
THE EMPIRE STATE BUILDING

EDUCATIONAL MATERIALS

ENGINEERING:
GRADES 9-12



STEEL BEAMS, TOSSING RIVETS, AND THE ENGINEERING OF SKYSCRAPERS IN THE 1920s & 1930s

Exhibit Connections: Construction; Modern Marvel, Otis Elevators; Observation Deck

OVERVIEW OF LESSON PLAN

Students will research and write about the different materials used at different times in history to construct buildings. The trip to the Empire State Building provides a fascinating opportunity to see an exhibit that shows the construction of the interior structure of one of the most famous and iconic buildings in the world, while students are standing inside the actual structure. This project will leverage that opportunity; after students see an exhibit about the construction of the steel interior (and the teams attaching rivets in one of the fastest construction projects in history), they can see one of the actual beams holding up the structure. They can also see the exterior masonry that gives the Empire State Building its famous Art Deco appearance.

After seeing and learning about the internal structure of the Empire State Building, students will conduct research and write an essay that considers the advantages and disadvantages of the various materials used as the structural elements of buildings in history—clay, wood, brick, stone, steel frame, concrete with steel rebar, and modern composite materials. Students will learn about steel frame construction, and each student (or group) will also choose one additional material to research. They will find out when and where that material was most commonly used as a building material, its advantages and disadvantages, and how it is used today. Students will consider how the mass production of steel (beginning in the Industrial Revolution) effected a massive shift in building processes around the world. The availability of steel helped bring about the construction of high-rise buildings and allowed the massive urbanization of the world's population that began in the early 1900s. Indeed, the construction of the Empire State Building is symbolic of the growth

of cities that would not have been possible without the availability of steel and innovations like the “riveting” that we see in the Empire State Building exhibits. Finally, students will read about the recent renovations of the Empire State Building that dramatically reduced its energy consumption, and students will consider the environmental implications of the building materials they researched.

OBJECTIVES

Students will deepen their understanding of:

- The differences between various materials that are (or have been) used as the main structural elements in buildings
- Various considerations of builders when designing a building and choosing materials (cost, speed, and ease of construction, availability in the location, strength and potential height of the structure, fire safety, durability for time and in local weather)
- The specific advantages and disadvantages of steel beam construction and riveting
- How the availability of steel changed society and led to an era of mass urbanization
- How builders are reducing energy consumption (to reduce a building’s carbon footprint) and how the building materials impact energy use.

SUGGESTED TIME ALLOWANCE:

1.5 hours



THE SITE IN THE 1920s



The original Waldorf-Astoria Hotel once stood right here. Look through these surveyor's levels to see the site in the 1920s.

Unter Waldorf-Astoria an Standort ist geblieben. Vor den von den Jahren 1920.
WALDORF-ASTORIA.
 Hier stand einst das erste Waldorf-Astoria Hotel. Nachdem die ersten Stiele auf die Träger kamen. Das wurde auf insgesamt 11 Stockwerke gebaut. Genaue Kontrolle lagst auch 20.
 Alles andere wird in dem Waldorf-Astoria. Mehr konnte in 1920.
 11 Stockwerke hoch zu bauen und auch in 1920.
 Die 11 Stockwerke wurden in 1920.
 11 Stockwerke hoch zu bauen und auch in 1920.

RESOURCES/ MATERIALS:

- Information provided in the Empire State Building exhibits, particularly the history of the building's construction, the timeline of the construction, the exhibit showing the teams of riveters attaching steel beams, and the exposed steel beam
- Article from *The Washington Post*, "Empire State of Green"
- Paper or notebook for taking notes at the Empire State Building
- Additional research and writing will be done on a computer after the trip

ACTIVITIES/ PROCEDURES:

PRE-TRIP ACTIVITY

Students will conduct brief preliminary research about the various materials that have been used in different places and time periods to construct buildings. They should find photographs and examples of buildings structurally made from as many materials as they can. Students should find examples of building construction using these materials and begin to take notes on the advantages and disadvantages of each:

- Wood
- Clay, brick
- Stone, masonry
- Steel frame
- Concrete with rebar
- Modern composite materials

This article [An Innovative Skyscraper](#) is a good place to start.

ON-SITE ACTIVITIES One-1.5 hours

EXHIBIT: CONSTRUCTION (15-20 minutes)

Students will carefully observe and take notes on what they see in the exhibits related to the construction of the steel framing inside the Empire State Building. They will take notes on the information in the exhibit of the teams of steel riveters and the exposed steel beam and on the timeline of the building's construction. (Note that the steel beam with the statues of riveters is a structural beam of the Empire State Building.)

EXHIBIT: MODERN MARVEL AND/OR OTIS ELEVATORS (15-30 minutes)

The Empire State Building is being built all around you! Take a moment to observe the pieces coming together, and how the workers are connecting them. Sketch the path of a material as it connects to others. Add pictures and notes to describe what you see. (For example, you could track the path of a rivet or a beam.)

