall in Earthquakes?
6. Japan's Explosive Geology Explained
7. San Francisco Bay Region Geology
8. https://www.ck12.org/earth-science/earthquake-safe-structures/lesson/Earthquake-Safe-Structures-MS-ES/?referrer=concept_details
9. Earthquake proof: Japan building made quake-safe by curtain of cables anchoring it down - TomoNews
10. Fitriani, D. N., Kaniawati, I., & Ramalis, T. R. (2017). Creativity of Junior High School's Students in Designing Earthquake Resistant Buildings. *Journal of Physics: Conference Series,895*, 012162. doi:10.1088/1742-6596/895/1/012162
11. Turgeon, B. (2014). Designing Earthquake Resistant Structures: Integrating Science and Engineering Practices. *Science Scope*,49-57.
12. https://www.tinkercad.com/
13. The Earthquake-Proof Tower in Japan - Secret Revealed