EXHIBIT: OBSERVATION DECK (15-20 minutes)

What do students notice about the materials on the outside of the building? What do they notice about the materials of other buildings visible from the observation deck?

POST-TRIP ACTIVITY/FURTHER DISCUSSION

After the trip to the Empire State Building, students will choose one alternative material that is used in building construction and write an essay comparing that material to the use of steel framing. The students' essays will discuss the advantages and disadvantages of steel and one other material and will highlight the ways in which the material can impact the height of buildings and the cost of construction. The essay should also describe the societal impact of the availability of steel for building construction and how the ability to build large high-rises effected an era of urbanization in the early 20th Century. Finally, the essay should consider recent efforts to reduce energy consumption, and how the choice of building materials might impact a building's carbon footprint.

If the teacher chooses to continue with additional learning after students conduct their research and write their essays, students could design a building of their own. Students could choose what type of structure they are building (home, office, high-rise, museum, or anything else) and choose a construction material that will serve as the core of the structure. They could make a model or use 3D software to create an image of their structure, with particular attention on the reasons why they chose the particular materials.

EVALUATION AND ASSESSMENT

Teachers can review and assess the final essays written by each student according to the standards and grade levels appropriate for their class. Students should be able to write about engineering and construction using appropriate terminology and with connections to material addressed in the course. Teachers can adjust the details of the assessment as they see fit. Moreover, depending on the grade level, accommodations for students with disabilities or students learning English could be provided by sharing specific links for research or a template for the essay.



CONNECTIONS TO THE STANDARDS

NEXTGEN SCIENCE STANDARDS

HS-ETS1-1 ENGINEERING DESIGN

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 ENGINEERING DESIGN

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 ENGINEERING DESIGN

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

PRE-TRIP WORKSHEET

PRELIMINARY (PRE-TRIP) RESEARCH

In order to prepare for your trip to the Empire State Building, we will do research to learn about the various materials that are used (or have been used in other places or times in history) as the core structural elements of buildings. When and where have people built structures out of clay? Wood? Brick, stone, masonry? When did people start using steel frames to build structures? Concrete with rebar? Other composite materials? Were some materials more popular for building construction at various times in history? Were some invented later?

Find photos of buildings made of various materials—but be careful not to focus only on the external facade, which is often decorative (and not structural). Your research assignment is to find building structures that are supported by each of these core materials.

While you identify and find photographs of these different building materials, take notes on information you find about the advantages and disadvantages of each material. For example, are certain materials more or less helpful for the building's:

- Height
- Cost
- Speed of construction
- Environmental impact, energy use
- Fire safety
- Strength, weather resistance
- Longevity



PRE-TRIP WORKSHEET

NAME _____

DATE _____



EMPIRE STATE BUILDING TRIP, ENGINEERING 9-12

TRIP NOTE-TAKING SHEET

Look carefully at the exhibits about the construction of the Empire State Building, especially the exhibit about the construction teams and the internal structure of the building.

What materials are used in its construction? How was it assembled?

How long did it take? What new technologies are currently being implemented to make the Empire State Building energy efficient? When you see the Observation Deck, what do you notice about the sides of the structure?

Notes:

PRE-TRIP WORKSHEET

RESEARCH PAPER ASSIGNMENT

You have completed your trip to the Empire State Building and learned about one of the most famous examples of a new material that changed how humans construct buildings forever. When steel beams became widely available, we built structures much taller than ever before—which allowed us to transform cities vertically and culminated in incredible structures like the Empire State Building.

To wrap up this experience, you will write a research paper based on the research you began before the trip, the information you learned on your trip, and additional research you will conduct now. Your assignment is to write an essay comparing and contrasting two materials that people use (or used in history) to construct buildings. Everyone will write about steel, and you will also choose one additional material (from the list of materials you researched before the trip).

In your research paper, try to answer the following questions:

- What are the advantages and disadvantages of building structures out of the two materials you are writing about? Consider the cost, strength, longevity, height of the possible buildings, ability to withstand weather conditions, fire safety, and any other advantages or disadvantages.
- When and where were the two materials most commonly used to construct the structural support for buildings? When were they discovered or invented? What types of buildings are most appropriate for these materials?
- Specifically, when was steel commonly available for use as a building structure? How did the availability of steel impact the potential height of buildings? How did this affect history and demographics? What percentage of the population lived in cities (compared to rural areas) before the availability of steel? After? Today?
- Builders are increasingly considering the possible environmental impacts of their construction. How much energy will be required for lighting, heating, and cooling a building using this material? How do these materials impact a building's carbon footprint?

(Read this article [“Empire State of Green”](#) from *The Washington Post* for background on the Empire State Building's recent renovation.)

